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APPENDIX A Working Group 4 Recommendations for Experimental Program

A.1 Introduction

This appendix summarizes the test plan established in early 2017 to guide the PEER-CEA Project Working Group 4 testing. This information is included to provide information on the overall experimental testing scope, objectives, and approach. Some aspects of the testing plan were revised during implementation. In particular, this is true of the small-component tests detailed in Attachment A, in which choice of test specimens further evolved as testing was being conducted. This report provides recommendations for testing to be conducted under the Task 4 experimental program.

A.2 Testing Group A: Cripple-Wall Components

What: Testing of cripple wall components to develop load-deflection behavior for analytical modeling and loss modeling; these tests will also serve to identify characteristics of damage evolution to the cripple-wall component during combined lateral and axial (gravity) loading.

Why: The load-deflection behavior of cripple walls is key to predicting seismic response of cripple wall dwellings and related damage. Existing data is very limited.

Approach: Small-component testing as described below for finish materials with limited continuity and for correlation studies with large-component testing.

Large-component testing as described below to capture influence of component size, boundary conditions, and continuity of finish materials to occupied story wall above. Intent is to use limited number of tests for comparison to small-component tests. This will determine whether it is possible to capture response in small-component tests, or larger component is required.

A.3 Testing Group A: Small Component

Tests: Thirty-two tests varying materials, condition, year of construction, and load path connections (consistent with year of construction); see attached spreadsheet and Figures A.1 and A.2. Note: the setup adopted in the UC Davis cripple wall test program (Chai and Hutchinson) is proposed; with modified edge conditions for specimens finished in stucco to capture the additional restraint anticipated at the floor and end-wall boundaries.

Test Location: UC San Diego

Estimated Schedule: These tests are proposed in two phases, beginning with pre-1940 era specimens (start in November 2017).

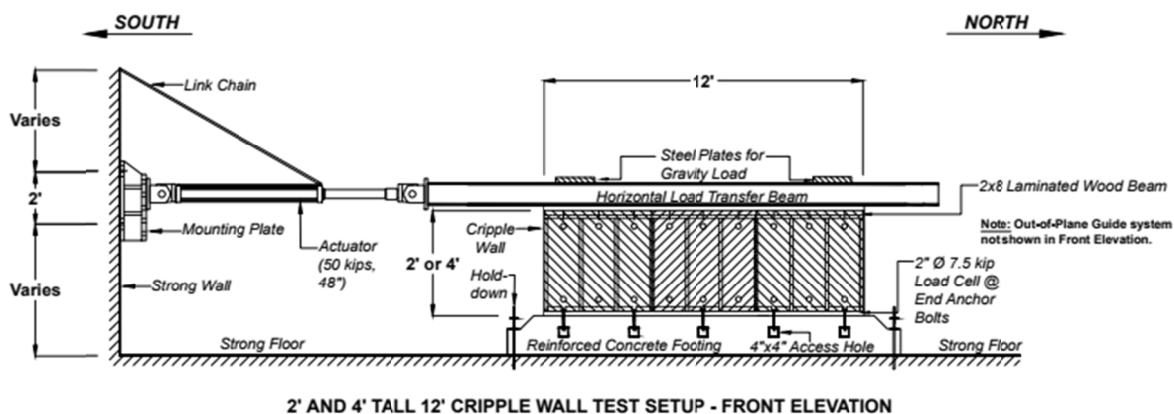


Figure A.1 Group A small-component test setup (2 ft and 4 ft CW) is proposed to be similar to that used in CUREE testing by Chai and Hutchinson (CUREE W-17, 2002).

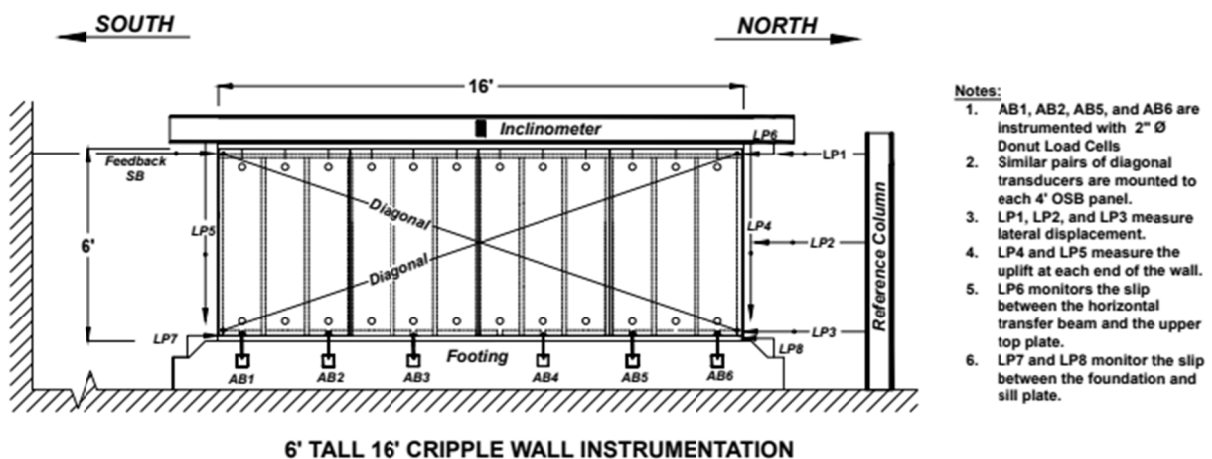


Figure A.2 Group A small-component instrumentation setup (6 ft CW) is proposed to be similar to that used in CUREE testing by Chai and Hutchinson (CUREE W-17, 2002).

A.4 Testing Group A: Large Component

Tests: Four tests including two different exterior finish materials and with and without retrofit; see Figure A.3.

Specimen	Existing (E) of retrofit (R)	Exterior finish	Interior finish
AL-1	E	Stucco over horizontal sheathing	Gypsum wallboard
AS-2	R	Stucco + S+HS	Gypsum wallboard

Test Location UC Berkeley

Estimated Schedule: February 2018

Test Setup: See attached “Attachment B” sketches 1 to 4 of 6.

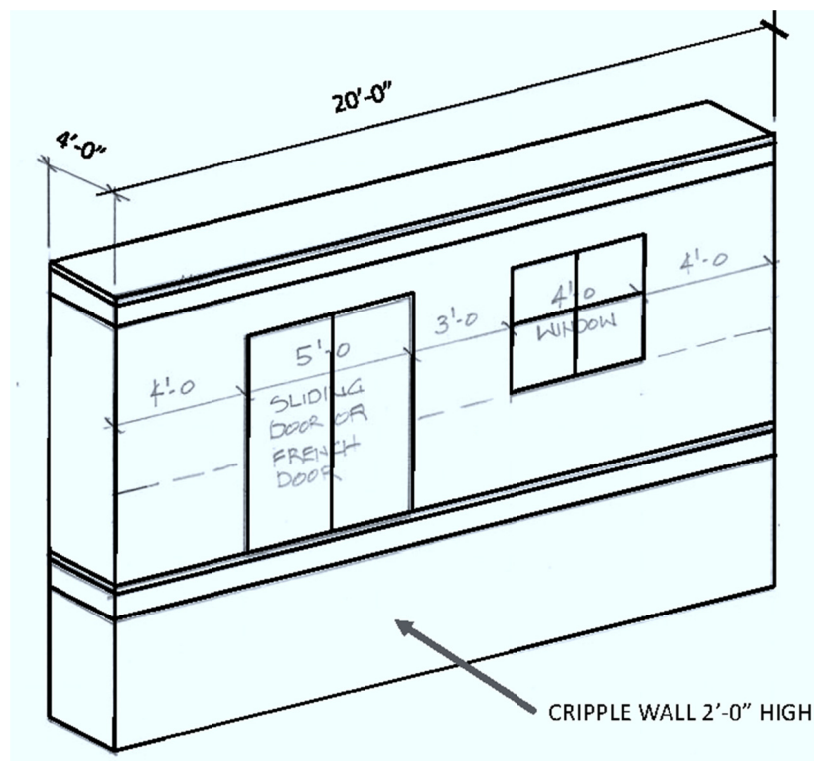


Figure A.3 Group A large-component test setup is proposed to be similar to that used in CUREE-CEA testing by Arnold, Uang and Filiatrault (CUREE EDA-03, CUREE EDA-07, 2003).

A.5 Testing Group B: Load Path Connections

What: Testing of load path connections between foundation sill plate and foundation and connections between cripple-wall top plate and floor framing above. These tests will include retrofit conditions.

Why: These connections are critical to the performance of cripple walls and anchorage, and there is little or no publicly available information on performance, especially performance within representative cripple-wall assemblies.

Approach: Testing of retrofit anchors to foundations, used where there is not enough height to use roto-hammer in installation of anchor bolts. These retrofit anchors are bolted to the face of the foundation rather than the top and will be tested in a 2-ft-high cripple wall assembly.

Testing with retrofit anchors will include representative connections from cripple-wall top plate to floor framing above.

Tests: One tests of back to back cripple walls, with retrofit

Specimen	Existing (E) or Retrofit (R)	Left Side		Right Side	
		Top Connection	Bottom Connection	Top Connection	Bottom Connection
B-1	R	A35	URFP	A35	URFP

(1) Post-installed anchors. Concrete anchor type TBD (epoxy vs. expansion anchor).

Test Location: UC Berkeley

Estimated Schedule: TBD estimated summer 2018

Test Setup: Reuses base from large-component testing; see attached “Attachment B” sketch Sheet 5 of 6.

A.6 Testing Group C: Combined Materials in Occupied Stories

What: Limited testing of full story-height walls in occupied stories with key combinations of interior and exterior finish materials.

Why: The only combination of materials with substantial test information that includes appropriate wall configuration, boundary conditions, and loading protocol is the CUREE-CEA testing of combined stucco and gypboard. Rules currently used to combine finish material hysteretic behavior is known to be very approximate. Description of the combined finishes is key to study of propagation of damage into the occupied stories and resulting losses.

Approach: Tests of priority combinations of materials using wall configuration and boundary conditions similar to the CUREE-EDA testing. Priority will be given to material combinations thought to be most damageable and therefore more critical to estimating losses.

Tests: Two tests of back-to-back walls.

Specimen	Existing (E) or Retrofit (R)	Exterior Finish	Interior Finish	Matching Small-Component Specimen
C-1	E	Horizontal wood siding (shiplap)	Plaster on wood lath	A-9
C-2	E	T1-11 sheathing with typical non-shear wall installation	1/2-inch gypboard installed per conventional construction	A-25

Test Location: UC Berkeley

Estimated Schedule: TBD estimated fall 2018

Test Setup: Reuses base from large-component testing; see attached “Attachment B” sketch Sheet 6 of 6.

A.7 Future Testing

The following were identified as testing of interest that did not rise to the level of priority or fit within the available budget. These are provided for consideration for future testing:

- Further testing of combined materials in occupied stories to better describe performance of the superstructure.
- Systematic testing of cripple walls with deteriorated materials or fastening in order to further expand the limited testing recommended to be conducted under Group AS. Discussion is needed of types and extents of deterioration can reasonably be studied through physical testing.

- Testing of large subassemblies using box configurations rather than planar walls in order to inform analytical modeling of three-dimensional structures. Additionally, this may inform concerns that cripple walls can fail due to excessive out of plane movement of the wall top, creating a p-delta condition that overcomes the stud top and bottom connection capacities.
- Hybrid testing combining a large-scale cripple wall test with an analytical model of a full building in order to allow understanding of differences and possible model calibration required to capture response.
- Full-dwelling shake table test of dwelling with and without cripple wall retrofit as a proof of concept and to allow modeling validation/calibration. It is noted that this type of test specimen is the focus of planning for the final year of the project, as requested in the CEA RFQ.

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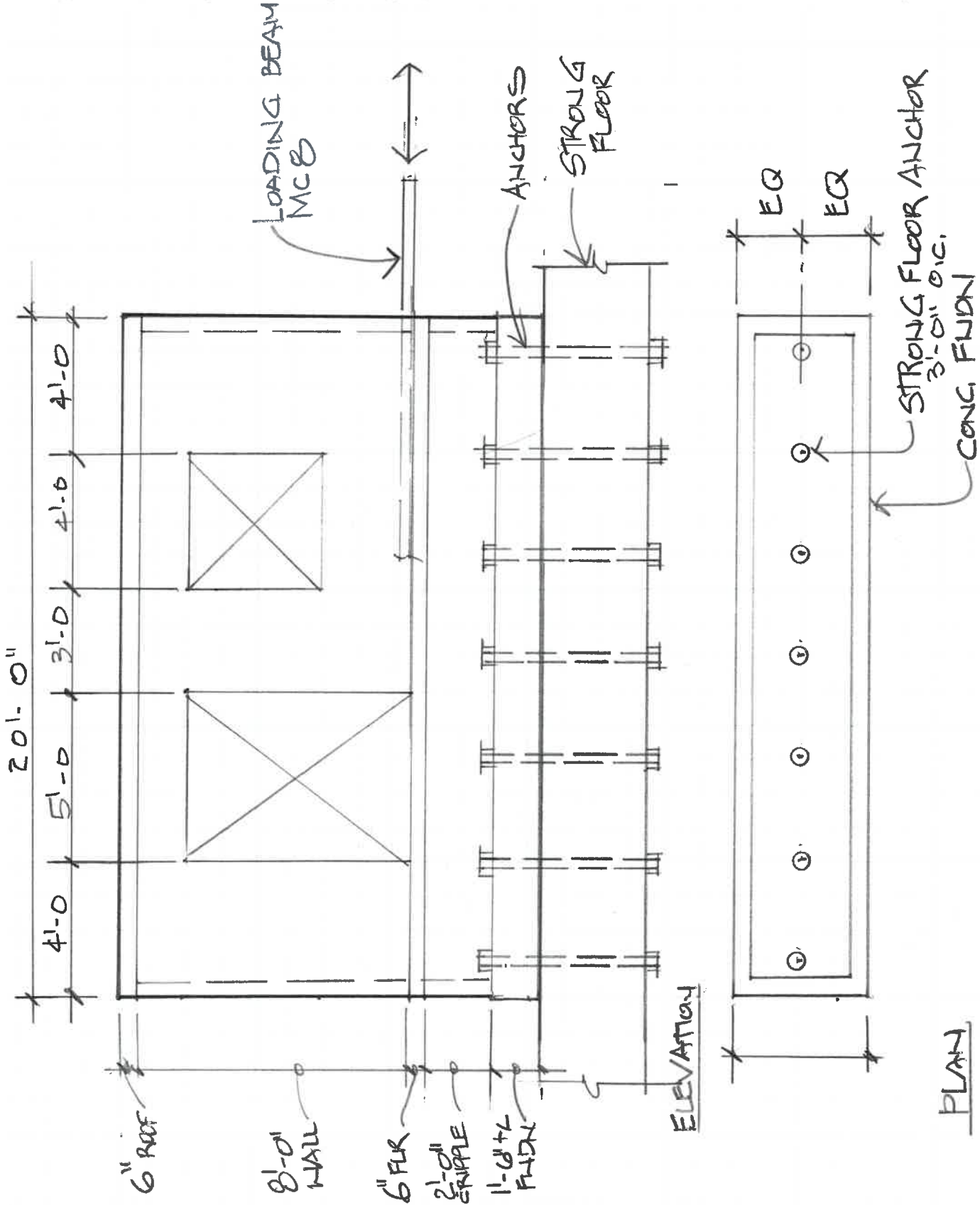
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LARGE COMPONENT TEST
ELEVATION & PLAN



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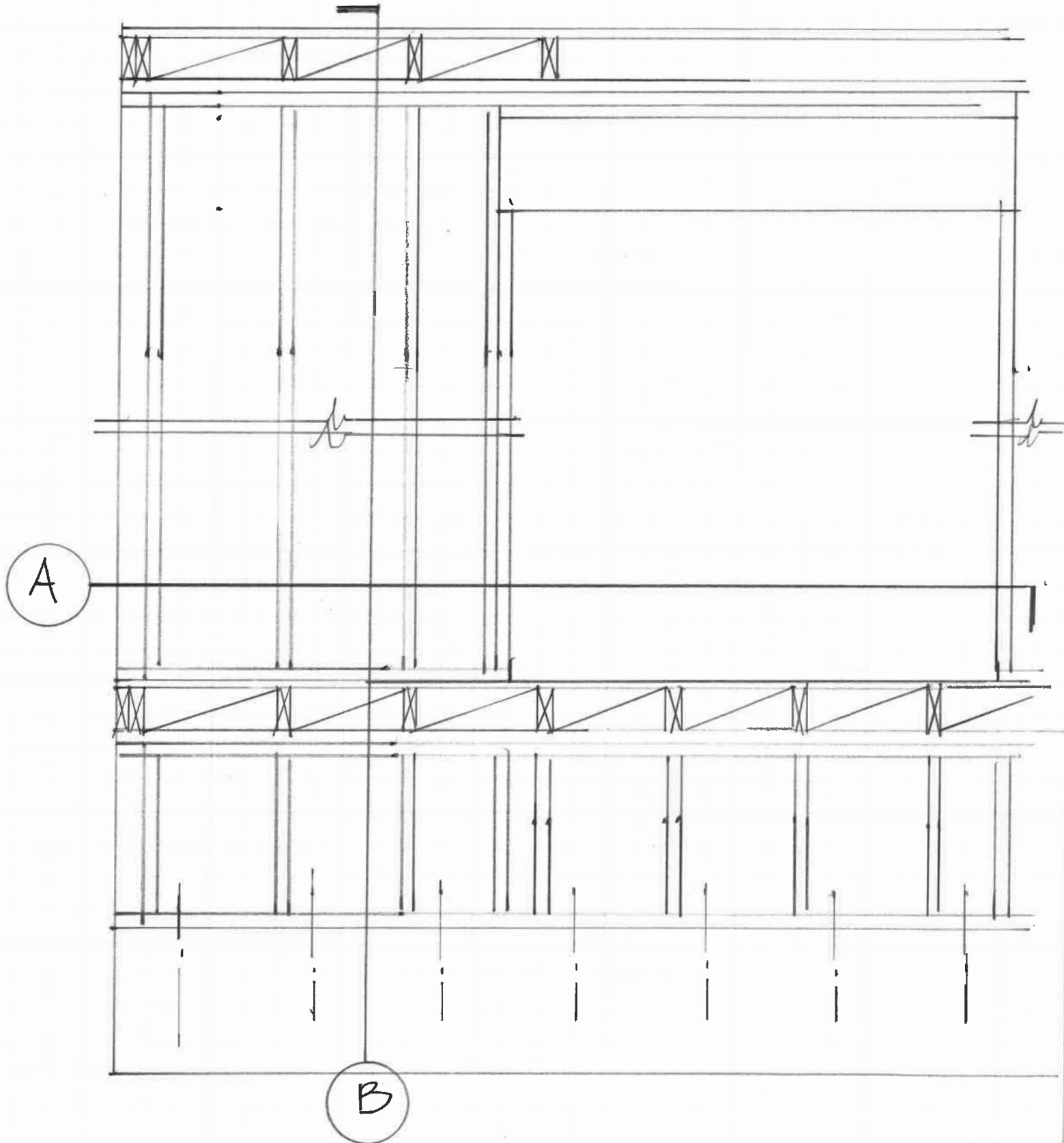
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LARGE COMPONENT TEST
PARTIAL FRAMING ELEVATION



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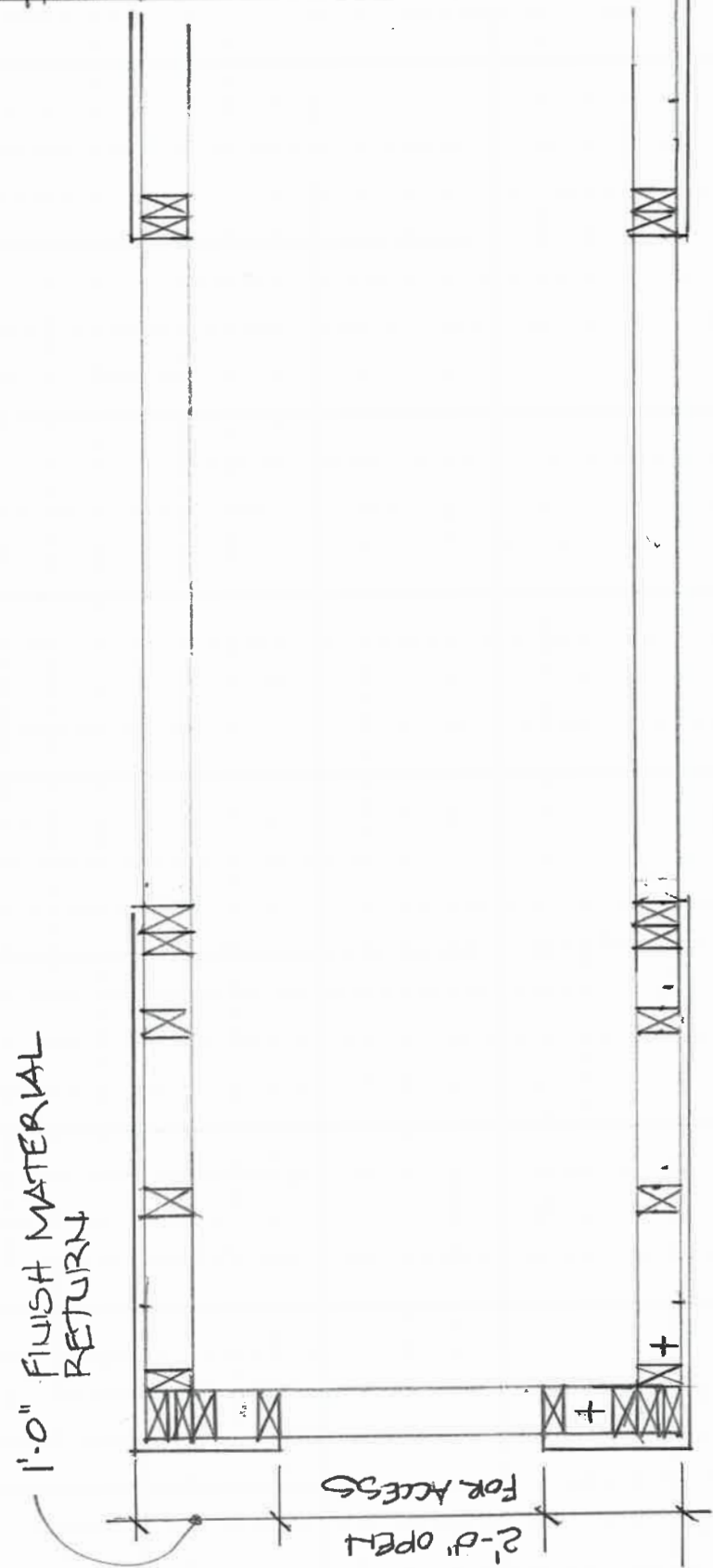
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LARGE COMPONENT TEST PARTIAL FRAMING PLAN



A PARTIAL FRAMING PLAN
3/4" = 1'-0"

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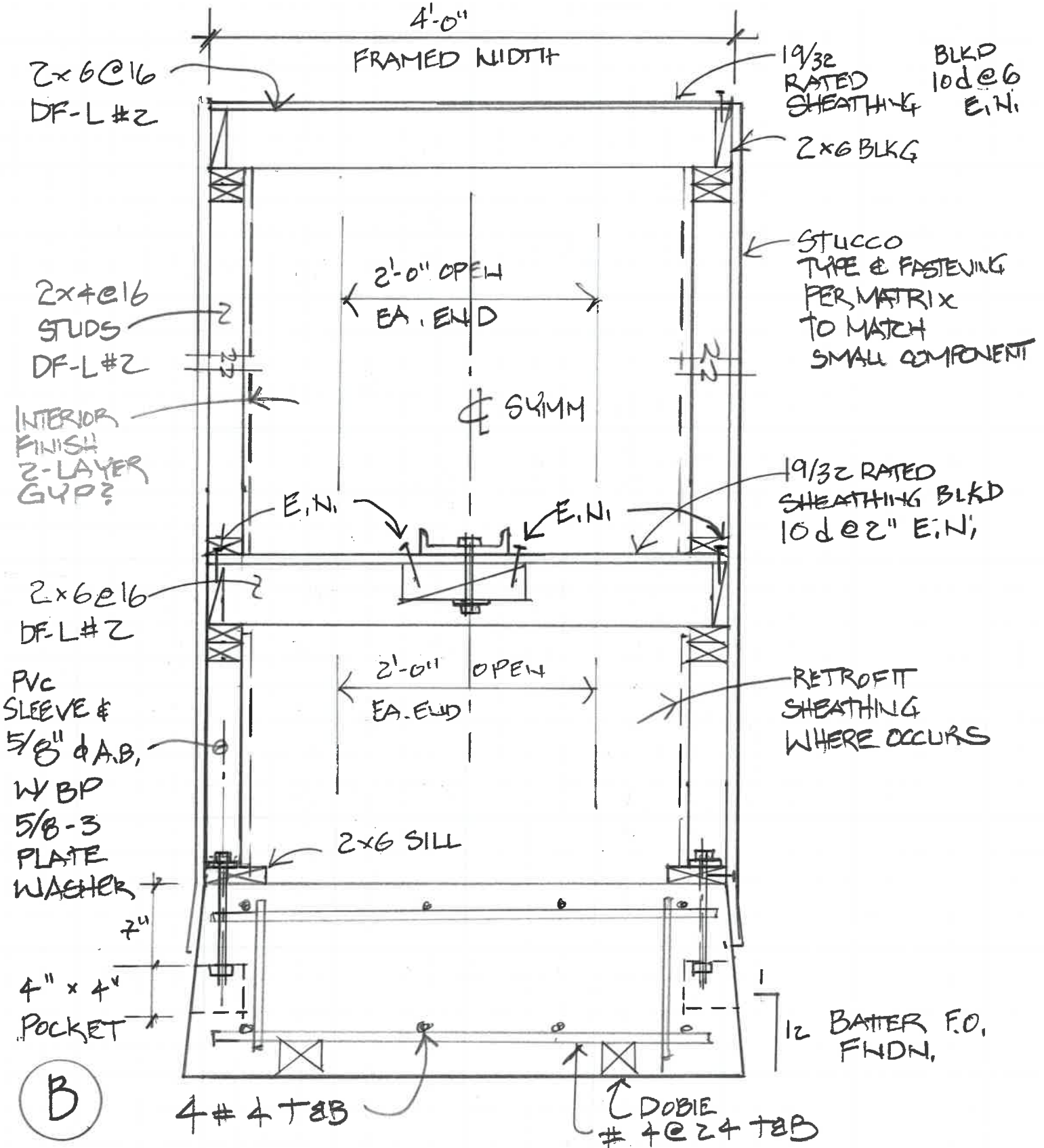
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LARGE COMPONENT TEST SECTION



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Project Number

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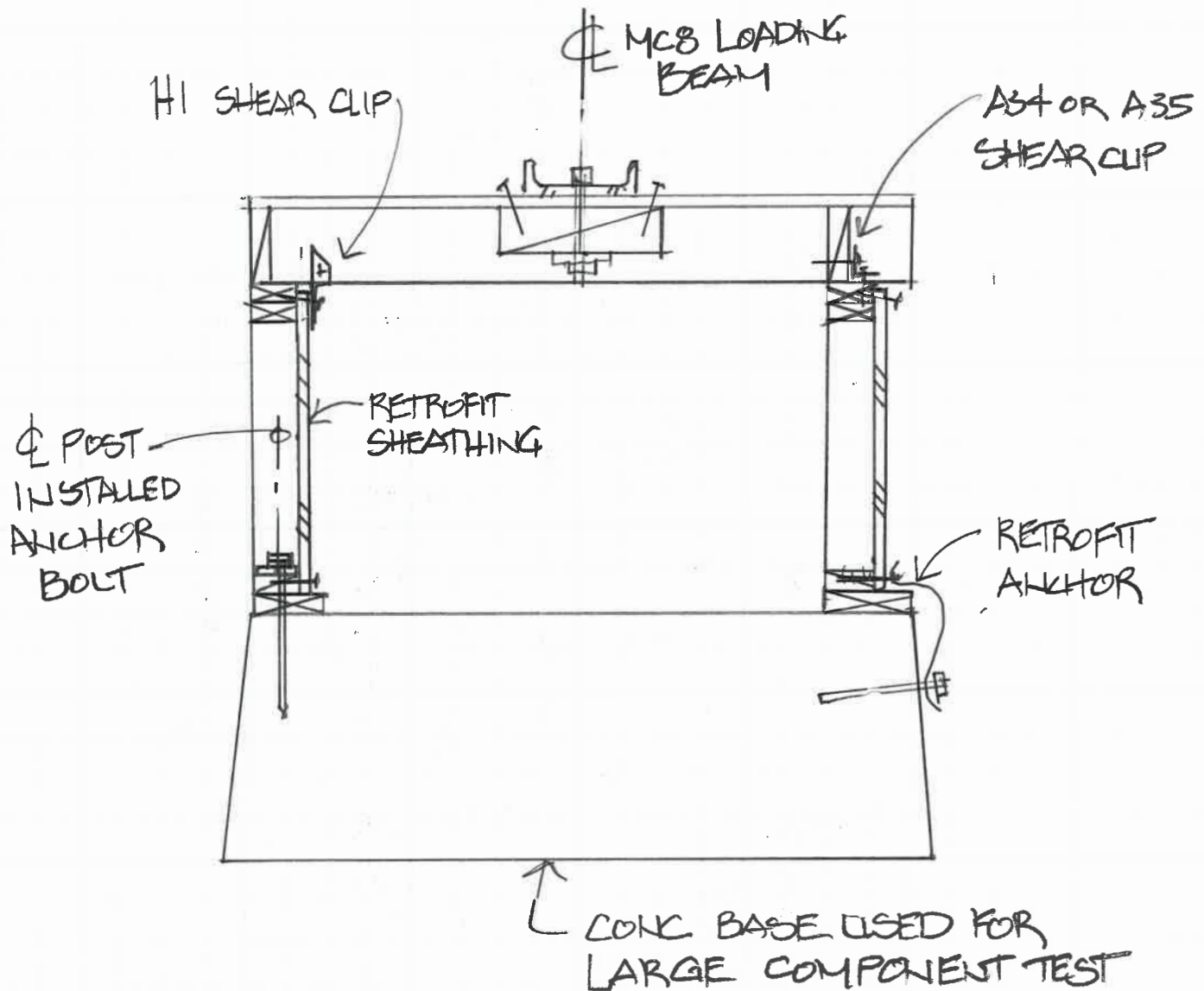
Date

9.9.2017

GROUP B LOAD PATH CONNECTION

TEST B-2 AS SHOWN

TEST B-3 TO INCLUDE ALT FEMA PLAN SET DETAIL



Made By

KEL

6/6

Checked By

Project Number

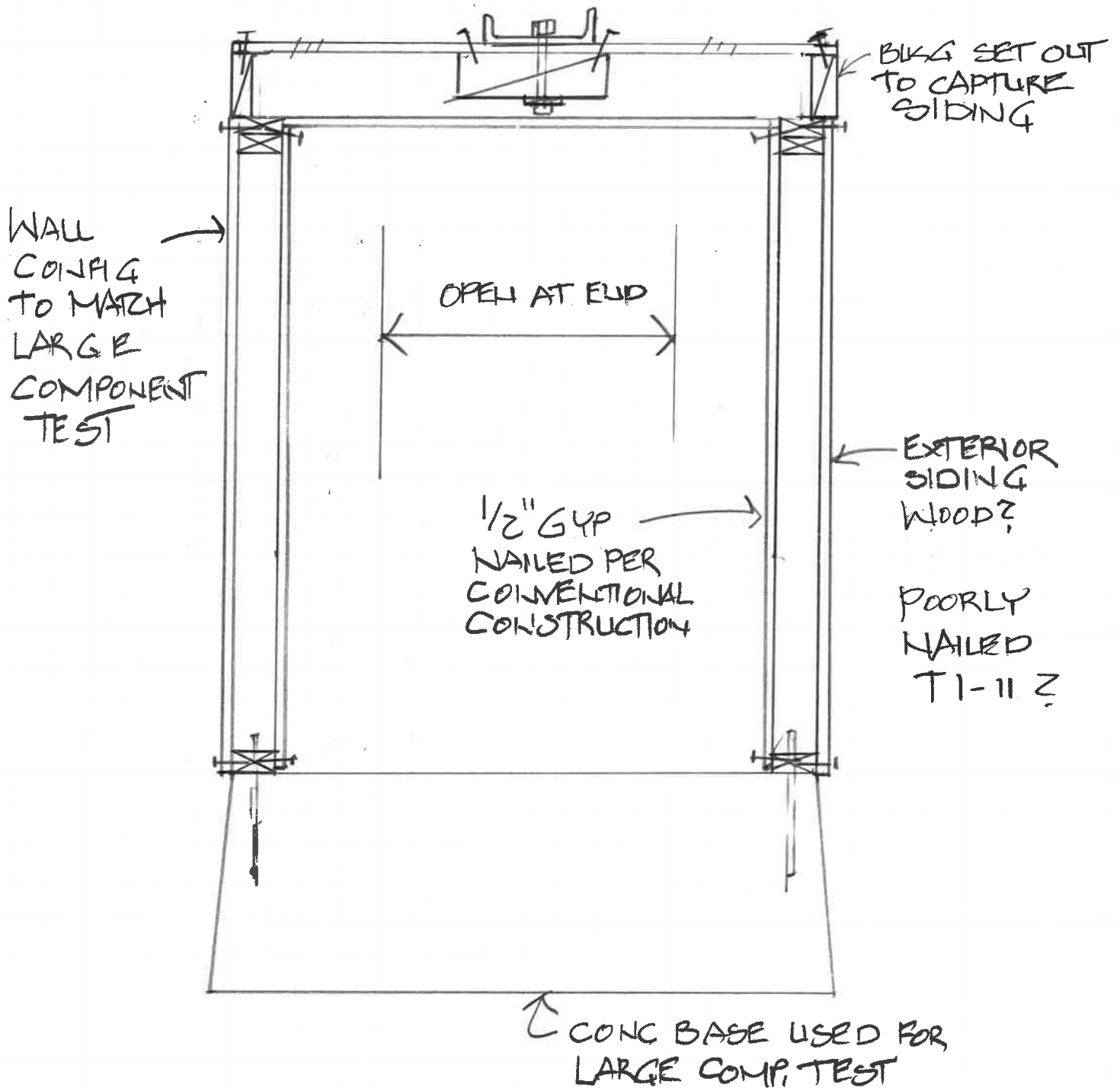
Sheet Number

Date

9.9.2017

GROUP C

COMBINED MATERIALS - OCCUP. STORIES



APPENDIX B Test Specimen Drawings: Working Group 4

**“Quantifying the Performance of Retrofit of Cripple Walls and Sill Anchorage in
Single Family Wood-frame Buildings”**

Large Component Test - Working Group 4 - General Drawings

Updated: June 5, 2018

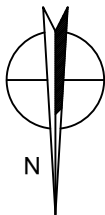
Construction: Text loading fixture and foundation details

Loading Fixture:

GE1-L1	General Text Fixture Plan
GE1-L2	Loading Fixture
GE1-L3	Load Fixture Detailing
GE1-L4	Loading Beam

Foundation Drawing:

GE1-F1	Foundation
GE1-F2	Foundation Reinforcing Details



GE-L1

University of California, Berkeley
Large Component Test
All Specimen Groups

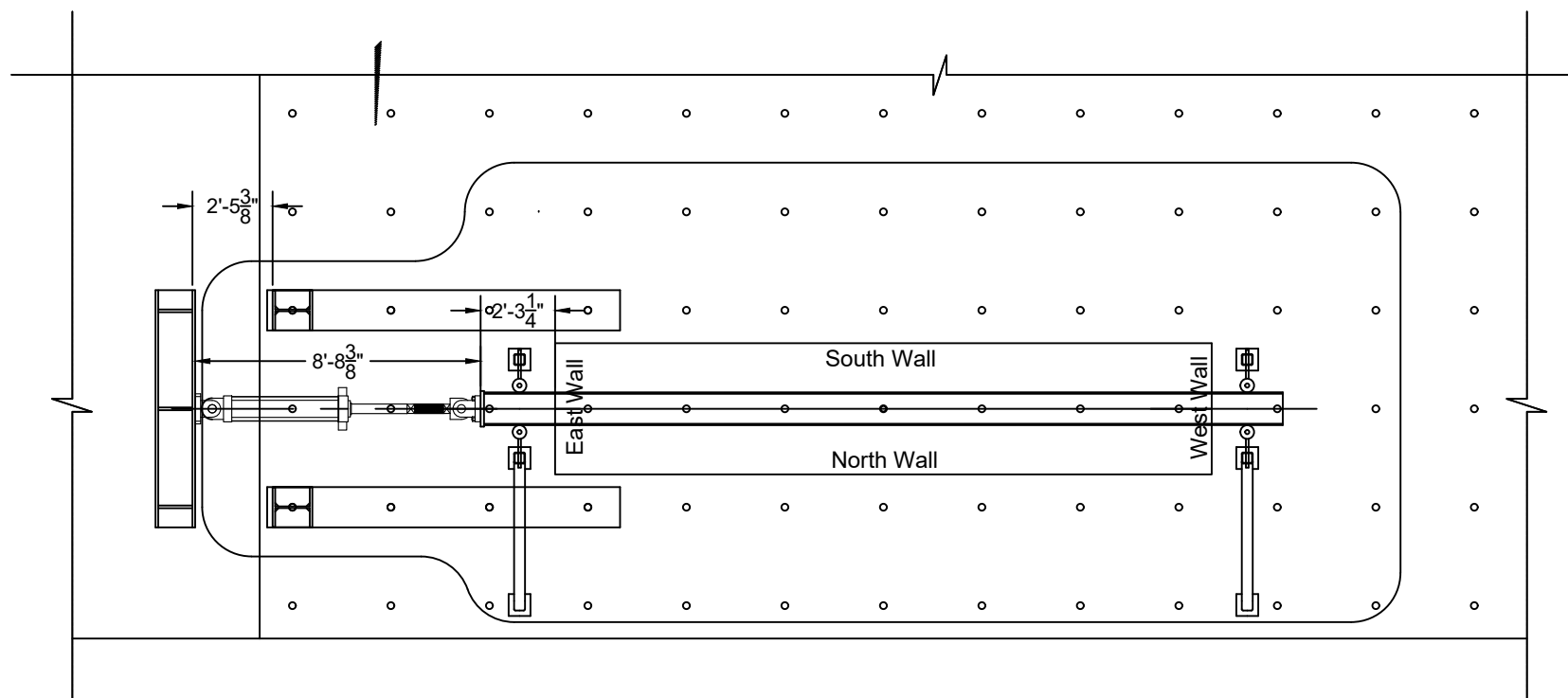
Drawing title: General Text Fixture Plan

Drawn by: Shakhzod TakhirovC

Controlled by: Kelly Cobeen, Vahid MahdaviFar

Revision history:

Rev01.02 3/12/2018



Scale: 1" = 66" on 8.5x11

General Text Fixture Plan

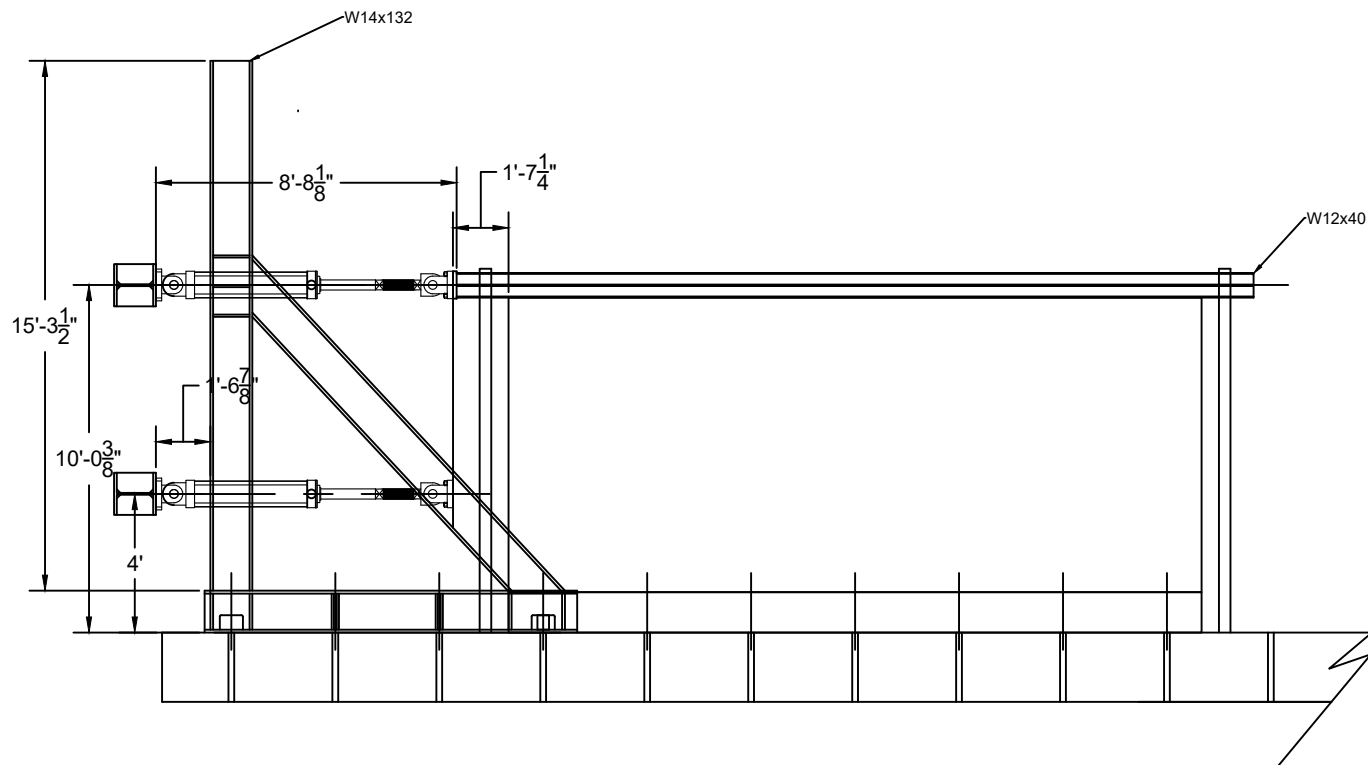
Drawing title: Loading Fixture

Drawn by: Shakhzod Takhirov

Controlled by: Kelly Cobeen, Vahid Mahdaviyar

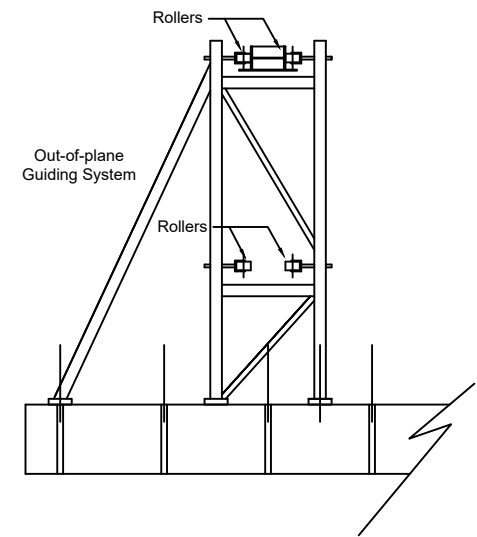
Revision history:

Rev01.02 3/12/2018



Scale: 1" = 66" on 8.5x11

Loading Fixture and Restraining Frame - North View



Scale: 1" = 66" on 8.5x11

Restraining Frame - West View

1 - Braced legs (2 units);
2 - All welds are two-sided 1/2" fillets unless noted.

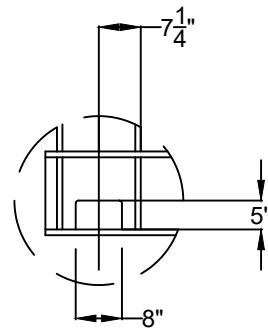


Diagram showing the elevation of a window with dimensions:

- Overall width: $7' - 2\frac{3}{4}"$
- Overall height: $3' - 6\frac{7}{8}"$
- Left side offset: $7"$
- Right side offset: $7"$

GE1-L3 University of California, Berkeley
Large Component Test
All Specimen Groups

Drawing title: Load Fixture Detailing
 Drawn by: Shakhzod Takhirov
 Controlled by: Kelly Cobeen, Vahid Mahdaviyar

Revision history:
 Rev01.02 3/12/2018

W14x132

1" stiffener: $\frac{1}{2}$ " fillet both sides

15'-3 $\frac{1}{2}$ "

10 $\frac{1}{4}$ "

10 $\frac{1}{4}$ "

13'-2 $\frac{3}{4}$ "

9'-8 $\frac{1}{8}$ "

47.00°

1'-6 $\frac{1}{2}$ "

4 $\frac{1}{4}$ "

Detail A

Detail B

9 $\frac{1}{4}$ "

3'

3'

3'

11 $\frac{3}{4}$ "

10'-9"

B-6

GE1-L4

University of California, Berkeley
Large Component Test
All Specimen Groups

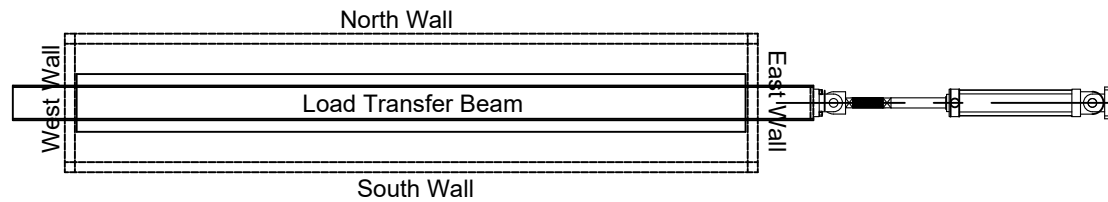
Drawing title: Loading Beam

Drawn by: Vahid Mahdavifar

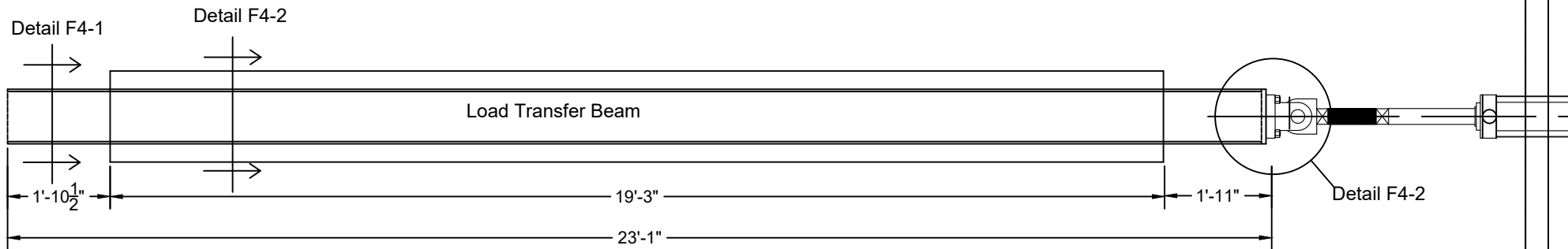
Controlled by: Kelly Cobeen, Shakhzod Takhirov

Revision history:

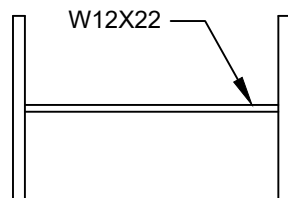
Rev01.02 3/12/2018



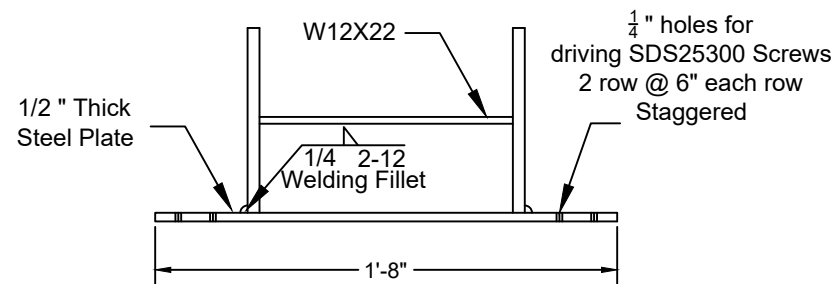
Load Transfer Beam Location



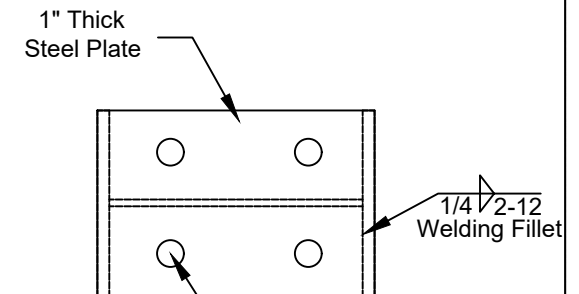
Load Transfer Beam Top View



Detail F4-1



Detail F4-2



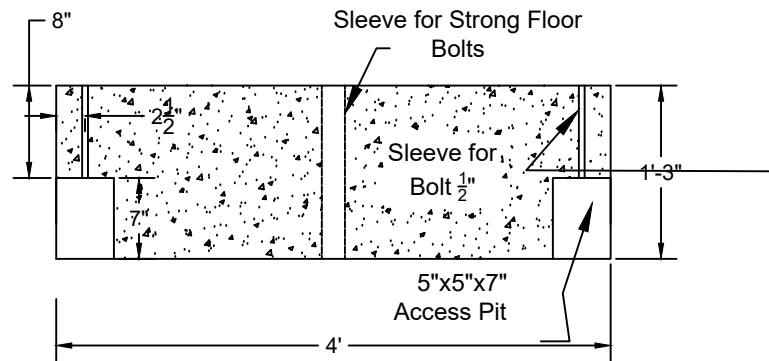
Detail F4-3

GE1-F1

University of California, Berkeley
Large Component Test
Specimen AL-1

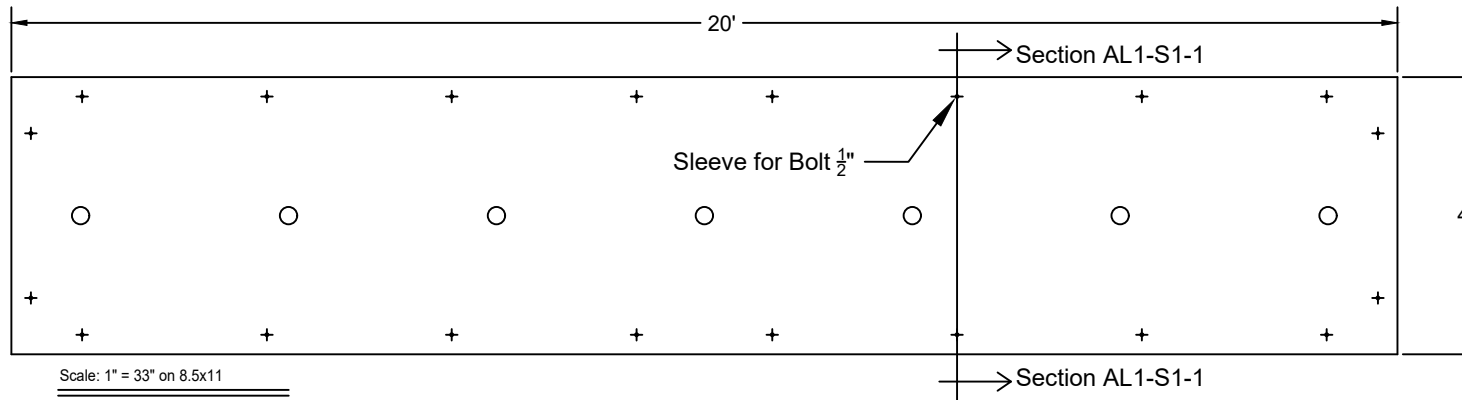
Drawing title: Foundation
Drawn by: Vahid Mahdavifar
Controlled by: Kelly Cobeen

Revision history:
Rev01.07 5/27/2018



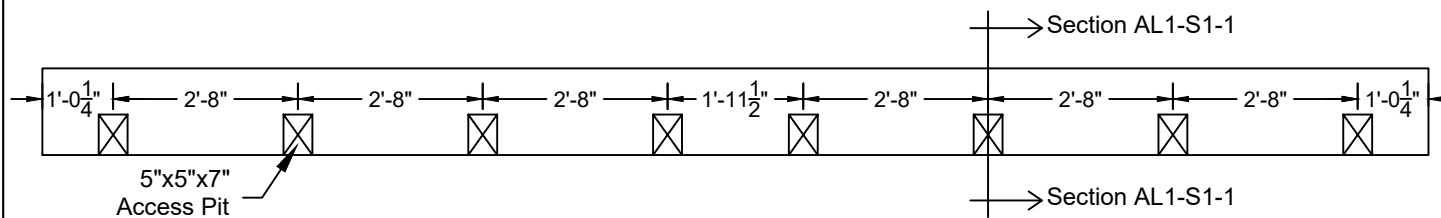
Scale: 1" = 16 - 1/2" on 8.5x11

Section S1-1



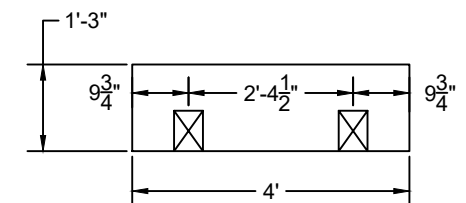
Scale: 1" = 33" on 8.5x11

Top View



Scale: 1" = 33" on 8.5x11

North and South Side View



Scale: 1" = 33" on 8.5x11

East and West End View

Notes:

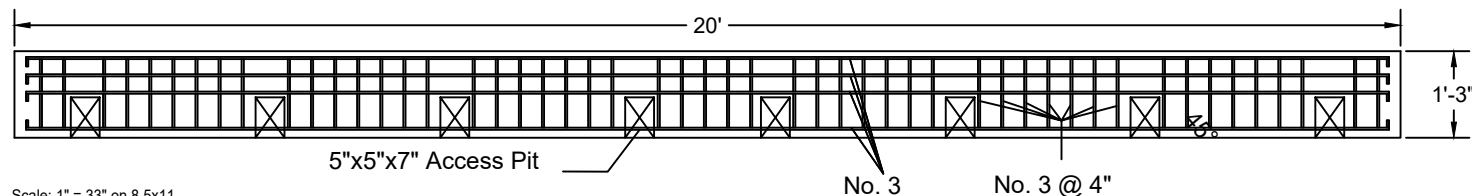
- 1 - Reinforcement No. 3 each 4";
- 2 - Concrete 2000 psi with max aggregate size of $1\frac{1}{2}$ ";
- 3 - Concrete cover to be $1\frac{1}{2}$ " for the top and bottom and 1" for the sides;
- 4 - For casting the access pits, wooden blocks should be used and then will be removed.

GE1-F2

University of California, Berkeley
Large Component Test
Specimen AL-1

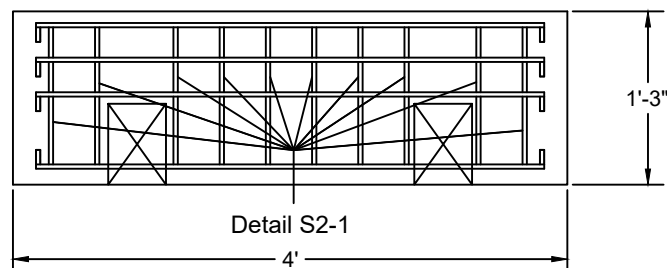
Drawing title: Foundation Reinforcing Details
Drawn by: Vahid MahdaviFar
Controlled by: Kelly Cobeen

Revision history:
Rev01.04 5/27/2018



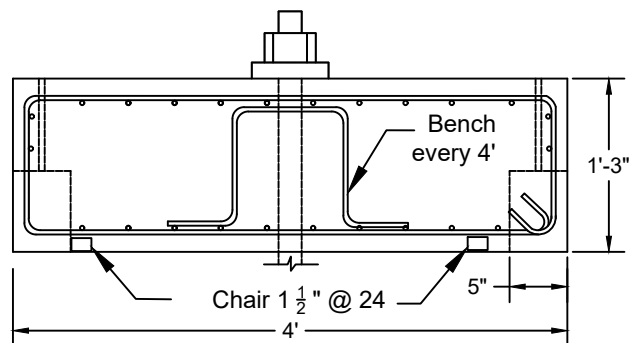
Scale: 1" = 33" on 8.5x11

North and South Side Reinforcement Schedule



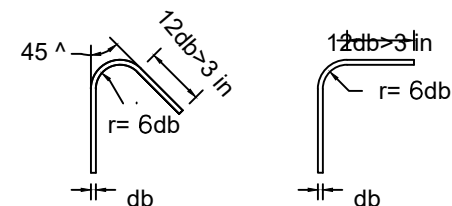
Scale: 1" = 16 - $\frac{1}{2}$ " on 8.5x11

East and West End Reinforcement Schedule



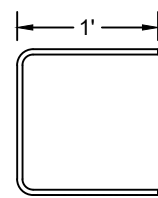
Scale: 1" = 16 - $\frac{1}{2}$ " on 8.5x11

Section A



Scale: Not to be scaled

Hook Details



Scale: Not to be scaled

Detail S3-1

Bar Bending Schedule				
Pos	Size	No. of Bars	Cut off Length	Shape
1	No. 3	26	20' - 8"	5" U 19'-10"
2	No. 3	54	10' - 6"	1' U 3'-10" 5"
3	No. 3	20	2' - 11 $\frac{1}{4}$ "	12" U 11 $\frac{1}{4}$ "
4	No. 3	5	4' - 9"	10 $\frac{1}{2}$ " S 1' 1'
5	No. 3	8	4' - 8"	5" U 3' - 10"

“Quantifying the Performance of Retrofit of Cripple Walls and Sill Anchorage in Single Family Wood-frame Buildings”

Large Component Test - Working Group 4 - Specimen AL-1

Updated: June 5, 2018

Construction:

Cripple wall:

$\frac{7}{8}$ " 3-coat stucco over horizontal lumber sheathing

Super Structure:

$\frac{7}{8}$ " 3-coat stucco over horizontal lumber sheathing (Exterior)

$\frac{1}{2}$ " gypsum board (Interior)

Loading Fixture:

AL1-F1	General Text Fixture Plan
AL1-F2	Loading Fixture
AL1-F3	Load Fixture Detailing
AL1-F4	Load Transfer Beam

Stucco and Sheathing Drawings:

AL1-C1	Horizontal Sheathing
AL1-C2	Stucco Horizontal Sheathing Sequence
AL1-C3	Stucco Fastening Schedule

Structural Drawings:

AL1-S1	Overall Plan and Elevations
AL1-S2	Framing Elevations
AL1-S3	Framing Plan
AL1-S4	Diaphragm Sheathing
AL1-S5	Framing Details A
AL1-S6	Framing Details B
AL1-S7	Fastening Schedule
AL1-S8	Load Transfer Beam Detailing
AL1-S9	Corner Detailing 1
AL1-S10	Corner Detailing 2
AL1-S11	Siding Details

Instrumentation Plan:

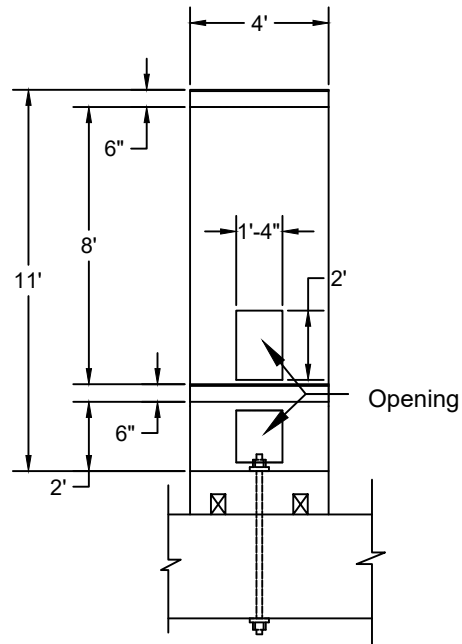
AL1-I1	Instrumentation Plan West Wall
AL1-I2	Instrumentation Plan Floor Diaphragm
AL1-I3	Reserved
AL1-I4	Instrumentation Schedule A
AL1-I5	Instrumentation Schedule B
AL1-I6	Instrumentation Schedule C
AL1-I7	Instrumentation Schedule D

AL1-S1

University of California, Berkeley
Large Component Test
Specimen AL-1

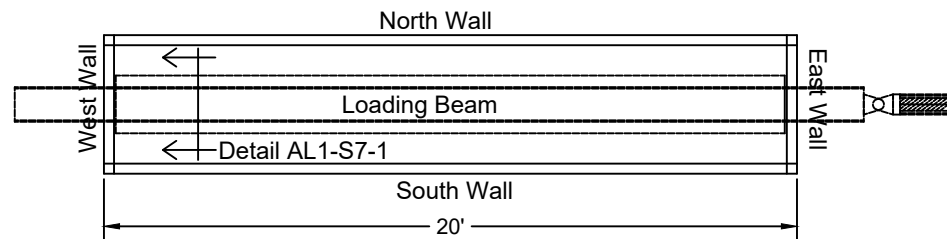
Drawing title: Overall Plan and Elevations
Drawn by: Vahid MahdaviFar
Controlled by: Kelly Cobeen

Revision history:
Rev01.04 5/27/2018



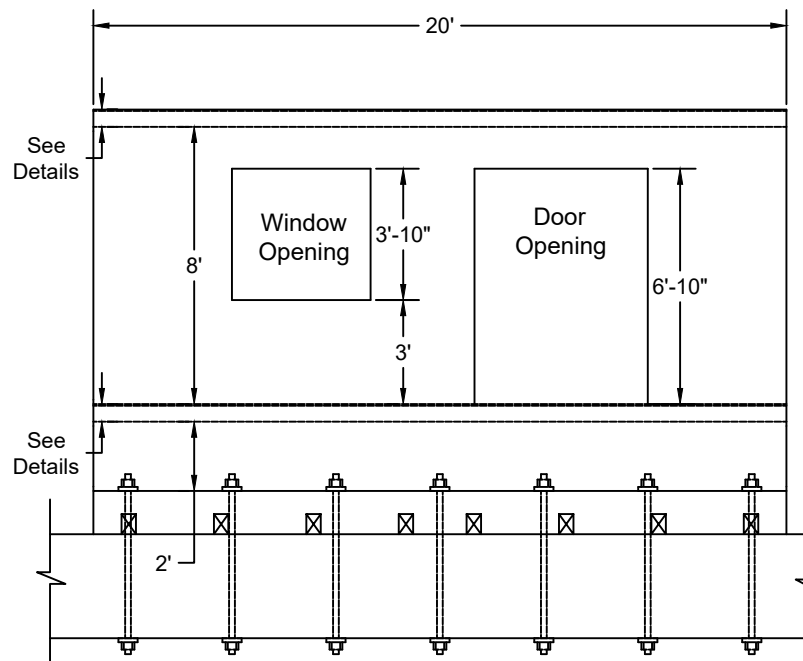
Scale: 1" = 66" on 8.5x11

East and West Walls Elevation



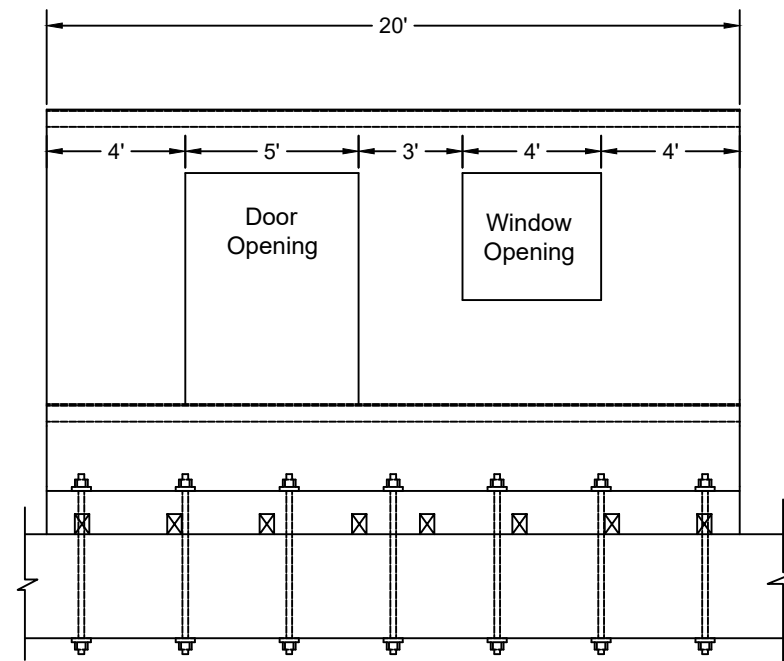
Scale: 1" = 66" on 8.5x11

Wall Label



Scale: 1" = 66" on 8.5x11

North Wall Elevation



Scale: 1" = 66" on 8.5x11

South Wall Elevation

Notes:

1 - 2x4" lumber are ripped from 2x6 lumber;

2- Use of Box or Common nails are alternatively permitted, unless otherwise is marked.

AL1-S2

University of California, Berkeley
Large Component Test
Specimen AL-1

Drawing title: Framing Elevations

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

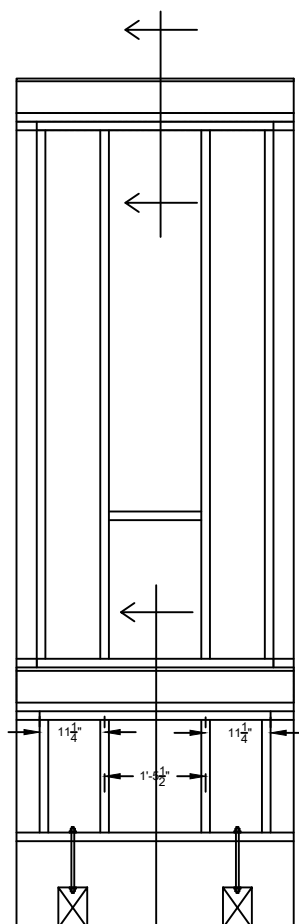
Revision history:

Rev01.04 5/27/2018

Detail AL1-S6-1

Detail AL1-S9-1

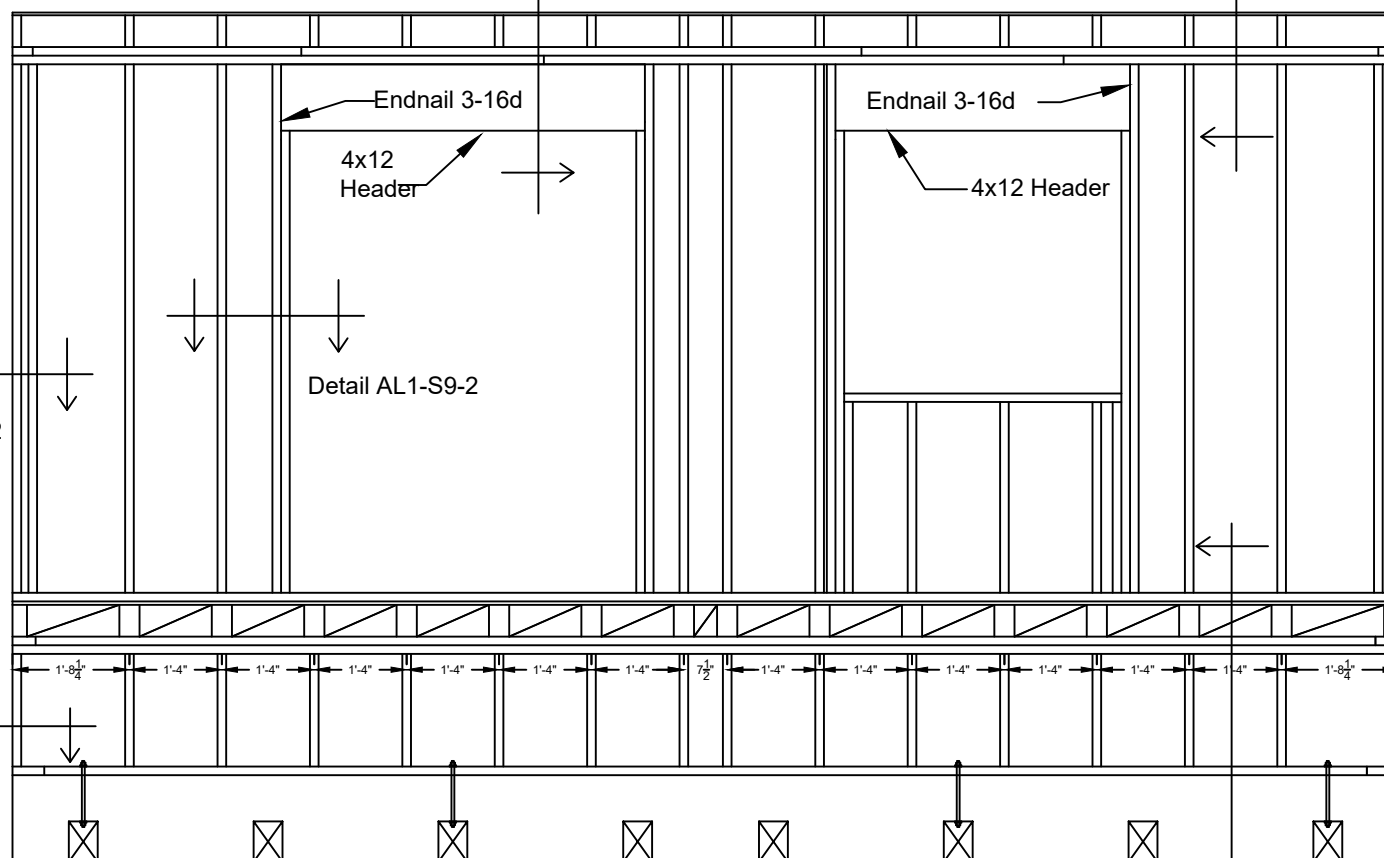
Detail AL1-S6-1



Detail AL1-S10-2

Detail AL1-S9-2

Detail AL1-S10-1



Detail AL1-S6-2

Detail AL1-S6-2

Scale: 1" = 33" on 8.5x11

Scale: 1" = 33" on 8.5x11

East and West Walls Framing

South Wall Framing

Notes:

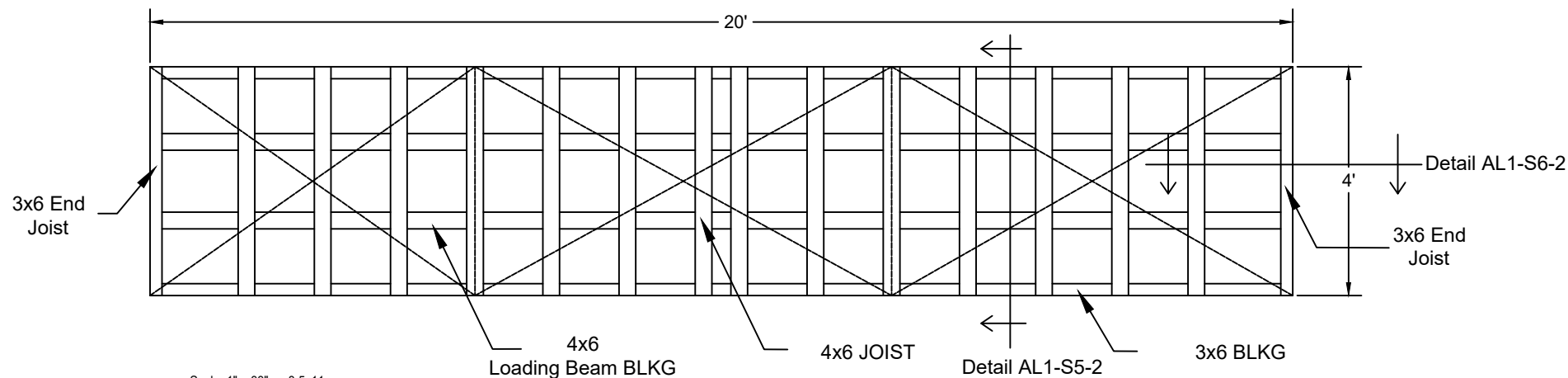
- 1 - 2x4" lumber are ripped from 2x6 lumber;
- 2- Use of Box or Common nails are alternatively permitted, unless otherwise is marked.

AL1-S3

University of California, Berkeley
Large Component Test
Specimen AL-1

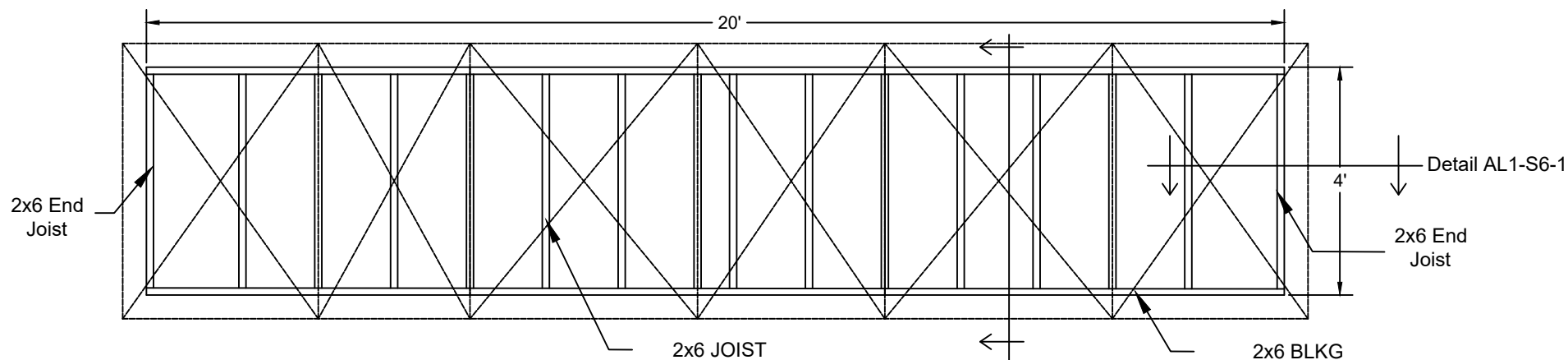
Drawing title: Framing Plan
Drawn by: Vahid MahdaviFar
Controlled by: Kelly Cobeen

Revision history:
Rev01.05 5/27/2018



Scale: 1" = 33" on 8.5x11

Floor High Load Framing Plan



Scale: 1" = 33" on 8.5x11

Roof Framing Plan

Notes:

1 - 2x4" lumber are ripped from 2x6 lumber;

2- Use of Box or Common nails are alternatively permitted, unless otherwise is marked.

AL1-S4

University of California, Berkeley
Large Component Test
Specimen AL-1

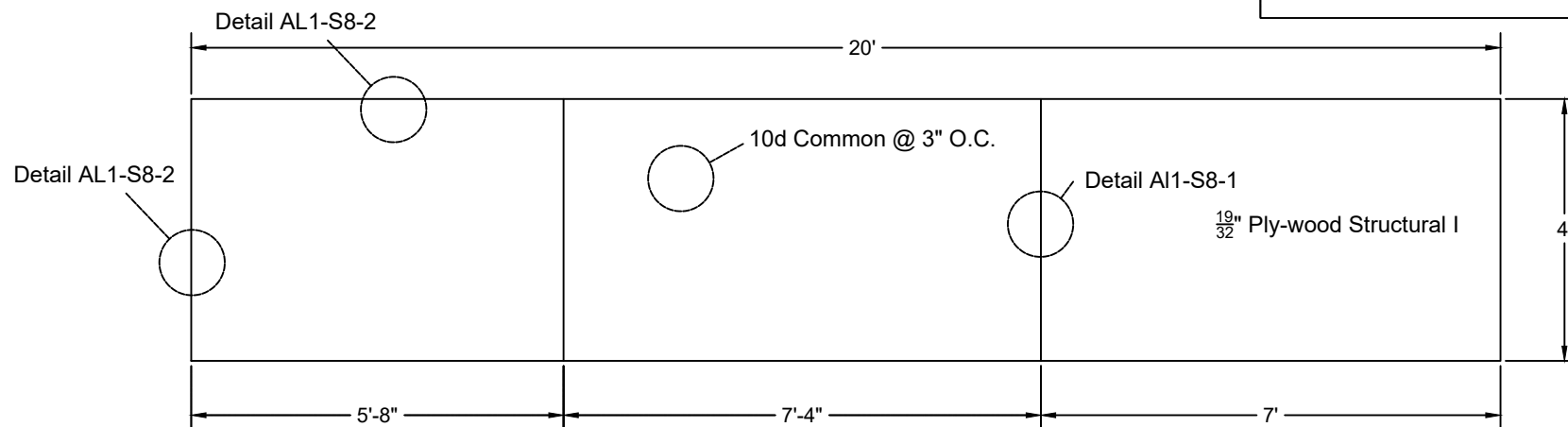
Drawing title: Diaphragm Sheathing

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

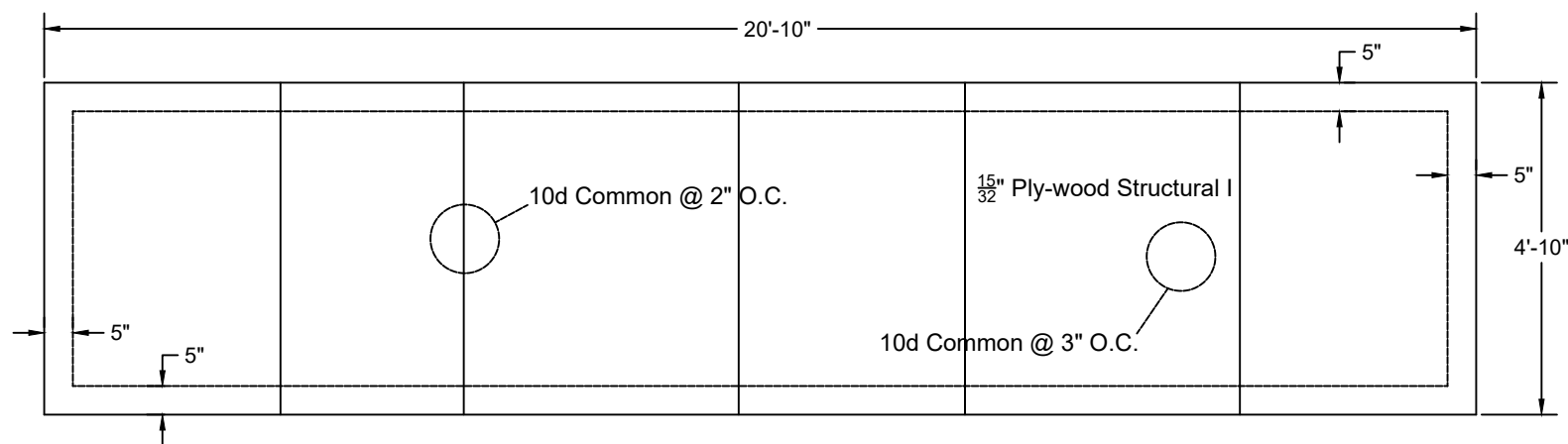
Revision history:

Rev01.04 5/27/2018



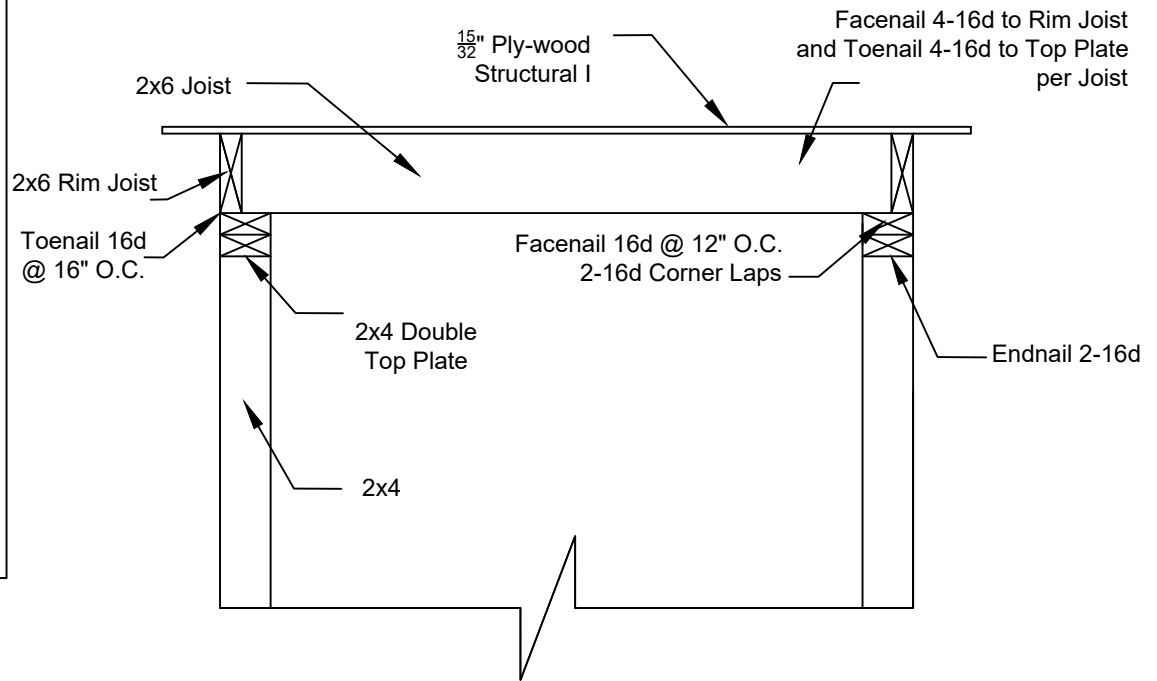
Scale: 1" = 33" on 8.5x11

Floor Ply-wood Cut Diagram

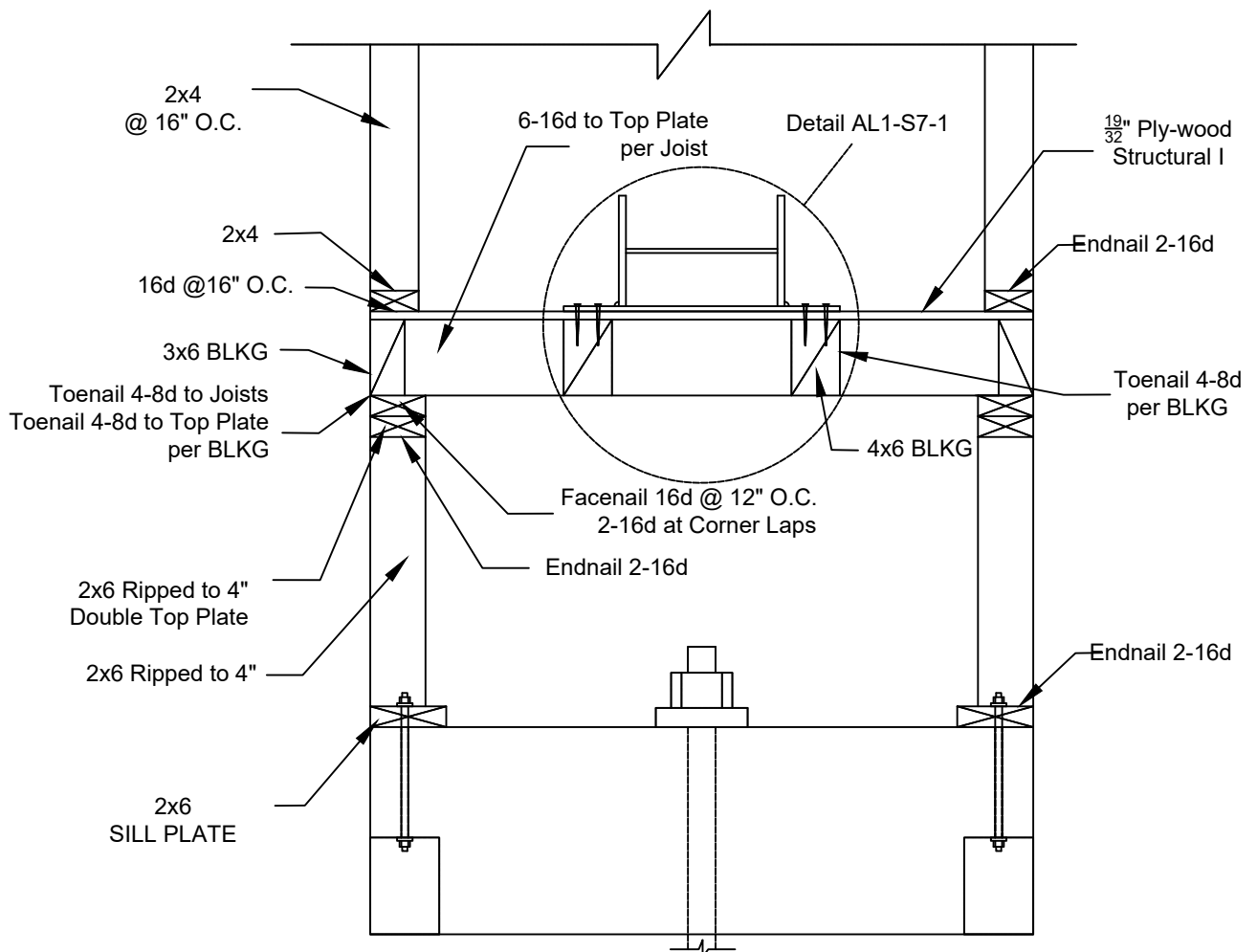


Scale: 1" = 33" on 8.5x11

Roof Ply-wood Cut Diagram

Drawing title: Framing Details A
Drawn by: Vahid Mahdavi
Controlled by: Kelly CobeenRevision history:
Rev01.03 5/27/2018Scale: 1" = 13 - $\frac{1}{2}$ " on 8.5x11

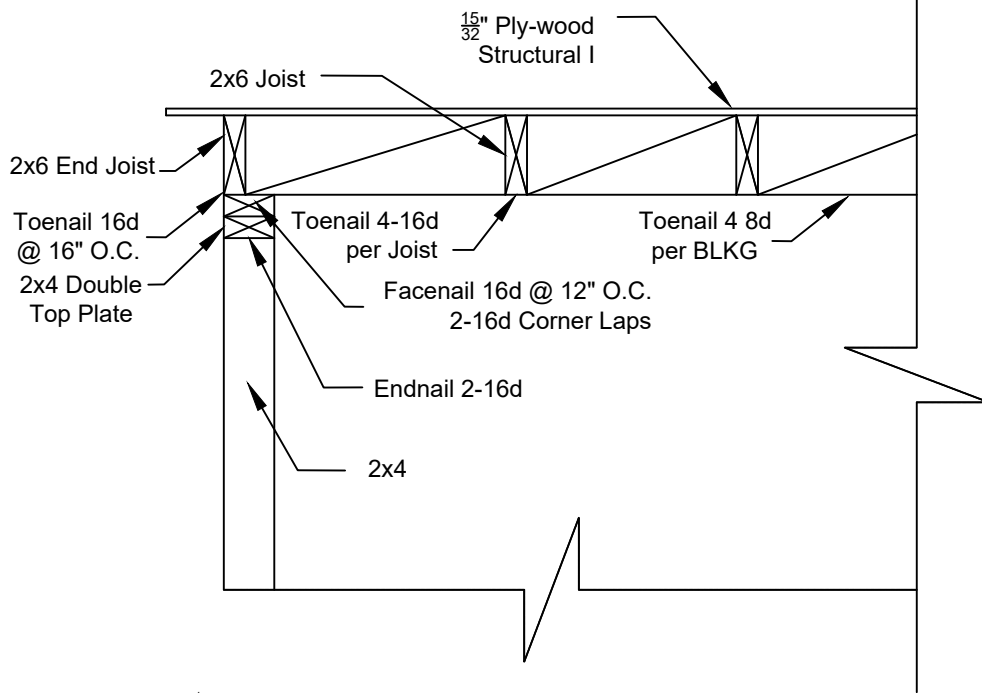
Detail AL1-S5-1

Scale: 1" = 13 - $\frac{1}{2}$ " on 8.5x11

Detail AL1-S5-2

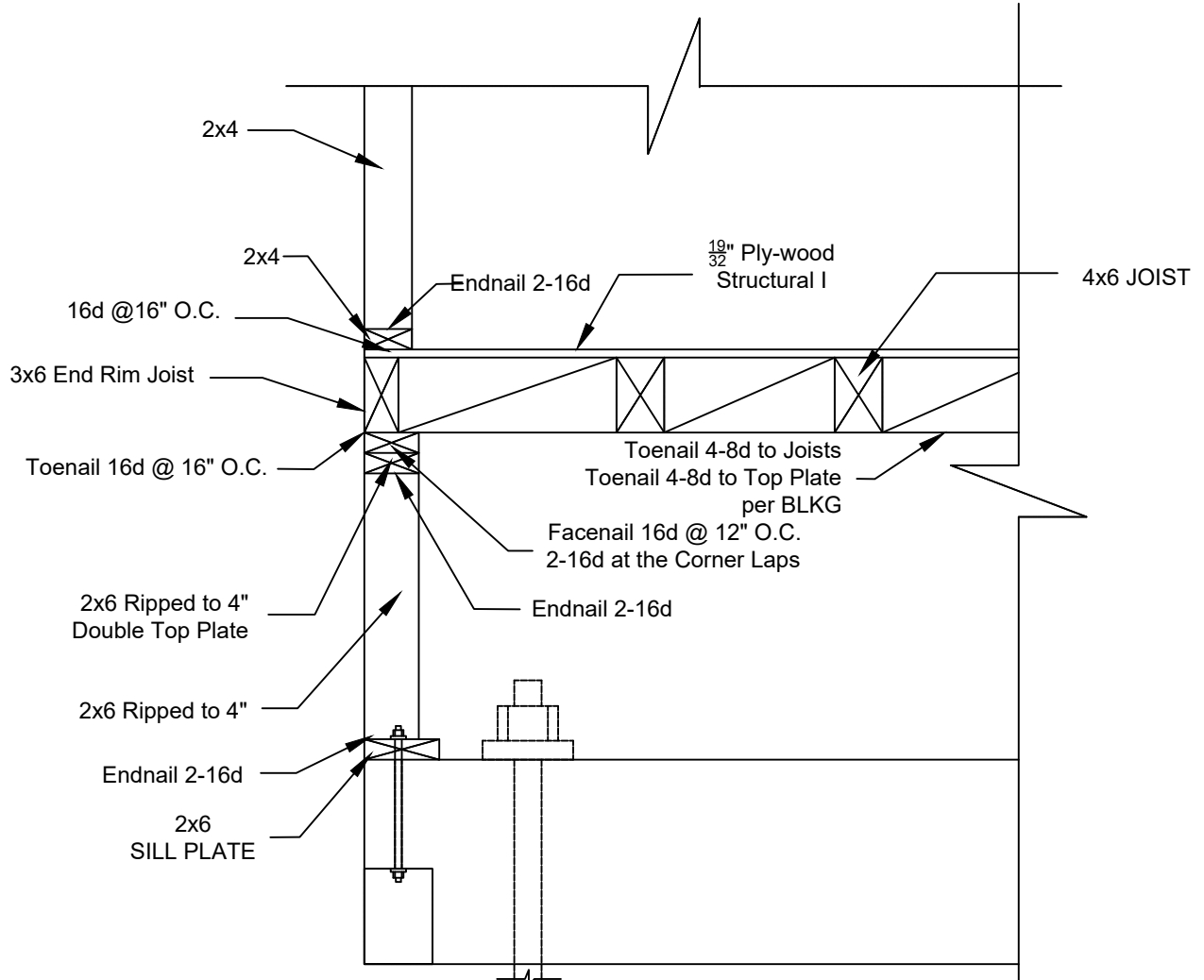
Notes:

- 1 - 2x4" lumber are ripped from 2x6 lumber;
- 2- Use of Box or Common nails are alternatively permitted, unless otherwise is marked.

Drawing title: Framing Details B
Drawn by: Vahid Mahdavi
Controlled by: Kelly CobeenRevision history:
Rev01.03 5/27/2018

Scale: 1" = 13 - 1/2" on 8.5x11

Detail AL1-S6-1



Scale: 1" = 13 - 1/2" on 8.5x11

Detail AL1-S6-2

Notes:

- 1 - 2x4" lumber are ripped from 2x6 lumber;
- 2- Use of Box or Common nails are alternatively permitted, unless otherwise is marked.

Drawing title: **Fastening Schedule A**

Drawn by: Vahid Mahdaviyar

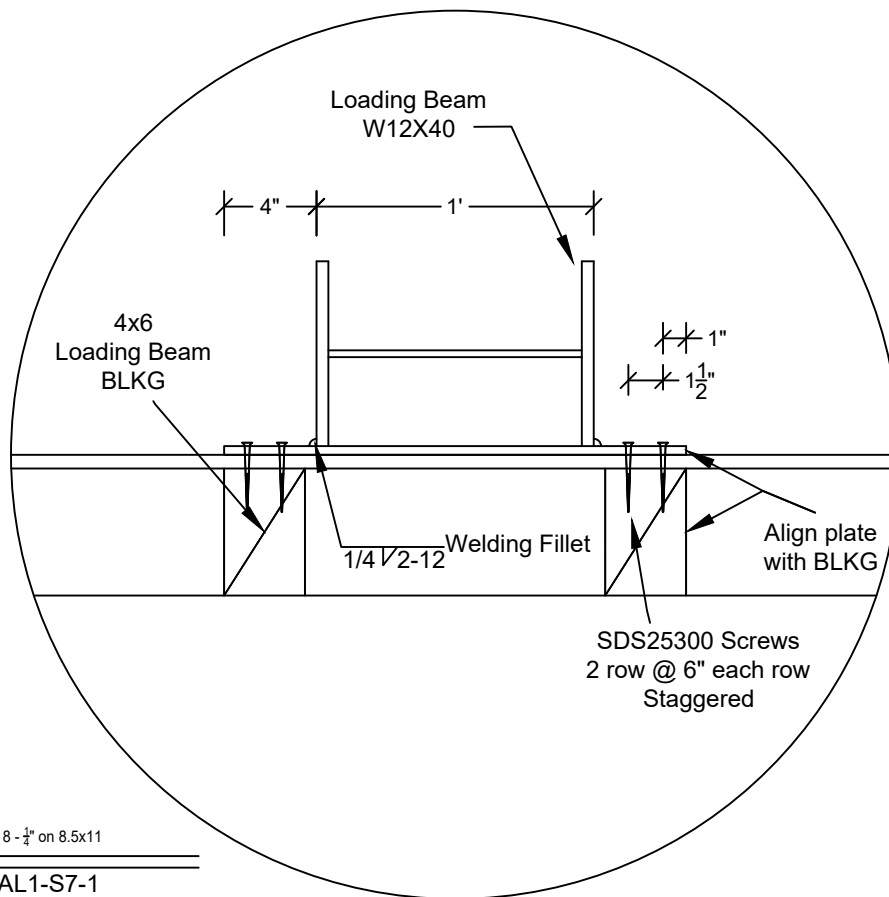
Controlled by: Kelly Cobeen

Revision history:

Rev01.03 5/27/2018

Fastening Schedule per UBC 1955

Pos	Connection	Fastening	Location
1	Joist to Sill or Girder	2 - 16d Common	Toenail
2	Bridging to Joist	2 - 8d Common	Toenail
3	1x6 Subfloor to Joist	2 - 8d Common	Facenail
4	2-inch Subfloor to Joist	2 - 16d Common	Facenail
5	Top Plate to Joist or Blocking	16d Common @ 16" O.C.	
6	Stud to Top Plate	2 - 16d Common	Endnail
7	Stud to Top Plate	3 - 16d Common	Toenail
8	Top Plate Spike Together	16d Common @ 24" O.C.	
9	Top Plate Laps and Intersections	2 - 16d Common	
10	Ceiling Joist to Top Plate	2 - 16d Common	Toenail
11	Rafter to Top Plate	3 - 16d Common	
12	1-inch Sheathing to Bearing	2 - 8d Common	
13	Corner Studs and Angels	16d Common @ 30" O.C.	
14			
15			



Scale: 1" = 8 - 1/4" on 8.5x11

Detail AL1-S7-1

Notes:

- 1 - Minimum Spacing between the lines of the fasteners is $\frac{3}{8}$ ";
- 2 - Space between adjoining panel edges is $\frac{1}{8}$ ";
- 3 - Use of Box or Common nails are alternatively permitted, unless otherwise is marked.

AL1-S8

University of California, Berkeley
Large Component Test
Specimen AL-1

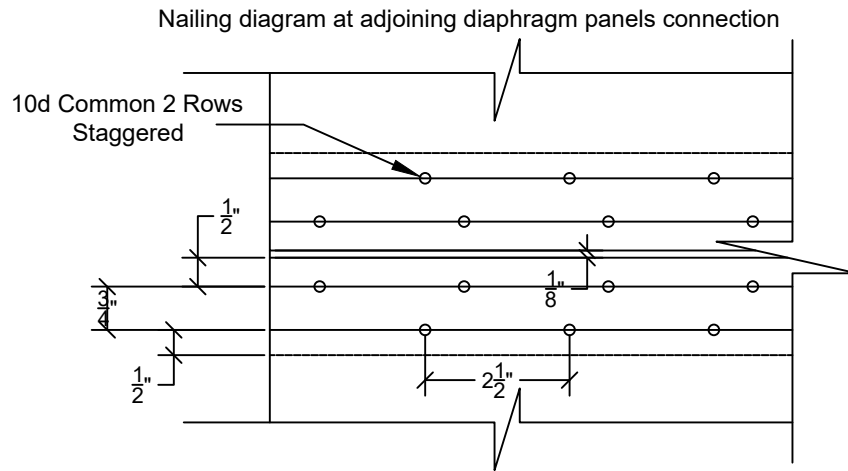
Drawing title: **Fastening Schedule B**

Drawn by: Vahid Mahdaviyar

Controlled by: Kelly Cobeen

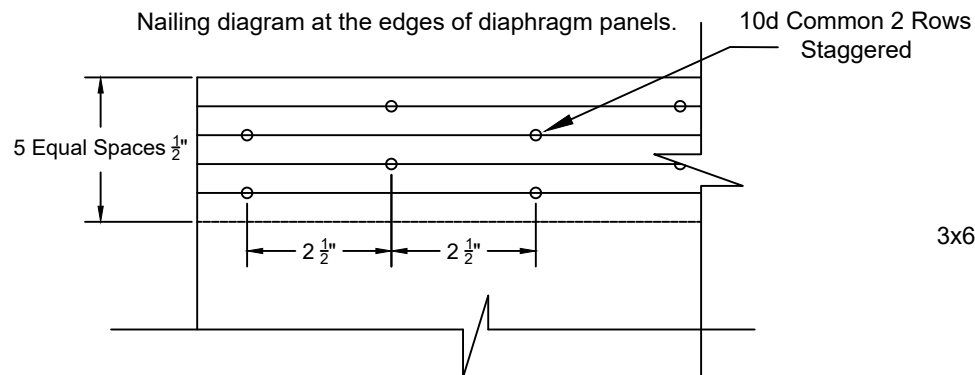
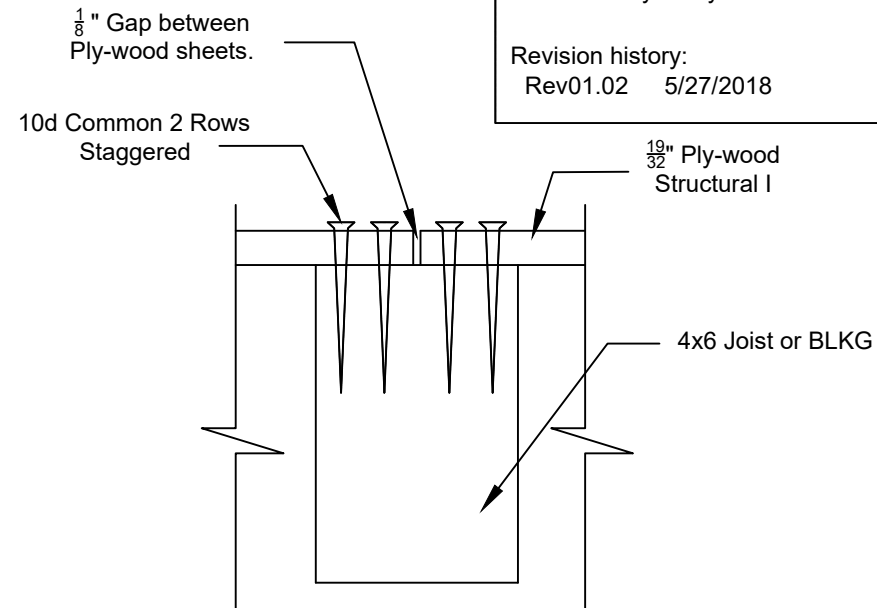
Revision history:

Rev01.02 5/27/2018



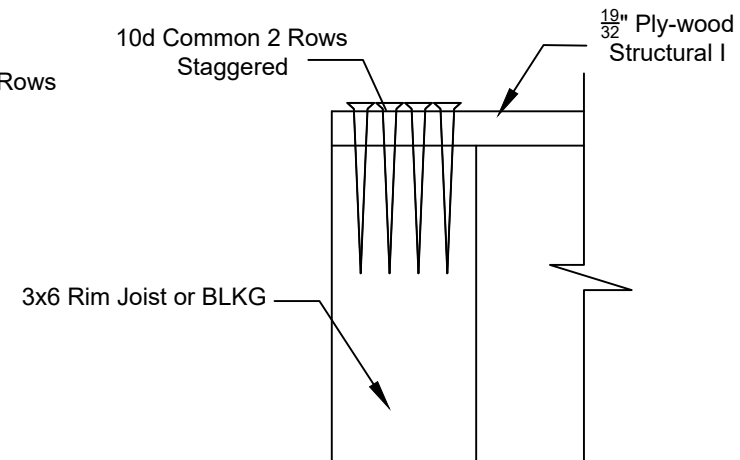
Scale: Not to be scaled

Detail AL1-S8-1



Scale: Not to be scaled

Detail AL1-S8-2



AL1-S9

University of California, Berkeley
Large Component Test
Specimen AL-1

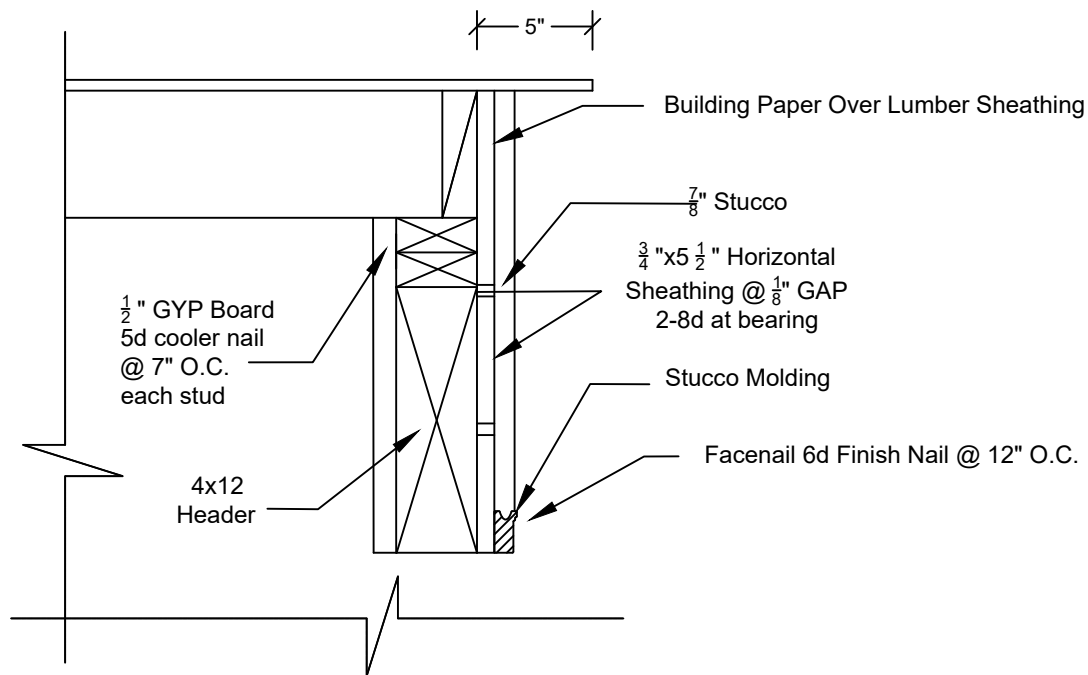
Drawing title: **Corner Detailing 1**

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

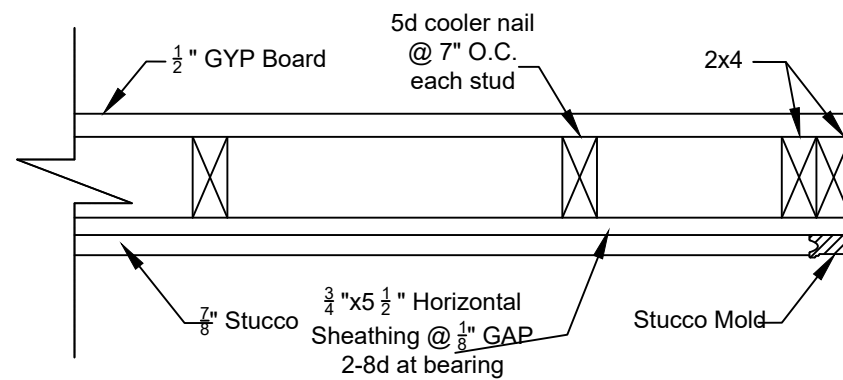
Revision history:

Rev01.02 5/27/2018



Scale: 1" = 8 - $\frac{1}{4}$ " on 8.5x11

Detail AL1-S9-1



Scale: 1" = 8 - $\frac{1}{4}$ " on 8.5x11

Detail AL1-S9-2

AL1-S10

University of California, Berkeley
Large Component Test
Specimen AL-1

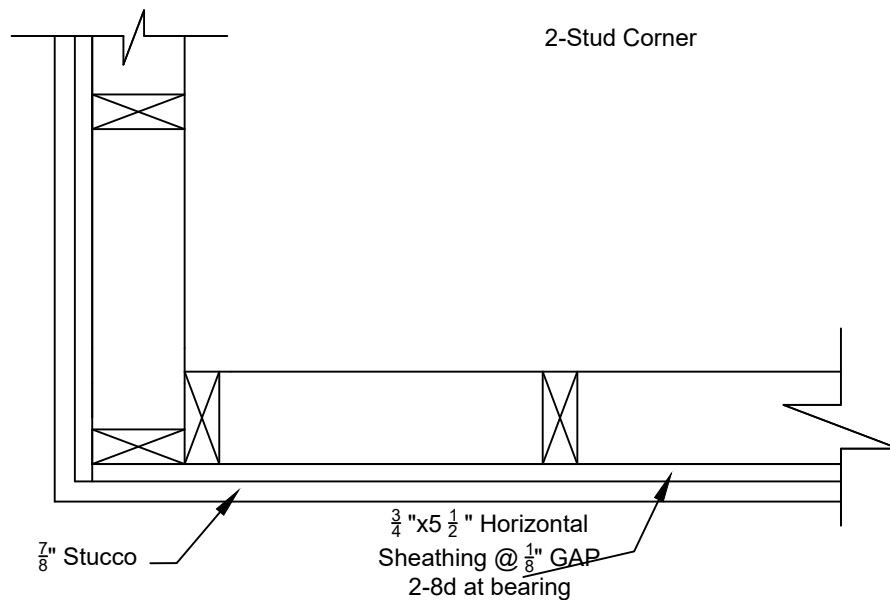
Drawing title: **Corner Detailing 2**

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

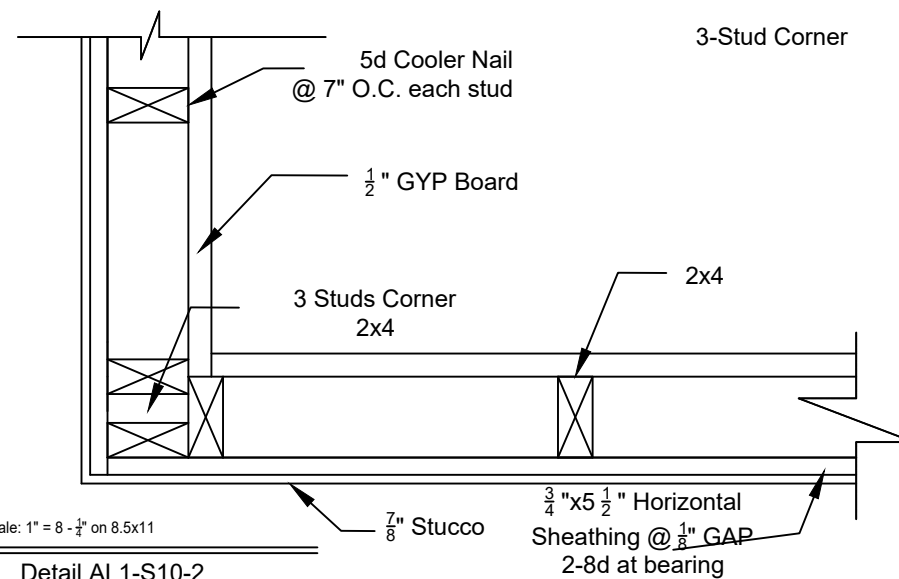
Revision history:

Rev01.02 5/27/2018



Scale: 1" = 8' - $\frac{1}{4}$ " on 8.5x11

Detail AL1-S10-1



Scale: 1" = 8' - $\frac{1}{4}$ " on 8.5x11

Detail AL1-S10-2

Drawing title: Siding Details
Drawn by: Vahid Mahdavi
Controlled by: Kelly CobeenRevision history:
Rev01.03 5/27/2018 $\frac{3}{4}$ "x $5\frac{1}{2}$ " Horizontal
Sheathing @ $\frac{1}{8}$ " GAP $\frac{7}{8}$ " Stucco $\frac{1}{2}$ " GYP Board

Building Paper Over Lumber Sheathing

5d Cooler Nail
@ 7" O.C. each studScale: 1" = 13 - $\frac{1}{2}$ " on 8.5x11

Detail AL1-S11-1

 $\frac{7}{8}$ " Stucco $\frac{1}{2}$ " GYP Board

Building Paper

5d Cooler Nail
@ 7" O.C. each stud $\frac{3}{4}$ "x $5\frac{1}{2}$ " Horizontal
Sheathing @ $\frac{1}{8}$ " GAP
2-8d at bearingScale: 1" = 13 - $\frac{1}{2}$ " on 8.5x11

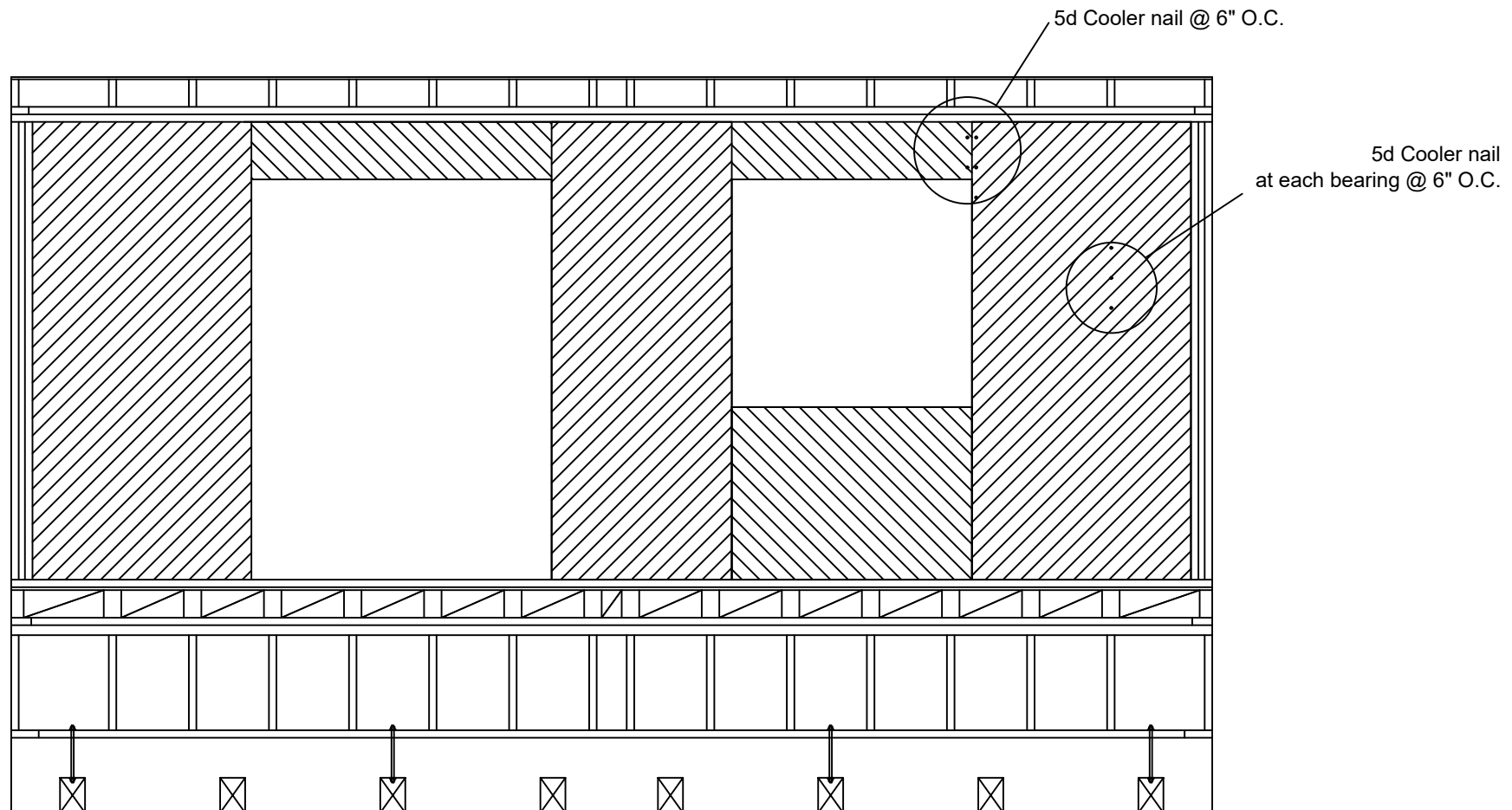
Detail AL1-S11-2

AL1-S12

University of California, Berkeley
Large Component Test
Specimen AL-1

Drawing title: **Gyp Borad**
Drawn by: Vahid MahdaviFar
Controlled by: Kelly Cobeen

Revision history:
Rev01.01 7/11/2018



Notes:

- 1 - Grade D building paper with horizontal joints lapped 2" and vertical joints lapped 6" placed directly over studs, fastened with $\frac{3}{8}$ " staples;
- 2 - Sheathing is squared with no overlap, leaving a $\frac{1}{8}$ " gap between panels;
- 3 - Full width sheathing board panels start from top and bottom, the cut to width required panel should be placed at the center of each specimen;
- 4 - Stucco mixtures remain consistent for scratch and brown coat;
- 5 - $\frac{3}{8}$ " thick scratch coat applied first and cured 2 days while keeping moist;
- 6 - $\frac{3}{8}$ " brown coat applied second and cured 7 days while keeping moist;
- 7 - $\frac{3}{8}$ " finish coat applied last and cured for 3 days while keeping moist.

AL1-C1

University of California, Berkeley
Large Component Test
Specimen AL-1

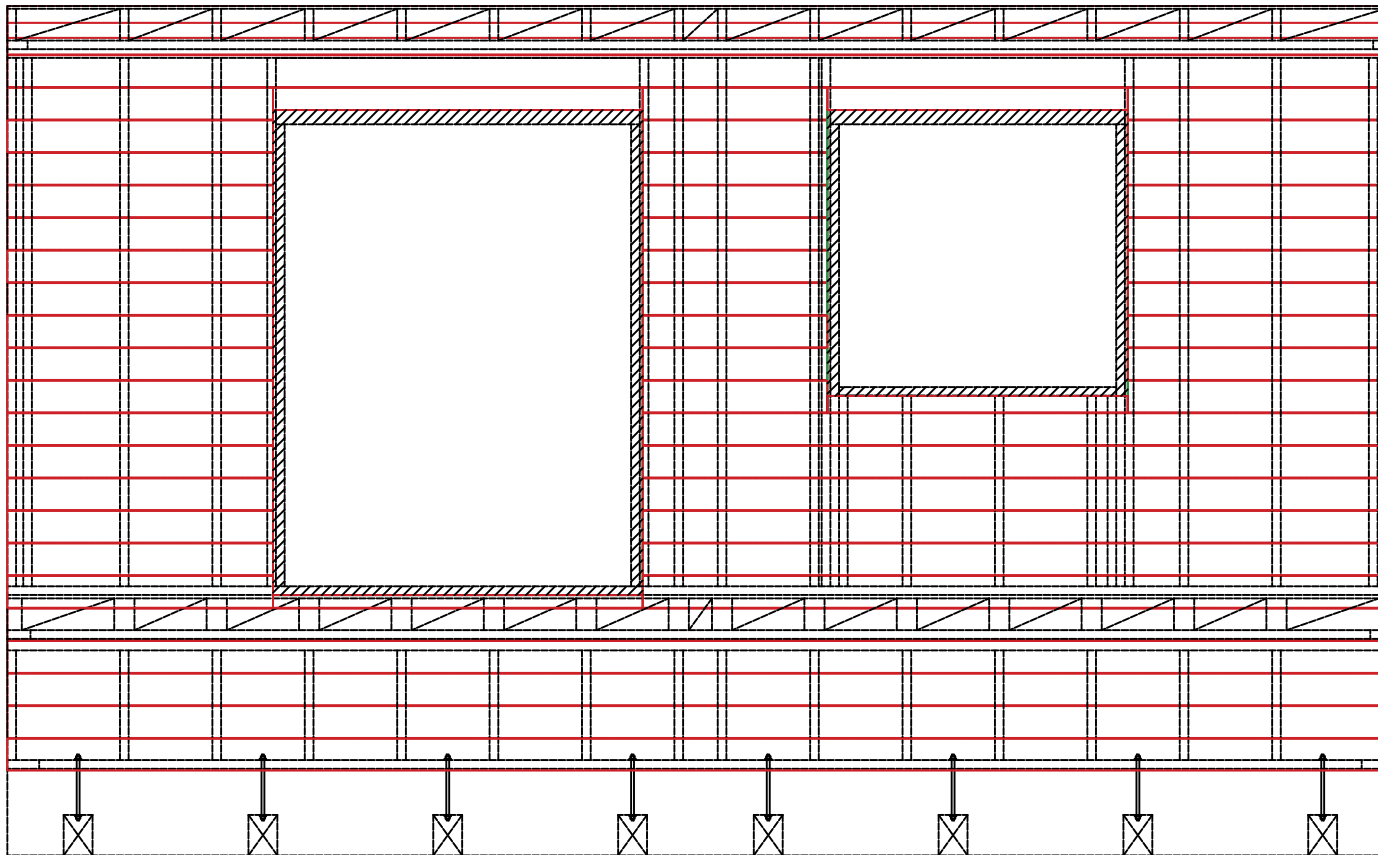
Drawing title: Horizontal Sheathing

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

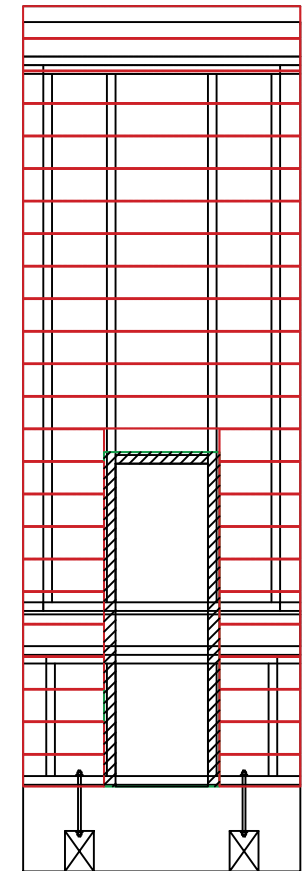
Revision history:

Rev01.04 5/27/2018



Scale: 1" = 33" on 8.5x11

Front and Back Wall Stucco Sheathing



Scale: 1" = 33" on 8.5x11

Side Walls Stucco Sheathing

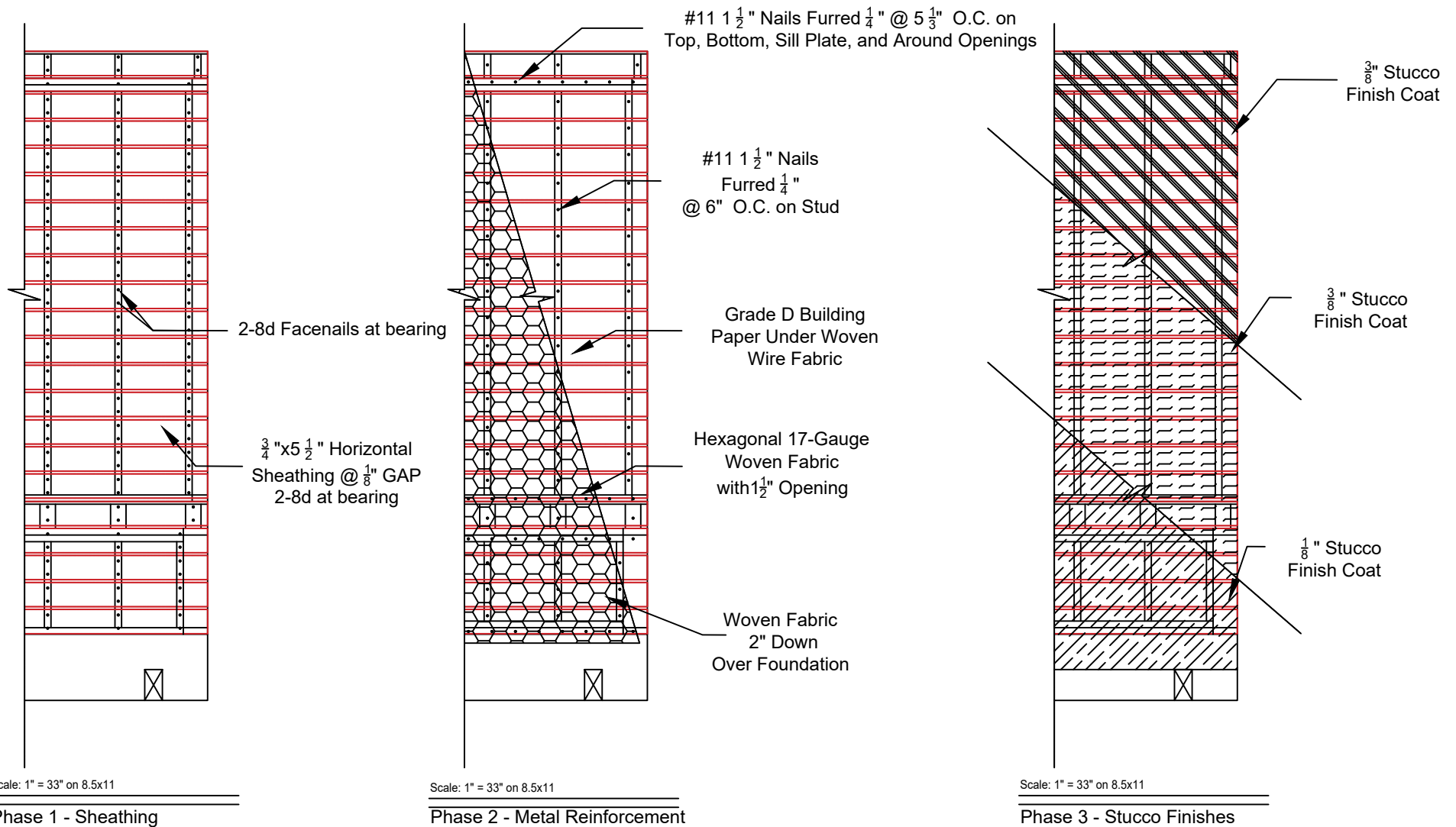
Drawing title: Stucco Horizontal Sheathing Sequence

Drawn by: Vahid MahdaviFar

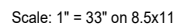
Controlled by: Kelly Cobeen

Revision history:

Rev01.03 5/27/2018



Rev01.04 7/26/2018



Instrumentation Plan South Wall

AL1-I2

University of California, Berkeley
Large Component Test
Specimen AL-1

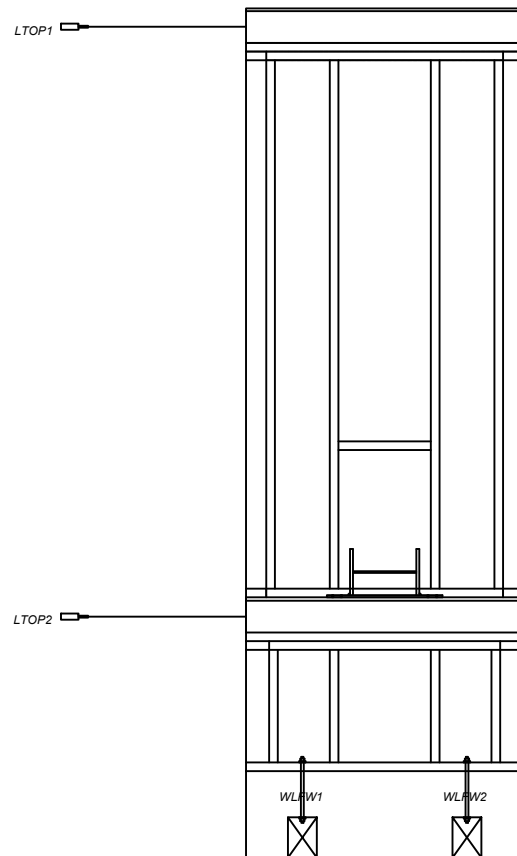
Drawing title: Instrumentation Plan Floor Diaphragm

Drawn by: Vahid Mahdaviyar

Controlled by: Kelly Cobeen

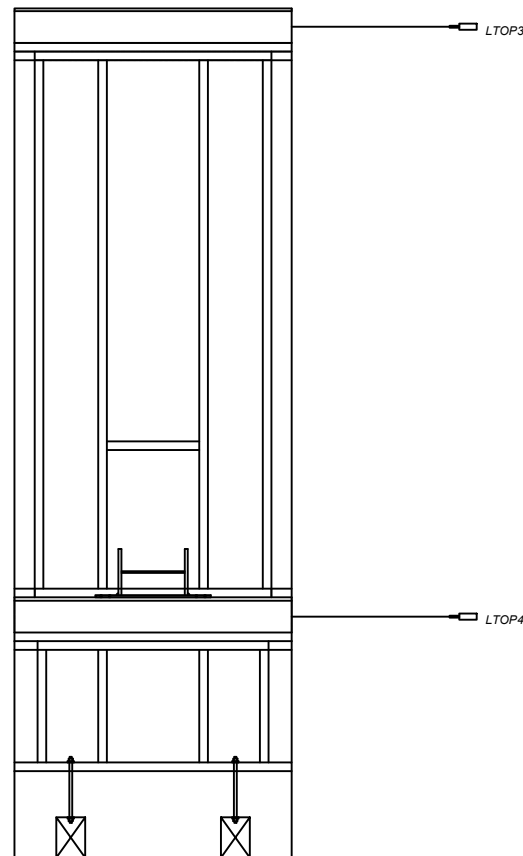
Revision history:

Rev01.04 7/26/2018



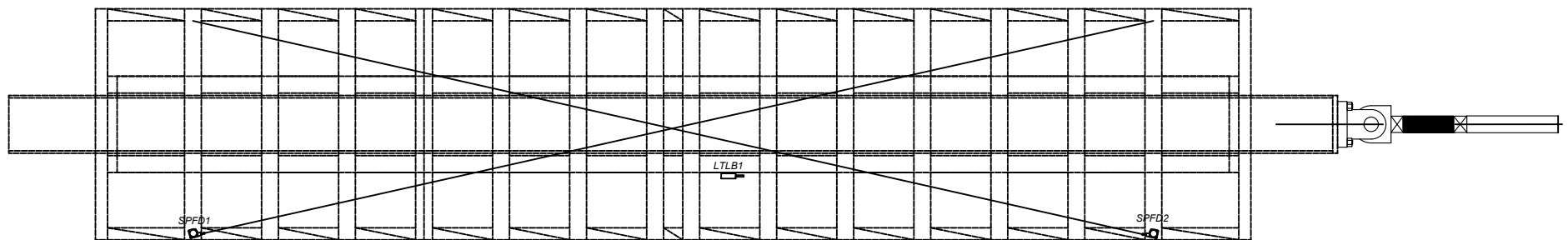
Scale: 1" = 33" on 8.5x11

Instrumentation Plan West Wall



Scale: 1" = 33" on 8.5x11

Instrumentation Plan East Wall



Scale: 1" = 33" on 8.5x11

Instrumentation Plan Floor Diaphragm

AL1-I3

University of California, Berkeley
Large Component Test
Specimen AL-1

Drawing title: Camera Setup

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

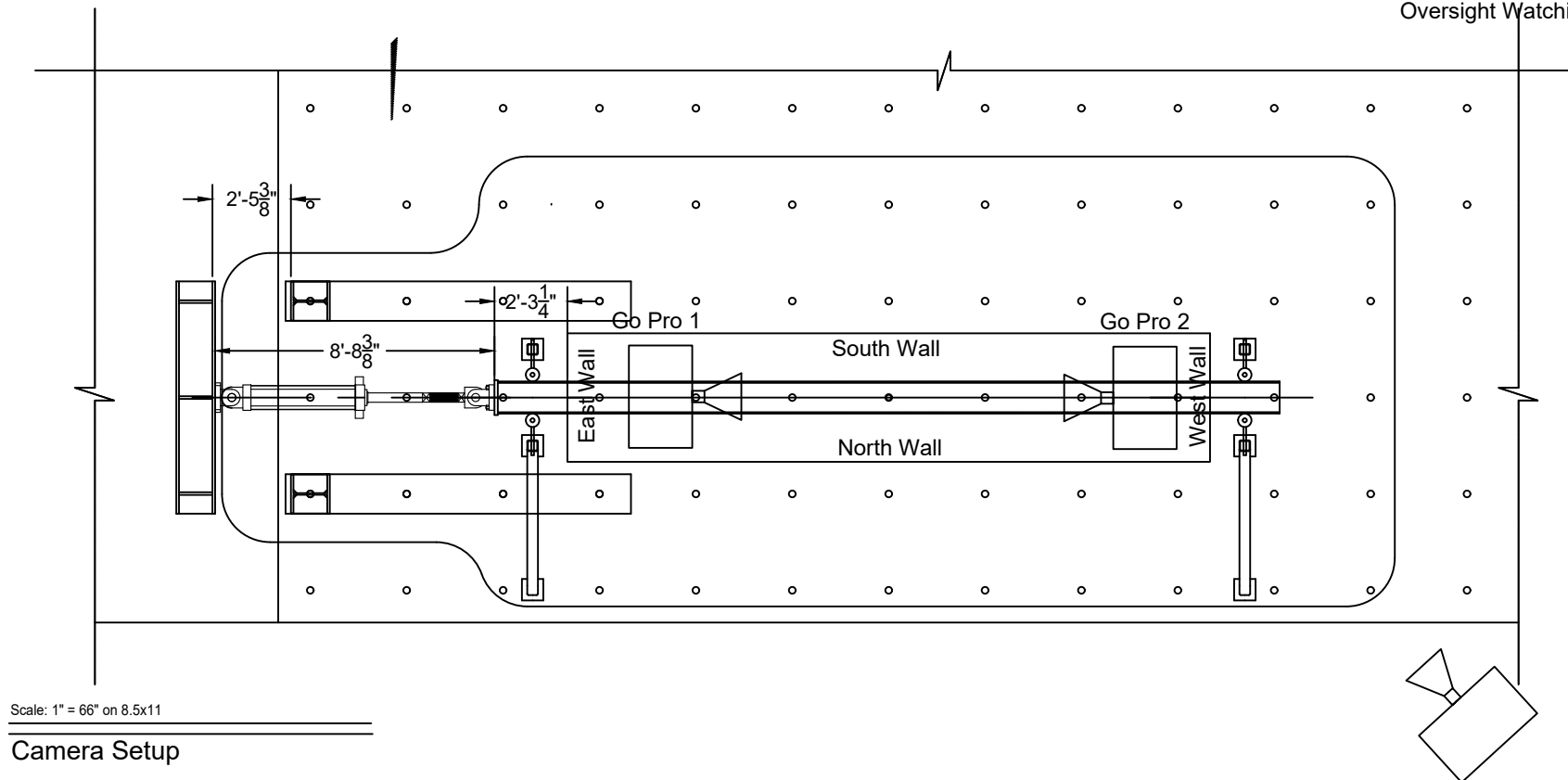
Revision history:

Rev01.01 9/20/2018

South Watching Camera

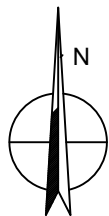
Oversight Watching Camera

North West Watching Camera



Scale: 1" = 66" on 8.5x11

Camera Setup



AL1-I4

University of California, Berkeley
Large Component Test
Specimen AL-1

Drawing title: Washer Load Cell Mapping

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

Revision history:

Rev01.01 10/06/2018



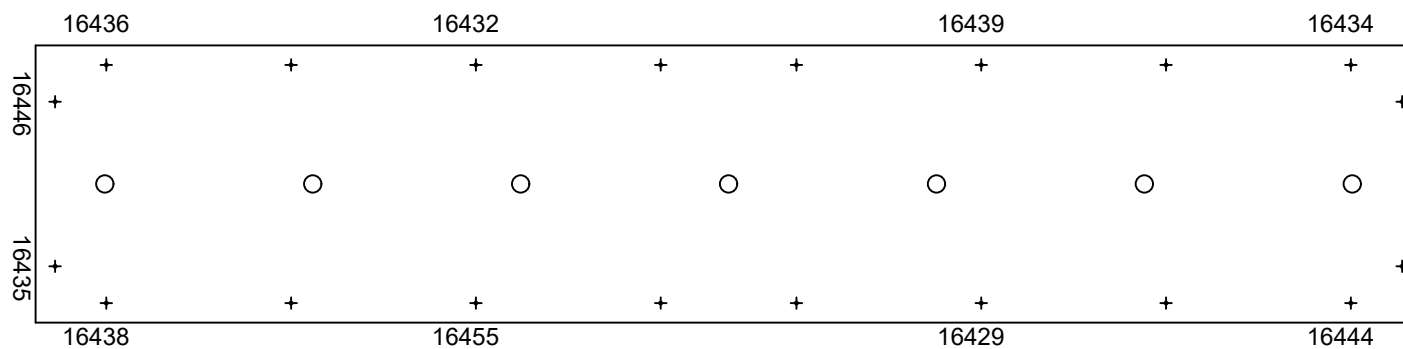
Scale: Not to be scaled

North Side View



Scale: Not to be scaled

West Side View



Scale: Not to be scaled

Top View



Scale: Not to be scaled

South Side View

Tag in the Raw Data File

Tag in the Instrumentation
Tables

Instrumentation Plan **						
Index	Tag	Type	Range	Resolution	Comment	Location
1	LTFO1	LVDT *	25mm	0.01" or better	Uplift between foundation and strong floor.	Foundation
2	LTFO2	LVDT	50mm	0.01" or better	Slip between foundation and strong floor.	Foundation
3	LTFO3	LVDT *	25mm	0.01" or better	Uplift between foundation and strong floor.	Foundation
4	LTFO4	LVDT	50mm	0.01" or better	Slip between foundation and strong floor.	Foundation
5	LTSF1	LVDT	50mm	0.01" or better	Slip between foundation and sill plate.	South Cripple Wall.
6	LTSF2	LVDT	50mm	0.01" or better	Slip between foundation and sill plate.	South Cripple Wall.
7	LTCS1	LVDT *	25mm	0.01" or better	V. disp. sill plate and sheathing.	South Cripple Wall.
8	LTCS2	LVDT	50mm	0.01" or better	H. disp. sill plate and sheathing.	South Cripple Wall.
9	LTCS3	LVDT *	25mm	0.01" or better	V. disp. sill plate and sheathing.	South Cripple Wall.
10	LTCS4	LVDT	50mm	0.01" or better	H. disp. sill plate and sheathing.	South Cripple Wall.
11	LTCS5	LVDT *	25mm	0.01" or better	V. disp. sill plate and sheathing.	South Cripple Wall.
12	LTCS6	LVDT	50mm	0.01" or better	H. disp. sill plate and sheathing.	South Cripple Wall.
13	LTCS7	LVDT *	25mm	0.01" or better	V. disp. cripple wall top plate and sheathing.	South Cripple Wall.
14	LTCS8	LVDT	50mm	0.01" or better	H. disp. cripple wall top plate and sheathing.	South Cripple Wall.
15	LTCS9	LVDT *	25mm	0.01" or better	V. disp. cripple wall top plate and sheathing.	South Cripple Wall.
16	LTCS10	LVDT	50mm	0.01" or better	H. disp. cripple wall top plate and sheathing.	South Cripple Wall.
17	LTCS11	LVDT *	25mm	0.01" or better	V. disp. cripple wall top plate and sheathing.	South Cripple Wall.
18	LTCS12	LVDT	50mm	0.01" or better	H. disp. cripple wall top plate and sheathing.	South Cripple Wall.
19	LTCS13	LVDT	50mm	0.01" or better	V. disp. cripple wall sheathing and stucco.	South Cripple Wall.
20	LTCS14	LVDT	50mm	0.01" or better	H. disp. cripple wall sheathing and stucco.	South Cripple Wall.

AL1-I5

University of California, Berkeley
Large Component Test
Specimen AL-1

Drawing title: Instrumentation Schedule A

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.04 7/26/2018

Notes:

1 - All the LVDTs should be installed with stroke bar half way so it can travel in both direction, excluding the LVDTs are marked by *** in the instrumentation tables;

2 - The LVDTs marked by *** in the instrumentation tables should be installed by having the stroke bar positioned at the maximum and travel just on direction.

Instrumentation Plan **						
Index	Tag	Type	Range	Resolution	Comment	Location
21	LTCS15	LVDT	50mm	0.01" or better	V. disp. cripple wall sheathing and stucco.	South Cripple Wall.
22	LTCS16	LVDT	50mm	0.01" or better	H. disp. cripple wall sheathing and stucco.	South Cripple Wall.
23	LTFD1	LVDT	100mm	0.01" or better	Slip between cripple wall top plate and floor diaphragm.	Floor & south cripple wall.
24	LTFD2	LVDT	100mm	0.01" or better	Slip between cripple wall top plate and floor diaphragm.	Floor & south cripple wall.
25	LTWS1	LVDT ***	25mm	0.01" or better	V. disp. substructure sill plate and sheathing.	South Wall.
26	LTWS2	LVDT	50mm	0.01" or better	H. disp. substructure sill plate and sheathing.	South Wall.
27	LTWS3	LVDT ***	25mm	0.01" or better	V. disp. substructure sill plate and sheathing.	South Wall.
28	LTWS4	LVDT	50mm	0.01" or better	H. disp. substructure sill plate and sheathing.	South Wall.
29	LTWS5	LVDT	50mm	0.01" or better	V. disp. superstructure wall sheathing and stucco.	South Wall.
30	LTWS6	LVDT	50mm	0.01" or better	H. disp. superstructure wall sheathing and stucco.	South Wall.
31	LTWS7	LVDT	50mm	0.01" or better	V. disp. superstructure wall sheathing and stucco.	South Wall.
32	LTWS8	LVDT	50mm	0.01" or better	H. disp. superstructure wall sheathing and stucco.	South Wall.
33	LTLB1	LVDT	50mm	0.01" or better	Slip between the loading beam and floor diaphragm.	Load Beam.
34	LTLB1E	LVDT	75mm	0.01" or better	Absolute vertical movement of the loading beam.	Load Beam.
35	LTCW1	LVDT	75mm	0.01" or better	Sepration between wall sheathing and stucco.	West Cripple Wall.
36	LTWW1	LVDT	75mm	0.01" or better	Sepration between wall sheathing and stucco.	West Wall.
37	LTSS1	LVDT	50mm	0.01" or better	V. displacement between wall sheathing and studs.	South Wall.
38	LTSS2	LVDT	50mm	0.01" or better	H. displacement between wall sheathing and studs.	South Wall.
39	LTSS3	LVDT	50mm	0.01" or better	V. displacement between wall sheathing and studs.	South Wall.
40	LTSS4	LVDT	50mm	0.01" or better	H. displacement between wall sheathing and studs.	South Wall.

AL1-I6

University of California, Berkeley
Large Component Test
Specimen AL-1

Drawing title: Instrumentation Schedule B

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

Revision history:

Rev01.04 7/26/2018

Notes:

1 - All the LVDTs should be installed with stoke bar half way so it can travel in both direction, excluding the LVDTs are marked by *** in the instrumentation tables;

2 - The LVDTs marked by *** in the instrumentation tables should be installed by having the stroke bar positioned at the maximum and travel just on direction.

AL1-I7University of California, Berkeley
Large Component Test
Specimen AL-1

Drawing title: Instrumentation Schedule B

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeon

Revision history:

Rev01.03 7/25/2018

Notes:

1 - All the LVDTs should be installed with stroke bar half way so it can travel in both direction, excluding the LVDTs are marked by *** in the instrumentation tables;

2 - The LVDTs marked by *** in the instrumentation tables should be installed by having the stroke bar positioned at the maximum and travel just on direction.

Instrumentation Plan **

Index	Tag	Type	Range	Resolution	Comment	Location
41	LTOP1	LVDT	150mm	0.01" or better	Out-of-plane deformation.	West Wall.
42	LTOP2	LVDT	150mm	0.01" or better	Out-of-plane deformation.	West Wall.
43	LTOP3	LVDT	150mm	0.01" or better	Out-of-plane deformation.	East Wall.
44	LTOP4	LVDT	150mm	0.01" or better	Out-of-plane deformation.	East Wall.
45						
46						
47						
48						
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50						
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59						
60						

AL1-I8University of California, Berkeley
Large Component Test
Specimen AL-1

Drawing title: Instrumentation Schedule C

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

Revision history:

Rev01.04 7/26/2018

Instrumentation Plan						
Index	Tag	Type	Range	Resolution	Comment	Location
1	SPRF1	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
2	SPRF2	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
3	SPRF3	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
4	SPRF4	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
5	SPRF5	String Pot	15"	0.01" or better	Vertical building deformation profile.	Reference Column
6	SPCS1	String Pot	10"	0.01" or better	Diagonal deformation in cripple wall.	South cripple wall.
7	SPCS2	String Pot	10"	0.01" or better	Diagonal deformation in cripple wall.	South cripple wall.
8	SPCS3	String Pot	10"	0.01" or better	Diagonal deformation in cripple wall.	South cripple wall.
9	SPCS4	String Pot	10"	0.01" or better	Diagonal deformation in cripple wall.	South cripple wall.
10	SPWS1	String Pot	10"	0.01" or better	Diagonal deformation in the superstructure wall.	South wall.
11	SPWS2	String Pot	10"	0.01" or better	Diagonal deformation in the superstructure wall.	South wall.
12	SPFD1	String Pot	10"	0.01" or better	Diagonal deformation in floor diaphragm.	Floor.
13	SPFD2	String Pot	10"	0.01" or better	Diagonal deformation in floor diaphragm.	Floor.
14						
15						
16						
17						
18						
19						
20						

Instrumentation Plan						
Index	Tag	Type	Range	Resolution	Comment	Location
1	WLFS1	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16438)	Foundation south side.
2	WLFS2	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16455)	Foundation south side.
3	WLFS3	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16429)	Foundation south side.
4	WLFS4	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16444)	Foundation south side.
5	WLFN1	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16436)	Foundation north side.
6	WLFN2	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16432)	Foundation north side.
7	WLFN3	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16439)	Foundation north side.
8	WLFN4	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16434)	Foundation north side.
9	WLFW1	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16435)	Foundation west side.
10	WLFW2	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16436)	Foundation west side.
11						
12						

AL1-I9

University of California, Berkeley
Large Component Test
Specimen AL-1

Drawing title: Instrumentation Schedule D

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.04 10/07/2018

“Quantifying the Performance of Retrofit of Cripple Walls and Sill Anchorage in Single Family Wood-frame Buildings”

Large Component Test - Working Group 4 - Specimen AL-2

Updated: December 12, 2018

Construction:

Cripple wall:

$\frac{7}{8}$ " 3-coat stucco over horizontal lumber sheathing

Super Structure:

$\frac{7}{8}$ " 3-coat stucco over horizontal lumber sheathing (Exterior)

$\frac{1}{2}$ " gypsum board (Interior)

Retrofit:

Extra Bolts

Extra Brackets A35 Simposn Strong Tie

Plywood shear wall

Structural Drawings:

AL1-S1	Retrofit Bracket
AL1-S2	Plywood Retrofit Detail A
AL1-S3	Plywood Retrofit Detail B
AL1-S4	Plywood Retrofit Detail C

AL2-S1

University of California, Berkeley
Large Component Test
Specimen AL-2

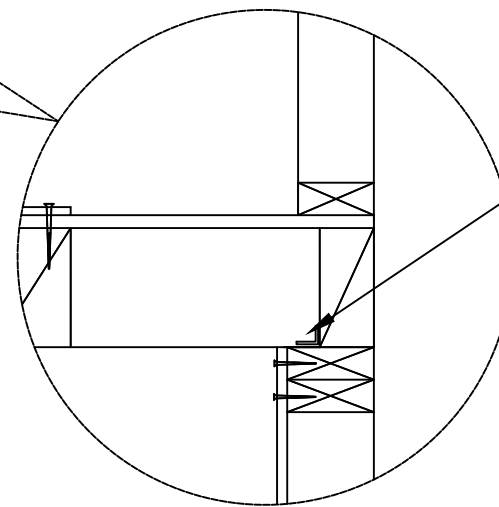
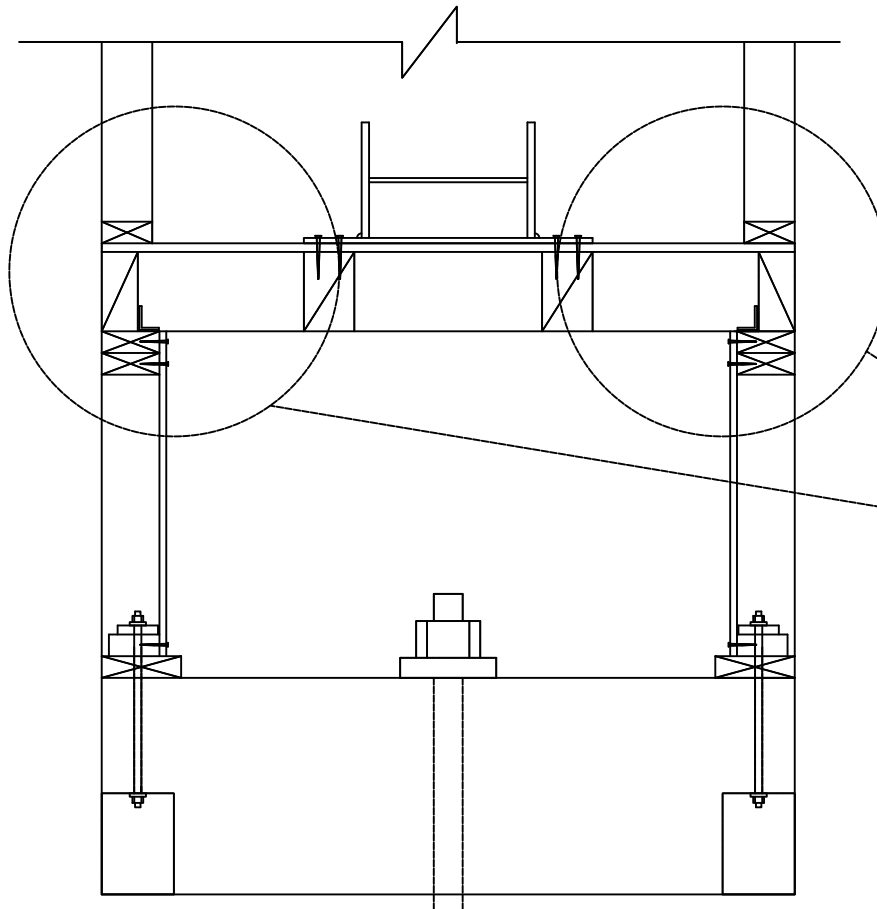
Drawing title: **Retrofit Bracket**

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

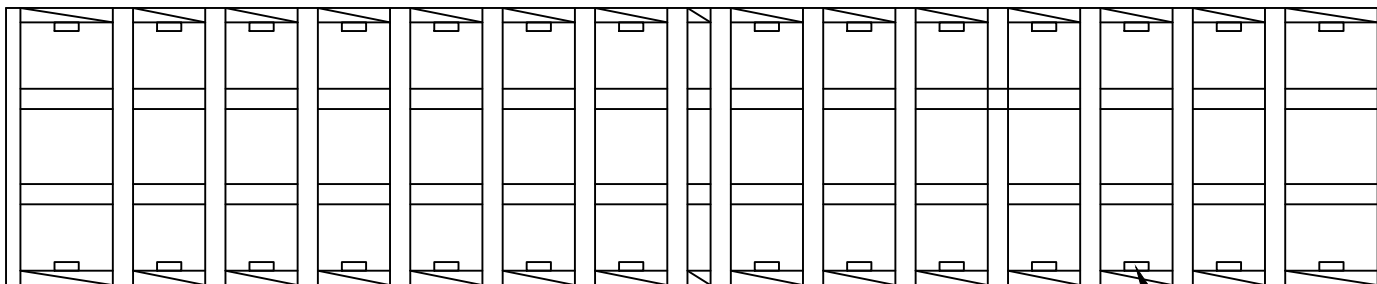
Rev01.02 9/06/2018



A35 Angles w/ Nail
(12) 8d x 1 1/2" x 0.131"

Scale: Not to be scaled

A35 Retrofit Angles



Scale: 1" = 33" on 8.5x11

A35 Retrofit Angles

A35 Angle
12 8d x 1 1/2" (6 on each side)

Notes:

- 1 - In total, 8 new threaded rods $\frac{1}{2}$ " in diameter are needed to be installed using concrete epoxy adhesive;
- 2- Threaded rods should be placed in the middle of the blocking, and at least 2" from the blocking ends;
- 3- Threaded rods minimum embedment depth is 4 $\frac{1}{2}$ " into foundation concrete;
- 4- For all the bolts and extra threaded rods, bearing plates from the product line of Simpson Strong Tie should be installed;
- 5- $\frac{1}{8}$ " Gap to be considered between all Plywood;
- 6- In total, 28 angles (A35 Simpson Strong Tie) will be installed using total of (12) 8d x 1 $\frac{1}{2}$ " x 0.131" nails per angle;
- 7- Nails should be offset $\frac{1}{2}$ " to $\frac{3}{8}$ " from the plywood panel edges;
- 8-

AL2-S2

University of California, Berkeley
Large Component Test
Specimen AL-2

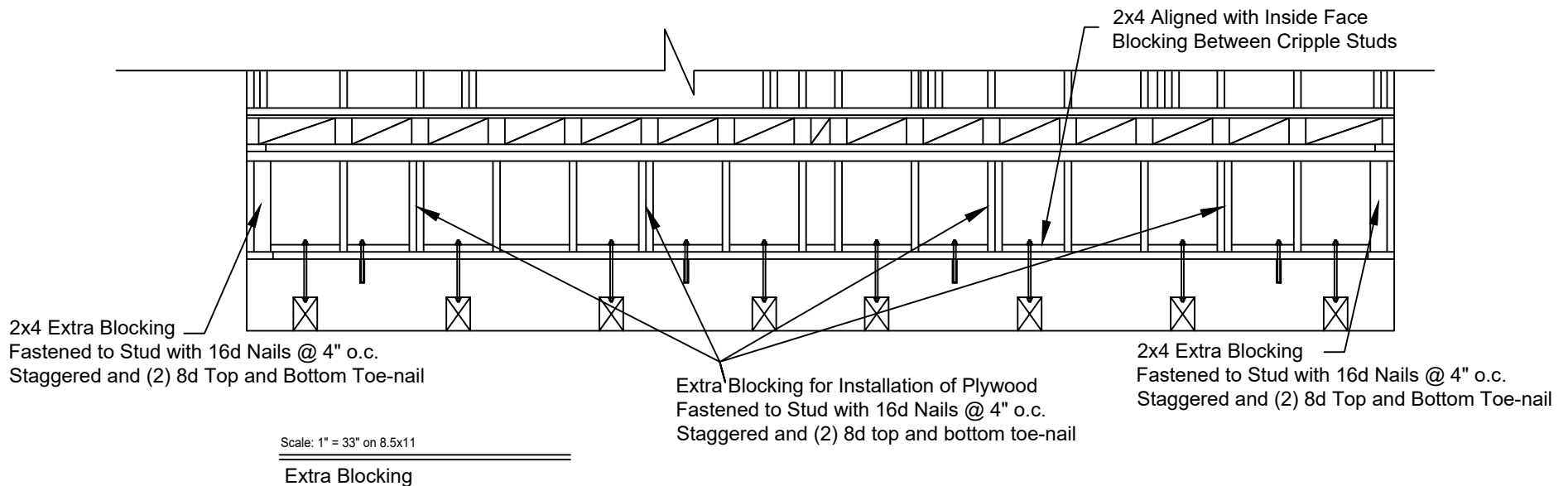
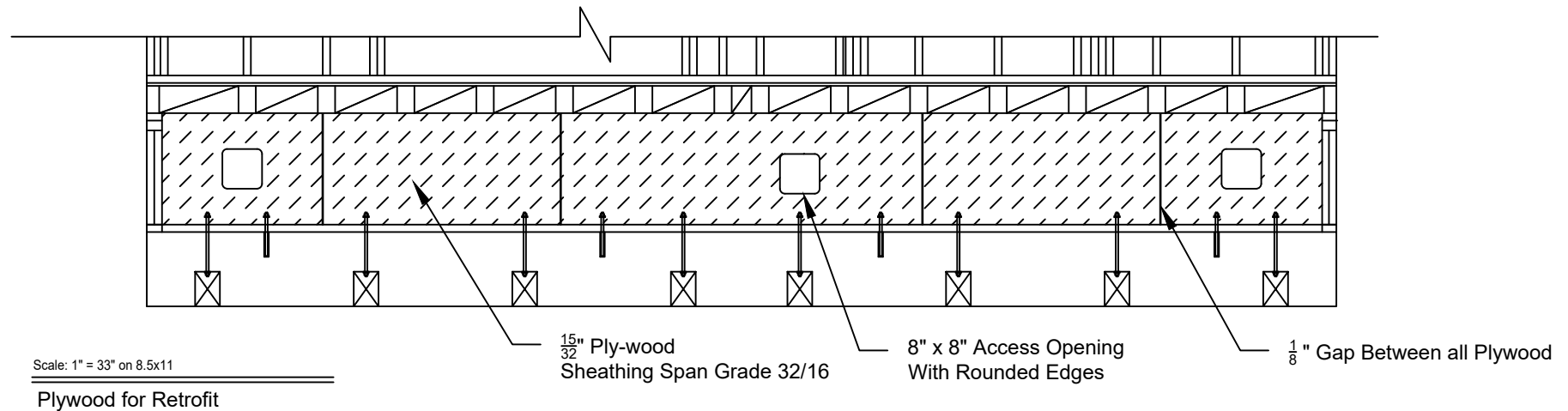
Drawing title: **Plywood Retrofit Detail A**

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.02 9/6/2018



AL2-S3

University of California, Berkeley
Large Component Test
Specimen AL-2

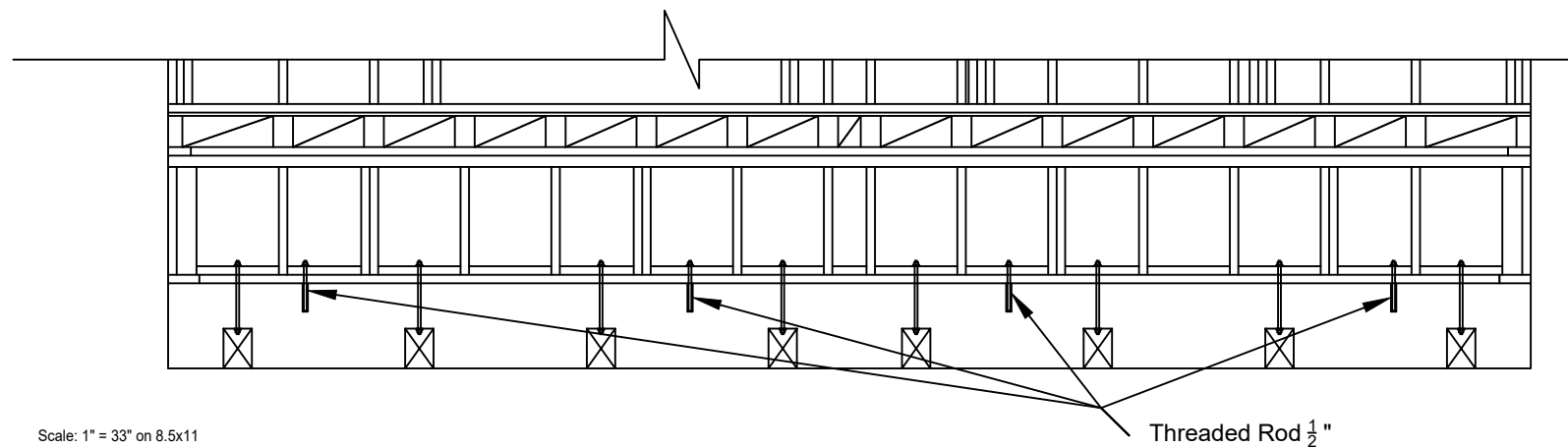
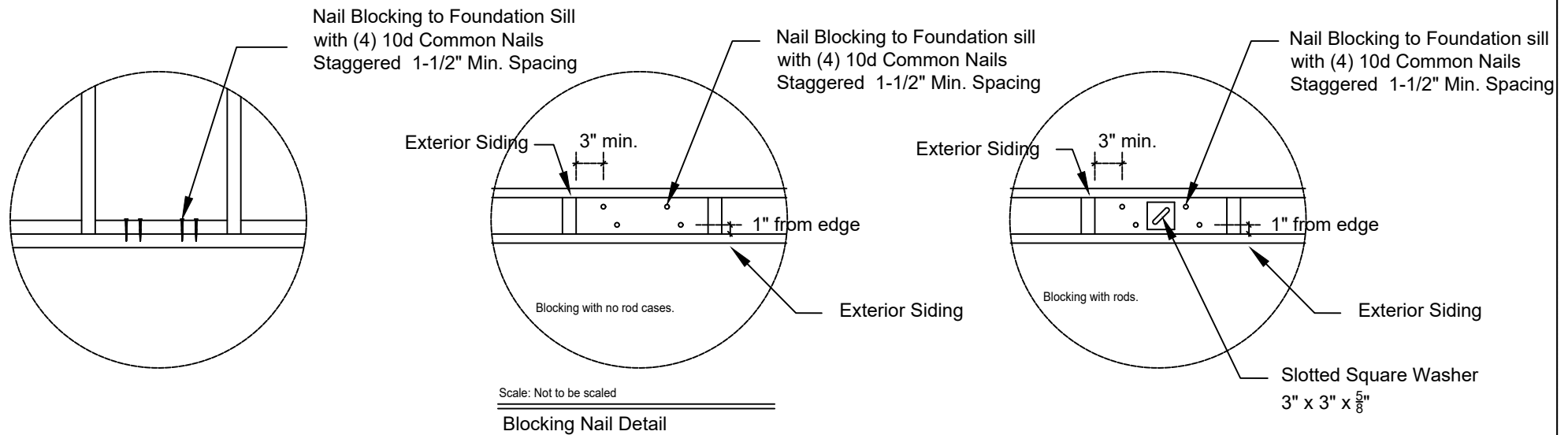
Drawing title: **Plywood Retrofit Detail B**

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.02 9/6/2018



Scale: 1" = 33" on 8.5x11

Extra Reinforcing Bolts

AL2-S4

University of California, Berkeley
Large Component Test
Specimen AL-2

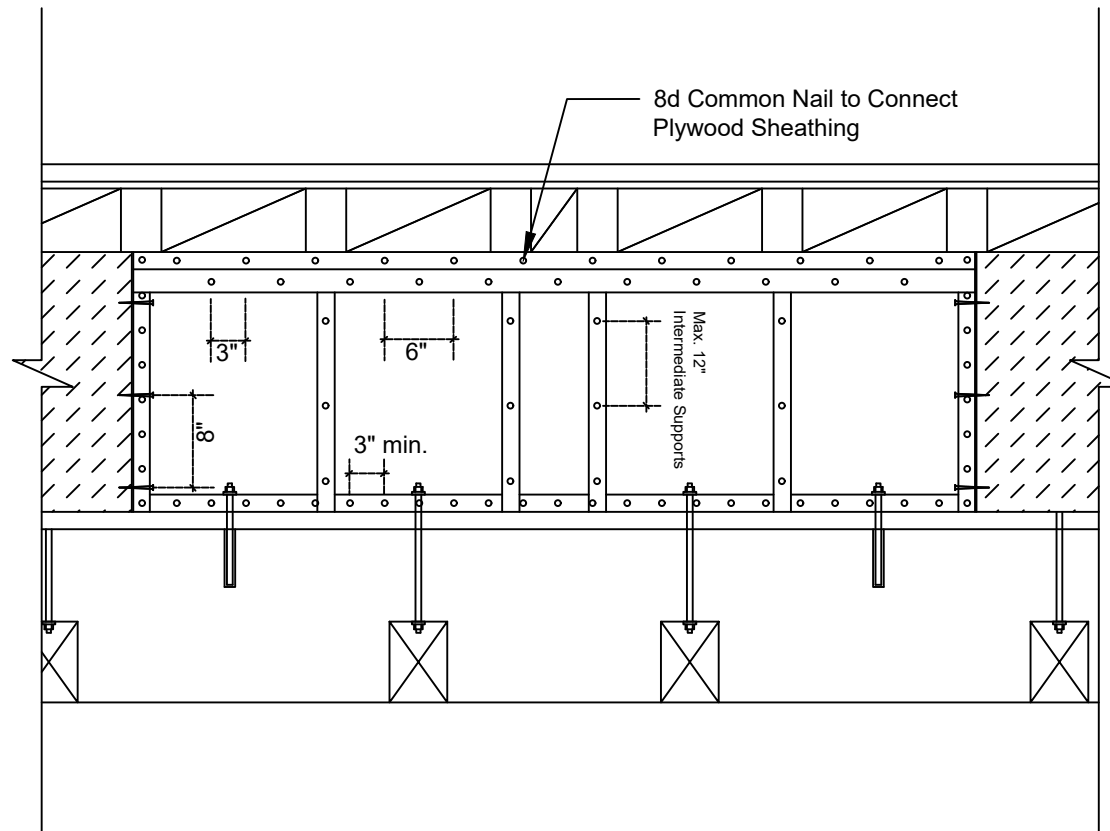
Drawing title: **Plywood Retrofit Detail C**

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.02 9/6/2018



Scale: 1" = 33" on 8.5x11

Plywood Nailing Pattern

“Quantifying the Performance of Retrofit of Cripple Walls and Sill Anchorage in Single Family Wood-frame Buildings”

Large Component Test - Working Group 4 - Specimen B-1

Updated: April 22, 2019

Construction:

Structural Drawings:

B1-S1	Wall Framing Elevations
B1-S2	Plywood Retrofit Detail Middle Section
B1-S3	Plywood Retrofit Detail West Section
B1-S4	Diaphragm Sheathing and Framing
B1-S5	Retrofit Foundation Plates
B1-S6	Shiplaps Siding
B1-S7	Framing Details A
B1-S8	Framing Details B
B1-S9	Framing Details C

Instrumentation Plan:

B1-I1	Instrumentation Plan
B1-I2	Instrumentation Schedule A
B1-I3	Instrumentation Schedule B

Notes:

- 1- $\frac{1}{8}$ " Gap to be considered between all Plywood;
- 2- Nails should be offset $\frac{1}{2}$ " to $\frac{3}{8}$ " from the plywood panel edges;

B1-S1

University of California, Berkeley
Large Component Test
Specimen B-1

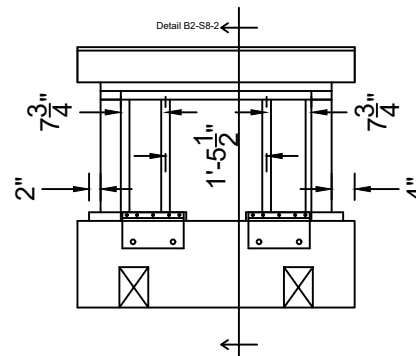
Drawing title: Wall Framing Elevation

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

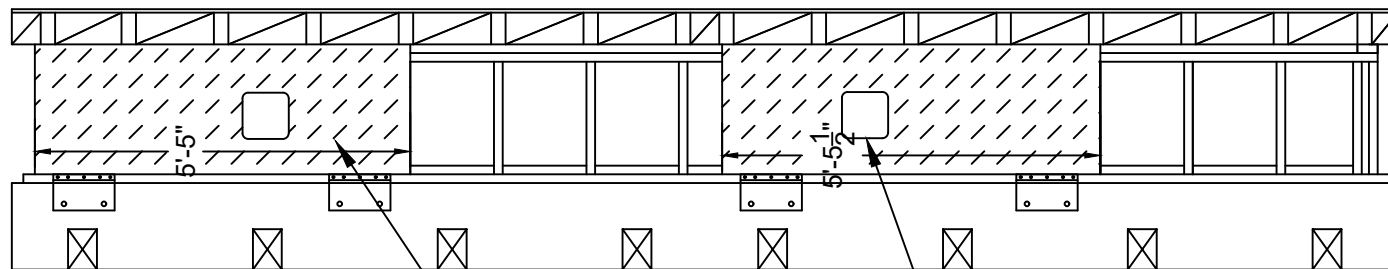
Revision history:

Rev01.03 04/10/2019



Scale: 1" = 33" on 8.5x11

East and West Walls Framing



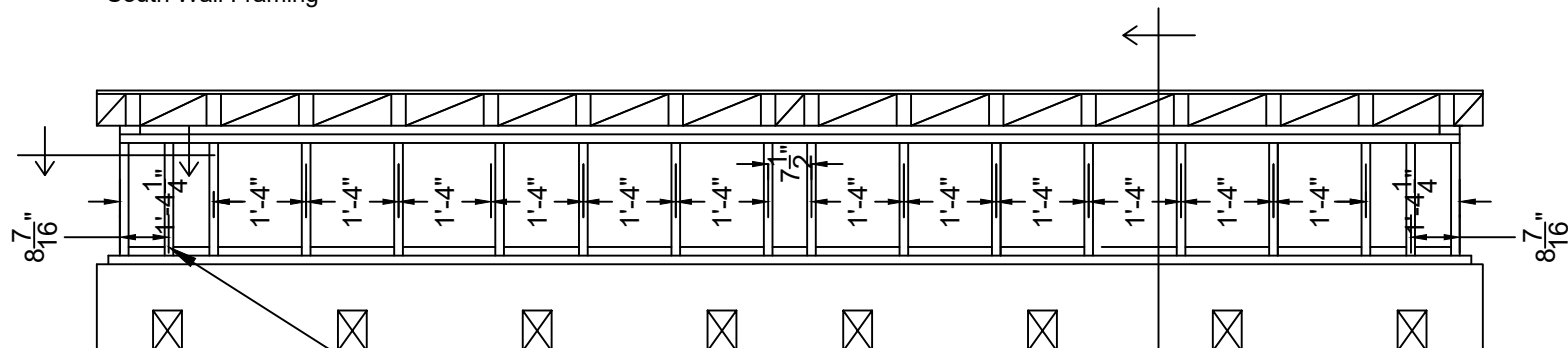
Scale: 1" = 33" on 8.5x11

South Wall Framing

15/32" Ply-wood Sheathing
Span Grade 32/16

8" x 8" Access Opening
With Rounded Edges

Detail B1-S8-2



Scale: 1" = 33" on 8.5x11

South Wall Framing

Extra Blocking for Installation Shiplaps
Fastened to Stud with 16d Nails @ 4" o.c.
Staggered and (2) 8d top and bottom toe-nail

Detail B1-S7-2

B-40

Notes:

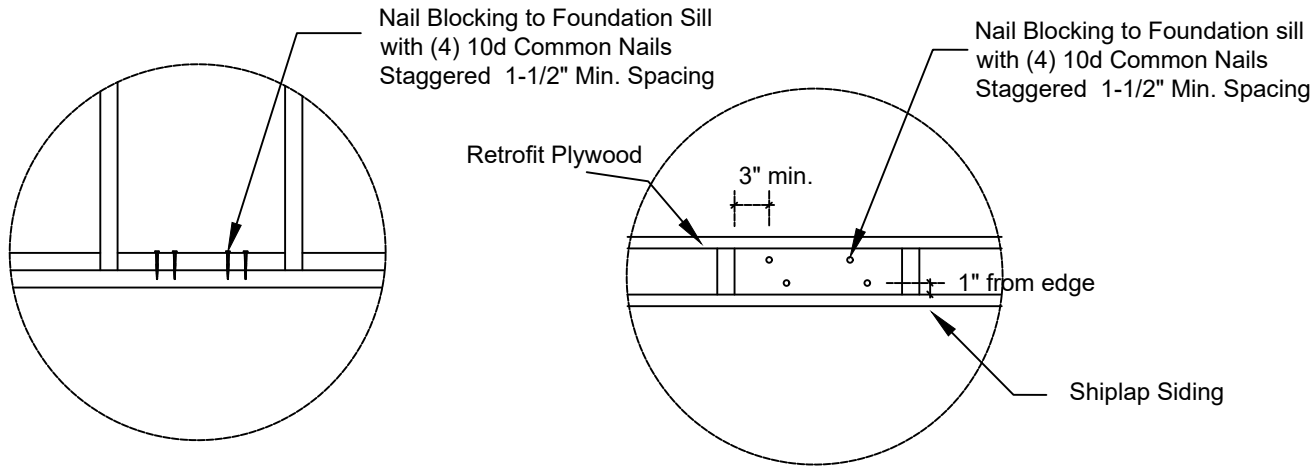
- 1- $\frac{1}{8}$ " Gap to be considered between all Plywood;
- 2- Nails should be offset $\frac{1}{2}$ " to $\frac{3}{8}$ " from the plywood panel edges.

B1-S2

University of California, Berkeley
Large Component Test
Specimen B-1

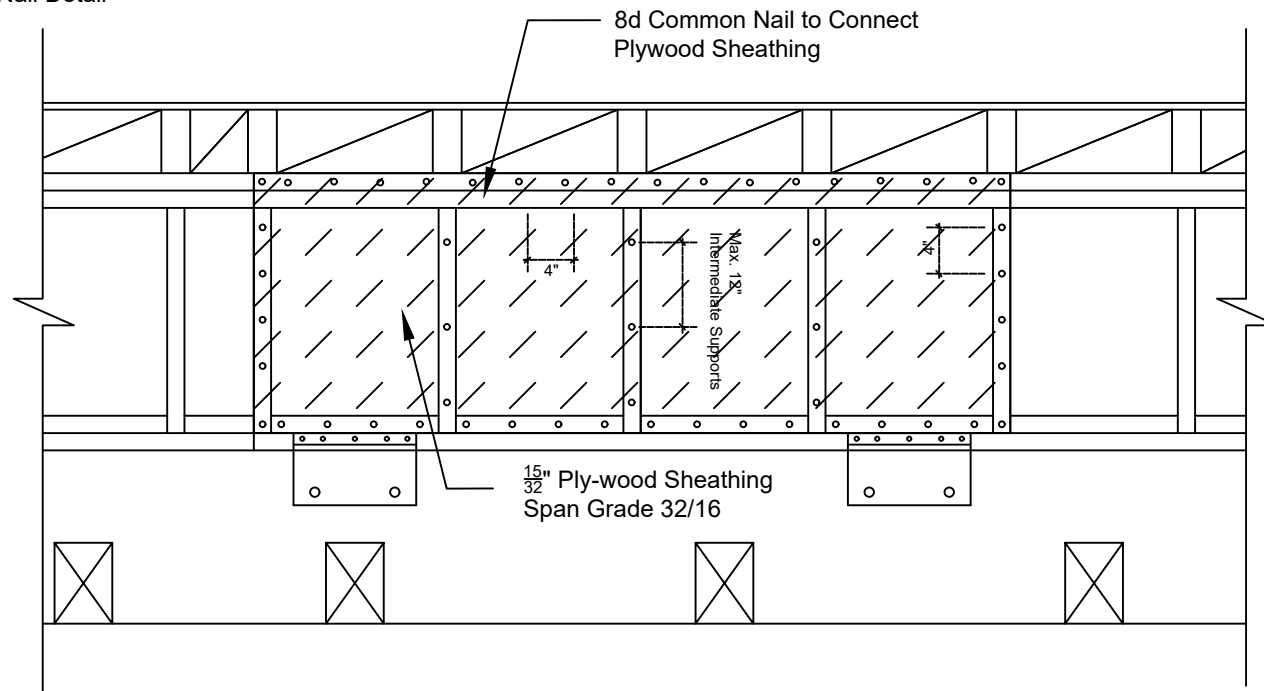
Drawing title: Plywood Retrofit Detail Middle
Drawn by: Vahid MahdaviFar
Controlled by: Kelly Cobeen

Revision history:
Rev01.03 04/10/2019



Scale: Not to be scaled

Blocking Nail Detail



Scale: 1" = 33" on 8.5x11

Plywood Retrofit Nailing Pattern at the Middle

Notes:

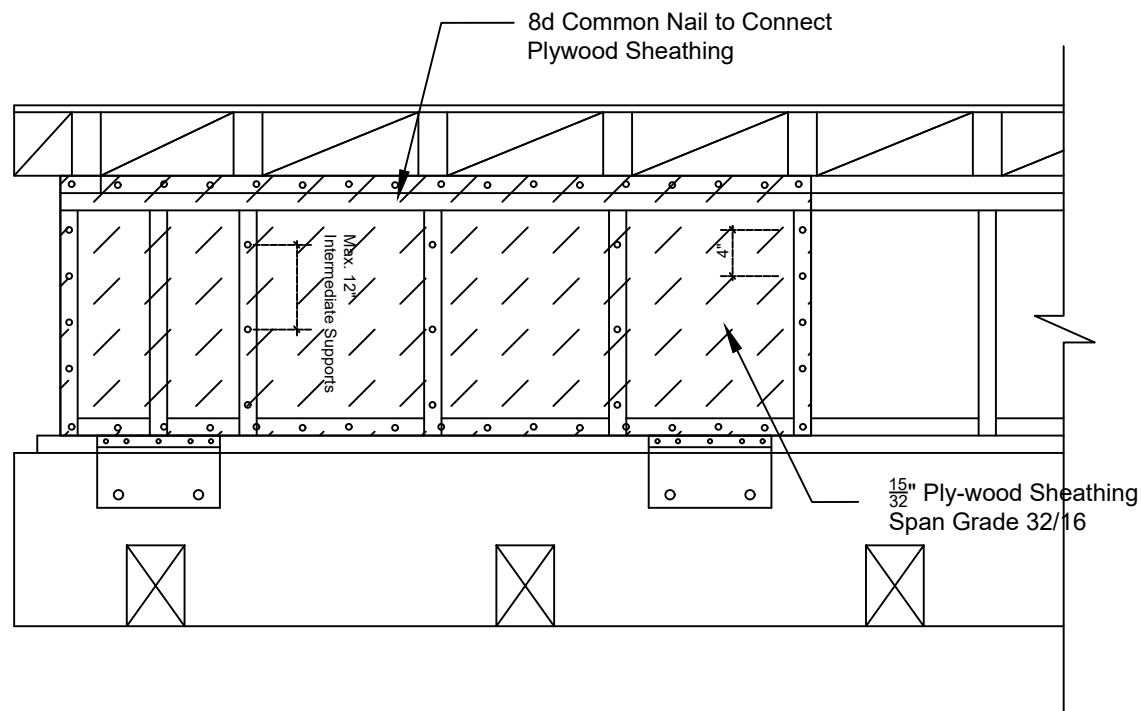
- 1- $\frac{1}{8}$ " Gap to be considered between all Plywood;
- 2- Nails should be offset $\frac{1}{2}$ " to $\frac{3}{8}$ " from the plywood panel edges.

B1-S3

University of California, Berkeley
Large Component Test
Specimen B-1

Drawing title: Plywood Retrofit Detail West End
Drawn by: Vahid MahdaviFar
Controlled by: Kelly Cobeen

Revision history:
Rev01.03 04/10/2019



Scale: 1" = 33" on 8.5x11

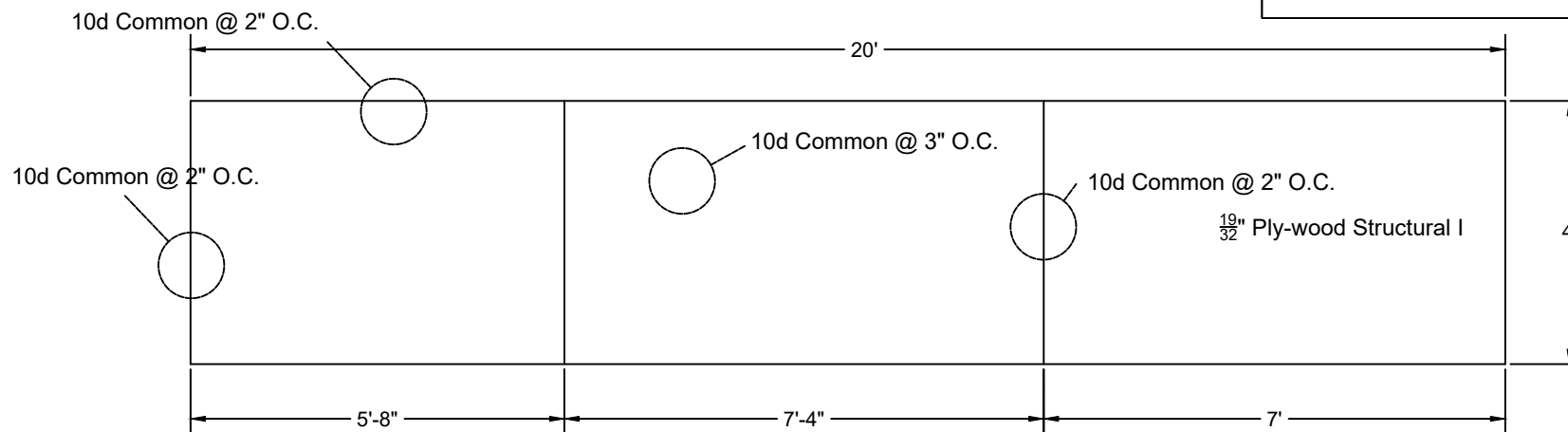
Plywood Retrofit Nailing Pattern at the West End

B1-S4

University of California, Berkeley
Large Component Test
Specimen B-1

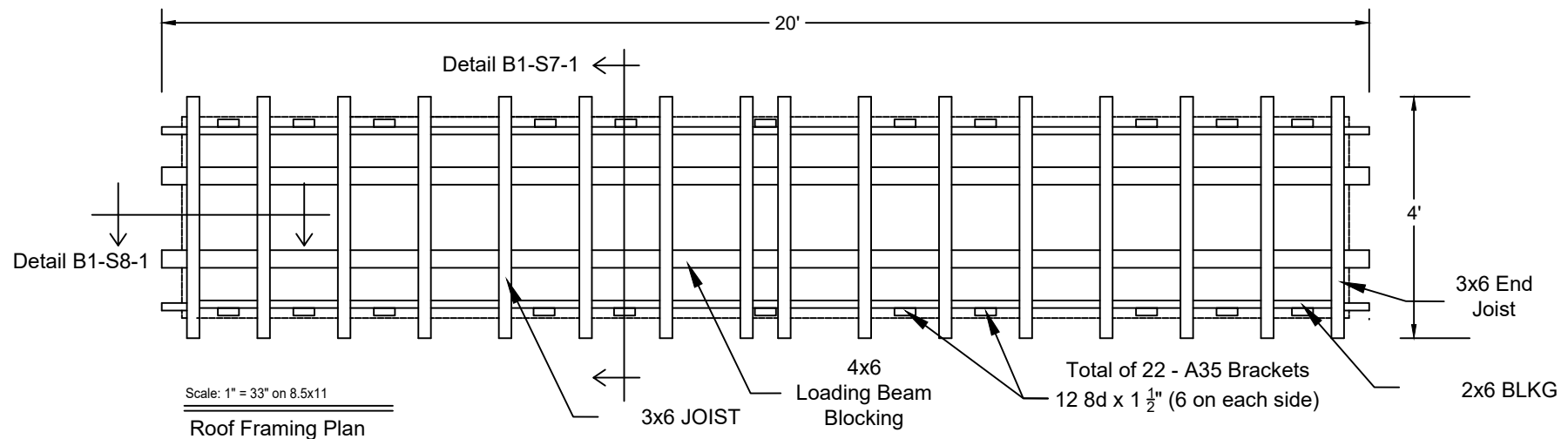
Drawing title: Diaphragm Sheathing and Framing
Drawn by: Vahid Mahdavifar
Controlled by: Kelly Cobeen

Revision history:
Rev01.04 04/16/2019



Scale: 1" = 33" on 8.5x11

Floor Ply-wood Cut Diagram



Scale: 1" = 33" on 8.5x11

Roof Framing Plan

Notes:

- 1- Nominal embedment depth for post-installed anchors must be 4";
- 2- For fixing the bolts, use High-Strength Epoxy Adhesive similar to SET-3G or AT-XP;
- 3- Use Threaded Rod $\frac{1}{2}$ " for connecting the retrofit foundation plates to foundation;
- 4- Each anchor bolt requires a standard-cut washer.

B1-S5

University of California, Berkeley
Large Component Test
Specimen B-1

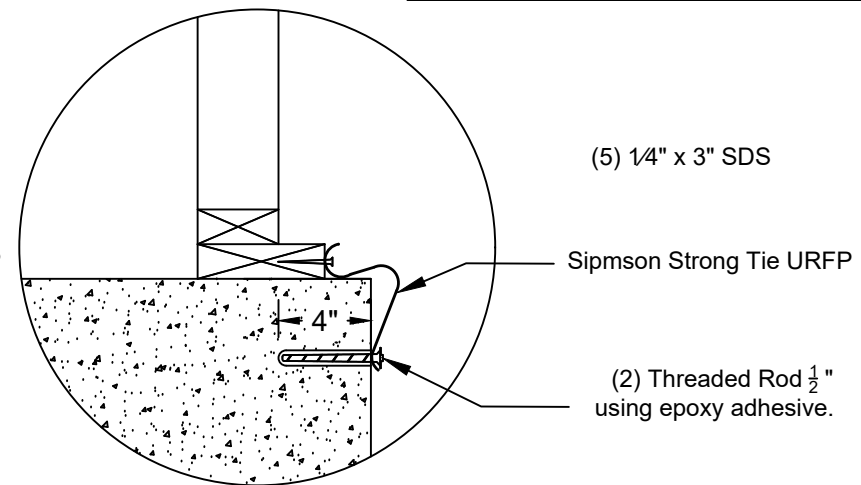
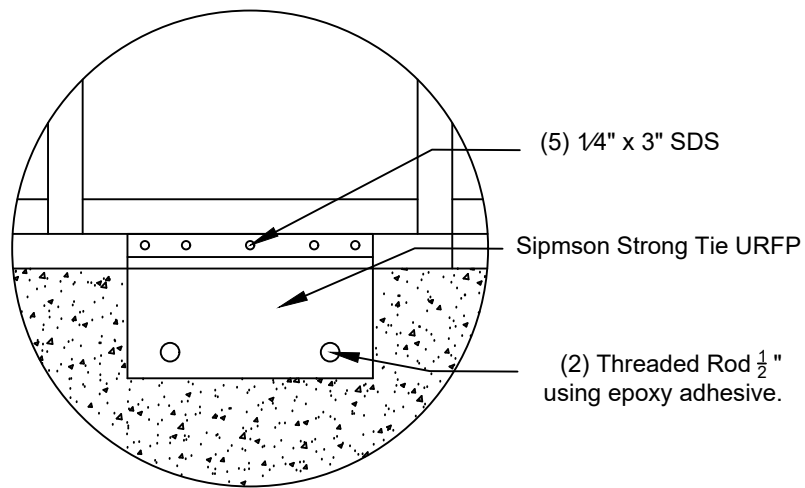
Drawing title: Retrofit Foundation Plates

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

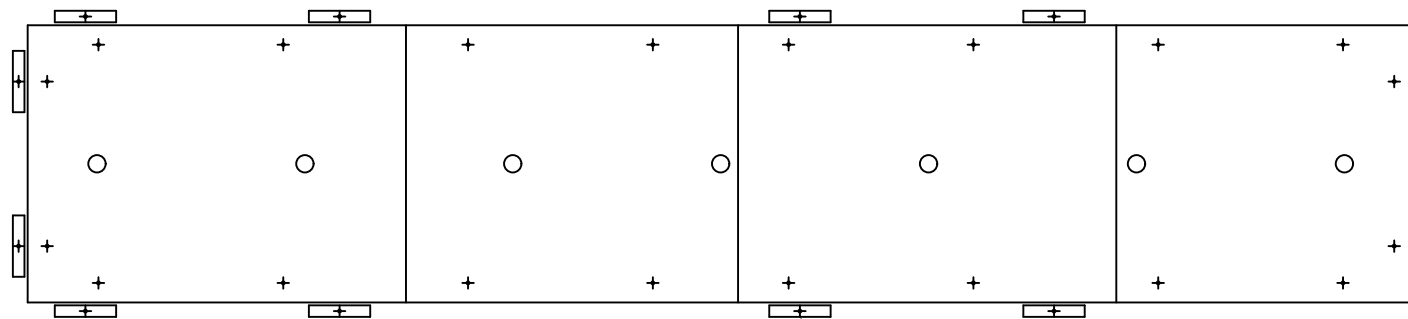
Revision history:

Rev01.03 04/10/2019



Scale: Not to be scaled.

Simpson URFP Detail



Scale: 1" = 33" on 8.5x11

Simpson URFP

12 Simpson Strong Tie URFP Retrofit Foundation Plates with
2 Threaded Rod $\frac{1}{2}$ "
5 Strong Drive Screws

B-44

Notes:

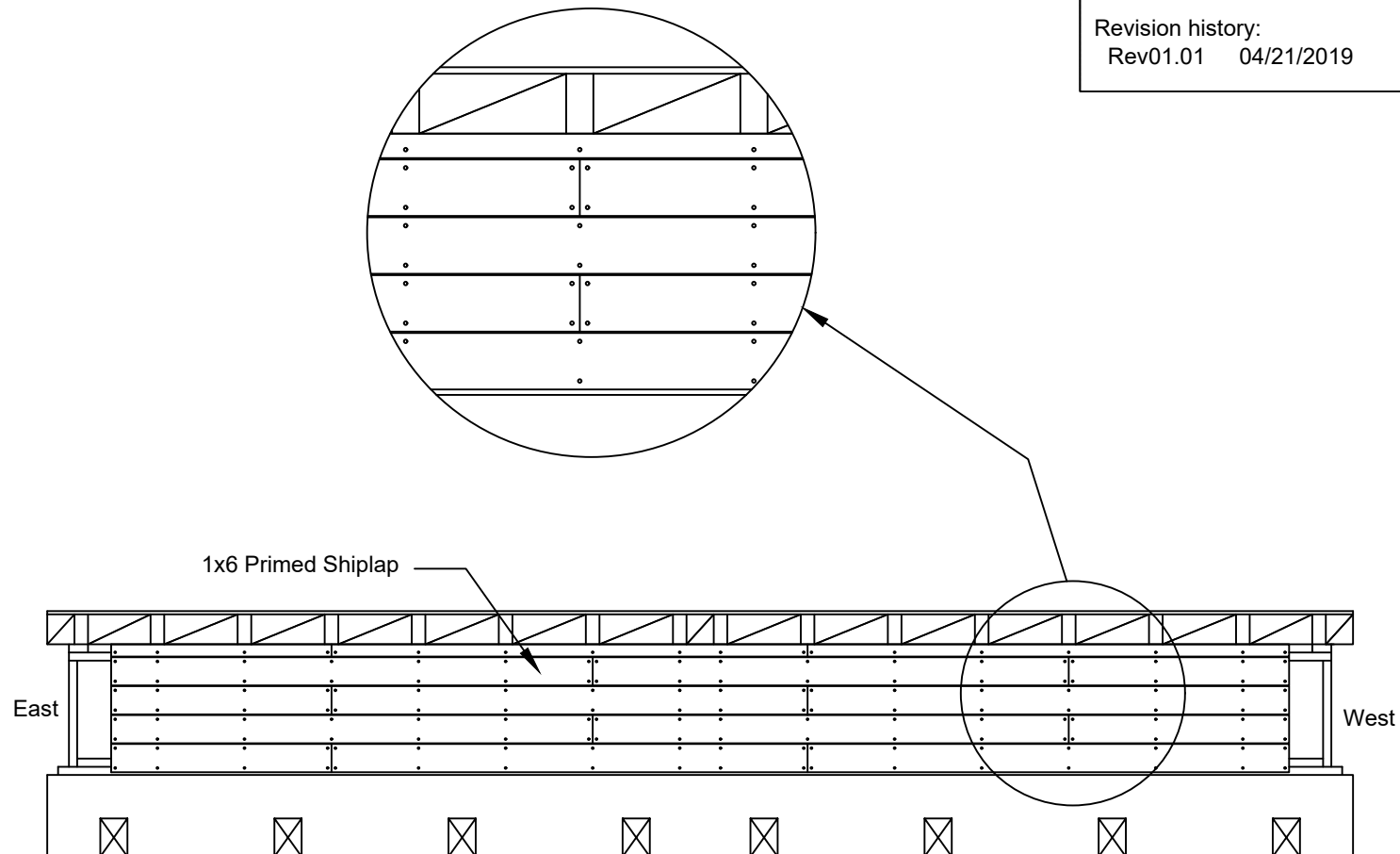
- 1- Shiplaps are connected using 2-8d HDG nail at each bearing;
- 2- The first shiplap should be spaced $\frac{1}{2}$ " from the surface of concrete;
- 3- A gap of $\frac{1}{8}$ " should be assigned between the adjacent rows of shiplap.

B1-S6

University of California, Berkeley
Large Component Test
Specimen B-1

Drawing title: Shiplap Siding
Drawn by: Vahid MahdaviFar
Controlled by: Kelly Cobeen

Revision history:
Rev01.01 04/21/2019



Scale: 1" = 33" on 8.5x11

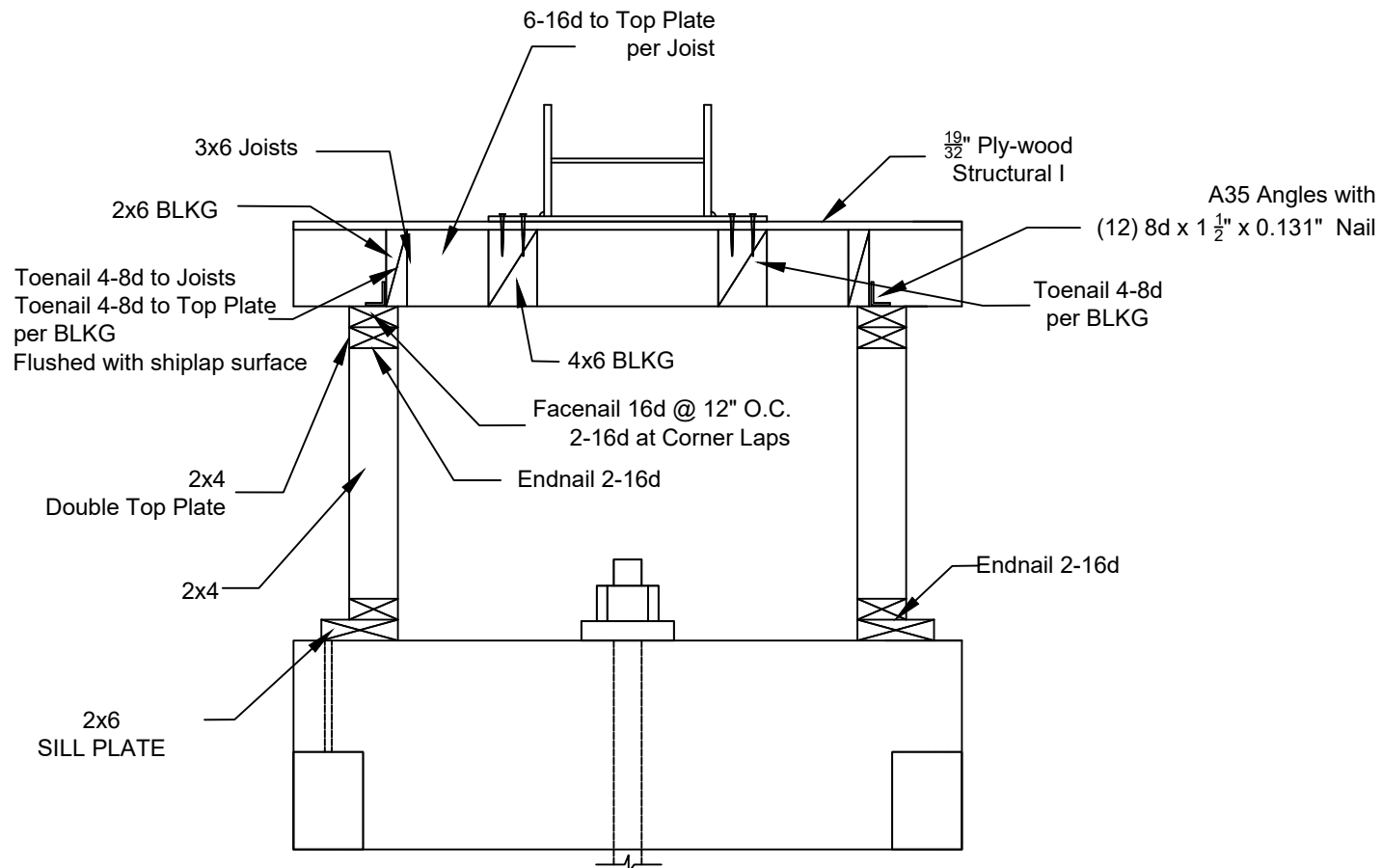
South Wall Framing

B1-S7

University of California, Berkeley
Large Component Test
Specimen B-1

Drawing title: Framing Details A
Drawn by: Vahid MahdaviFar
Controlled by: Kelly Cobeen

Revision history:
Rev01.03 04/10/2019



Scale: 1" = 13 - $\frac{1}{2}$ " on 8.5x11

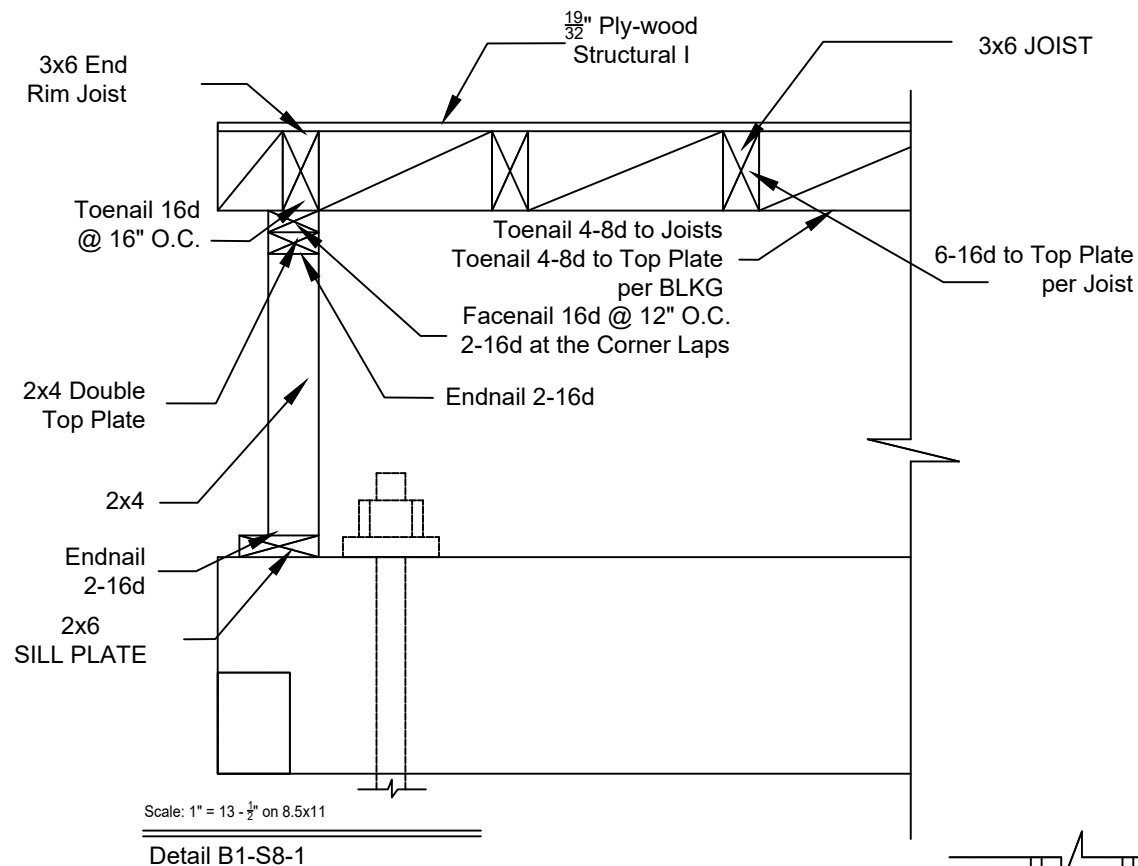
Detail B1-S7-1

B1-S8

University of California, Berkeley
Large Component Test
Specimen B-1

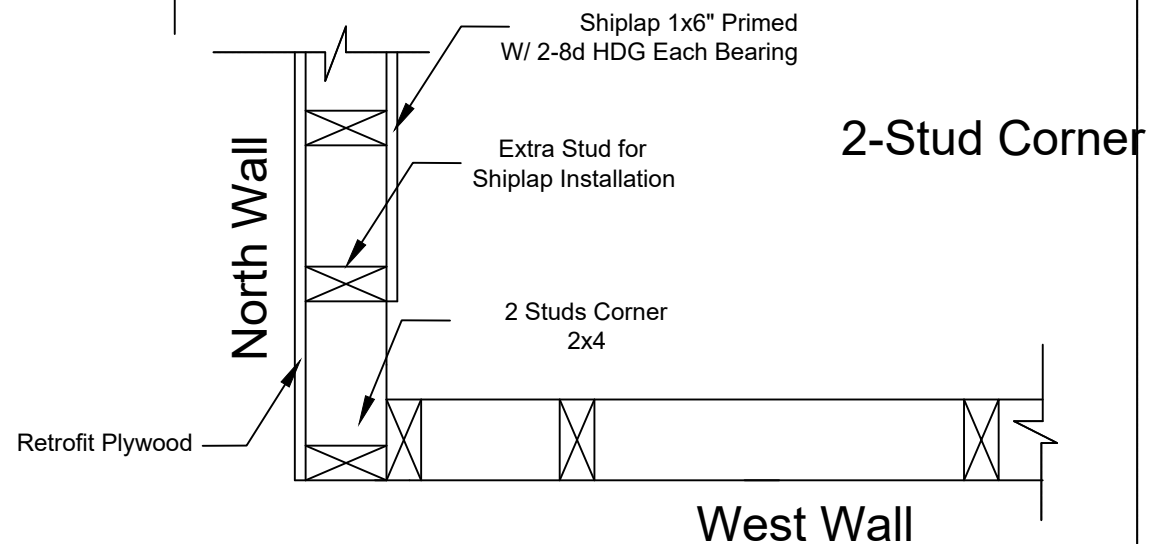
Drawing title: Framing Details B
Drawn by: Vahid MahdaviFar
Controlled by: Kelly Cobeen

Revision history:
Rev01.03 04/10/2019



Notes:

- 1- Shiplaps are connected using 2-8d HDG nail at each bearing;
- 2- The first shiplap should be spaced $\frac{1}{2}$ " from the surface of concrete;
- 3- A gap of $\frac{1}{8}$ " should be assigned between the adjacent rows of shiplap.

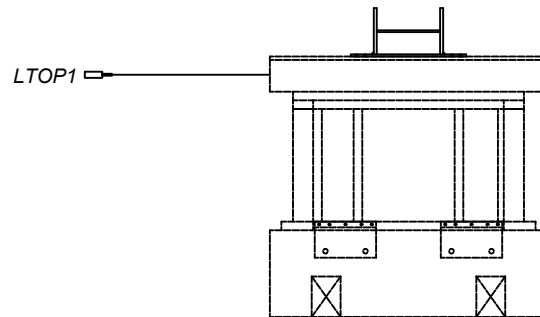


B1-I1

University of California, Berkeley
Large Component Test
Specimen B-1

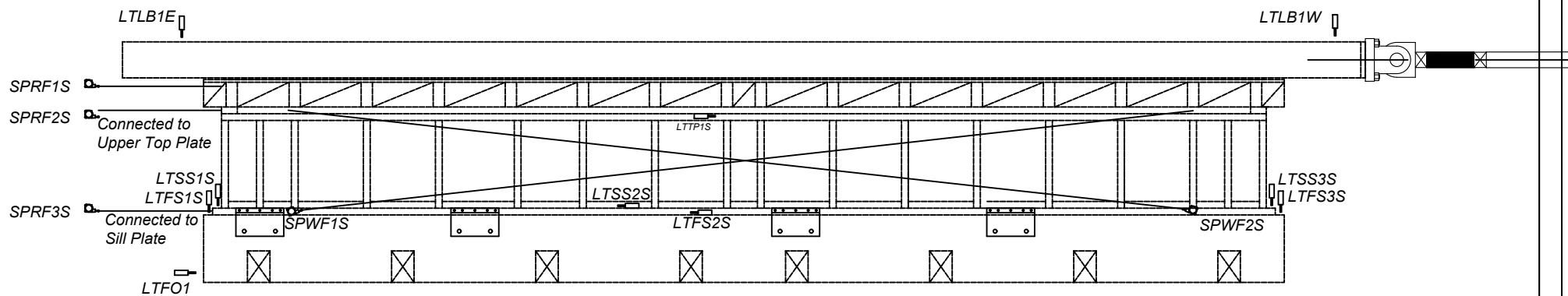
Drawing title: Instrumentation Plan
Drawn by: Vahid Mahdavifar
Controlled by: Kelly Cobeen

Revision history:
Rev01.03 04/23/2019



Scale: 1" = 33" on 8.5x11

Instrumentation Plan West Wall



Scale: 1" = 33" on 8.5x11

Instrumentation Plan South Wall

Instrumentation Plan **						
Index	Tag	Type	Range	Resolution	Comment	Location
1	LTFO1	LVDT *	25mm	0.01" or better	Uplift between foundation and strong floor.	Foundation
2	LTLB1E	LVDT	100mm	0.01" or better	Absolute vertical movement of the loading beam.	Load Beam.
3	LTLB1W	LVDT	100mm	0.01" or better	Absolute vertical movement of the loading beam.	Load Beam.
4	LTOP1	String Pot	5"	0.01" or better	Out-of-plane deformation.	West Wall.
5	SPRF1S	String Pot	20"	0.01" or better	Vertical building deformation profile.	Reference Column
6	SPRF2S	String Pot	20"	0.01" or better	Vertical building deformation profile.	Reference Column
7	SPRF3S	String Pot	20"	0.01" or better	Vertical building deformation profile.	Reference Column
8	SPRF1N	String Pot	20"	0.01" or better	Vertical building deformation profile.	Reference Column
9	SPRF2N	String Pot	20"	0.01" or better	Vertical building deformation profile.	Reference Column
10	SPRF3N	String Pot	20"	0.01" or better	Vertical building deformation profile.	Reference Column
11	SPWF1N	String Pot	20"	0.01" or better	Diagonal deformation in the superstructure wall.	North wall.
12	SPWF2N	String Pot	20"	0.01" or better	Diagonal deformation in the superstructure wall.	North wall.
13	SPWF1S	String Pot	20"	0.01" or better	Diagonal deformation in the superstructure wall.	South wall.
14	SPWF2S	String Pot	20"	0.01" or better	Diagonal deformation in the superstructure wall.	South wall.
15	LTFS1S	LVDT	100mm	0.01" or better	V. Uplift of the Sill Plate from the foundation.	South Wall.
16	LTFS2S	LVDT	100mm	0.01" or better	H. slip Sill Plate from the foundation.	South Wall.
17	LTFS3S	LVDT	100mm	0.01" or better	V. Uplift of the Sill Plate from the foundation.	South Wall.
18	LTFS1N	LVDT***	100mm	0.01" or better	V. Uplift of the Sill Plate from the foundation.	North wall.
19	LTFS2N	LVDT	200mm	0.01" or better	H. slip Sill Plate from the foundation.	North wall.
20	LTFS3N	LVDT***	100mm	0.01" or better	V. Uplift of the Sill Plate from the foundation.	North wall.

B1-I2

University of California, Berkeley
Large Component Test
Specimen C-2

Drawing title: Instrumentation Schedule A

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.02 04/22/2019

Notes:

1 - All the LVDTs should be installed with stroke bar half way so it can travel in both direction, excluding the LVDTs are marked by *** in the instrumentation tables;

2 - The LVDTs marked by *** in the instrumentation tables should be installed by having the stroke bar positioned at the maximum and travel just on direction.

Instrumentation Plan **						
Index	Tag	Type	Range	Resolution	Comment	Location
1	LTSS1S	LVDT***	100mm	0.01" or better	V. Uplift of the framing stud from the sill plate.	South Wall.
2	LTSS2S	LVDT	150mm	0.01" or better	H. slip retrofit blocking from the sill plate.	South Wall.
3	LTSS3S	LVDT***	100mm	0.01" or better	V. Uplift of the framing stud from the sill plate.	South Wall.
4	LTSS1N	LVDT***	100mm	0.01" or better	V. Uplift of the framing stud from the foundation.	North wall.
5	LTSS2N	LVDT	150mm	0.01" or better	H. slip retrofit blocking from the foundation.	North wall.
6	LTSS3N	LVDT***	100mm	0.01" or better	V. Uplift of the framing stud from the foundation.	North wall.
7	LTP1S	LVDT	100mm	0.01" or better	Slip between the upper and lower top plates.	South Wall.
8	LTP1N	LVDT	100mm	0.01" or better	Slip between the upper and lower top plates.	North wall.
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

B1-I3

University of California, Berkeley
Large Component Test
Specimen C-2

Drawing title: Instrumentation Schedule B

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobein

Revision history:

Rev01.03 04/23/2019

Notes:

1 - All the LVDTs should be installed with stroke bar half way so it can travel in both direction, excluding the LVDTs are marked by *** in the instrumentation tables;

2 - The LVDTs marked by *** in the instrumentation tables should be installed by having the stroke bar positioned at the maximum and travel just on direction.

“Quantifying the Performance of Retrofit of Cripple Walls and Sill Anchorage in Single Family Wood-frame Buildings”

Large Component Test - Working Group 4 - Specimen C-1

Updated: December 12, 2018

Construction:

Structural Drawings:

C1-S1	Overall Plan and Elevations
C1-S2	Framing Elevations
C1-S3	Framing Details A
C1-S4	Framing Details B
C1-S5	Framing Details C
C1-S6	Framing Details D
C1-S7	Framing Details E
C1-S8	Framing Details F

Instrumentation Plan:

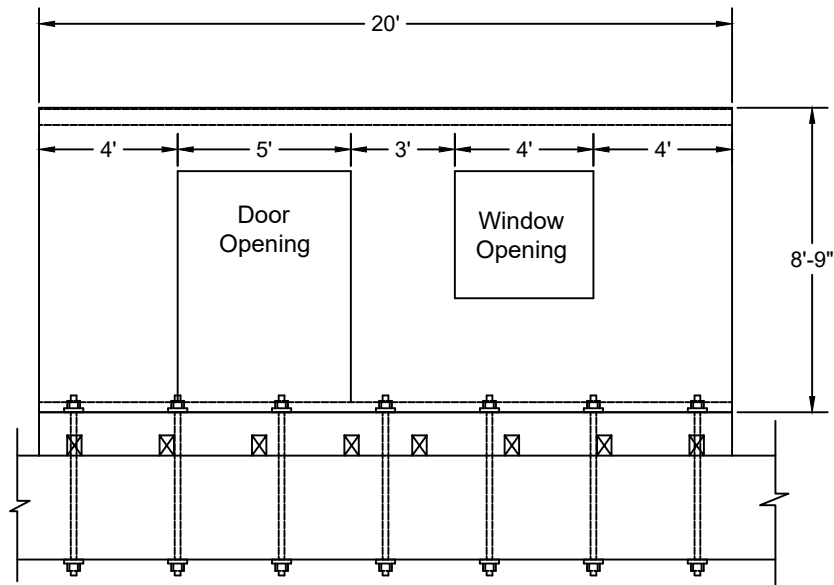
C1-I1	Instrumentation Plan North Wall
C1-I2	Instrumentation Plan South Wall
C1-I3	Instrumentation Plan Roof + Wall
C1-I4	Instrumentation Schedule A
C1-I5	Instrumentation Schedule B
C1-I6	Instrumentation Schedule C
C1-I7	Instrumentation Schedule D

C1-S1

University of California, Berkeley
Large Component Test
Specimen C-1

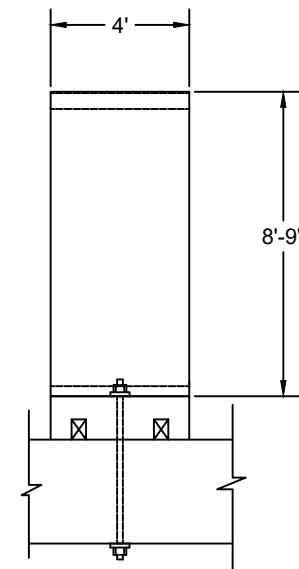
Drawing title: Overall Plan and Elevations
Drawn by: Vahid MahdaviFar
Controlled by: Kelly Cobeen

Revision history:
Rev01.01 11/02/2018

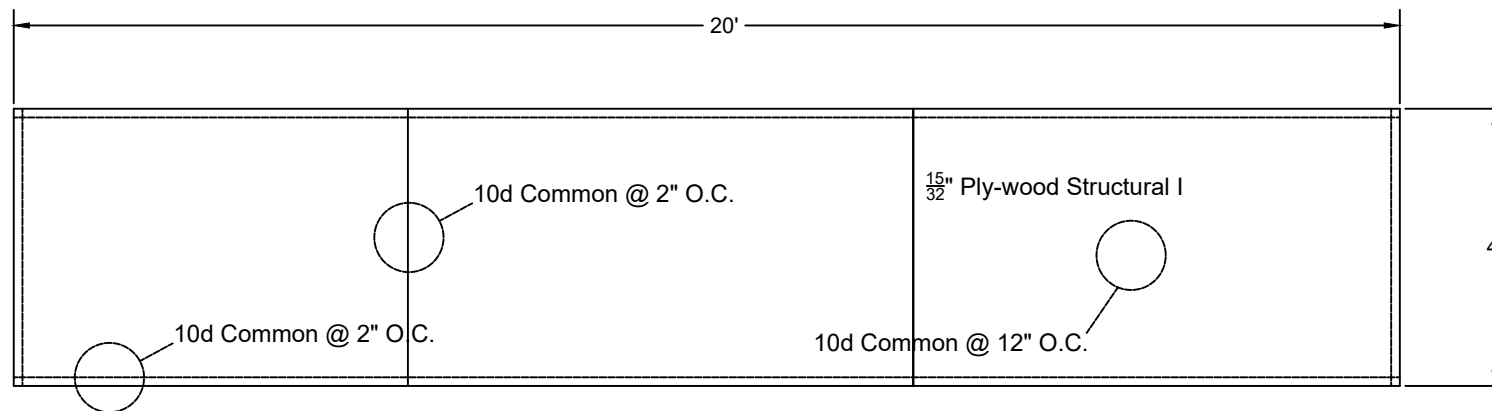


Scale: 1" = 66" on 8.5x11

South Wall Elevation



Scale: 1" = 66" on 8.5x11



Scale: 1" = 33" on 8.5x11

Roof Ply-wood Cut Diagram

Notes:

1 - Use of Box or Common nails are alternatively permitted, unless otherwise is marked.

C1-S2

University of California, Berkeley
Large Component Test
Specimen C-1

Drawing title: Framing Elevations

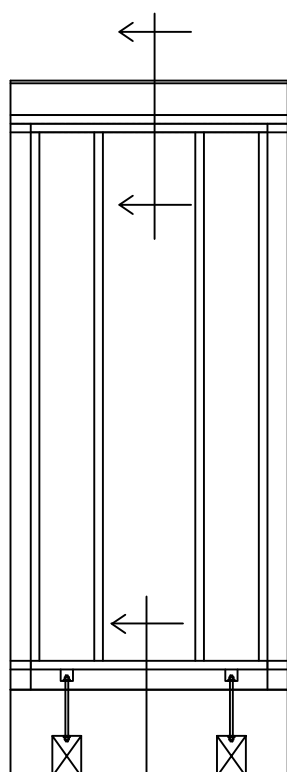
Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.03 12/11/2018

Detail C1-S5-1

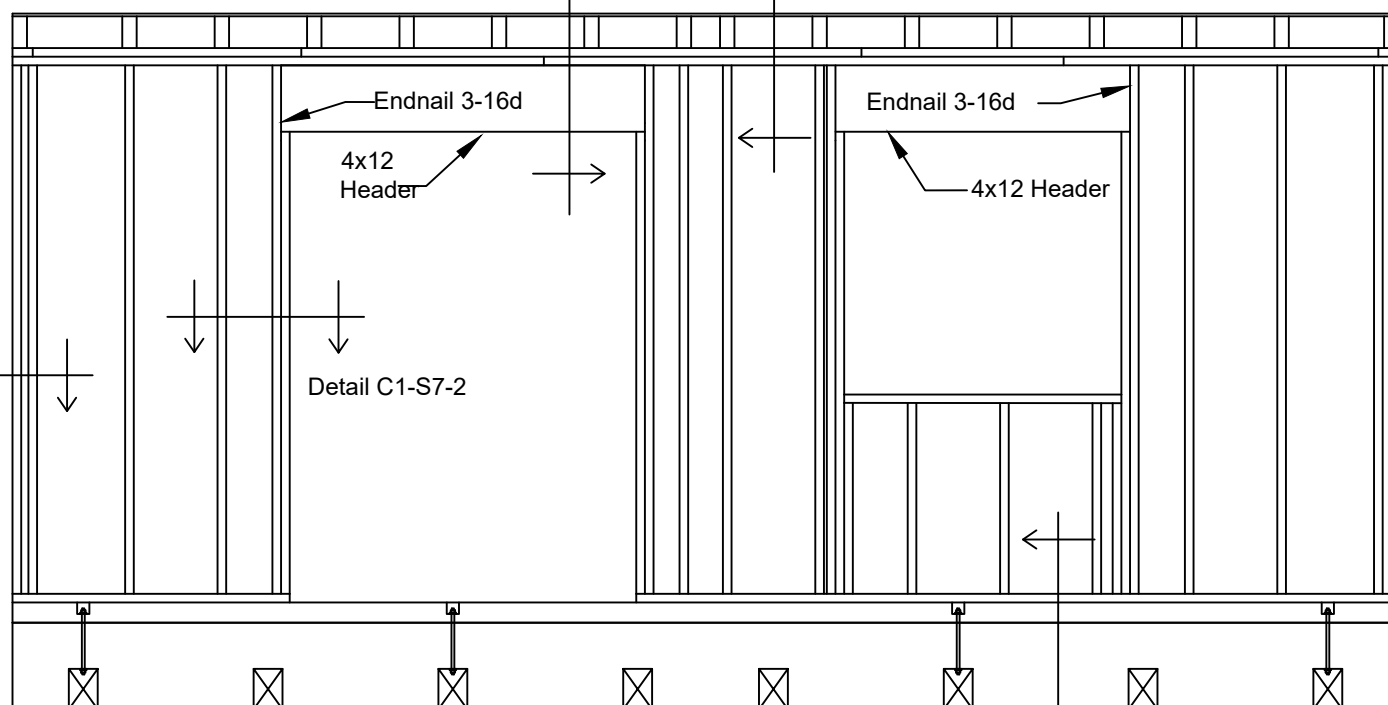


Detail C1-S5-2

Detail C1-S8-1

Detail C1-S7-1

Detail C1-S4-1



Detail C1-S7-2

Endnail 3-16d
4x12 Header

Detail C1-S4-2

Scale: 1" = 33" on 8.5x11

East and West Walls Framing

Scale: 1" = 33" on 8.5x11

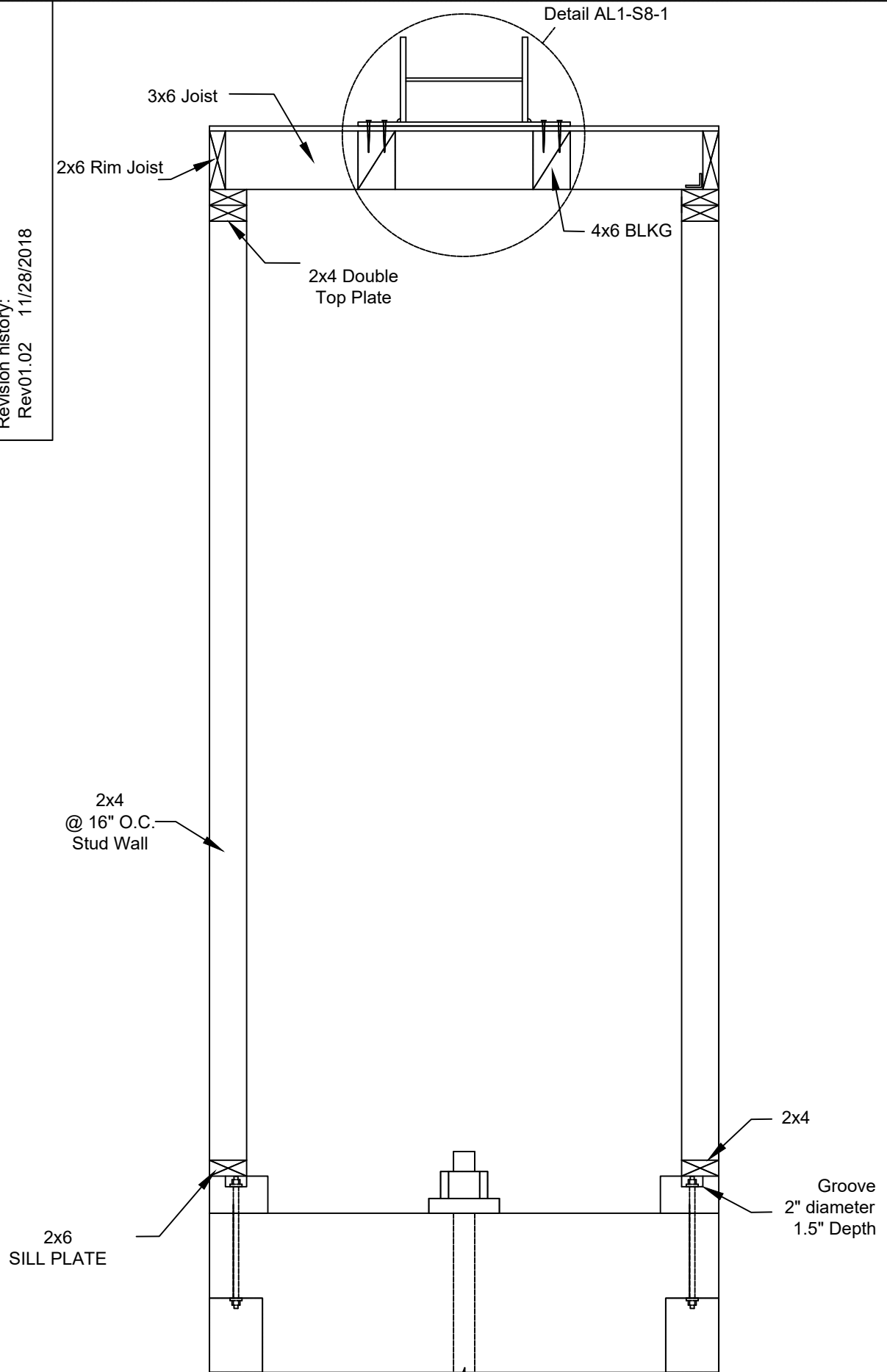
South Wall Framing

C1-S3

University of California, Berkeley
Large Component Test
Specimen C-1

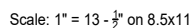
Drawing title: Framing Details A
Drawn by: Vahid Mahdavi
Controlled by: Kelly Cobeen

Revision history:
Rev01.02 11/28/2018



Framing Cross Section

Revision history:
Rev01.04 11/28/2018



2x4
@ 16" O.C.

2 Rows, Staggered
16d Sinker @ 6"
O.C. Each Row

4x6
Supporting Beam

2x4

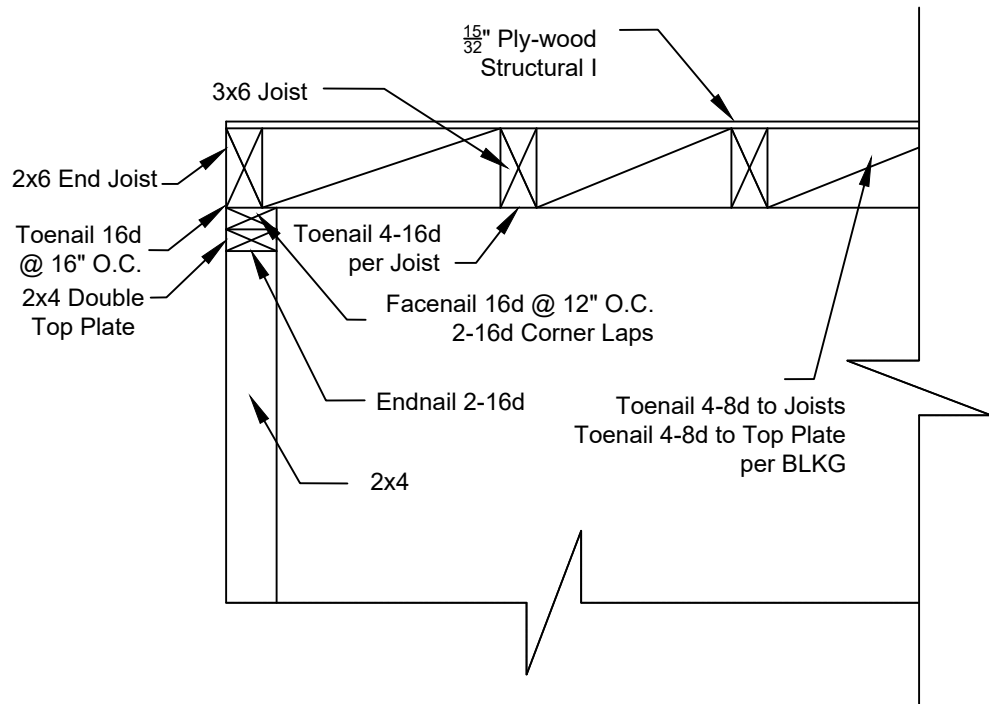
Endnail 2-16d

Scale: 1" = 13 - $\frac{1}{2}$ " on 8.5x11

B-55

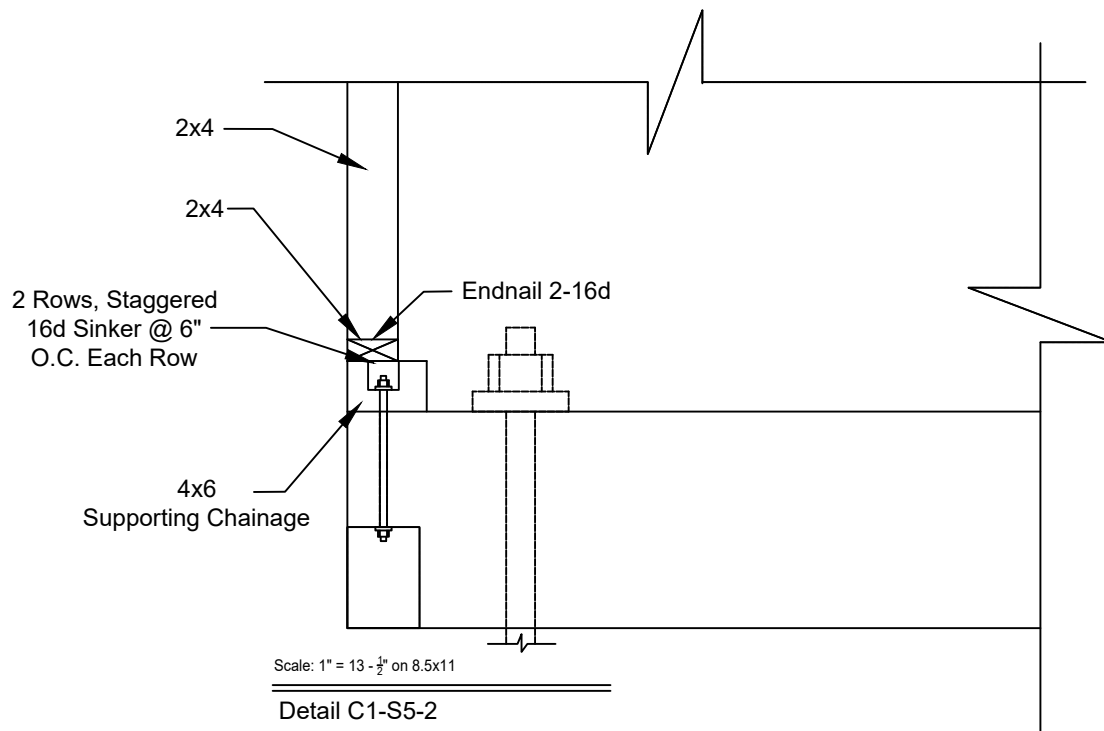
Drawing title: Framing Details C
 Drawn by: Vahid Mahdaviifar
 Controlled by: Kelly Cobeen

Revision history:
 Rev01.02 11/28/2018



Scale: 1" = 13 - ¹/₂" on 8.5x11

Detail C1-S5-1



Scale: 1" = 13 - ¹/₂" on 8.5x11

Detail C1-S5-2

Notes:

1 -

C1-S6

University of California, Berkeley
Large Component Test
Specimen C-1

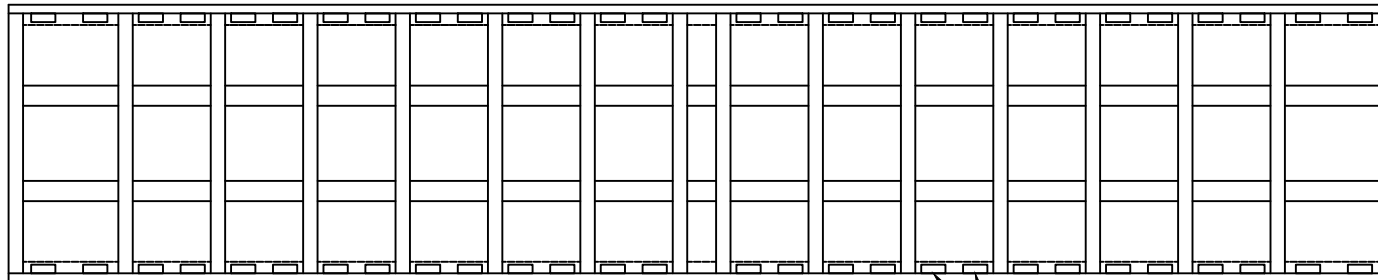
Drawing title: Framing Deatils D

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

Revision history:

Rev01.02 11/28/2018

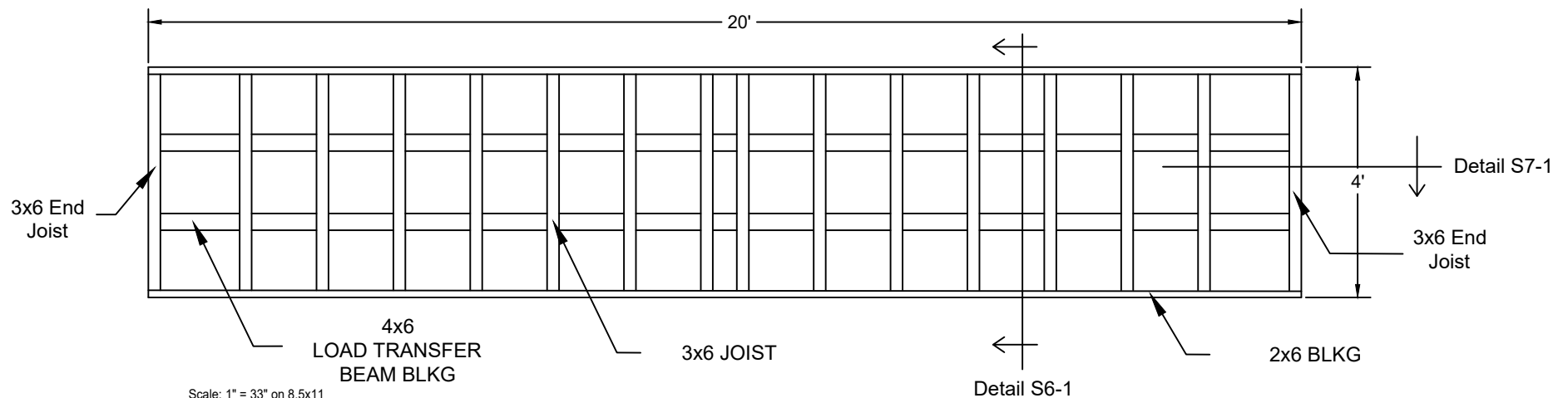


Scale: 1" = 33" on 8.5x11

A35 Retrofit Angles

2 - A35 Brackets

12 8d x 1 1/2" (6 on each side)



Scale: 1" = 33" on 8.5x11

Roof Framing Plan

B-57

Notes:

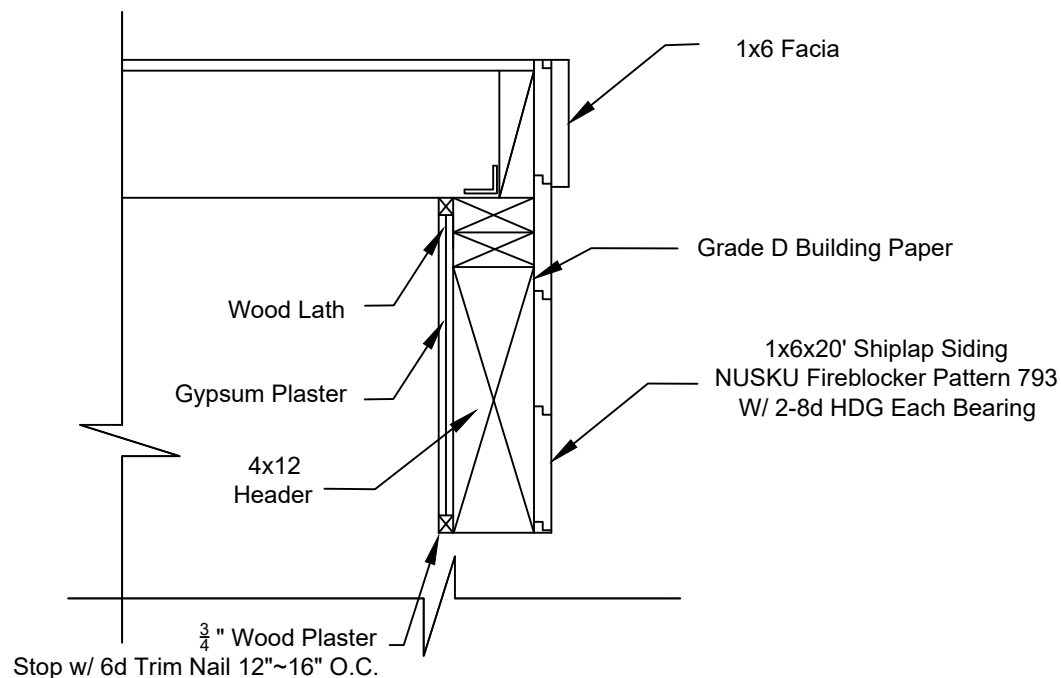
- 1 - To avoid splitting at the end of lath, it is recommended to use predrilled holes at the ends;
- 2- HDZ stands for Hot Deep Galvanized nails, and should be used to connect the shiplaps to the building frame;
- 3- Building paper should be mounted to building frame using stapler and have at least 6" overlap between horizontal layers.

C1-S7

University of California, Berkeley
Large Component Test
Specimen C-1

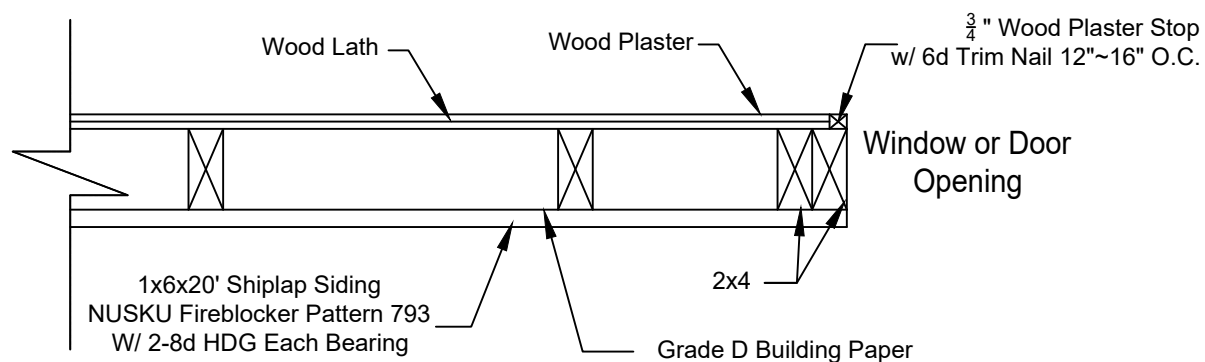
Drawing title: Framing Deatils E
Drawn by: Vahid Mahdavifar
Controlled by: Kelly Cobeen

Revision history:
Rev01.02 12/11/2018



Scale: 1" = 8 - $\frac{1}{4}$ " on 8.5x11

Detail C1-S7-1



Scale: 1" = 8 - $\frac{1}{4}$ " on 8.5x11

Detail C1-S7-2

C1-S8

University of California, Berkeley
Large Component Test
Specimen C-1

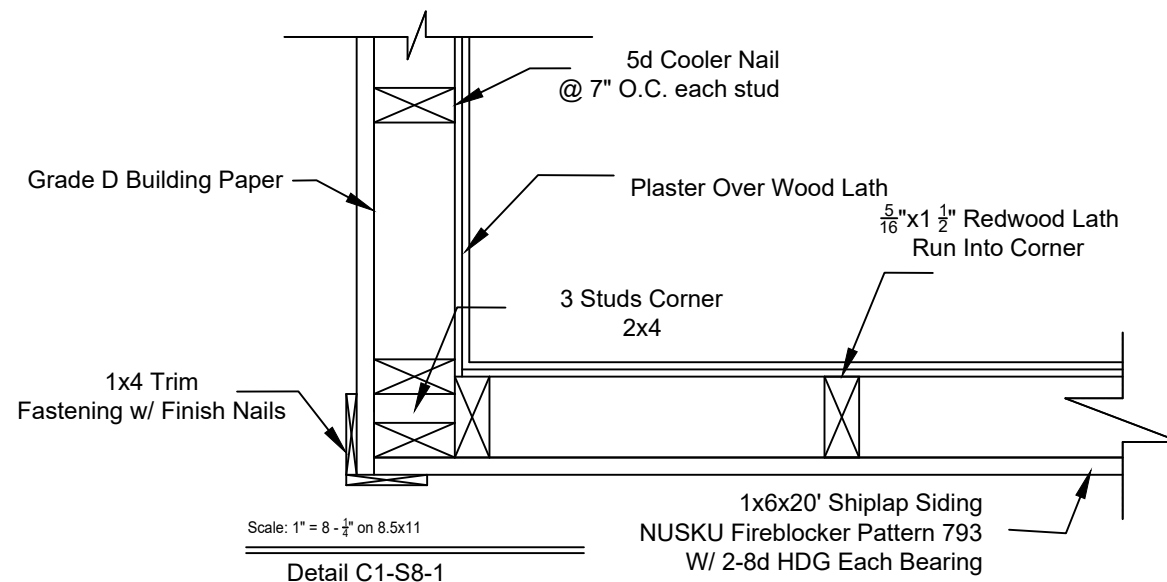
Drawing title: **Framing Details F**

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.03 12/11/2018



C1-I1

University of California, Berkeley
Large Component Test
Specimen C-1

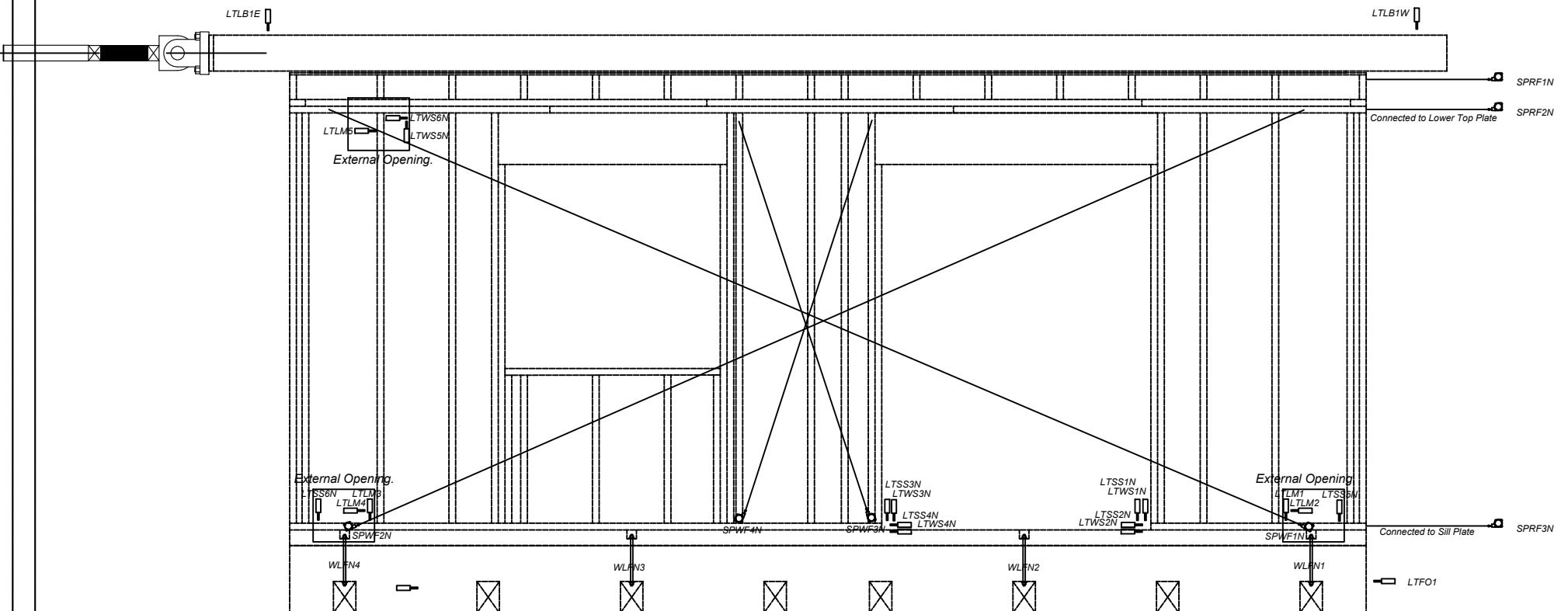
Drawing title: Instrumentation Plan North Wall

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

Revision history:

Rev01.03 01/06/2019



Scale: 1" = 33" on 8.5x11

Instrumentation Plan North Wall

C1-I2

University of California, Berkeley
Large Component Test
Specimen C-1

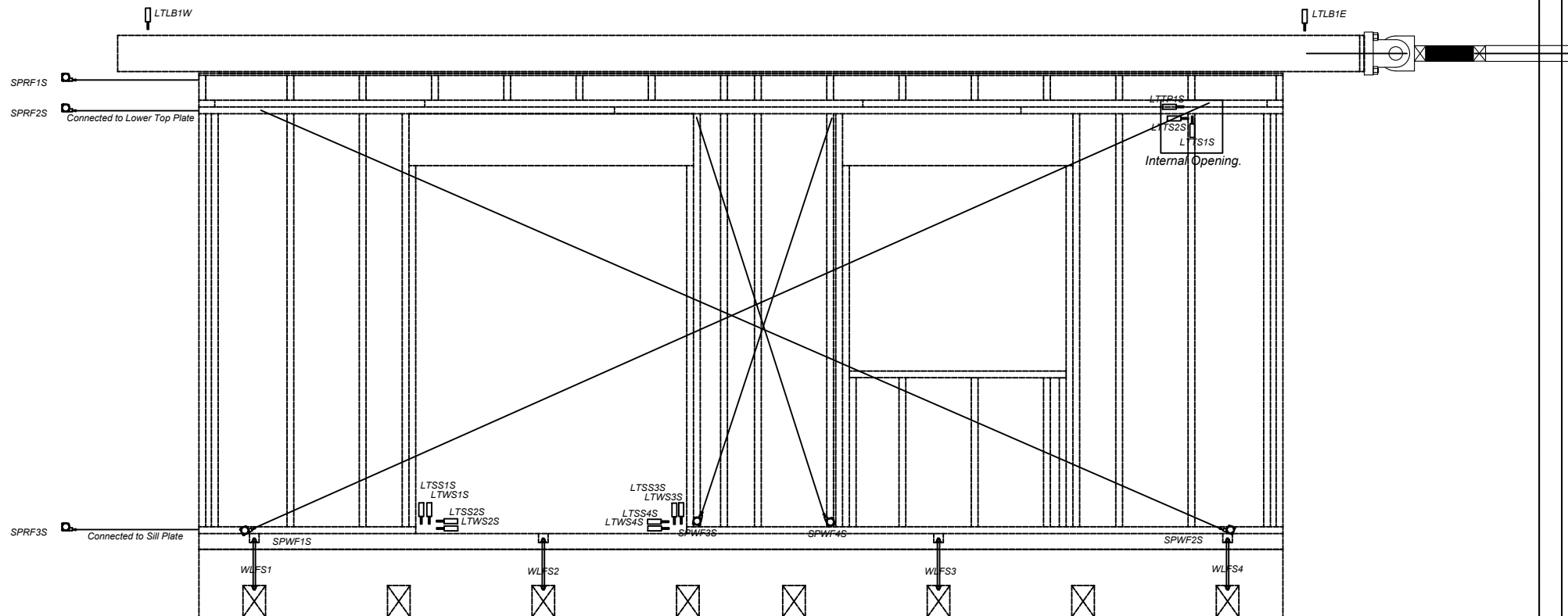
Drawing title: Instrumentation Plan South Wall

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.01 01/07/2019



Scale: 1" = 33" on 8.5x11

Instrumentation Plan South Wall

C1-I3

University of California, Berkeley
Large Component Test
Specimen C-1

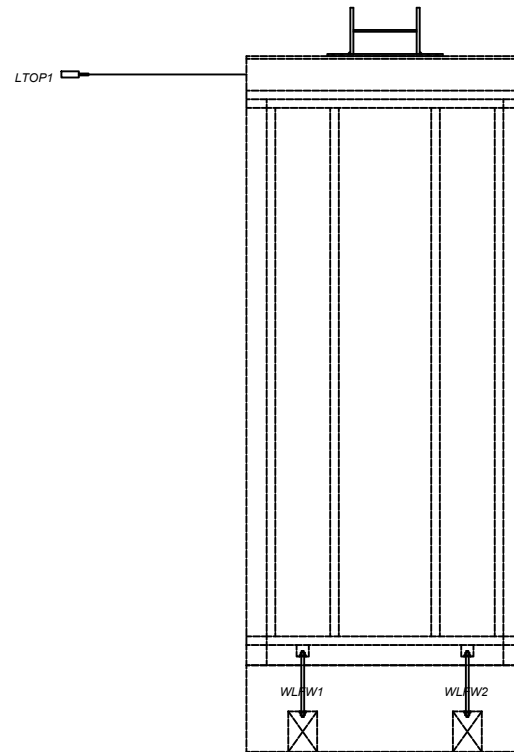
Drawing title: Instrumentation Plan Roof + Wall

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

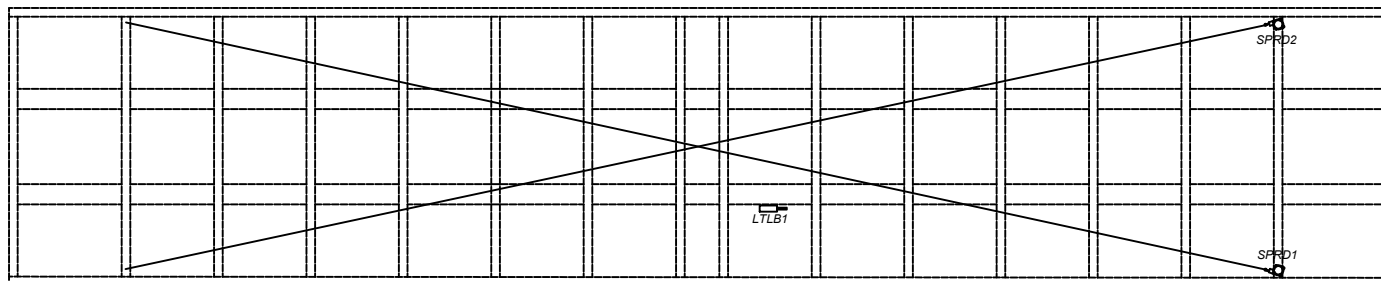
Revision history:

Rev01.02 12/11/2018



Scale: 1" = 33" on 8.5x11

Instrumentation Plan West Wall



Scale: 1" = 33" on 8.5x11

Instrumentation Plan Roof Diaphragm

Instrumentation Plan **						
Index	Tag	Type	Range	Resolution	Comment	Location
1	LTFO1	LVDT *	25mm	0.01" or better	Uplift between foundation and strong floor.	Foundation
2	LTLB1	LVDT	25mm	0.01" or better	Slip between the loading beam and floor diaphragm.	Load Beam.
3	LTLB1E	LVDT	75mm	0.01" or better	Absolute vertical movement of the loading beam.	Load Beam.
4	LTLB1W	LVDT	75mm	0.01" or better	Absolute vertical movement of the loading beam.	Load Beam.
5	LTWS1N	LVDT	100mm	0.01" or better	V. slip between the shiplap and the stud.	North Wall.
6	LTWS2N	LVDT***	100mm	0.01" or better	H. slip between the shiplap and the stud.	North Wall.
7	LTWS3N	LVDT	100mm	0.01" or better	V. slip between the shiplap and the stud.	North Wall.
8	LTWS4N	LVDT***	100mm	0.01" or better	H. slip between the shiplap and the stud.	North Wall.
9	LTWS5N	LVDT	100mm	0.01" or better	V. slip between the shiplap and the stud.	North Wall.
10	LTWS6N	LVDT***	100mm	0.01" or better	H. slip between the shiplap and the stud.	North Wall.
11	LTSS1N	LVDT	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block).	North Wall.
12	LTSS2N	LVDT***	100mm	0.01" or better	H. slip of sill plate from the foundation (4x6 block)..	North Wall.
13	LTSS3N	LVDT	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block)..	North Wall.
14	LTSS4N	LVDT***	100mm	0.01" or better	H. slip of sill plate from the foundation (4x6 block)..	North Wall.
15	LTSS5N	LVDT***	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block)..	North Wall.
16	LTSS6N	LVDT***	100mm	0.01" or better	V. slip of sill plate from the foundation (4x6 block)..	North Wall.
17						
18						
19						
20						

C1-I4

University of California, Berkeley
Large Component Test
Specimen C-1

Drawing title: Instrumentation Schedule A

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.02 01/07/2019

Notes:

1 - All the LVDTs should be installed with stroke bar half way so it can travel in both direction, excluding the LVDTs are marked by *** in the instrumentation tables;

2 - The LVDTs marked by *** in the instrumentation tables should be installed by having the stroke bar positioned at the maximum and travel just on direction.

Instrumentation Plan **						
Index	Tag	Type	Range	Resolution	Comment	Location
1	LTWS1S	LVDT	100mm	0.01" or better	V. slip between the shiplap and the stud.	South Wall.
2	LTWS2S	LVDT***	100mm	0.01" or better	H. slip between the shiplap and the stud.	South Wall.
3	LTWS3S	LVDT	100mm	0.01" or better	V. slip between the shiplap and the stud.	South Wall.
4	LTWS4S	LVDT***	100mm	0.01" or better	H. slip between the shiplap and the stud.	South Wall.
5	LTSS1S	LVDT	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block).	South Wall.
6	LTSS2S	LVDT***	100mm	0.01" or better	H. slip of sill plate from the foundation (4x6 block)..	South Wall.
7	LTSS3S	LVDT	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block)..	South Wall.
8	LTSS4S	LVDT***	100mm	0.01" or better	H. slip of sill plate from the foundation (4x6 block)..	South Wall.
9	LTP1S	LVDT	100mm	0.01" or better	Slip between the upper and lower top plate.	South Wall.
10	LTTS1S	LVDT	100mm	0.01" or better	V. Slip between the lower top plate and stud.	South Wall.
11	LTTS2S	LVDT	100mm	0.01" or better	H. Slip between the lower top plate and stud.	South Wall.
12	LTLM1	LVDT	50mm	0.01" or better	V. Slip between the lath and stud.	North Wall.
13	LTLM2	LVDT	50mm	0.01" or better	H. Slip between the lath and stud.	North Wall.
14	LTLM3	LVDT	50mm	0.01" or better	V. Slip between the lath and stud.	North Wall.
15	LTLM4	LVDT	50mm	0.01" or better	H. Slip between the lath and stud.	North Wall.
16	LTLM5	LVDT	50mm	0.01" or better	H. Slip between the lath and stud.	North Wall.
17						
18						
19						
20						

C1-I5

University of California, Berkeley
Large Component Test
Specimen C-1

Drawing title: Instrumentation Schedule B

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.01 01/07/2019

Notes:

1 - All the LVDTs should be installed with stroke bar half way so it can travel in both direction, excluding the LVDTs are marked by *** in the instrumentation tables;

2 - The LVDTs marked by *** in the instrumentation tables should be installed by having the stroke bar positioned at the maximum and travel just on direction.

Instrumentation Plan						
Index	Tag	Type	Range	Resolution	Comment	Location
1	WLFS1	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16438)	Foundation south side.
2	WLFS2	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16455)	Foundation south side.
3	WLFS3	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16429)	Foundation south side.
4	WLFS4	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16444)	Foundation south side.
5	WLFN1	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16436)	Foundation north side.
6	WLFN2	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16432)	Foundation north side.
7	WLFN3	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16439)	Foundation north side.
8	WLFN4	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16434)	Foundation north side.
9	WLFW1	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16435)	Foundation west side.
10	WLFW2	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16436)	Foundation west side.
11	SPRF1N	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
12	SPRF2N	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
13	SPRF3N	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
14	SPRF1S	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
15	SPRF2S	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
16	SPRF3S	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
17	SPWF1N	String Pot	30"	0.01" or better	Diagonal deformation in the superstructure wall.	North wall.
18	SPWF2N	String Pot	30"	0.01" or better	Diagonal deformation in the superstructure wall.	North wall.
19	SPWF3N	String Pot	10"	0.01" or better	Diagonal deformation in the subsection wall.	North wall.
20	SPWF4N	String Pot	10"	0.01" or better	Diagonal deformation in the subsection wall.	North wall.

C1-I6

University of California, Berkeley
Large Component Test
Specimen C-1

Drawing title: Instrumentation Schedule C

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

Revision history:

Rev01.02 01/07/2019

Instrumentation Plan						
Index	Tag	Type	Range	Resolution	Comment	Location
1	SPWF1S	String Pot	30"	0.01" or better	Diagonal deformation in the superstructure wall.	South wall.
2	SPWF2S	String Pot	30"	0.01" or better	Diagonal deformation in the superstructure wall.	South wall.
3	SPWF3S	String Pot	10"	0.01" or better	Diagonal deformation in the subsection wall.	South wall.
4	SPWF4S	String Pot	10"	0.01" or better	Diagonal deformation in the subsection wall.	South wall.
5	SPRD1	String Pot	10"	0.01" or better	Diagonal deformation in floor diaphragm.	Floor.
6	SPRD2	String Pot	10"	0.01" or better	Diagonal deformation in floor diaphragm.	Floor.
7	LTOP1	String Pot	5"	0.01" or better	Out-of-plane deformation.	West Wall.
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C1-I7

University of California, Berkeley
Large Component Test
Specimen C-1

Drawing title: Instrumentation Schedule D

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.02 01/07/2019

**“Quantifying the Performance of Retrofit of Cripple Walls and Sill Anchorage in
Single Family Wood-frame Buildings”**

Large Component Test - Working Group 4 - Specimen C-2

Updated: February 4, 2019

Construction:

Structural Drawings:

C2-S1	South Wall T1-11 Siding Cut Plan
C2-S2	Framing Details A
C3-S3	Framing Details B

Instrumentation Plan:

C2-I1	Instrumentation Plan North Wall
C2-I2	Instrumentation Plan South Wall
C2-I3	Instrumentation Plan Roof + Wall
C2-I4	Instrumentation Schedule A
C2-I5	Instrumentation Schedule B
C2-I6	Instrumentation Schedule C
C2-I7	Instrumentation Schedule D

Notes:

1 - Plywood siding panel T1-11 used (Common: 19/32 in. x 4 ft. x 9 ft.; Actual: 0.578 in. x 48 in. x 108 in.);

2- $\frac{1}{8}$ " Gap to be considered between the plywood siding panel T1-11 joints as well as at the top beneath the fascia;

C2-S1

University of California, Berkeley
Large Component Test
Specimen C-2

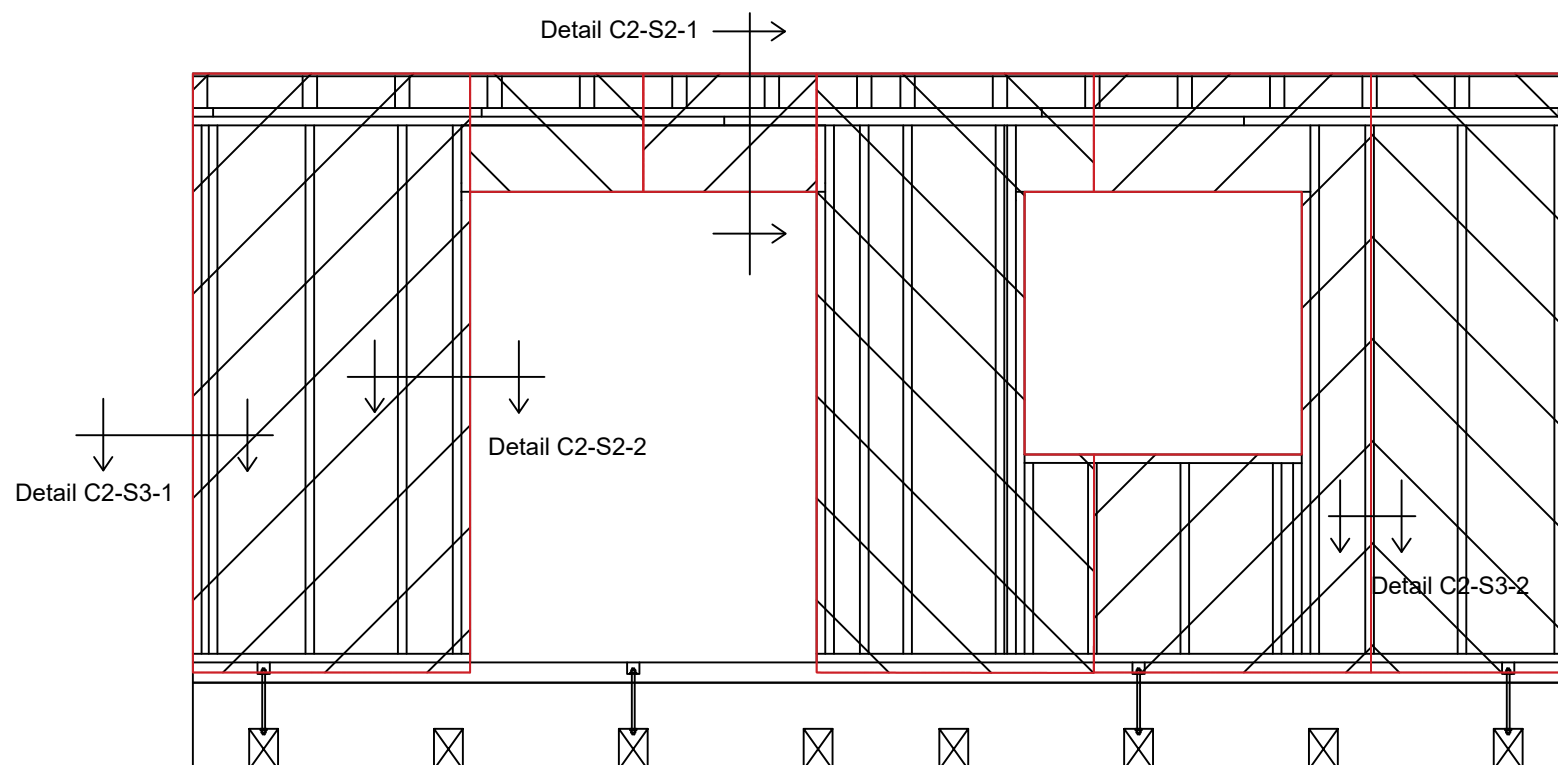
Drawing title: South Wall T1-11 Siding Cut Plan

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.02 02/04/2019



Scale: 1" = 33" on 8.5x11

South Wall T1-11 Sheathing Cut

Notes:

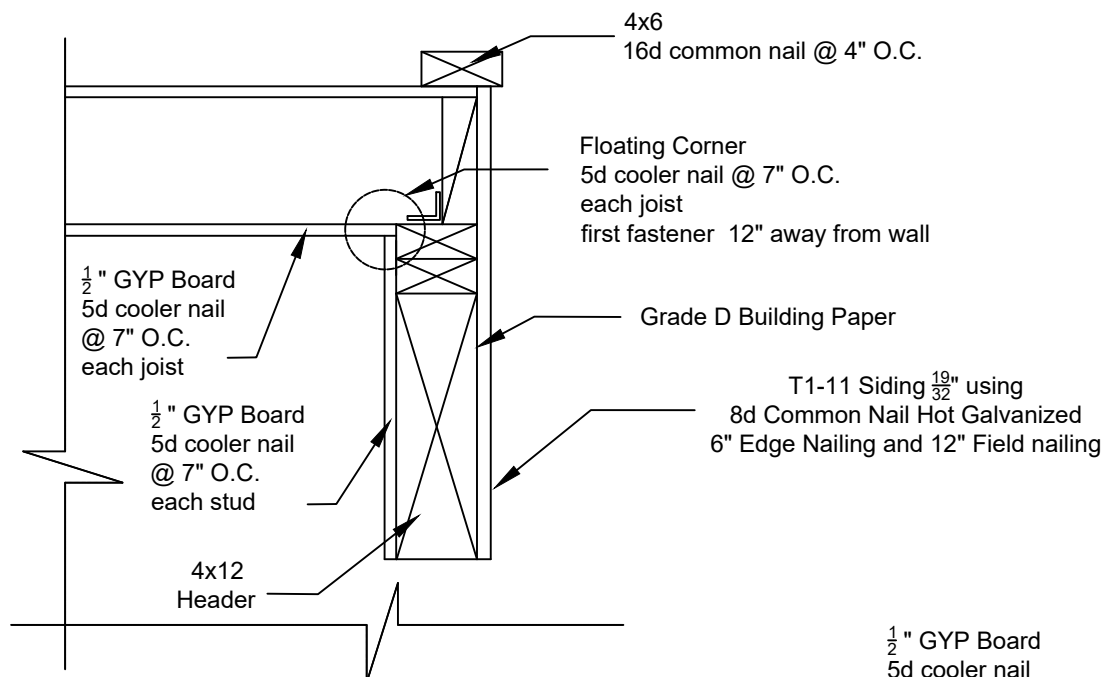
- 1 - To avoid splitting at the end of lath, it is recommended to use predrilled holes at the ends;
- 2- HDG (Hot Deep Galvanized) nails should be used to connect the shiplaps to the building frame;
- 3- Building paper should be mounted to building frame using stapler and have at least 6" overlap between horizontal layers;
- 4- Floating corners should be performed at the intersection of the ceiling and wall gypsum boards. First install the ceiling gypsum board, but not nailing the edge adjacent to the wall;
- 5- The first fastener in ceiling gypsum board would be installed 12" away from the wall.

C2-S2

University of California, Berkeley
Large Component Test
Specimen C-2

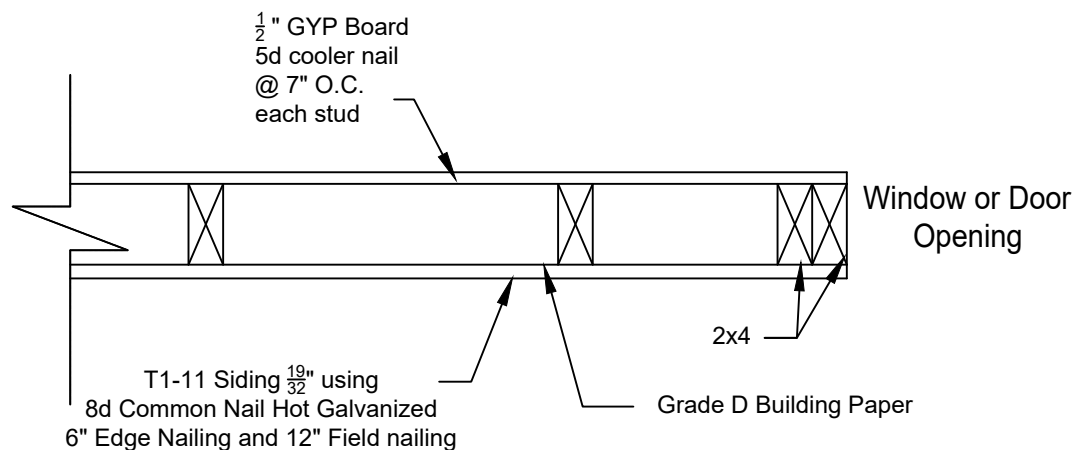
Drawing title: Framing Deatils A
Drawn by: Vahid Mahdavifar
Controlled by: Kelly Cobeen

Revision history:
Rev01.02 12/11/2018



Scale: 1" = 8' - 0" on 8.5x11

Detail C2-S2-1



Scale: 1" = 8' - 0" on 8.5x11

Detail C1-S2-2

C2-S3

University of California, Berkeley
Large Component Test
Specimen C-2

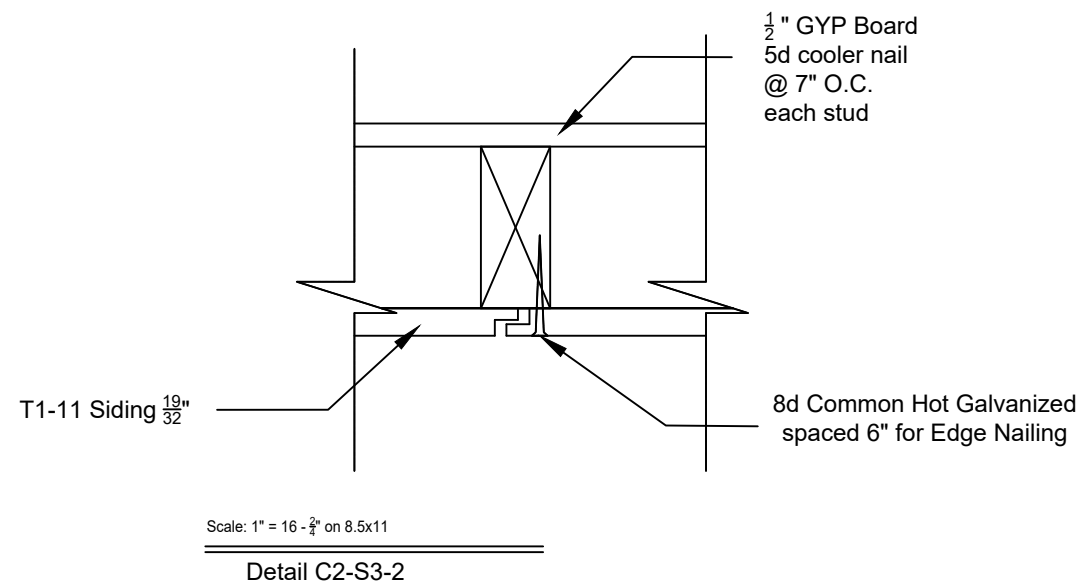
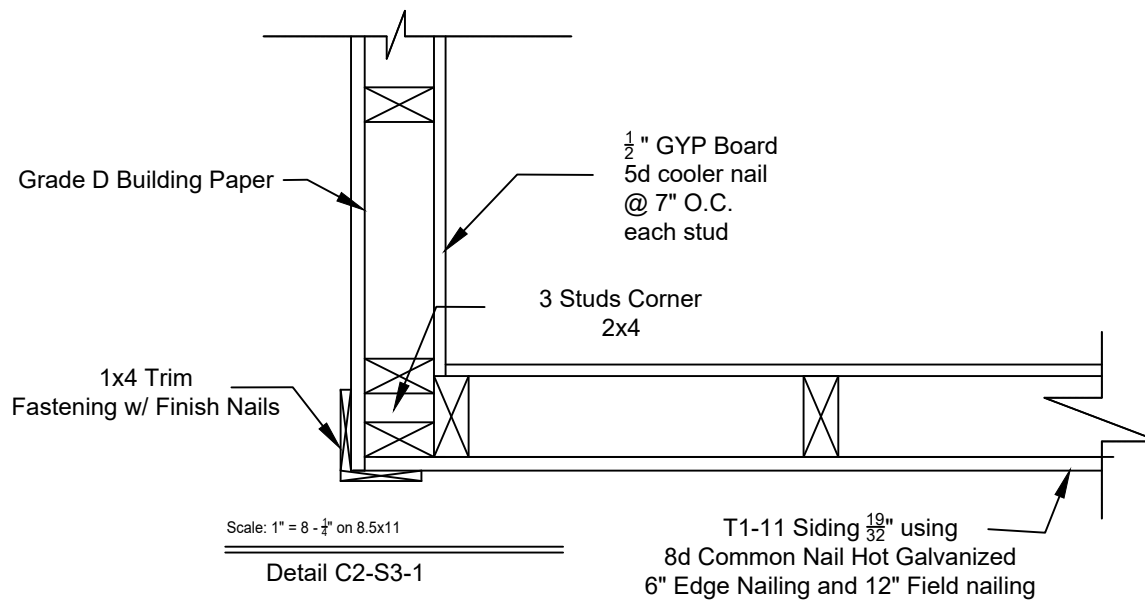
Drawing title: **Framing Details B**

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobein

Revision history:

Rev01.03 12/11/2018



C2-I1

University of California, Berkeley
Large Component Test
Specimen C-2

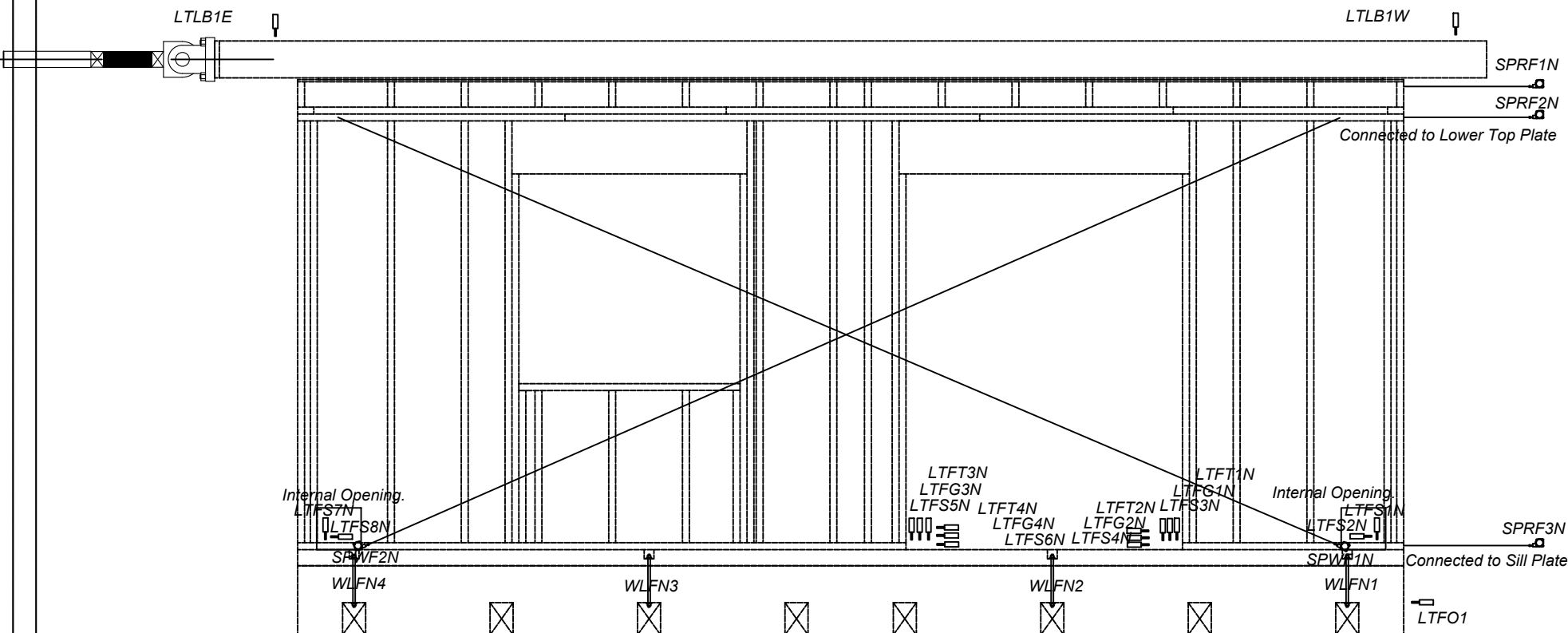
Drawing title: Instrumentation Plan North Wall

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

Revision history:

Rev01.01 02/04/2019



Scale: 1" = 33" on 8.5x11

Instrumentation Plan North Wall

C2-I2

University of California, Berkeley
Large Component Test
Specimen C-2

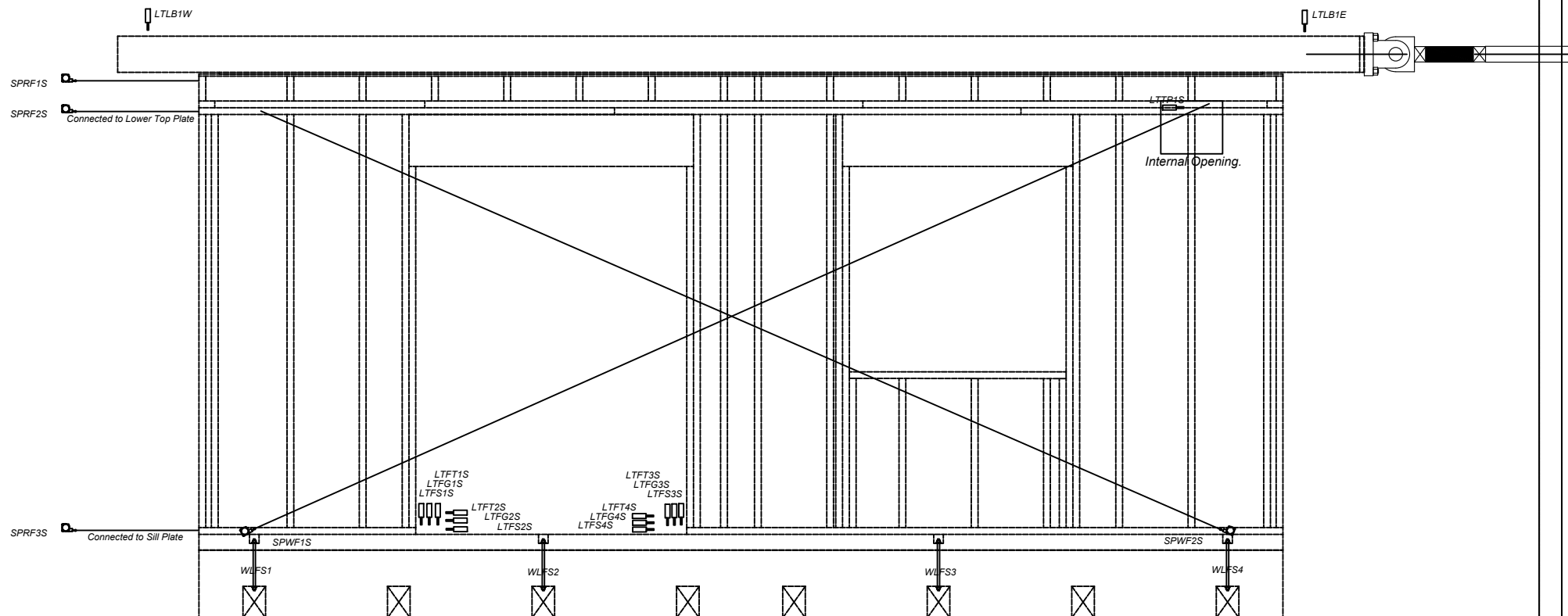
Drawing title: Instrumentation Plan South Wall

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.01 02/04/2019



Scale: 1" = 33" on 8.5x11

Instrumentation Plan South Wall

C2-I3

University of California, Berkeley
Large Component Test
Specimen C-2

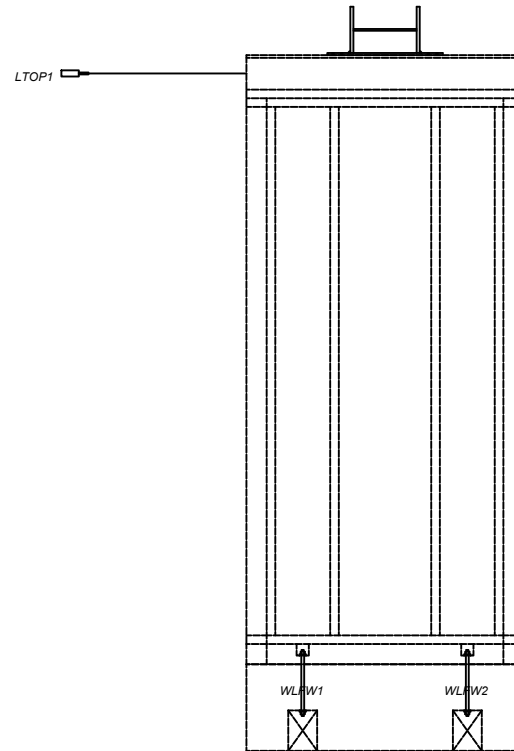
Drawing title: Instrumentation Plan Roof + Wall

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

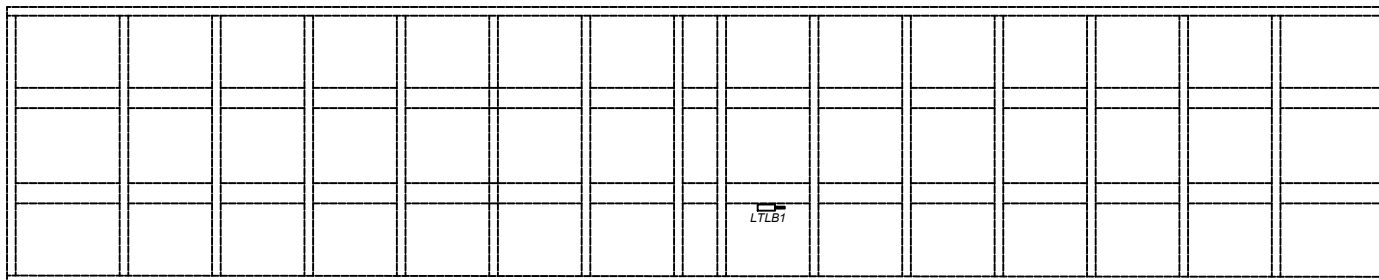
Revision history:

Rev01.01 02/04/2019



Scale: 1" = 33" on 8.5x11

Instrumentation Plan West Wall



Scale: 1" = 33" on 8.5x11

Instrumentation Plan Roof Diaphragm

Instrumentation Plan **						
Index	Tag	Type	Range	Resolution	Comment	Location
1	LTFO1	LVDT *	25mm	0.01" or better	Uplift between foundation and strong floor.	Foundation
2	LTLB1	LVDT	25mm	0.01" or better	Slip between the loading beam and floor diaphragm.	Load Beam.
3	LTLB1E	LVDT	75mm	0.01" or better	Absolute vertical movement of the loading beam.	Load Beam.
4	LTLB1W	LVDT	75mm	0.01" or better	Absolute vertical movement of the loading beam.	Load Beam.
5	LTFT1N	LVDT	100mm	0.01" or better	V. slip between the T1-11 and the stud.	North Wall.
6	LTFT2N	LVDT***	100mm	0.01" or better	H. slip between the T1-11 and the stud.	North Wall.
7	LTFT3N	LVDT	100mm	0.01" or better	V. slip between the T1-11 and the stud.	North Wall.
8	LTFT4N	LVDT***	100mm	0.01" or better	H. slip between the T1-11 and the stud.	North Wall.
9	LTFT1S	LVDT	100mm	0.01" or better	V. slip between the T1-11 and the stud.	South Wall.
10	LTFT2S	LVDT***	100mm	0.01" or better	H. slip between the T1-11 and the stud.	South Wall.
11	LTFT3S	LVDT	100mm	0.01" or better	V. slip between the T1-11 and the stud.	South Wall.
12	LTFT4S	LVDT***	100mm	0.01" or better	H. slip between the T1-11 and the stud.	South Wall.
13	LTFS1N	LVDT	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block).	North Wall.
14	LTFS2N	LVDT***	100mm	0.01" or better	H. slip of stud and sill plate.	North Wall.
15	LTSS3N	LVDT	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block)..	North Wall.
16	LTSS4N	LVDT***	100mm	0.01" or better	H. slip of stud from the foundation (4x6 block)..	North Wall.
17	LTSS5N	LVDT***	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block)..	North Wall.
18	LTSS6N	LVDT***	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block)..	North Wall.
19	LTFS1S	LVDT	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block).	South Wall.
20	LTFS2S	LVDT***	100mm	0.01" or better	H. slip of stud and sill plate.	South Wall.

C2-I4

University of California, Berkeley
Large Component Test
Specimen C-2

Drawing title: Instrumentation Schedule A

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

Revision history:

Rev01.01 02/04/2019

Notes:

1 - All the LVDTs should be installed with stroke bar half way so it can travel in both direction, excluding the LVDTs are marked by *** in the instrumentation tables;

2 - The LVDTs marked by *** in the instrumentation tables should be installed by having the stroke bar positioned at the maximum and travel just on direction.

Instrumentation Plan **						
Index	Tag	Type	Range	Resolution	Comment	Location
1	LTSS3N	LVDT	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block)..	North Wall.
2	LTSS4N	LVDT***	100mm	0.01" or better	H. slip of stud from the foundation (4x6 block)..	North Wall.
3	LTSS5N	LVDT***	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block)..	North Wall.
4	LTSS6N	LVDT***	100mm	0.01" or better	V. slip of stud from the foundation (4x6 block)..	North Wall.
5	LTFG1N	LVDT	100mm	0.01" or better	V. slip between the Gyp board and the stud.	North Wall.
6	LTFG2N	LVDT***	100mm	0.01" or better	H. slip between the Gyp board and the stud.	North Wall.
7	LTFG3N	LVDT	100mm	0.01" or better	V. slip between the Gyp board and the stud.	North Wall.
8	LTFG4N	LVDT***	100mm	0.01" or better	H. slip between the Gyp board and the stud.	North Wall.
9	LTFG1S	LVDT	100mm	0.01" or better	V. slip between the Gyp board and the stud.	South Wall.
10	LTFG2S	LVDT***	100mm	0.01" or better	H. slip between the Gyp board and the stud.	South Wall.
11	LTFG3S	LVDT	100mm	0.01" or better	V. slip between the Gyp board and the stud.	South Wall.
12	LTFG4S	LVDT***	100mm	0.01" or better	H. slip between the Gyp board and the stud.	South Wall.
13	LTPP1S	LVDT	100mm	0.01" or better	Slip between the upper and lower top plate.	South Wall.
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C2-I5

University of California, Berkeley
Large Component Test
Specimen C-2

Drawing title: Instrumentation Schedule B

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

Revision history:

Rev01.01 02/04/2019

Notes:

1 - All the LVDTs should be installed with stoke bar half way so it can travel in both direction, excluding the LVDTs are marked by *** in the instrumentation tables;

2 - The LVDTs marked by *** in the instrumentation tables should be installed by having the stroke bar positioned at the maximum and travel just on direction.

Instrumentation Plan						
Index	Tag	Type	Range	Resolution	Comment	Location
1	WLFS1	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16438)	Foundation south side.
2	WLFS2	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16455)	Foundation south side.
3	WLFS3	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16429)	Foundation south side.
4	WLFS4	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16444)	Foundation south side.
5	WLFN1	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16436)	Foundation north side.
6	WLFN2	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16432)	Foundation north side.
7	WLFN3	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16439)	Foundation north side.
8	WLFN4	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16434)	Foundation north side.
9	WLFW1	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16435)	Foundation west side.
10	WLFW2	Load Washer	20 kips	100 lbf or less	Developed load in found. to structure bolt. (Raw Data Tag 16436)	Foundation west side.
11	SPRF1N	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
12	SPRF2N	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
13	SPRF3N	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
14	SPRF1S	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
15	SPRF2S	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
16	SPRF3S	String Pot	30"	0.01" or better	Vertical building deformation profile.	Reference Column
17						
18						
19						
20						

C2-I6

University of California, Berkeley
Large Component Test
Specimen C-2

Drawing title: Instrumentation Schedule C

Drawn by: Vahid Mahdavifar

Controlled by: Kelly Cobeen

Revision history:

Rev01.01 02/04/2019

C2-I7

University of California, Berkeley
Large Component Test
Specimen C-2

Drawing title: Instrumentation Schedule D

Drawn by: Vahid MahdaviFar

Controlled by: Kelly Cobeen

Revision history:

Rev01.01 02/04/2019

Instrumentation Plan						
Index	Tag	Type	Range	Resolution	Comment	Location
1	SPWF1N	String Pot	30"	0.01" or better	Diagonal deformation in the superstructure wall.	North wall.
2	SPWF2N	String Pot	30"	0.01" or better	Diagonal deformation in the superstructure wall.	North wall.
3	SPWF1S	String Pot	30"	0.01" or better	Diagonal deformation in the superstructure wall.	South wall.
4	SPWF2S	String Pot	30"	0.01" or better	Diagonal deformation in the superstructure wall.	South wall.
5	LTOP1	String Pot	5"	0.01" or better	Out-of-plane deformation.	West Wall.
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APPENDIX C Working Group 4: Damage Observations for All Specimens

Table C-1 Damage Observations for Specimen AL-1 - Cripple Wall Without Retrofit

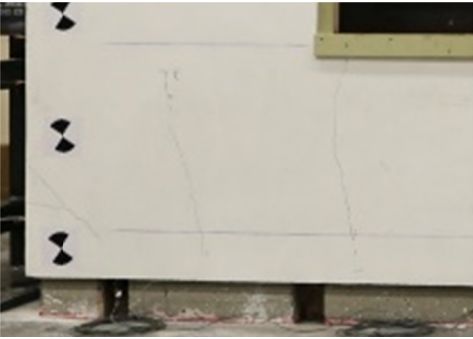

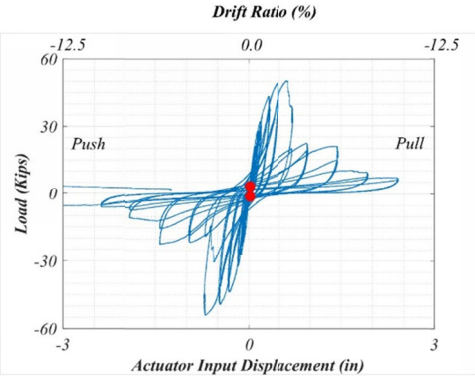

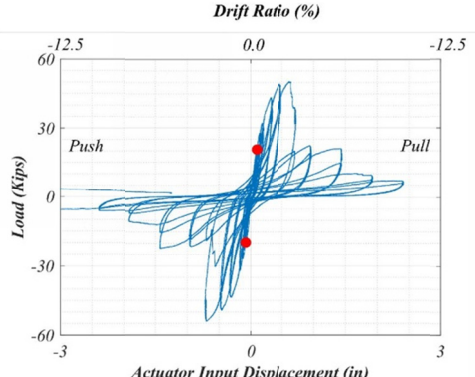
		Damage Appearance		Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
Exterior stucco over horizontal lumber sheathing	Stucco wall finish cracking occurred after stucco installation due to shrinkage and to settling of the building following application of the lead weights used for supplemental gravity load. These cracks were hairline, tended to follow a vertical direction, and were generally uniformly distributed along the specimen length.			0%	
No perceptible progression of cracking was observed.				0.2%	
End Walls: Stucco cracking initiated in the east and west end walls at the floor level. North and South Walls: Limited spreading and additional hairline cracking was observed.				0.4%	
			East end wall start of stucco cracking at floor level		

Table C-1 Damage Observations for Specimen AL-1 - Cripple Wall Without Retrofit

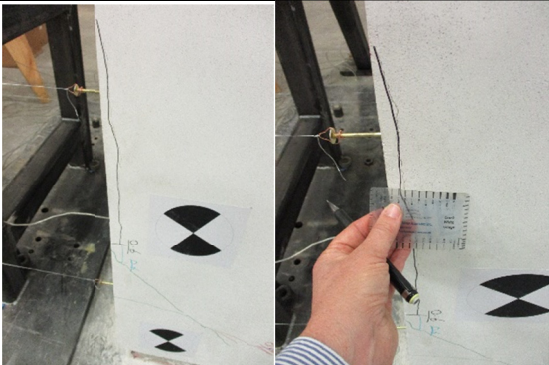
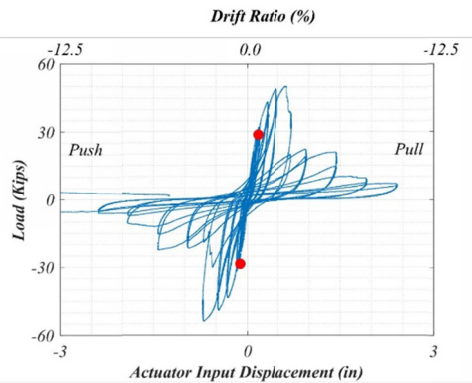

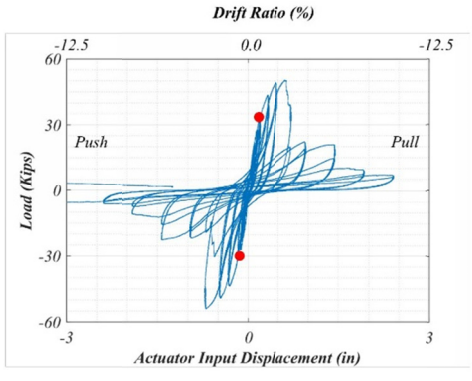
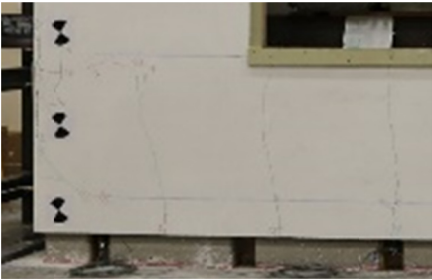

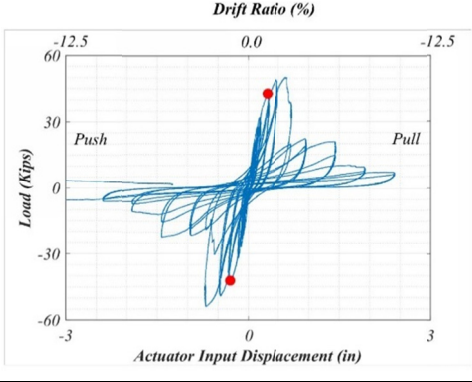
		Damage Appearance		Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
	<p>End Walls: Stucco cracking at the end walls at floor level started to spread vertically. Maximum crack width measured at 0.050 inches.</p> <p>North and South Walls: Limited spreading and additional hairline cracking was observed. Some horizontal cracking near floor line.</p>			0.6%	
	<p>End Walls: Stucco cracking at the end walls at floor level continued to spread vertically. Maximum crack width was still measured at 0.050 inches.</p>			0.8%	
	<p>End Walls: Stucco cracking at end walls continued to spread and started to open up. Maximum crack widths ranged from 0.075 to 0.125 inches.</p> <p>North and South Walls: Spreading of existing cracks and distributed additional hairline cracking was observed.</p> <p>Interior: Slight offsets in gypsum wallboard panel edges were noted on interior</p>			1.4%	

Table C-1 Damage Observations for Specimen AL-1 - Cripple Wall Without Retrofit

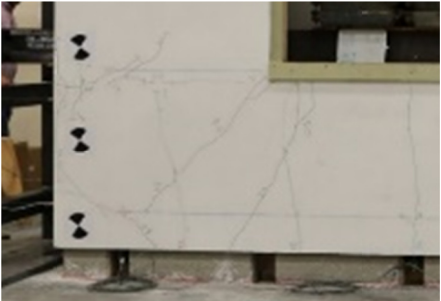

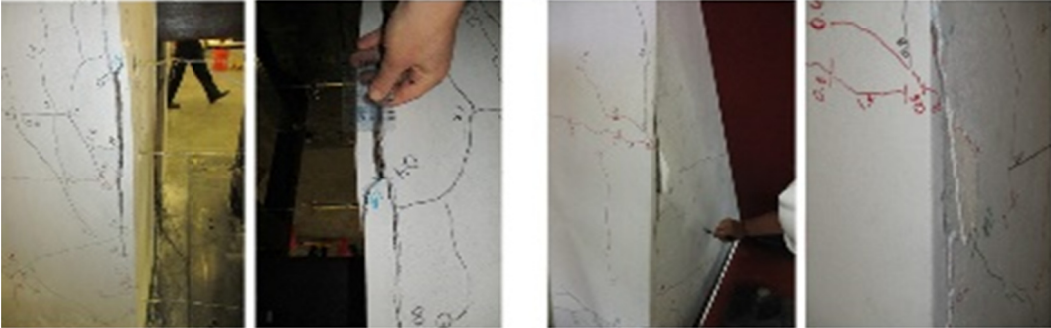
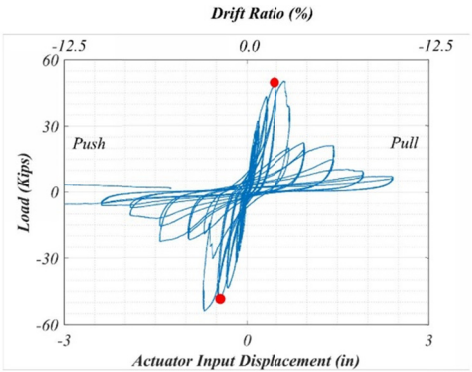



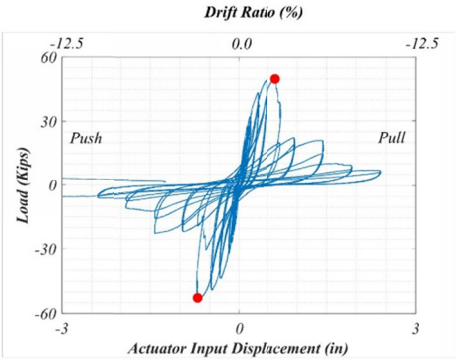
		Damage Appearance		Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
	<p>End Walls: Stucco continued to deteriorate with the stucco visibly being pushed off the east and west framing, small chunks of stucco starting to work loose, and cracks up to maximum 3/16-inch wide were measured</p> <p>North and South Walls: 1/4-inch slip occurred between stucco and lumber sheathing at floor line while stucco cracking on north and south faces remained near hairline. Cracking remains near hairline but extends over the full height of the cripple wall and is fairly distributed.</p>		 	2.0%	
	<p>End Walls: stucco continues to deteriorate and be pushed off of the framing</p> <p>North and South Walls: Stucco had extensive networks of cracks but they remain near hairline. A 1/8-inch out-of-plane gap opened between the stucco and sheathing at the floor line. Following popping noises, visible out-of-plane gaps opened up between the stucco and the concrete foundation. This is understood to be the stucco debonding from the foundation. The gaps were large enough to slide a crack card into and are estimated at 1/16-inch.</p>		 	3.0%	
		Gap of approximately 1/16-inch between foundation and stucco following loss of bond (above, red arrow), gap between stucco and lumber sheathing at floor level (left) progressing damage to end wall stucco (middle and right)			

Table C-1 Damage Observations for Specimen AL-1 - Cripple Wall Without Retrofit

		Damage Appearance				Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance				
	<p>End Walls: Stucco at end wall corners continues to deteriorate and be pushed off of end wall sheathing and framing. Gaps of up to approximately 1/2-inch observed between stucco and sheathing at end walls.</p> <p>North and South Walls: For 4% drift and above, only very limited spreading or additional cracks in the north and south walls were observed.</p>					4.0%	
	<p>End Walls: Stucco cracking at corners opened up enough that wood sheathing below could be clearly observed.</p>					6.0%	
	<p>End Walls; Chunks of stucco started falling off at corners.</p> <p>North and South Walls: Permanent flaring of the bottom of the stucco away from the underlying sheathing and framing was clearly visible.</p>					8.0%	

Table C-1 Damage Observations for Specimen AL-1 - Cripple Wall Without Retrofit

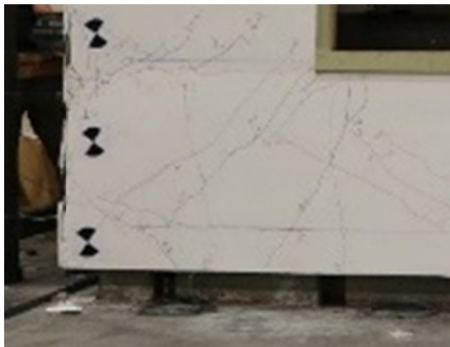

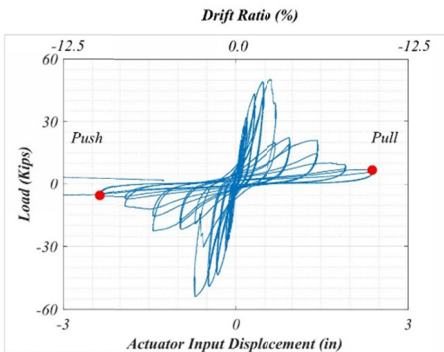
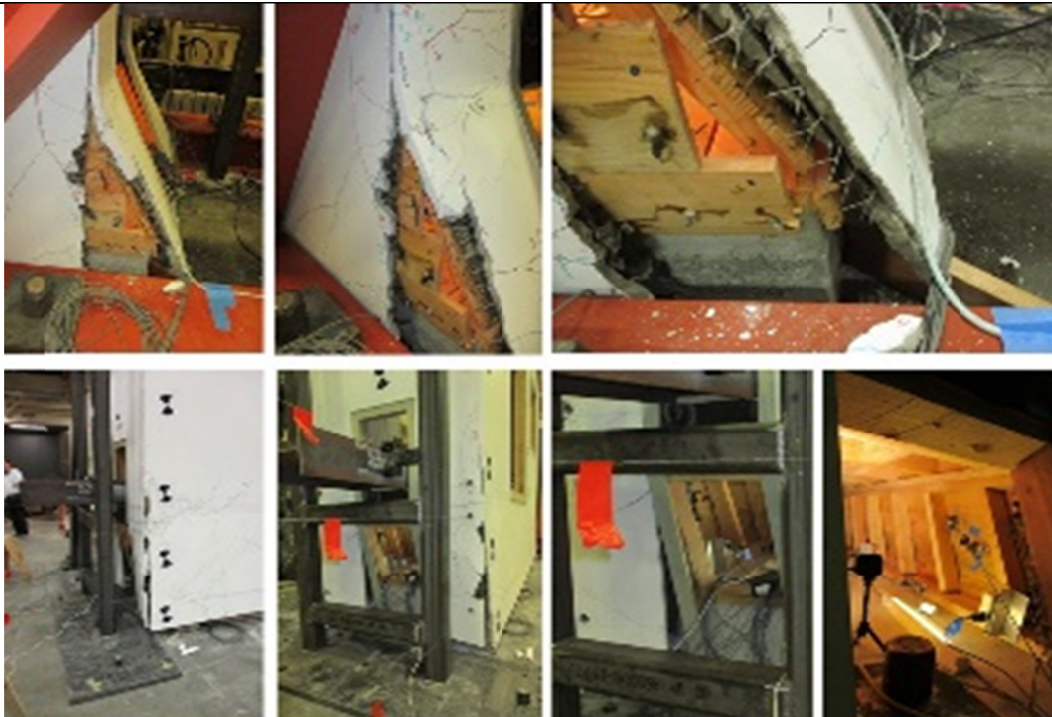
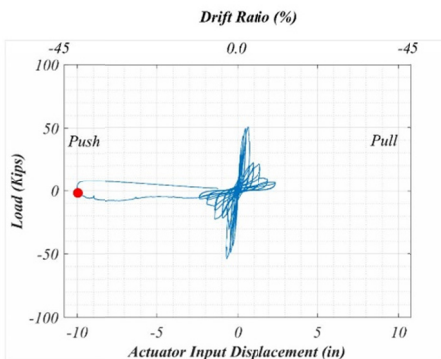
		Damage Appearance				Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance				
	End, north and South Walls: The stucco was seen to be clearly detached from the underlying sheathing and framing over the full height of the cripple wall. The racking of the lumber sheathing below could be observed.					10%	
	The final monotonic push took the 24 inch tall cripple wall to a ten inch (40%) drift. The already separated stucco was pushed away at the east end and sucked under the cripple wall at the west end. The horizontal sliding of the lumber sheathing was clearly visible, with the sheathing nails being fully withdrawn from lower sheathing boards towards the end of the monotonic push. Even with the sheathing board nails being withdrawn, the overlying stucco tended to hold the lumber sheathing boards in place.					40% Monotonic	
		Wall 2 stucco cracking at failure (no crack widths provided)					

Table C-2 Damage Observations for Specimen AL-2 - Cripple Wall With Retrofit




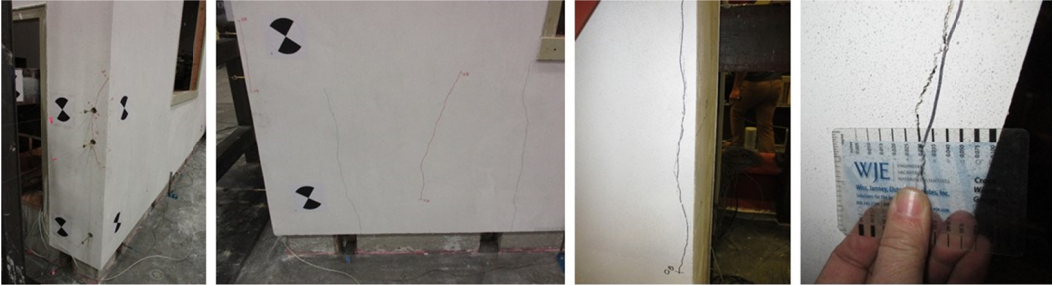
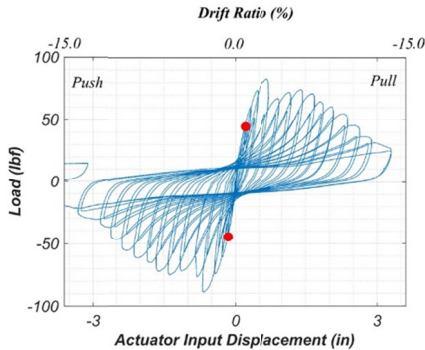

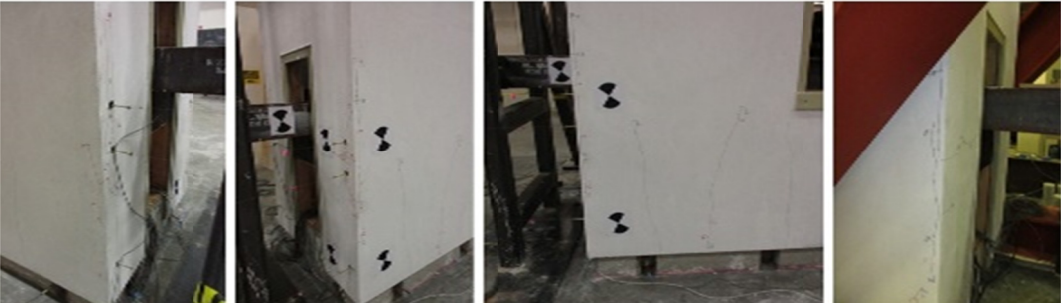
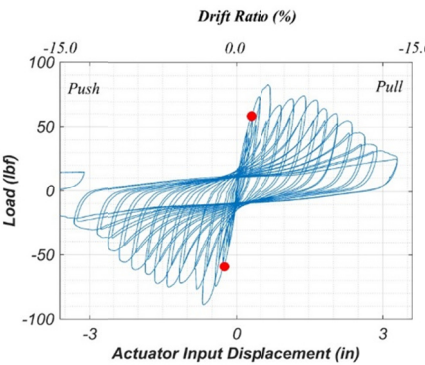
		Damage Appearance		Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
Exterior stucco over horizontal lumber sheathing	Stucco wall finish cracking occurred after stucco installation due to shrinkage and to settling of the building following application of the lead weights used for supplemental gravity loading. These cracks were hairline, tended to follow a vertical direction, and were generally uniformly distributed along the specimen length.			0%	
	End Walls: Cracking was first observed at the west and east end walls near the floor line. Crack widths of up to 0.030 inch were measured. North and South Walls: Limited spread of and new cracking was observed.			0.8%	
	End Walls: Cracking was observed to spread up and down from the floor level. North and South Walls: Modest spreading and new hairline cracks were observed.			1.4%	

Table C-2 Damage Observations for Specimen AL-2 - Cripple Wall With Retrofit

		Damage Appearance				Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve	
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance					
	<p>End Walls: Limited spread of stucco cracking was observed on end walls. Cracks opened to a maximum measured crack width of 0.050 inches.</p> <p>North and South Walls: Limited spreading of cracks was observed.</p>	 <p>South wall stucco cracking at 2.0% target drift</p>	 <p>West end wall stucco cracking spreading vertically</p>					
	<p>End Walls: Cracks at the floor line widened to approximately 1/8-inch. Stucco appeared to be pushed off of end walls. Limited small pieces of stucco started falling off at corners.</p> <p>North and South Walls: Popping noises were observed to correspond to debonding of the stucco from the foundation. A gap of approximately 1/16-inch was measured between the foundation and the stucco.</p> <p>Retrofit: There was no observable damage to the retrofit.</p>	 <p>South wall stucco cracking at 3.0% target drift</p>	 <p>Further opening up of west and east end cracks and start of stucco spalling (top and bottom left), debonding of stucco from foundation and crack gage inserted between stucco and foundation (bottom center), and retrofit with no observable damage (bottom right)</p>					

Table C-2 Damage Observations for Specimen AL-2 - Cripple Wall With Retrofit

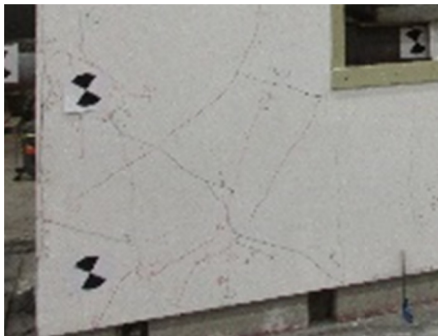

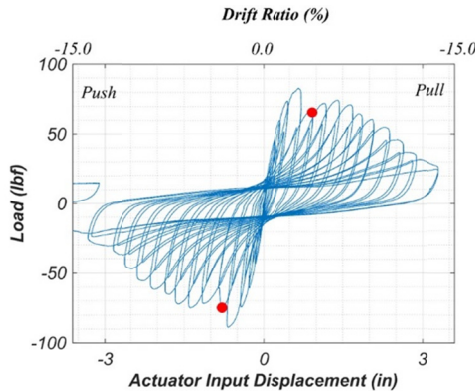
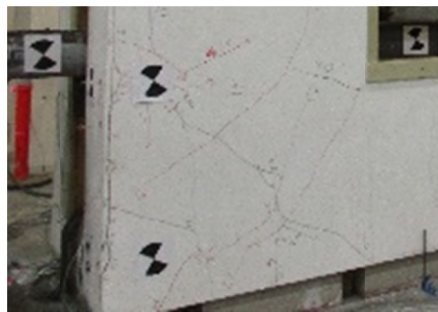

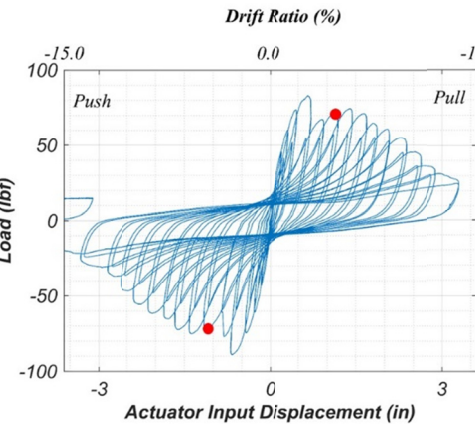
		Damage Appearance				Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve		
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance						
	<p>End Walls: Stucco damage progressed. Stucco at the west end corner was fractured over a significant height. Gaps of up to 1/4-inch were measured.</p> <p>North and South Walls: Hairline cracking and stucco flaring from the base continued. The stucco, however, remained substantially planar.</p> <p>Retrofit: There was no observable damage to the retrofit.</p>						4.0%		
	<p>End Walls: Stucco cracking and spalling progressed, as did separation of the stucco from the underlying sheathing and framing.</p> <p>North and South Walls: Stucco slid in-plane approx. 1/4-inch relative to sheathing and framing at the floor level. Additional hairline cracks near the floor line appeared related to additional flaring at the base of the stucco.</p> <p>Retrofit: Very modest withdrawal of nails from the upper top plate was seen (approx. 1/8-inch). Minor rotation of the plywood panels was seen, resulting in minor visible offsets of the panels at abutting panel edges. Very modest working of nail heads into the plywood was also observed.</p>						5.0%		

Table C-2 Damage Observations for Specimen AL-2 - Cripple Wall With Retrofit



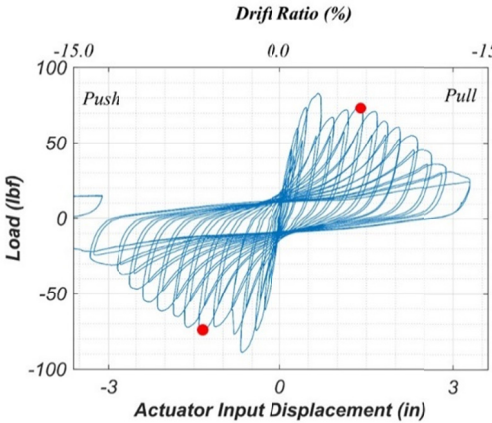

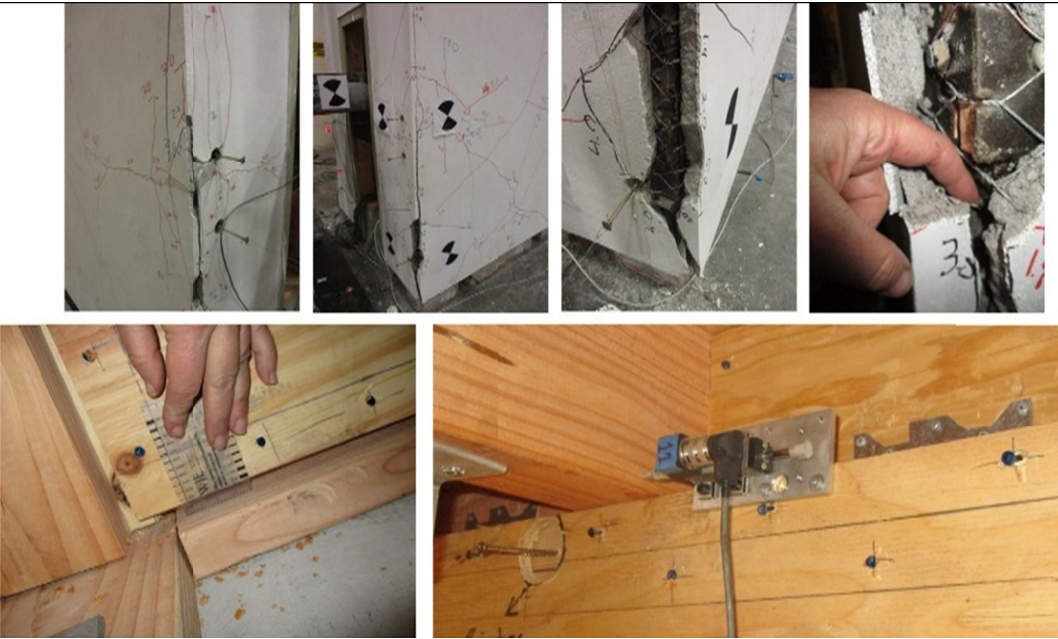
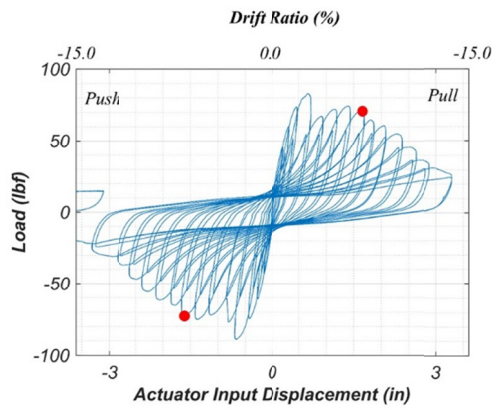
		Damage Appearance		Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
	<p>End Walls: Fairly complete fracture of the stucco at the corners was observed over the height of the cripple walls. Gaps of up to one inch opened between end wall stucco and the stucco on the north and south walls.</p> <p>North and South Walls: Very modest progression of cracking occurred. The stucco continued to flare further at the base of the walls. The gap between stucco and foundation increased to approximately 1/2-inch allowing us to put our fingers under the stucco.</p> <p>Retrofit: Further rotation of the plywood panels was seen, with vertical sliding of the plywood panels estimated as up to 1/4-inch at specimen east and west ends and 1/8-inch at interior panel joints. There was no observable damage to the clip angles (shear clips).</p>	 <p>South wall stucco cracking at 6.0% target drift</p>	 <p>Gapping of stucco at corners (top left), away from foundation (top middle), rotation of plywood panels (bottom left), and withdrawal of nails from upper top plate (bottom right)</p>	6.0%	
	<p>End Walls: Stucco continued to deteriorate with significant additional stucco spalling.</p> <p>North and South Walls: Additional cracking occurred, particularly near wall ends, but remained near hairline.</p> <p>Retrofit: Continued uplift of sheathing was observed at wall ends. Amount of nail withdrawal increased modestly.</p>	 <p>South wall stucco cracking at 7.0% target drift</p>	 <p>Continued deterioration of end wall and corner stucco (top), rotation of plywood panels (bottom left), and withdrawal of nails from upper top plate (bottom right)</p>	7.0%	

Table C-2 Damage Observations for Specimen AL-2 - Cripple Wall With Retrofit



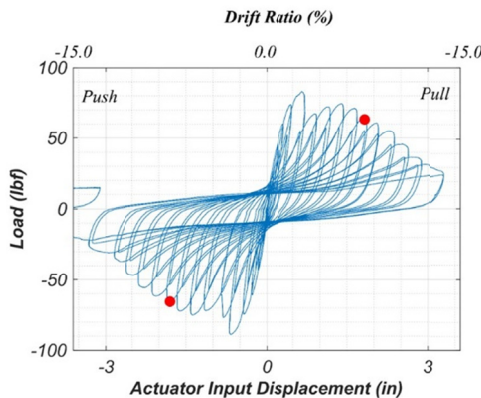


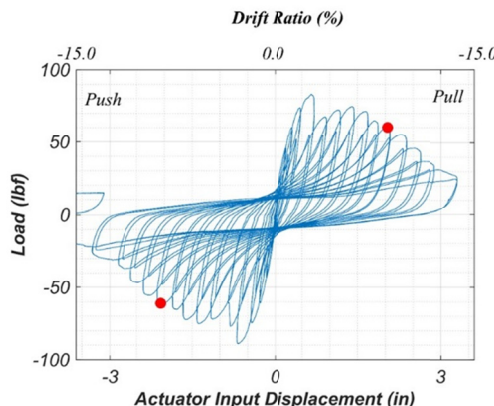
		Damage Appearance				Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve	
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance					
	<p>End Walls: Separation of stucco at the corners and breaking of stucco wires continued to increase.</p> <p>North and South Walls: These was no significant progression of cracking. Flaring of stucco at the base increased to approximately 3/4-inch.</p> <p>Retrofit: Cripple wall framing at the end walls was observed to have very visible lean. Rotation of the panels continued to increase. Nails in the upper top plate were withdrawn up to 1/8 to 1/4-inch. Retrofit remains very functional. No observable damage to clip angles.</p>						8.0%	
		Continued deterioration of end wall and corner stucco (top), rotation and in-plane slip of plywood panels (bottom left), no observable damage to clip angles (bottom right)						
	<p>End Walls: Similar to 8%.</p> <p>North and South Walls: Similar to 8%.</p> <p>Retrofit: Similar to 8%.</p>						9.0%	
		Continued deterioration of end wall and corner stucco (top), rotation of plywood panels (bottom left), and withdrawal of nails from upper top plate (bottom right)						

Table C-2 Damage Observations for Specimen AL-2 - Cripple Wall With Retrofit



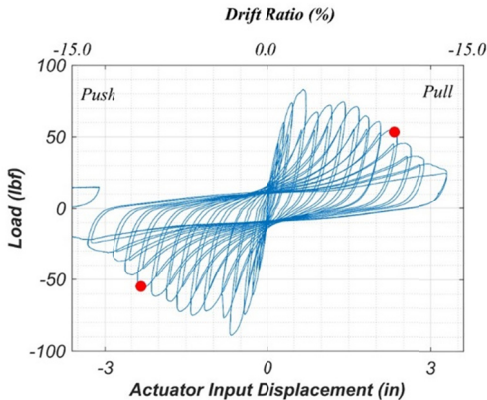


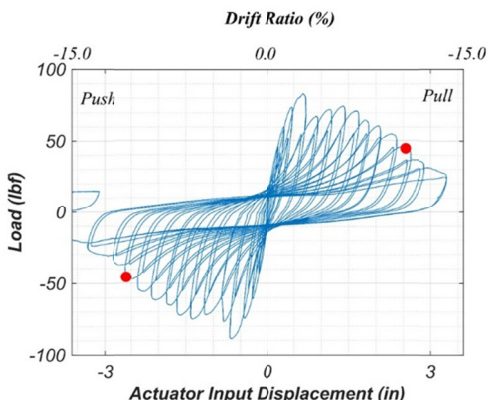
		Damage Appearance		Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
	<p>End Walls: Stucco at end walls is significantly detached and separates significantly from underlying sheathing and framing during loading. Wood siding is visible below.</p> <p>North and South Walls: Negligible new cracking. Stucco flare was measured as up to one inch.</p> <p>Retrofit: Some nails in the upper top plate were observed to be withdrawn up to one inch and be deformed (bending with limited change in angle). In limited locations at the top and bottom corners of the sheathing, sheathing nail heads were observed to be pulled through. Some limited gapping between the sheathing and underlying framing was observed.</p>			10%	
	<p>End Walls: Stucco at end walls is significantly detached and separates significantly from underlying sheathing and framing during loading. Wood siding is visible below.</p> <p>North and South Walls: Negligible new cracking.</p> <p>Retrofit: A number of nails into the upper top plate were observed to be completely withdrawn from the framing, and remain in place only due to embedment in the plywood sheathing. Nails at bottom plate were observed to be withdrawn up to between 1/2 and one inch.</p>			11%	

Table C-2 Damage Observations for Specimen AL-2 - Cripple Wall With Retrofit


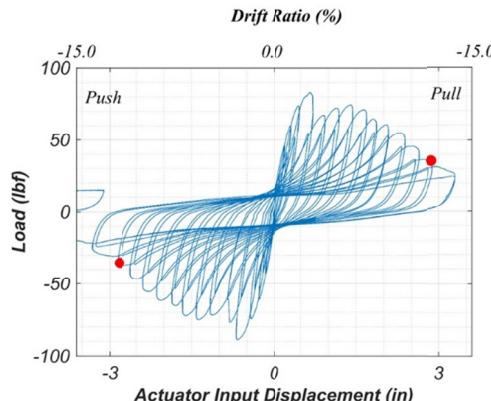

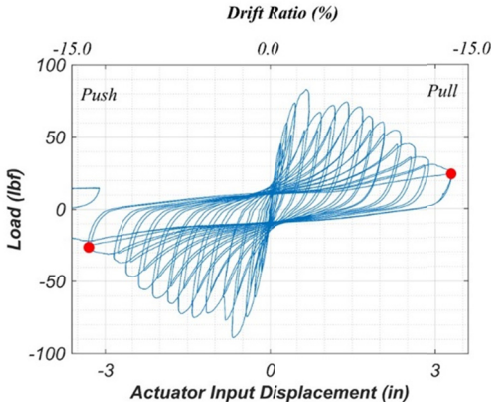
		Damage Appearance			Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve	
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance				
	End Walls: Stucco deterioration and spalling continued. North and South Walls: Negligible new cracking. Retrofit: top plate sheathing nails have started to fall off of the walls.					12%	
	South wall stucco cracking at 12.0% target drift Continued deterioration of end wall and corner stucco (top), sheathing nails to upper top plate have started to fall off wall (bottom left), clip angle has no observable damage (bottom center) and withdrawal of nails from bottom plate and stud (bottom right)						
	End Walls: Stucco deterioration and spalling continued. North and South Walls: Negligible new cracking. Flaring at stucco base up to almost two inches. Retrofit: Diaphragm and upper top plate start being pushed off of the lower top plate and cripple wall. This causes the top of the east wall rim joist to roll towards the west as the top of the rim joist gets pulled with the diaphragm sheathing. The south wall blocking is pulled with the diaphragm also.					14%	
	South wall stucco cracking at 14.0% target drift Continued deterioration of end wall and corner stucco (top), top of east wall floor rim joist is rolled to the west (bottom left), and sheathing nails at bottom plate (bottom right)						

Table C-2 Damage Observations for Specimen AL-2 - Cripple Wall With Retrofit


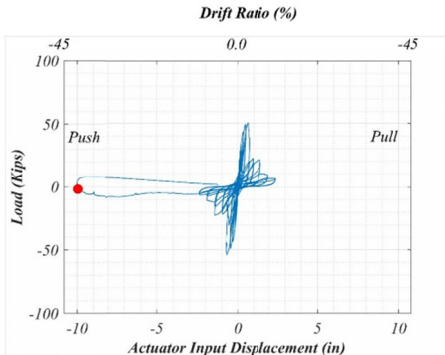
		Damage Appearance		Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
	The diaphragm and upper top plate are pushed off of the lower top plate and cripple walls. The cripple walls remain at a very low drift while the majority of the actuator displacement is taken up in diaphragm sliding.		<div></div> <p>West end of cripple wall with end wall stucco sucked under the floor and north wall stucco visibly flared (left), and east end cripple wall with little drift occurring over the height of the cripple wall and the floor diaphragm pushed westward off of the cripple wall.</p>	40% Monotonic	

Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections





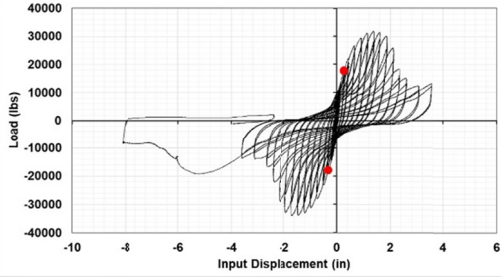
		Damage Appearance		Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
Horizontal wood siding with retrofit plywood	No damage was observed prior to start of testing	 South wall prior to start of testing	 Interior prior to start of testing	0%	
No damage or other condition issues were observed		NA	NA	0.2% 0.4% 0.6% 0.8%	
Initial slip on the order of 1/16-inch seen between bottom of plywood and foundation sill plate, between foundation sill plate and foundation		 South wall	 Initial slip between bottom of plywood and foundation sill plate (left), between foundation sill plate and foundation (right)	1.4%	

Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections

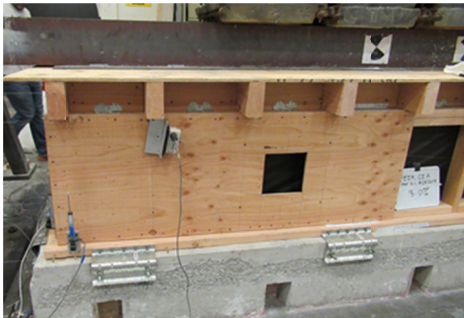
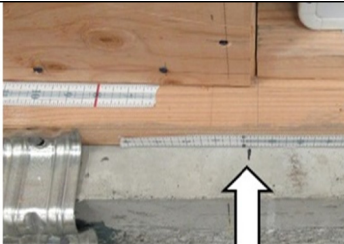
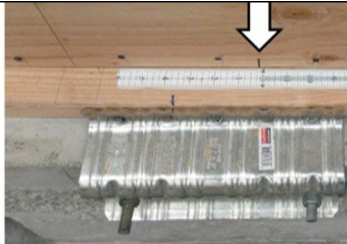
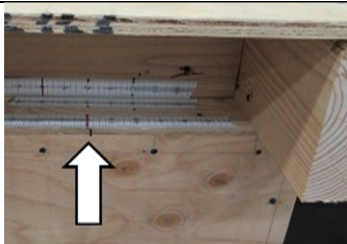
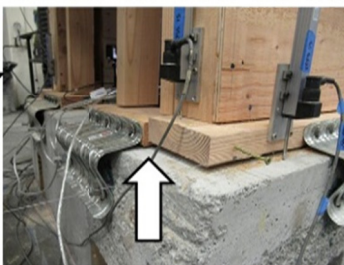

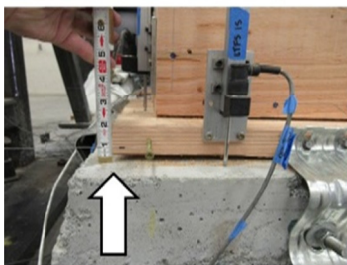
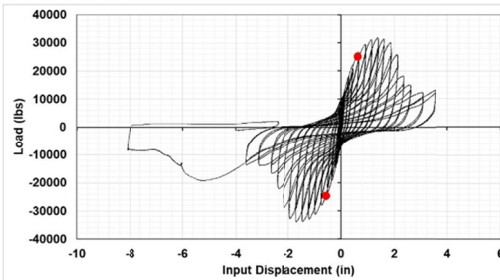

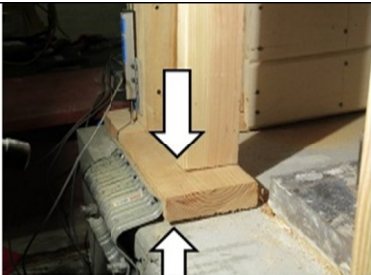




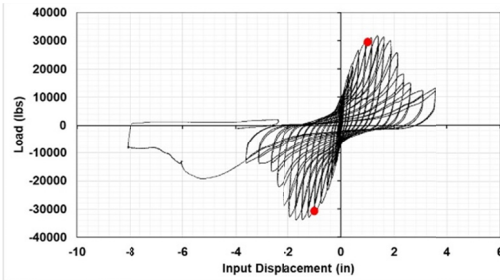
Damage Appearance						
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
	No changes in condition relative to 1.4% drift were observed	NA	NA		2.0%	NA
	<div>-Slip of approximately 1/8-inch at the three interfaces shown</div> <div>-Uplift of west end of south and north wall foundation sill plates</div>	<div></div> <div>South wall, west end</div>	<div></div> <div></div> <div>Slip between top plate and top of plywood (left top), between bottom of plywood and foundation sill plate (top center), and between foundation sill plate and foundation (top right), uplift of south wall foundation sill plate (bottom). Note that west wall foundation sill plate has minimal uplift (bottom right)</div>		3.0%	
	<div>-Slip remained similar to 3% drift</div> <div>-Uplift of foundation sill plate off of foundation at east end wall</div> <div>-Uplift at west end of north and south wall foundation sill plates</div> <div>-West end wall foundation sill plate stays in place and studs uplift off of plate</div>	<div></div> <div>South wall, west end</div>	<div></div> <div></div> <div>Uplift at east end wall, including foundation sill plate uplift off of the foundation and slight stud rocking (top), uplift of north and south walls at west end (bottom), with the west end foundation sill plate staying down and studs lifting off sill plate (bottom right)</div>		4.0%	

Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections



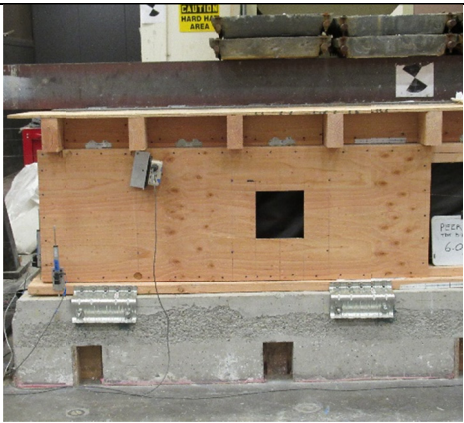
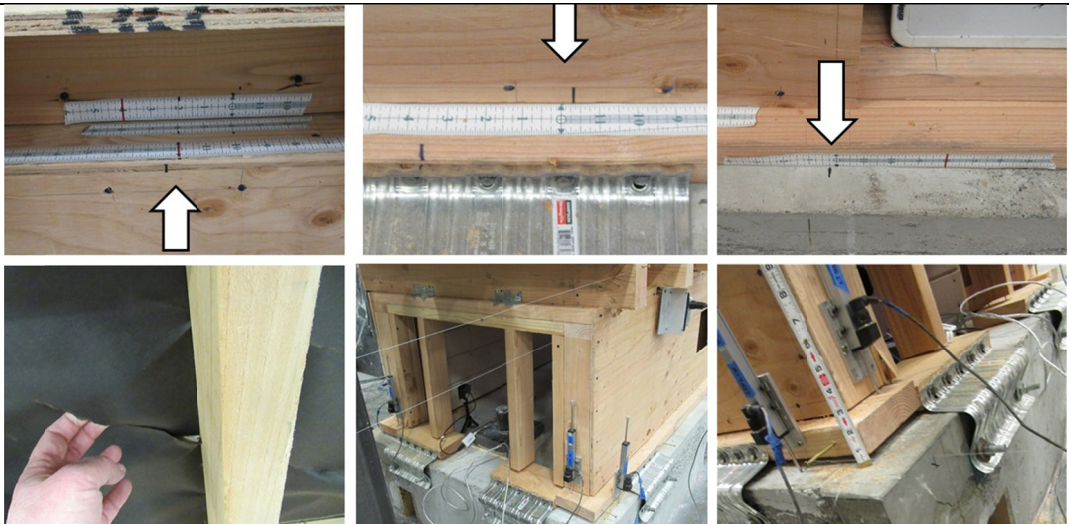
		Damage Appearance			Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Cripple Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance			
	<div>-Slip progresses to approx. 1/4-inch</div> <div>-Wall uplift at west end</div> <div>-Building paper develops tension field and tears</div> <div>-First and possibly only split in exposed blocking on top of foundation sill plate</div>					5.0%

Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections

- Slip progresses up to about 3/8-inch
- Uplift continues at west end
- Building paper buckling and tearing has occurred
- Plywood panels are observed to rotate, observed working of plywood nails including withdrawal and partial head pull through



South wall, west end



Slip between top plate and top of plywood (left top), between bottom of plywood and foundation sill plate (top center), and between foundation sill plate and foundation (top right), tearing and buckling of building paper (left bottom), continued west end uplift



(center and right bottom)

Rotation of plywood panels and withdrawal, partial pull through of nails

6.0%

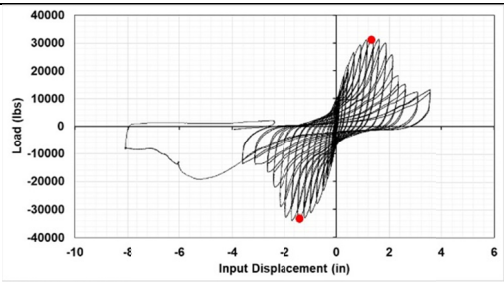
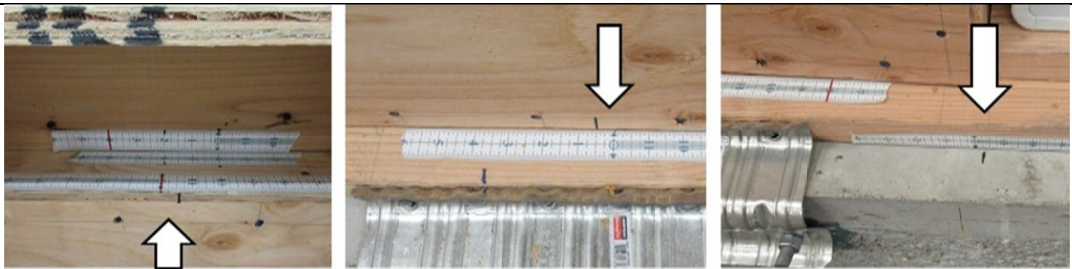


Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections

- Slip up to 5/8-inch between top plate and top of plywood, 1/2-inch between foundation sill plate and bottom of plywood, and remains approx. 3/8-inch between foundation sill plate and foundation
- Plywood is pushed away from framing. Gaps open up between plywood and framing with nail withdrawal and partial head pull thorough



South wall being inspected by Vahid



Slip between top plate and top of plywood (left top), between bottom of plywood and foundation sill plate (top center), and between foundation sill plate and foundation (top right)



Plywood is being pushed off of framing during cycling, resulting in gaps, nail withdrawal and partial nail head pull through. Gap width is approximately 1/2-inch

7.0%

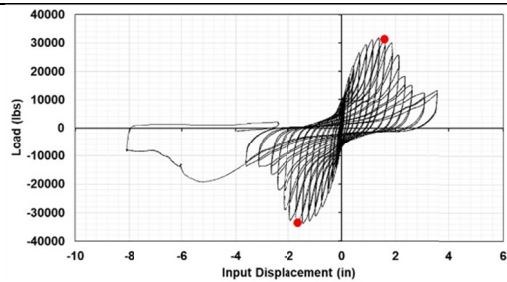
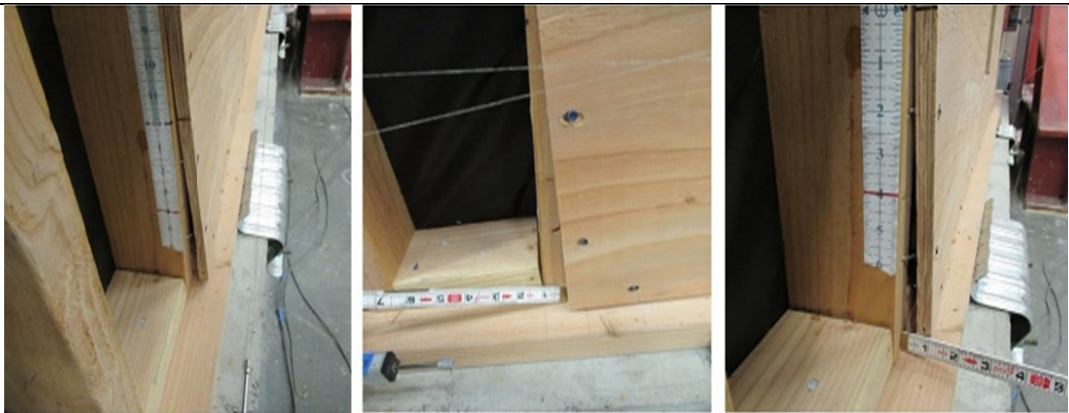


Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections

- Slip is up to 3/4-inch between top plate and top of plywood, 1/2-inch between foundation sill plate and bottom of plywood, and remains approx. 1/4-inch between foundation sill plate and foundation
- Gap between plywood and framing continues to grow
- East end foundation sill plate splits with stud rocking



South wall and test setup



Plywood continues to gap and slide (left, center), sheathing nails are bent in reverse curvature (right)



East wall foundation sill plate fractures with rotation of studs (left top, center top)), siding nails have small amount of withdrawal (right top), uplift continues at west end wall with studs uplifting and stud end nails withdrawing (bottom)

8.0%

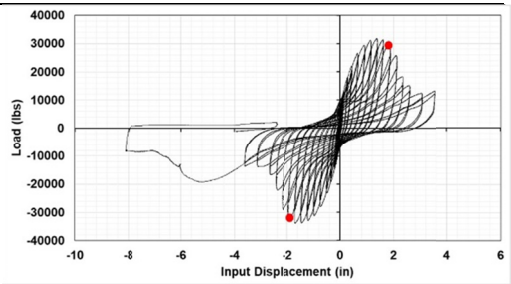
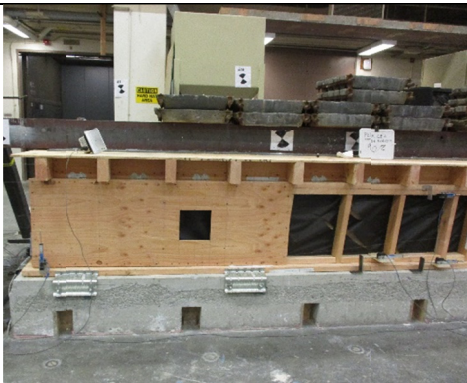


Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections

- Split in one corner stud
- Building paper is shredded and buckled
- Plywood is substantially pulled off of supporting framing, nails are substantially withdrawn with little penetration left into framing



South wall, west end



Corner stud has split along plywood edge nailing line (left, center), building paper is shredded, buckled (right)



Plywood slip and nail withdrawal at top of cripple wall (top) and bottom of cripple wall (bottom)

9.0%

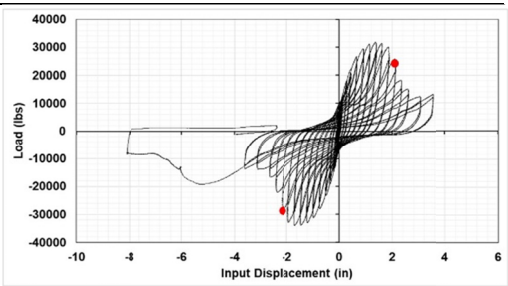


Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections

- Foundation sill plate at east end wall is completely split through
- Plywood nails are substantially withdrawn from framing



South wall



East end wall sill plates are split completely through (left and center), Top plates are moving free of sheathing, no longer connected (right)



Sheathing nails at top of wall are completely withdrawn from the framing, only retained in place by penetration into the plywood (top) Sheathing nails at bottom of wall are substantially withdrawn, framing and sheathing is gouged around nail (bottom)

10%

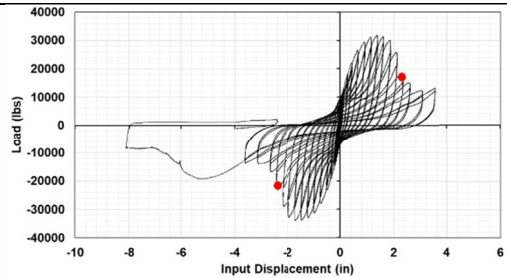


Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections

- Plywood substantially detached, moving away from framing, nail falling off
- Gap is opening up at east wall sill plate split



Plywood is substantially detached from and moving away from framing, sheathing nails are starting to fall off, pieces of split east wall sill are moving away from each other (right bottom)

11%

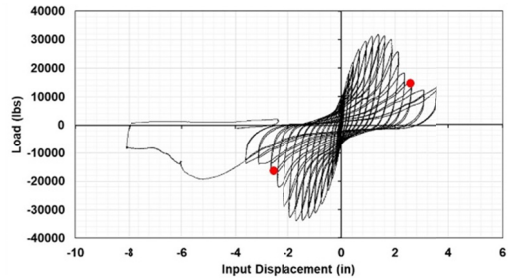
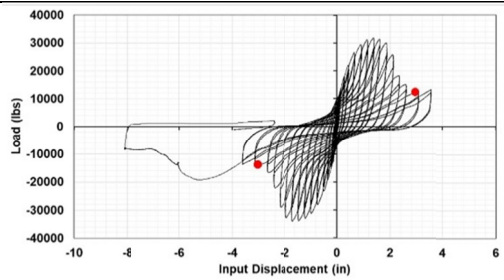


Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections

- Slip of up to 2-1/2-inches has occurred between top of plywood and cripple wall top plates
- Building paper is heavily damaged
- Plywood is substantially detached from framing
- Blocking between studs is still substantially intact, shows some signs of uplift from stud rocking
- Shear clips and anchorage plates are substantially intact



13%



Building paper is substantially destroyed (left), plywood is substantially detached (center), no deformation or damage is visible at the shear clips or anchorage plates (right).



Top of plywood has slipped approximately 2-1/2-inches relative to top plates (left top)
plywood is substantially detached from framing.



Blocks on top of foundation sill plates are still fastened, some uplift is occurring due to wedging of the studs.

Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections

- Plywood is substantially detached from framing
- Anchor plate shows no signs of damage

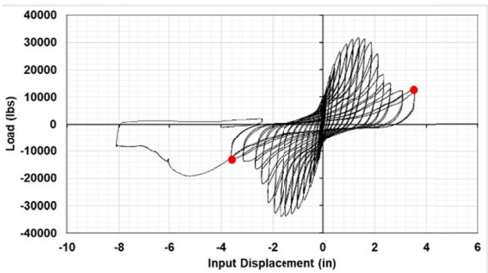


Southe wall



Plywood nailing is substantially withdrawn while anhorage plate has no visible damage (left) plywood is substantially detached from framing (right)

15%



- Plywood has moved several inches away from framing
- East and west wall experience significant lean, foundation sill plate on east end wall is cracked and separated



East wall



The south wall plywood has moved several inches away from the supporting framing

Monotonic

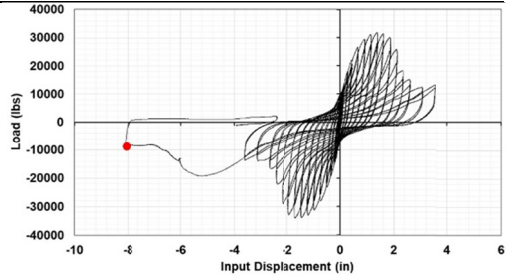


Table C-3 Earthquake Damage Observations for Specimen B-1 - Cripple Wall Load Path Connections



cracking at failure

Table C-4 Earthquake Damage Observations for Specimen C-1 - Superstructure with Shiplap Exterior, Plaster on Wood Lath Interior

		Damage Appearance		Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
Exterior horizontal wood (shiplap) siding, interior plaster on wood lath	No cracking or other signs of damage were observed prior to the start of testing.	 South wall at start of testing		0%	
	<p>-Popping noises were heard in first excursion to 0.2% drift in both push and pull directions. These corresponded to stucco cracks from corners of doors and windows in tension zones.</p> <p>-Puckering (buckling) of the plaster finish coat was seen in the compression zones, also in first excursion.</p> <p>-Additional cracking and puckering was very limited following the first displacement cycle.</p>	 Plaster at north wall window (seen through south wall window)	 Plaster cracking and spalling of finish coat at window openings, similar occurred at door openings	0.2%	

Table C-4 Earthquake Damage Observations for Specimen C-1 - Superstructure with Shiplap Exterior, Plaster on Wood Lath Interior

		Damage Appearance			Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance			
	<p>-Plaster finish coat started spalling in areas of pucker, cracking. Light falling of debris continued through displacement cycles.</p> <p>-Cracks continued to propagate and widen. Cracks of up to 0.035 inches were measured.</p> <p>-A vertical gap opened up between plaster and wall bottom plate at end wall, locally disrupting plaster.</p> <p>-At observation pocket, hairline cracks were seen between plaster keys and wood lath (suggesting start of debonding of plaster).</p>	 <p>Plaster at north wall window (seen through south wall window)</p>	 <p>Plaster cracking, finish coat spalling (left), detail of finish coat pucker and debris (right top), hairline crack between plaster key and wood lath (right bottom)</p>		0.4%	
	<p>-Patches of plaster start dropping off, keys are broken off and remain in place between wood lath boards.</p> <p>-Cracking continues to propagate, first hairline cracking of end wall plaster is seen.</p> <p>-Out-of-plane gaps develop between back of plaster and wood lath at windows and doors. This is seen as the plaster face no longer aligning with the plaster stop that was flush during plaster installation.</p>	 <p>Plaster at north wall window (seen through south wall window)</p>	 <p>Plaster cracking, finish coat spalling (left), plaster spalling off wood lath (right top and middle), plaster face approx. 5/8 inch above plaster stop that was installed flush (right bottom)</p>		0.6%	

Table C-4 Earthquake Damage Observations for Specimen C-1 - Superstructure with Shiplap Exterior, Plaster on Wood Lath Interior



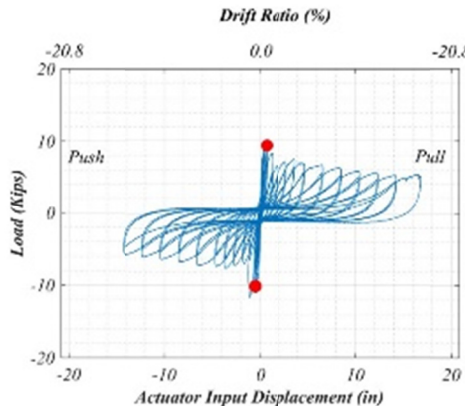


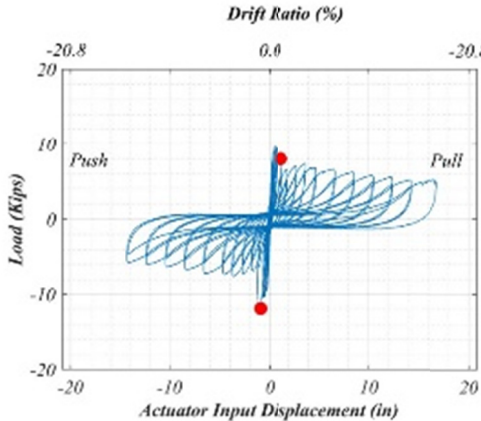
		Damage Appearance				Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve	
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance					
	<p>-Spalling continues, plaster keys are seen falling to bottom of wall cavity.</p> <p>-Cracks spread and widen, with crack widths up to 1/8-inch measured. Cracks at some wall piers have become closely spaced (approx. one foot on center) with classic shear-cracking pattern similar to concrete shear walls.</p> <p>-Plaster is loose and gapped from lath in a number of locations.</p> <p>-Uplift of stud framing at door opening is first observed.</p>						0.8%	
	<p>-By end of 1.4% cycles, about hlf of the plaster had fallen or was loose and about to fall. Further marking of plaster cracks had become impractical.</p> <p>-Working of wood siding nails started to be noticed and marked, with modest pull through and withdrawal of siding nail heads, and limited hairline splitting between nail near end and end of board.</p>						1.4%	

Table C-4 Earthquake Damage Observations for Specimen C-1 - Superstructure with Shiplap Exterior, Plaster on Wood Lath Interior


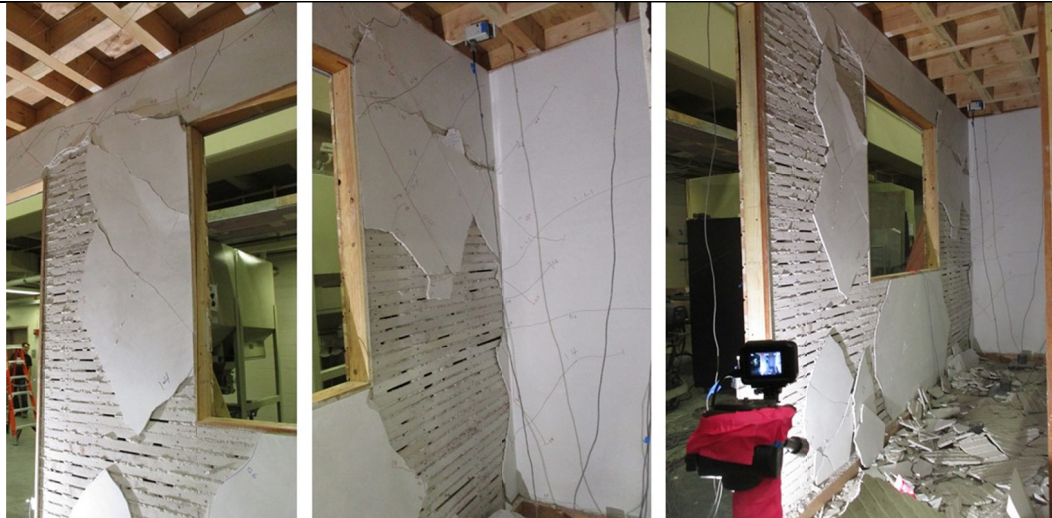
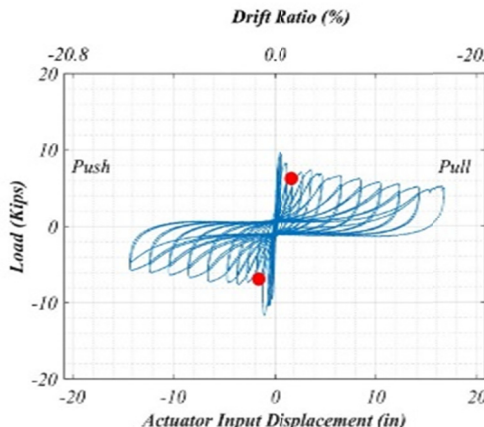

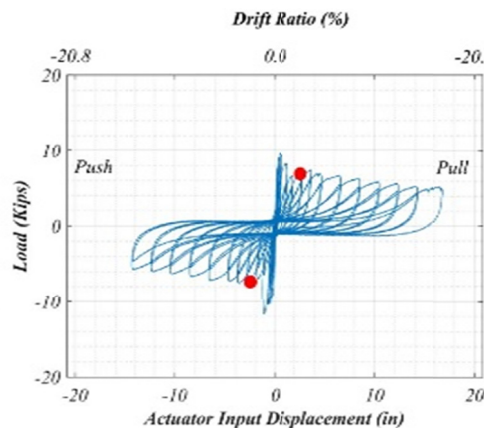
		Damage Appearance			Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance			
	-Plaster spalling continues. -Working of siding nails continues.					2.0% 
	-Plaster spalling continues. -Working of siding nails continues.					3.0% 

Table C-4 Earthquake Damage Observations for Specimen C-1 - Superstructure with Shiplap Exterior, Plaster on Wood Lath Interior

		Damage Appearance		Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
	<div>-Plaster is mostly spalled, many keys remain in place. -As siding is worked, gaps start forming between back side of siding and framing behind</div>			4.0%	
	<div>-Global rocking of specimen could be seen. Wood lath was seen to be working, spacing between lath board changing</div>	 <div>South wall stucco cracking at 6.0% target drift</div>		5.0%	
		Gaps between wood lath boards are noted to become less uniform, indicating working of the wood lath boards (left), wood siding continues to be worked (middle and right).			

Table C-4 Earthquake Damage Observations for Specimen C-1 - Superstructure with Shiplap Exterior, Plaster on Wood Lath Interior

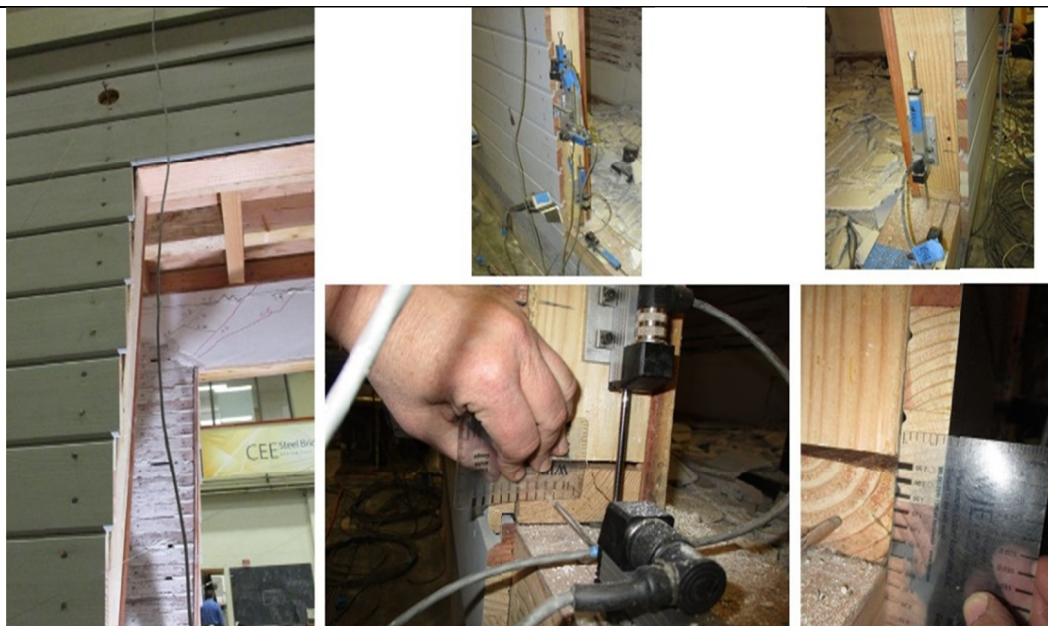
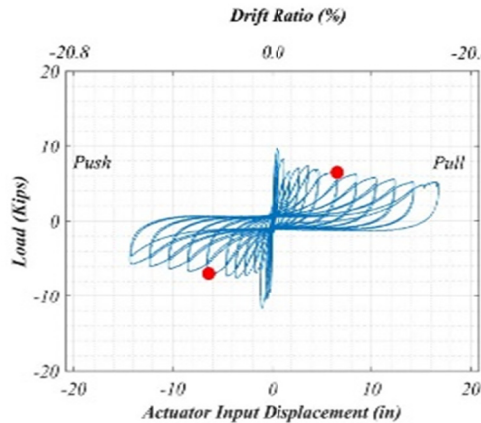


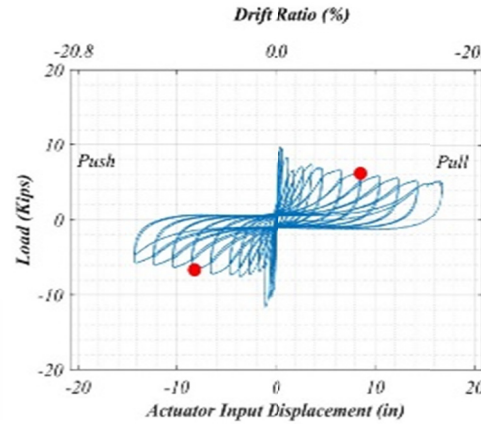
		Damage Appearance			Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance			
	<p>-Working of siding continues, more nail withdrawal is noted.</p> <p>-Vertical gaps of about 1/4-inch are noted between crippler studs at door and wall bottom plates. Gapping occurs when edge of wall pier is in uplift, reverses under compression when loading direction reverses.</p>				7.0%	
	<p>-Vertical gaps at door studs continue.</p> <p>-Wood lath is seen to buckle locally.</p> <p>-Siding at bottom of east end wall cracks in line with wall bottom plate.</p>				9.0%	
		Continued working of siding (left), door cripple stud uplift off of wall bottom plate (middle and right).				
		Buckling of wood lath seen through observation hole (left top), gapping between stud and bottom plate (left bottom), and splitting in east end wall siding at floor line (right).				

Table C-4 Earthquake Damage Observations for Specimen C-1 - Superstructure with Shiplap Exterior, Plaster on Wood Lath Interior



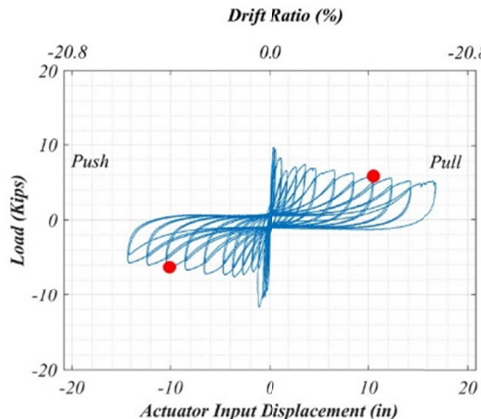


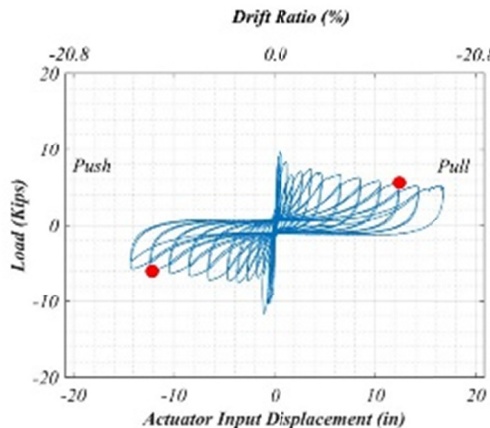
		Damage Appearance			Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance			
	<p>-Siding continues to work, siding condition and gap to wall framing are not significantly changed. There is no indication of siding being progressively worked off of the framing, as was seen with the horizontal lumber sheathing in Specimen AL-1</p>	 <p>South wall with push direction loading to the west</p>	 <p>Continued working of siding with little noted degradation of boards or nailing,, little change in gap between siding and framing.</p>		11%	
	<p>-Siding performance similar to 11% -Tension side vertical gapping increases between siding boards, with minor uplift of wall studs -Crack in end wall siding progresses</p>	 <p>South wall center wall pier pushed to west</p>	 <p>Working of siding without significant visible damage to siding or nailing (left top), at compression end of wall piers siding boards are just getting near contact but not bearing on each other (left bottom), at tension end of wall piers gaps between siding boards are opening up (right bottom), crack in end wall siding has progressed (right top)</p>		13%	

Table C-4 Earthquake Damage Observations for Specimen C-1 - Superstructure with Shiplap Exterior, Plaster on Wood Lath Interior

		Damage Appearance			Cripple Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance			
	-Siding performance remains similar -Gap at east end wall siding crack widens				15%	
	-Siding performance remains similar -Trim boards are damaged, pried off at corners				16% Monotonic	

Table C-5 Earthquake Damage Observations for Specimen C-2 - Superstructure with Plywood Siding (T1-11) Exterior, Gypsum Wallboard Interior

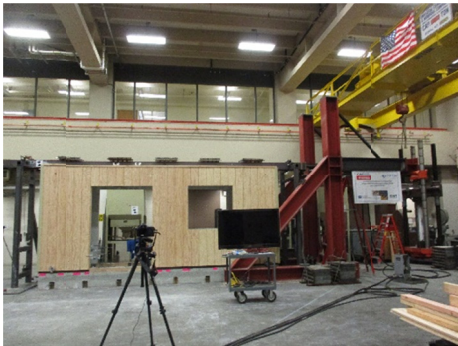

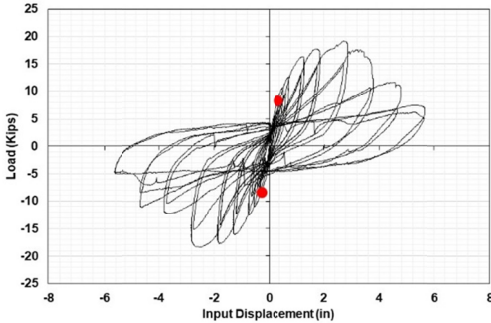
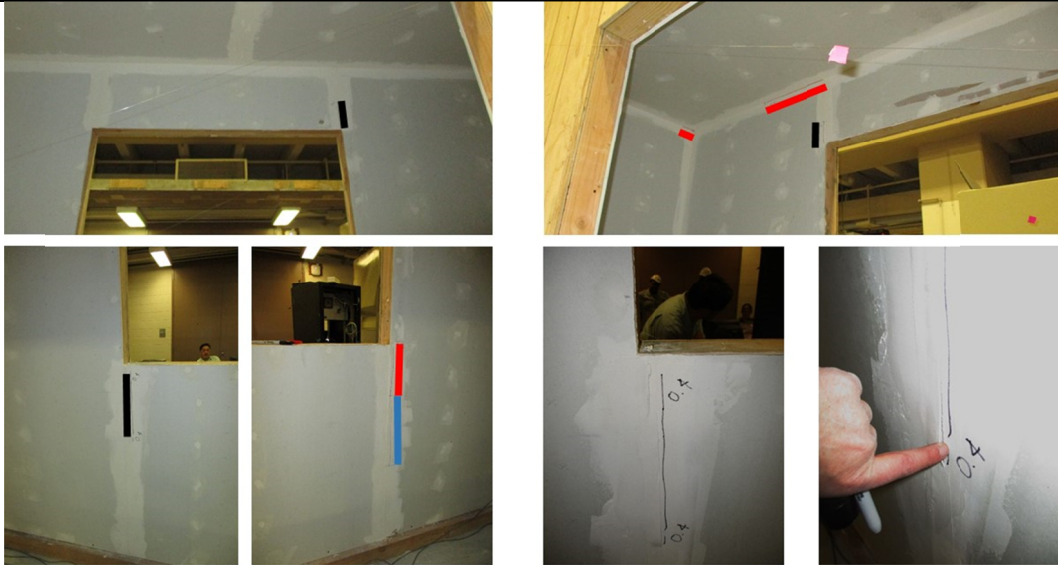
		Damage Appearance		Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
Exterior plywood siding (T1- 11) and interior gypboard	-No damage observed at the start of testing.	 South wall	 Interior gypboard	0%	
	-Cracking, spalling along panel taped joints	 Gypboard extent of cracking at north wall window marked on photos, with colors consistent with push, pull and balance of cycles (left) gypboard joint cracking at ceiling (right top), joint tape debonding and loose (right bottom)			

Table C-5 Earthquake Damage Observations for Specimen C-2 - Superstructure with Plywood Siding (T1-11) Exterior, Gypsum Wallboard Interior

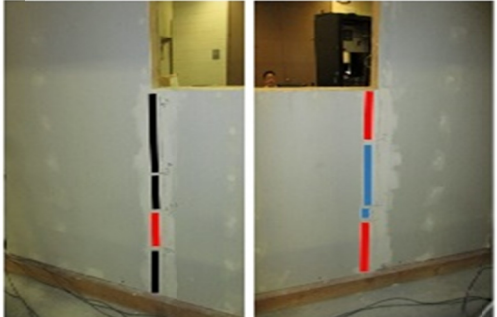


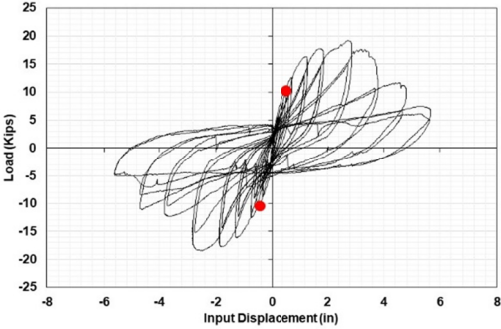



		Damage Appearance		Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
	<div>-Gypboard cracking spreads -Gypboard taped joints continue deterioration</div>	 	    	0.6%	
	<div>-Gypboard taped joints continue deterioration -Gypboard corners start to fracture, but are retained in place -Nail head pops start to be seen at gypboard nails. There is hairline cracking seen around the nail head perimeter, but nail heads are not protruding -Rotation of the plywood siding panels can be seen due to offsets in the panels at abutting panel joints. No particular damage or deterioration noted</div>	 	   	0.8%	

Table C-5 Earthquake Damage Observations for Specimen C-2 - Superstructure with Plywood Siding (T1-11) Exterior, Gypsum Wallboard Interior

		Damage Appearance			Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance			
	<p>-Uplift of the wall bottom plate off of the supporting 4x6 nailer started to become very evident. Gapping and withdrawal of the bottom plate nails was obvious where loading created uplift. When the loading reversed and the bottom plate was pushed back into bearing, the bottom plate nail heads could be seen to have withdrawn</p> <p>-Rotation of the plywood siding panels continued. Joints between the abutting panels were maintained</p> <p>-Gypboard nails at the base of the end walls were seen to gouge out the gypsum as the end wall experienced global uplift, leaving piles of the gypsum at the wall base and some visible tears of the gypboard paper</p>					
Progression of wall bottom plate uplift and nail withdrawal (left and center), rotation of plywood siding (right top and middle), and nail gouging of gypsum at base of end wall (right bottom)						
	<p>-Uplift of the wall bottom plate off of the supporting 4x6 nailer increased. Gapping and withdrawal of the bottom plate nails was obvious where loading created uplift</p> <p>-Rotation of the plywood siding panels continued. Joints between the abutting panels were maintained</p> <p>-Gypboard damage was seen to locally increase to include fractures</p> <p>-Sliding at the base of the wall of the wall bottom plate relative to the 4x6 nailer started to be noticed</p>					
Progression of wall bottom plate uplift and nail withdrawal (left and center top), gypboard breaking off at corner (center middle), rotation of plywood siding (right top), partial closing of gap between siding boards (right middle), and sliding at base of wall at door opening (right bottom)						

Table C-5 Earthquake Damage Observations for Specimen C-2 - Superstructure with Plywood Siding (T1-11) Exterior, Gypsum Wallboard Interior


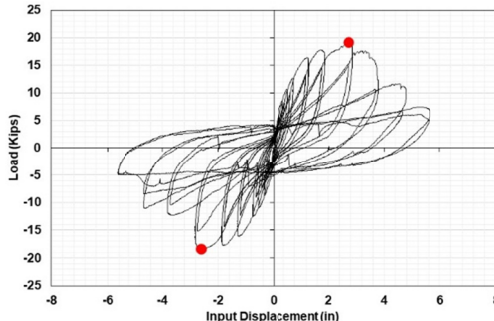

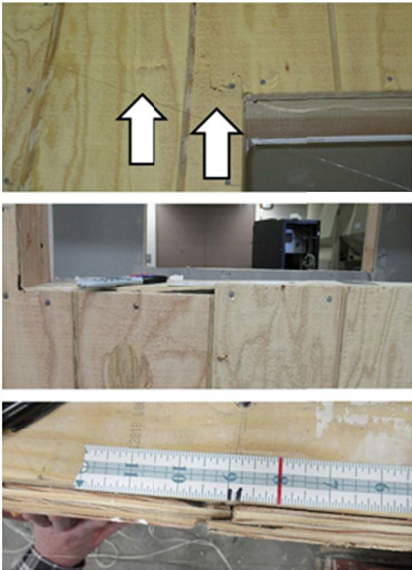
		Damage Appearance			Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance			
	<p>-Uplift of the wall bottom plate off of the supporting 4x6 nailer had notable increase in the gap dimension and in the length of bottom plate experiencing uplift. The length of plate uplifted extended over several feet in some locations</p> <p>-Rotation of the plywood in the full-height wall piers was visible, with signs of nail working being proportionally higher</p> <p>-Gaps were observed between the base of the plywood siding and the wall framing below</p> <p>-Nailing at the base of the wall gypboard was seen to experience damage as wall uplift occurred. Edge pullout occurred at some locations, with small divots of gypsum core being pulled out</p> <p>-Tape and joint compound at the panel joints was highly deteriorated leaving the panels to move independently of each other</p> <p>-Local fracture of the plywood siding occurred at one window corner</p> <p>-Warping of sill framing at vertical panel joints could be seen. This is thought to be driven by the siding rather than sheathing nailing pattern used. Deformations were seen to be local rather than global</p> <p>-Joints between panels were observed to partially close</p>	 <p>South wall with push displacement (towards the left). Left wall pier can be seen to have significant rotation including rotation that is independent of the global specimen overturning</p>	 <p>Bottom plate uplift with increased gap and increased extent of uplift. Damage to gypboard nails at wal base occurs in combination with the bottom plate uplift (left and center), gap between plywood siding and wall bottom plate is large enough that Dave can put is fingers between (right top), Vahid documents sill uplift (right bottom)</p>		3.0%	
		 <p>Stucco at floor level slip relative to framing (above), further deterioraton of stucco at end walls (below)</p>				

Table C-5 Earthquake Damage Observations for Specimen C-2 - Superstructure with Plywood Siding (T1-11) Exterior, Gypsum Wallboard Interior


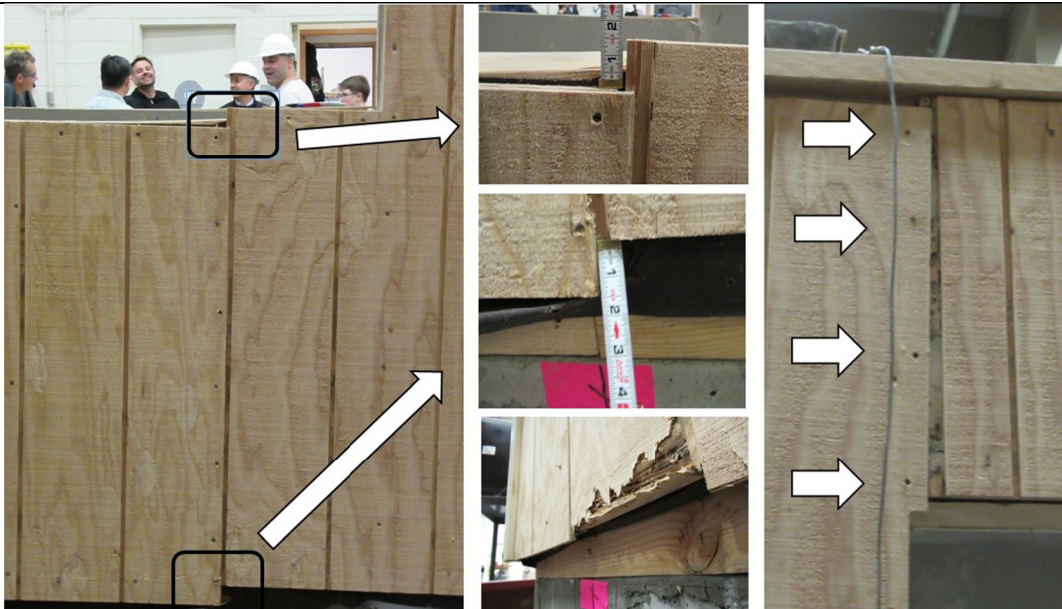
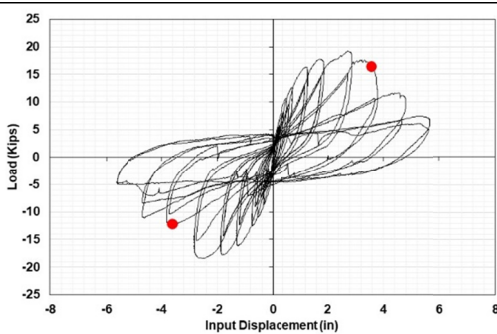
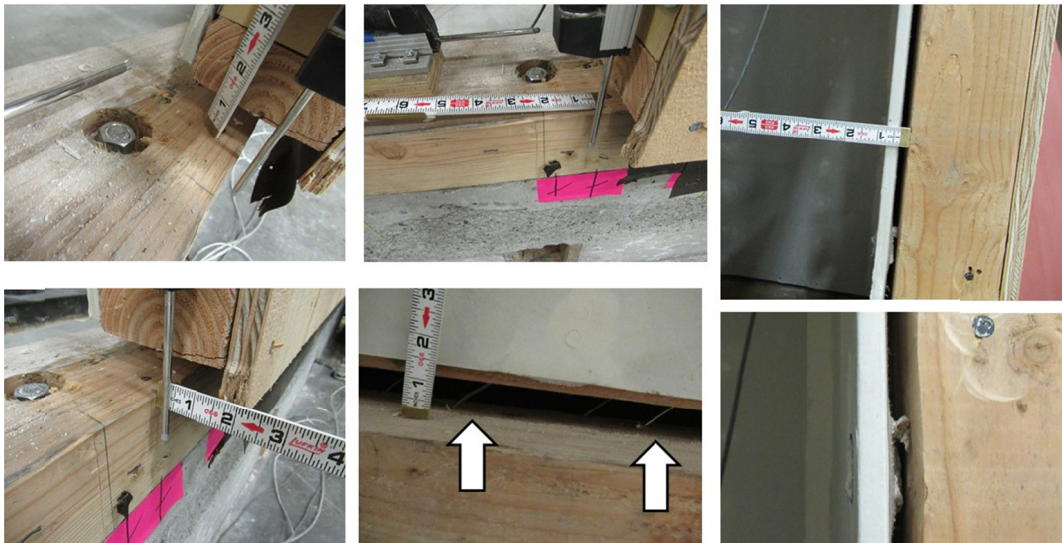


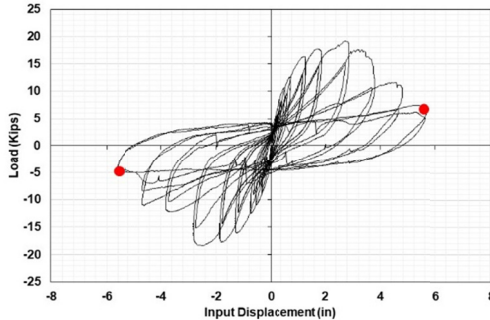
		Damage Appearance			Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance			
	<p>-Plywood siding panel rotation increases, with nail head pull through seen in a number of locations including at headers and below windows</p> <p>-The plywood siding at the base of the east wall has local crushing and fractures. When the east end wall experienced uplift the bottom of the siding was lifted up and slipped to the west at the same time. As the load reversed, the wall framing sat back down on top of the siding. The siding fractured and got folded under the wall framing</p> <p>-At the base of the wall at the door opening, in addition to uplift of the bottom plater off of the 4x6 nailed, the bottom plate was observed to slip several inches in the longitudinal direction and several inches in the transverse direction, such that the base of the wall was no longer vertically in line with the foundation</p> <p>-Gaps were observed between the gypboard and the framing at the door and window openings. Gouging and slots in the gypsum were observed at nails</p>	 <p>South wall with pull displacement (towards right)</p>	 <p>Plywood siding panel rotation results in greater vertical offsets and pull through of nail heads at panel corners and at Panel edge above door, end wall plywood siding is damaged at wall base (center bottom)</p>		4.0% Before first restraint was added	
			 <p>Uplift of the wall bottom plate at the door opening (left top), wall bottom plate slip in the transverse direction so that the wall is no longer in line with the foundation (left bottom), wall bottom plate slip of approximately two inches in the longitudinal d direction (center top), wal bottomplate nails partially withdrawn under uplift and racked due to longitudinal wall slip (center bottom), gypboard seperating from wall framing and gouging of gypsu core at nail (right)</p>			

Table C-5 Earthquake Damage Observations for Specimen C-2 - Superstructure with Plywood Siding (T1-11) Exterior, Gypsum Wallboard Interior

		Damage Appearance		Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance		
	<p>-Part of the way through the 4% drift cycles, the out-of-plane slip at the bottom of the center pier walls created concerns regarding specimen stability. It was decided to provide a strap wrapping around the two center piers to restrain the bottom of the piers from out of plane movement. This restraint remained in place for the balance of the testing</p> <p>-Significant increases occurred in the longitudinal sliding of the wall piers at the wall base between the bottom plate and the 4x6 nailer</p> <p>-continued damage occurred to the bottom of the east wall siding as it got dragged across the 4x6 nailer, breaking off the bottom of the siding panel</p>	 <p>South wall with restraint added on wall pier next to window to keep wall pier from pushing out-of-plane off of footing</p>	 <p>Longitudinal slip of wall bottom plate at door (left top), vertical uplift of wall bottom plate at door (right top), longitudinal slip and damage to siding at base of east end wall (bottom)</p>	4.0% After first restraint was added	
	<p>-Plywood siding panels continued to higher rotation with the increased drift. Where nail heads had pulled through the siding was observed to have limited separation from the underlying framing</p> <p>-Longitudinal direction sliding continued to increase</p>	  		5.0%	

Table C-5 Earthquake Damage Observations for Specimen C-2 - Superstructure with Plywood Siding (T1-11) Exterior, Gypsum Wallboard Interior

		Damage Appearance			Wall Peak Transient Target Drift Ratio (%)	Hysteresis Curve
Wall Finish Materials	Damage Description	Overall Pattern	Local Appearance			
	<p>-The base of the walls at the west wall pier had started to offset out-of-plane similar to the center piers. A second restraint was added for 6% drift cycles</p> <p>-The wall superstructure was generally observed to be pushed off of the 4x6 nailer and foundation</p> <p>-A substantial number of wall bottom plate nails were believed to have been fully withdrawn and there was little remaining capacity</p>	 <p>South wall at start of cycles to 6% drift, with restraint added to help keep west wall pier from moving out of plane off of foundation</p>	 <p>The superstructure wall being pushed along the 4x6 nailer and foundation, with slip up to four inches measured in both directions (left and center), Thor, Dave and Grace concur with decision to stop testing (right)</p>		6.0%	

APPENDIX D Working Group 4: Post-Test Finish Removal and Observations

Following completion of testing for each specimen, portions of the finish materials were selectively removed to allow detailed observations of the conditions underlying the materials and any hidden damage. This appendix provides a summary of those observations. The reader is reminded that the specimens were tested to very significant drift levels. In some instances, the drift at which observed behaviors occurred is known, while in others it is not known. The extreme level of displacement should be kept in mind when considering the observations that follow.

D.1 Specimen AL-1 Observations

The following describes observations made at the conclusion of testing Specimen AL-1. Included are detailed observations from the interior of the crawlspace and from removal of select portions of the exterior stucco.

D.1.1 Crawlspace Observations

While the crawlspace was overall substantially intact, the horizontal lumber sheathing could be seen to have pulled off of the framing in most locations. In many locations the sheathing boards were pulled one to 2 in. off of the face of the framing; in several instances, the lumber sheathing had completely detached, only held in place by surrounding framing and stucco. The prying off of the lumber sheathing resulted in gaps between the sheathing and studs, and varying spacing between the sheathing boards, which were initially installed with uniform gaps between boards; see Figure D.1.

Crushing and gapping could be seen at the stud to foundation sill plate interface. Gapping seen at the end of testing was on the order of 1/8-in. maximum and tended to be over the full stud area. Crushing occurred under the edge of most studs, but was less than 1/16 in. deep. The crushing is thought to be a result of rocking of the studs rather than axial compression over the full stud area; see Figure D.2.



(a)



(b)

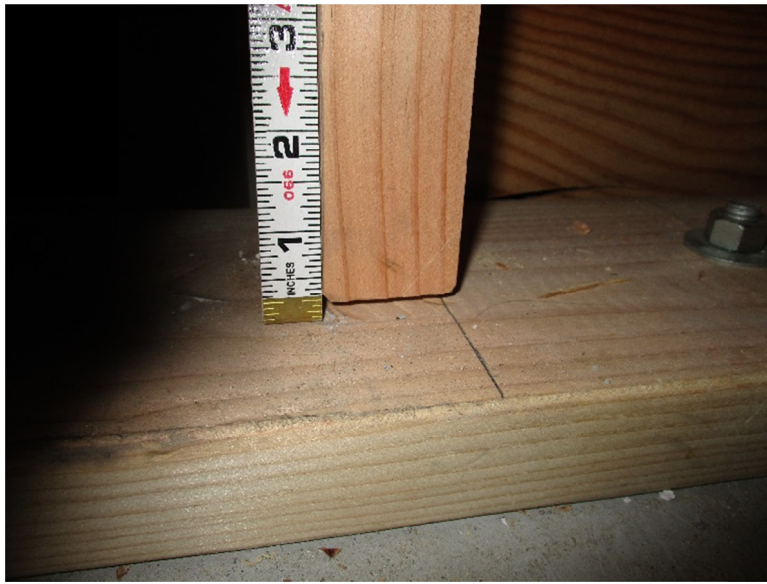


(c)



(d)

Figure D.1 Prying of the lumber sheathing resulted in gaps between the sheathing and studs, and varying spacings between the sheathing boards.



(a)



(b)

Figure D.2 Crushing of studs potentially due to rocking rather than axial compression over the full stud area.



(a)



(b)

Figure D.3 Negligible change in tension of the instrumented bolts during the entire duration of the test.

The nuts and cut washers were removed from a number of anchor bolts to allow detailed observation of the anchor bolt and surrounding foundation sill plate. There was no apparent indication of any slip, crushing of wood, or other similar behavior in any of the locations examined. The sill plate wood was observed to be slightly smoother under the cut washer, indicating very limited wood crushing. It is not clear if this is a result of the testing or the initial tensioning of the bolts to approximately 400 lbs. The tension of the instrumented bolts was seen to stay very close to 400 lbs during the entire duration of the test; see Figure D.3.

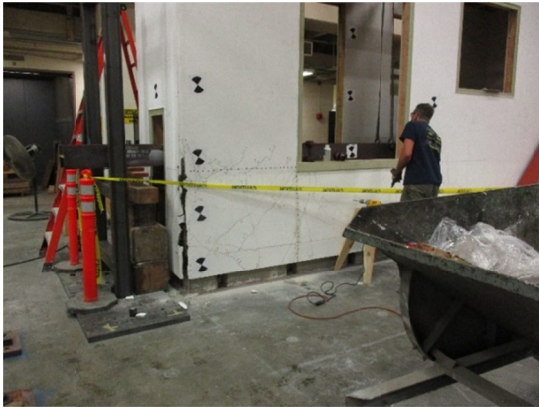
D.1.2 Stucco Removal Observations

Stucco was removed to observe underlying conditions at the south-west corner of the test specimen, as seen in Figure D.4. The removal involved drilling a series of closely spaced holes, chipping stucco out with a chisel to expose the wire lath, and then cutting the lath. Using this method, each section of stucco was able to be removed substantially intact. At time of removal, the stucco furring nails were providing little or no attachment of the stucco to the underlying framing.

The first section removed was the south end of the west-end wall, extending several feet up from the foundation. This panel showed that the building paper had been trapped in the bottom of the stucco. As a result, the building paper tore during panel removal and remained attached to the panel; it appeared the paper would have remained substantially intact had the panel not been removed. For this west-wall panel, the furring nails were almost exclusively withdrawn from the underlying sheathing. It is believed this is because the movement of the stucco during testing was out-of-plane relative to the sheathing below, thus pushing the stucco off of the sheathing and framing, and putting these nails in direct tension. The stucco was otherwise observed to be in good condition; see Figure D.5.

Next, the west end of the south wall was removed from the foundation up by several feet. On this panel, the stucco furring nails almost exclusively had the head of the nail pulled out of the stucco, and the remaining nails were embedded in the sheathing; see Figure D.6. During testing, the cripple wall stucco began flaring out away from the foundation and framing. The flaring increased as the level of displacement increased, which is consistent with the observed pull out of the nail heads, and the stucco being forced to ride over the top of the nail heads. The widening flare from the bottom of the wall upward from the foundation indicates the increasing number of nails pulling out of the wall as the test progressed.

At the end of testing, the building paper was seen to be in relatively good condition. Tearing of the paper had occurred at the corners, requiring that the stucco be removed as part of the repair and replacing the paper a possibility. In the field of the paper, there was little damage to observe. The nail holes through the building paper were observed to be slightly elongated; see Figure D.7.



(a)



(b)

Figure D.4 Stucco underlying conditions observed at south-west corner.



(a)



(b)

Figure D.5 Building paper in south-end of the west wall observed to be in good condition.



(a)



(b)

Figure D.6 Stucco underlying conditions at west-end of the south wall.



Figure D.7 Building paper at west end of the west-end wall observed to be in good condition.

D.2 Specimen AL-2 Observations

The following describes observations made at the conclusion of testing Specimen AL-2. Included are detailed observations from the interior of the crawlspace and from removal of select portions of the exterior stucco.

D.2.1 Crawlspace Observations

Overall, the crawlspace longitudinal walls were substantially intact, as seen in Figure D.8; however, the diaphragm had detached from the cripple walls near the end of testing (see Section 3.10), causing significant framing disruption at the two end walls and the corners where the end walls and longitudinal walls meet. Figure D.9 shows the framing disruption at the east-end wall

from the diaphragm slip, which occurred between the upper and lower top plates. The lapped top plates at the corners pulled apart. The rim joist at the east wall rolled over, with its top being pulled west. Figure D.10 shows framing and sheathing disruption at the west-end wall.

On the east- and west-end walls, the horizontal sheathing was seen as having pulled off of the framing, which is similar to behavior observed in Specimen AL-1; see Figure D.11.

On the longitudinal (north and south) walls, the lumber sheathing had significantly less disruption. The sheathing boards were seen from the interior to generally be flush to the cripple wall framing, and to have generally uniform spacing (consistent with original installation). Some limited nail withdrawal was visible from the exterior, but not the significant withdrawal seen in Specimen AL-1; see Figure D.12.

Crushing and gapping could be seen at the stud to foundation sill plate interface at the east- and west-end walls. Gapping seen at the end of testing was on the order of 1/8 in. maximum and tended to be over the full stud area. Crushing was seen to have occurred under the edge of most studs, but less than 1/16in. deep. The crushing is thought to be a result of rocking of the studs rather than axial compression over the full stud area; see Figure D.13(a) and (b) for the east-end wall and Figure D.13(c) for the south wall, with much less evident gapping.



(a)



(b)

Figure D.8 **Substantially intact longitudinal walls of crawlspace.**



(a)



(b)



(c)



(d)

Figure D.9 Framing disruption at the east-end wall from the diaphragm slip.



(a)



(b)

Figure D.10 Framing and sheathing disruption at the west-end wall from the diaphragm slip.



(a)



(b)

Figure D.11 Pull out of horizontal sheathing from framing east and west walls.



(a)



(b)

Figure D.12 Significantly less disruption of lumber sheathing of longitudinal (north and south) walls.



(a)



(b)



(c)

Figure D.13 Crushing and gapping at the stud to plate interface at the (a) east-end wall; (b) bottom of east end wall stud; and (c) top of south-wall stud.

The nuts and cut washers were removed from a number of anchor bolts to allow detailed observation of the anchor bolt and the 2×4 blocks that were connected to the foundation sill plate and foundation using the anchor bolts; see Figure D.14. There was no apparent indication of any slip, crushing of wood, or other similar behavior in any of the locations examined. The 2×4 blocking wood was observed to be slightly smoother under the cut washer, indicating very limited wood crushing. At the start of testing, the anchor bolts had been tightened to an initial tensioning force of approximately 100 lbs; during testing the anchor bolt loads were increased to between 500 and 1200 lbs. Figure D.14(a) shows an anchor bolt on the south wall. Figure D.14(b) shows an anchor bolt on the east wall.

The cripple wall top plates had been attached to the rim joist of the floor framing above with fourteen A35 shear clips on each of the 20-ft-long walls, as required by the FEMA P-1100 retrofit provisions; see Section 3.5. These angle clips are an important part of the load path that allows the capacity of the plywood retrofit sheathing to develop. The A35 clips did not show any indication of slip, degradation, or deformation or of the framing interface. Figure D.15 shows an A35 clip following testing.

The nailing for the plywood retrofit sheathing experienced significant withdrawal from the framing over most of the sheathing area. The sheathing nailing into the upper top plate withdrew ~ 2 in. over most of the plywood length. Because of the extent of this withdraw, the nails had completely withdrawn from the top plate framing. Most were left loosely embedded $1/2$ in. into the plywood, and some had dropped to the floor of the crawlspace. This is consistent with the upper top plate having moved with the floor diaphragm when it broke free of the cripple walls. The withdrawal of the nails from the lower top plate was on the order of $1/4$ in. to $1/2$ in. Most nails were observed to be significantly bent but not fractured. A few nails were found to be fractured; see Figure D.16.

Out-of-plane gaps were observed between the plywood sheathing and the supporting cripple wall framing. Gaps were estimated to $1/2$ -in. to $3/4$ in. at the top [see Figure D.17(a) and (b)], approximately $1/2$ in. at the bottom (Figure D.17(c)), and approximately $1/4$ in. at mid-height of the plywood; see Figure D.17(d).



(a)



(b)

Figure D.14 Anchor bolt and surrounding foundation sill plate.



Figure D.15 Condition of A35 clip following testing.



(a)



(b)

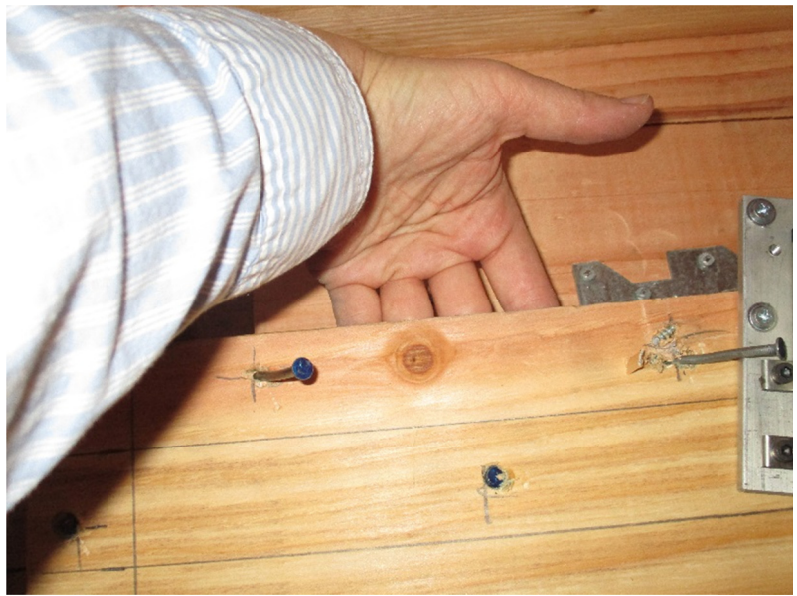


(c)

Figure D.16 Nailing damage for the plywood retrofit sheathing.



(a)



(b)



(c)



(d)

Figure D.17 Gaps between the plywood sheathing and the supporting cripple wall framing.

Gapping was also seen at the base of the plywood due to vertical upward movement at an end of the plywood, as seen in Figure D.18. This is believed to be associated with plywood rotation due to cripple-wall racking.

For the most part, there was no evidence that the plywood slipped enough vertically to bear on the framing above, as seen in Figure D.19(a). In one location, however, crushing of the floor joist consistent with plywood panel bearing down was observed; see Figure D.19(b).

Because splitting of blocking at anchor bolts had been observed in the small-component testing at UCSD, significant attention was paid to the condition of the blocking at anchor bolts in Specimen AL-2. Where access opening in the plywood sheathing permitted, photographs were taken from above looking for splitting of the block that might fracture the top surface. No splitting was seen in the blocks that were accessible; see Figure D.20.



Figure D.18 Gapping at base of the plywood due to vertical upward movement at an end of the plywood.



(a)



(b)

Figure D.19 Plywood vertical slip toward the framing above (a) not touching; (b) only spot observed to touch framing. Arrow shows location of limited crushing.



Figure D.20 No splitting in the retrofitted blocks.

Plywood cripple-wall sheathing was removed in selected locations to allow more complete access to observe splitting of the blocking. Figure D.21(a) shows an overview of the framing with the plywood removed. Figure D.21(b) shows a block with no splitting. Figure D.21(c) and (d) show the one block in which splitting occurred. The splitting can be seen in both the vertical and the top faces of the block. This block occurred near the middle of the north wall.



(a)



(b)



(c)



(d)

Figure D.21 Plywood cripple wall sheathing was removed to allow more complete access to observe splitting of the blocking. Gaps between the plywood sheathing and the supporting cripple wall framing are shown: (a) overview of the framing with the plywood removed; (b) a block with no splitting; and (c) and (d) the one block where splitting occurred.

D.2.2 Stucco Removal Observations

Stucco was removed to observe underlying conditions at the south west corner (Figure D.22) and south-east corner of the test specimen. The removal involved drilling a series of closely spaced holes, chipping stucco out with a chisel to expose the wire lath, and then cutting the lath. Using this method, each section of stucco was able to be removed substantially intact. At time of removal, the stucco furring nails provided little or no attachment of the stucco to the underlying framing.

The first section removed was the west end of the south-end wall, which extended several feet up from the foundation. In this panel, the building paper had adhered to stucco and came off with the removal of the stucco. Except for tearing at the corner, the building paper did not have

any significant tears. It did have slots of up to 5 in. that had been gouged by stucco nails; see Figure D.23(a) and (b). The stucco nails remained embedded in the lumber sheathing with the heads pulled out of the stucco; see Figure D.23(c).

The second section removed was the south end of the east wall. Similar to the west-end wall section removed from Specimen AL-1, the stucco appears to have been pushed out of plane, resulting in tension of the stucco nails and withdrawal of the nails from the lumber sheathing; see Figure D.24.



(a)



(b)

Figure D.22 Stucco removed to observe underlying conditions at the south-west corner and south-east corner.



(a)



(b)



(c)

Figure D.23 Stucco inspection in the west end of the south end wall: (a) building paper damage status while was adhered to stucco; (b) slots of up to 5 in. gouged by stucco nails; and (c) stucco nails remained embedded in the lumber sheathing with the heads pulled out of the stucco.



(a)



(b)



(c)

Figure D.24 Stucco inspection in the south end of the east wall.

D.3 Specimen B-1 Observations

The following describes observations made at the conclusion of testing Specimen B-1. Included are detailed observations of conditions at the end of testing, observations from removal of the plywood retrofit sheathing, and observations from removal of two retrofit anchors. As Chapter 4,

the use of retrofit anchors required that Specimen B-1 be constructed inside out, with the shiplap exterior siding on the inside of the specimen and the cripple-wall retrofit on the exterior.

D.3.1 Observed Conditions at End of Testing

Overall photos of the specimen at the end of testing can be seen in Figures D.25 to D. 32 to F4.8. Following the final monotonic push to the west, the specimen was brought back to as close to vertical as possible, with some lean remaining. The cripple-wall shiplap siding (Figures D.31 and D.33) had little or no sign of damage in spite of the significant drift it experienced. In one location, there was light visible between siding boards, indicating that some shifting of the boards had occurred.

At the east end, both 2×6 foundation sill plates split through their full 1-1/2-in. height, as seen in Figure D.33. The splitting resulted from out-of-plane leaning of the studs and the restraint provided by the retrofit anchor. As a result of the splitting of the foundation sill plates, these anchors would no longer be able to provide in-plane shear capacity. Also at the east end of the north and south walls, the 2×4 blocks nailed to the 2×6 foundation sill plate had lifted up, with the face nails partially withdrawn. Some blocks lifted up more than 1-1/2 in. but others considerably less; see Figure D.34. At the west end, the studs rotated but the 2×6 foundation sill plates did not split. Local stud splitting occurred but was not of structural concern.



Figure D.25 Specimen B-1 overall view of south wall at conclusion of testing.



Figure D.26 Specimen B-1 west end of south wall at conclusion of testing.



Figure D.27 Specimen B-1 center portion of south wall at conclusion of testing.

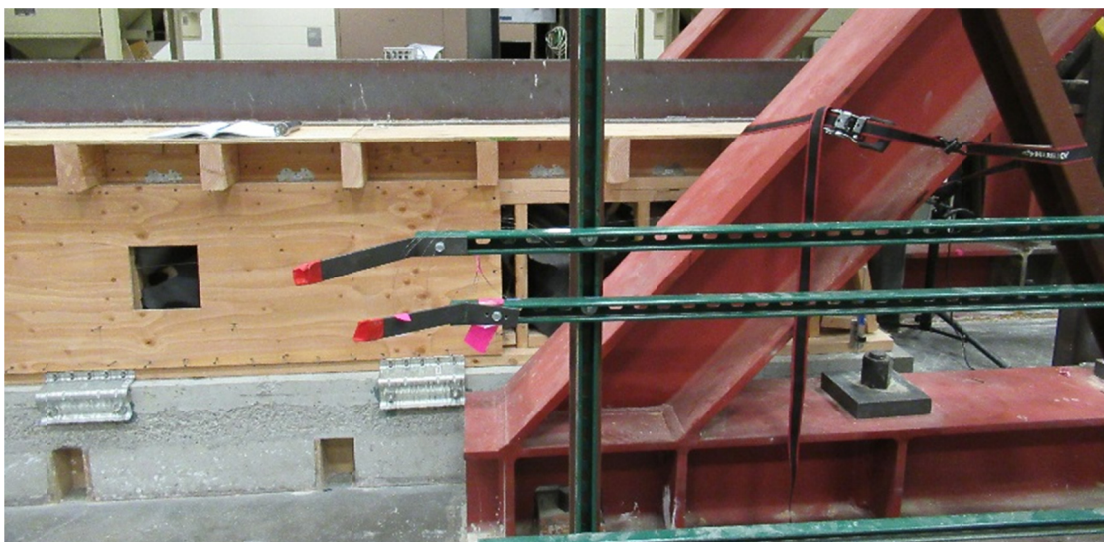


Figure D.28 Specimen B-1 east end of south wall at conclusion of testing.



Figure D.29 Specimen B-1 east end at conclusion of testing.



Figure D.30 Specimen B-1 east end at conclusion of testing.



Figure D.31 Specimen B-1 west end at conclusion of testing.



Figure D.32 Specimen B-1 west at conclusion of testing



Figure D.33 Specimen B-1 west end at end of testing. The foundation sill plates are seen to have split through their full depth.



Figure D.34 Specimen B-1 east end at end of testing. Note: 2× blocks on foundation sill plate that have lifted up.

At the end of testing the specimen was pushed back as close to vertical as possible and examined. The full north- and south-side the top of the studs had separated from the top plates above; see Figure D.35 and D.36. As shown in Figure D.35, the stud that used to be located under the edge of the plywood had fallen about 4 in. to the right of the plywood sheet. In Figure D.36, the end nails that fastened the top plate to the stud can be seen to be fully withdrawn. This separation is assumed to have occurred following the final monotonic push while the specimen was being re-centered. In one case, the top of the stud was observed to have split; see Figure D.37. This is believed to have occurred when the top of the studs slid.

The clip angles between the cripple-wall top plates and the floor-joist blocking did not have any noticeable signs of deformation or deterioration; see Figure D.38.

Of the four sections of retrofit plywood sheathing that had been installed, three of the panels had completely detached from the framing along the panel bottom and about one-third of the way up the vertical ends. For these nails, the failure mode was almost exclusively nail withdrawal. One plywood panel had completely detached at the top and one-third of the way down the sides, and was also separated from the top plates about 3 in. For these nails, two-thirds failed with a head pull-through mechanism and the other third in withdrawal; see Figures D.39 to D.40. Almost all of the nails that had withdrawn extended 1-1/2 in. past the face of the plywood, which left 1/2 in. of the nail lodged the plywood and 1/2-in. protruding out the back. The nails were no longer engaged in the framing at all, and showed indications of bending; see Figures D.41 through D.43.



Figure D.35 South wall plywood at conclusion of testing. Note that the stud has shifted approximately 4 in. relative to the plywood that used to be nailed to the stud.



Figure D.36 South wall at conclusion of testing. Note with drawn stud end nails at original stud location and new stud location approximately 4 in. to the left.



Figure D.37 South-wall stud shifted approximately 4 in. to the left. Stud splitting is believed to have occurred when the stud shifted.



Figure D.38 Shear clip with no visible indications of deformation or damage.



Figure D.39 Sheathing nailing withdrawal at the bottom of the plywood panel.



Figure D.40 Sheathing nailing damage at the top of the plywood panel, including both nail withdrawal and nail head pull through.



Figure D.41 Sheathing nails withdrawn enough to no longer engage the framing.



Figure D.42 Nails withdrawn from framing and only embedded in plywood.



Figure D.43 Sheathing nails withdrawn and bent.

D.3.2 Plywood Observations

The two plywood sheathing panels on the south wall were removed. The interior face of the sheathing can be seen in Figure D.44 through D.47.. Horizontal slots in the sheathing panel face were seen at all locations where the plywood nails had withdrawn. Most of the slots were horizontal and approximately 3/4 in. long. In addition, the framing had also been significantly slotted at the sheathing nail locations. Where the sheathing had been fully detached, slots of one to 1-1/4 in. were evident. Where the sheathing had remained attached, slots of about 1/2-in. were evident; see Figures D.48 to D.50. While occasional splits in framing were seen, they did not appear to be associated with the plywood nailing.



Figure D.44 Nail slotting observed on interior face of plywood after selective removal.



Figure D.45 Nail slotting on interior face of plywood.



Figure D.46 Nails and slotting at interior face of plywood following selective removal.



Figure D.47 Nail slotting on interior face of plywood at panel edge.



Figure D.48 Slotting observed on cripple wall framing with plywood removed.



Figure D.49 Slotting observed on cripple wall blocking on top of foundation sill plate with plywood removed.



Figure D.50 Slotting observed in cripple wall top plates with plywood removed.

D.3.3 Siding Observations

Several sections of the shiplap siding were removed for inspection. The exterior face of the siding once removed can be seen in Figures D.51 and D.52. Except for damage around the nail heads, which occurred during siding removal and some hairline cracking, there was no notable damage seen on the exterior face of the siding. The interior face of the siding can be seen in Figures D.53 through D.55. While some nail holes remained round, others were elongated up to about 3/4 in. Where siding was removed, small splits were observed in the studs at each siding nail, as seen in Figures D.56 and D.57. Note: the nails were very easy to pull during removal of the siding; this is thought to be related to the studs splitting. The same behavior was noted in Specimen C-1 shiplap siding.



Figure D.50 Slotting observed in cripple wall top plates with plywood removed.



Figure D.51 Exterior face of shiplap siding,



Figure D.52 Exterior face of shiplap siding,



Figure D.53 Interior face of shiplap siding showing slotting of the siding that is not evident from exterior face.



Figure D.54 Interior face of shiplap siding.

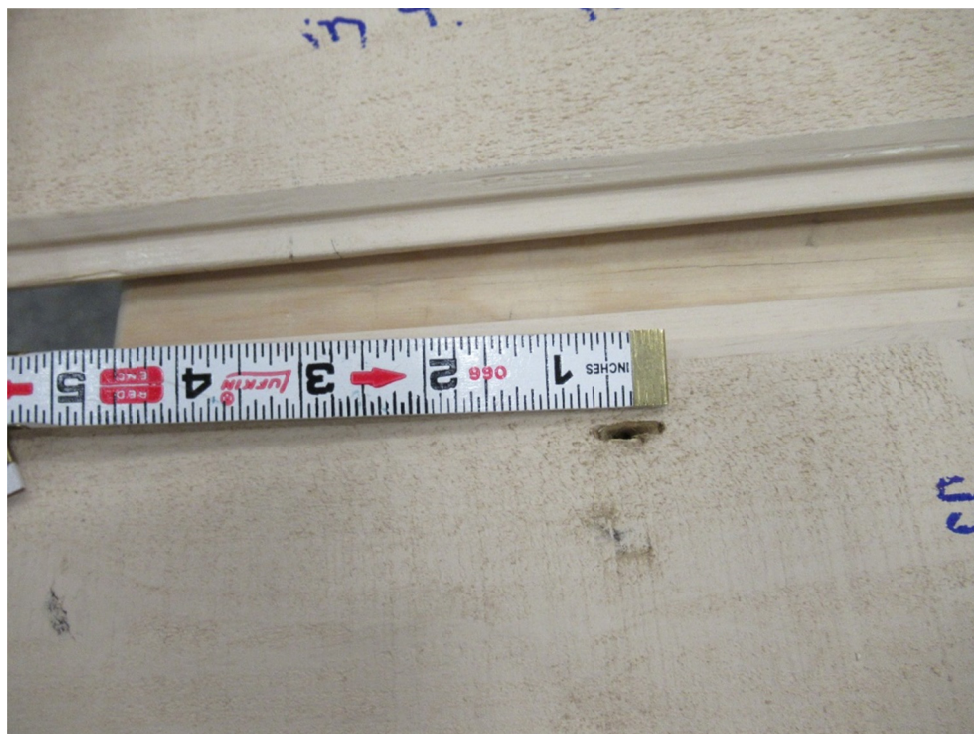


Figure D.55 Interior face of shiplap siding.



Figure D.56 Local splitting at stud end with horizontal lumber siding removed.



Figure D.57 Local splitting of stud with horizontal wood siding removed.

D.3.4 Retrofit Anchor Observations

At the end of testing there was little evidence of deformation or damage to the retrofit anchors anchoring the foundation sill plates to the foundation. Observations included a very slight horizontal rotation of the brackets, but too small to be easily measured. About half of the threaded rod nuts were loose, with one backed off about 1/4 in. Several of the threaded rods appeared to be slightly bent vertically, but with 1/16 in. or less of movement. There was no sign of local or global deformation of the retrofit brackets. Two of the retrofit plates were removed to inspect conditions below; see Figures D.58 through D.61. Behind the retrofit plate, minimal crushing and discoloring were noted where dimples in the plate bore against the 2 × 6 foundation sill plate. There was no appreciable distortion or elongation of the SDS screw holes into the 2 × 6 sill plate.



Figure D.58 Foundation and foundation sill plate following removal of retrofit anchor (seen above).



Figure D.59 Foundation sill plate following removal of foundation anchor.



Figure D.60 Foundation anchor following removal of foundation plate.



Figure D.61 Foundation anchor plate following removal.

D.4 Specimen C-1 Observations

The following describes observations made at the conclusion of testing Specimen C-1. Included are detailed overall observations at the conclusion of testing, as well as observations from removal of the exterior shiplap siding and removal of the interior wood lath

D.4.1 Observed Conditions at End of Testing

An overall view of the test specimen is provided in Figure D.62. By the end of testing, virtually all of the plaster had fallen off of the wood lath at the north and south walls, and was sitting in piles on the floor. Occasional small patches of plaster remained attached, as did the plaster at the very top of the north and south walls, from the bottom of the headers and up. The plaster at the east and west walls had significant cracking but remained attached to the lath; see Figures D.63 through D.65. The siding showed limited amounts of partial nail withdrawal, nail pull through, and occasional hairline cracking. The nail withdrawal and pull through was generally on the order of 0.10 in.; see Figures D.66 through D.70.



Figure D.62 Specimen C-1 overall photograph at conclusion of testing.



Figure D.63 Plaster remaining at north wall pier; plaster at south wall was in similar condition.

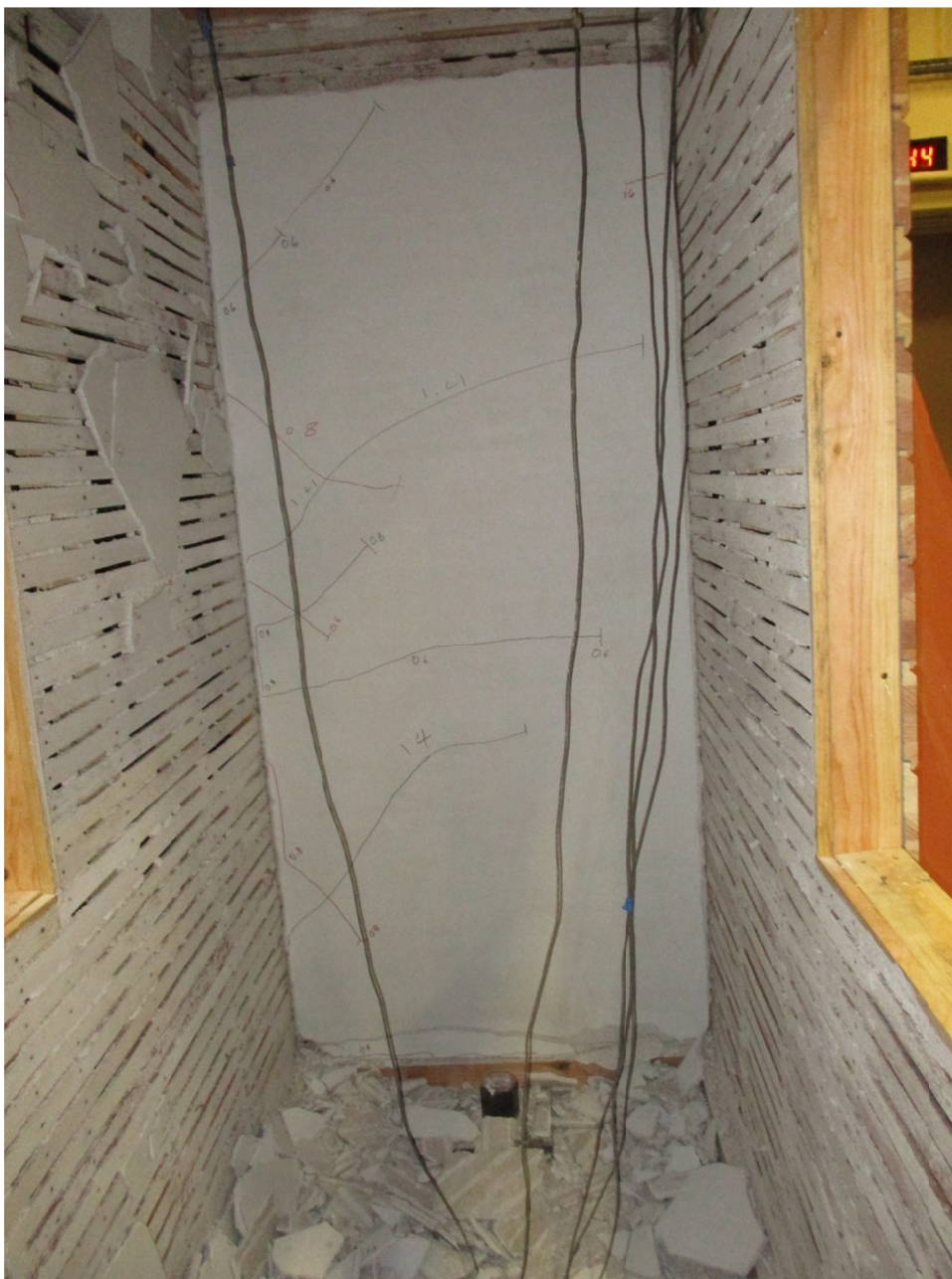


Figure D.64 Plaster cracked but still intact at the east end wall. Note piles of plaster debris on the floor.



Figure D.65 Plaster still intact at the very top of the south wall; plaster at the south wall was in similar condition.



Figure D.66 Siding condition at conclusion of testing. Nails with circles had limited nail withdrawal.



Figure D.67 Siding showing light nail withdrawal and slight nail head pull through at conclusion of testing.



Figure D.68 Head pull through at siding nailing.



Figure D.69 Siding nail withdrawal at conclusion of testing.



Figure D.70 Splitting of siding at top of foundation at east end wall.

D.4.2 Siding Observations

Several siding boards were removed to permit detailed observation of the siding conditions. Figures D.71 through D.73 show the backside of the siding and evidence of slotting of the siding back face. Figures D.74 and D.75 show local splitting of the studs observed at each siding nail. The siding nails were noted to be relatively easy to remove, which is believed to be in part to the stud splitting at the nails. Similar observations were made of the siding in Specimen B-1. The splitting was narrow, and there was generally a separate crack at each nail rather than the cracks propagating from each nail to each nail. For these reasons, the cracks did not cause concern regarding the capacity of the stud but did appear to affect the siding.

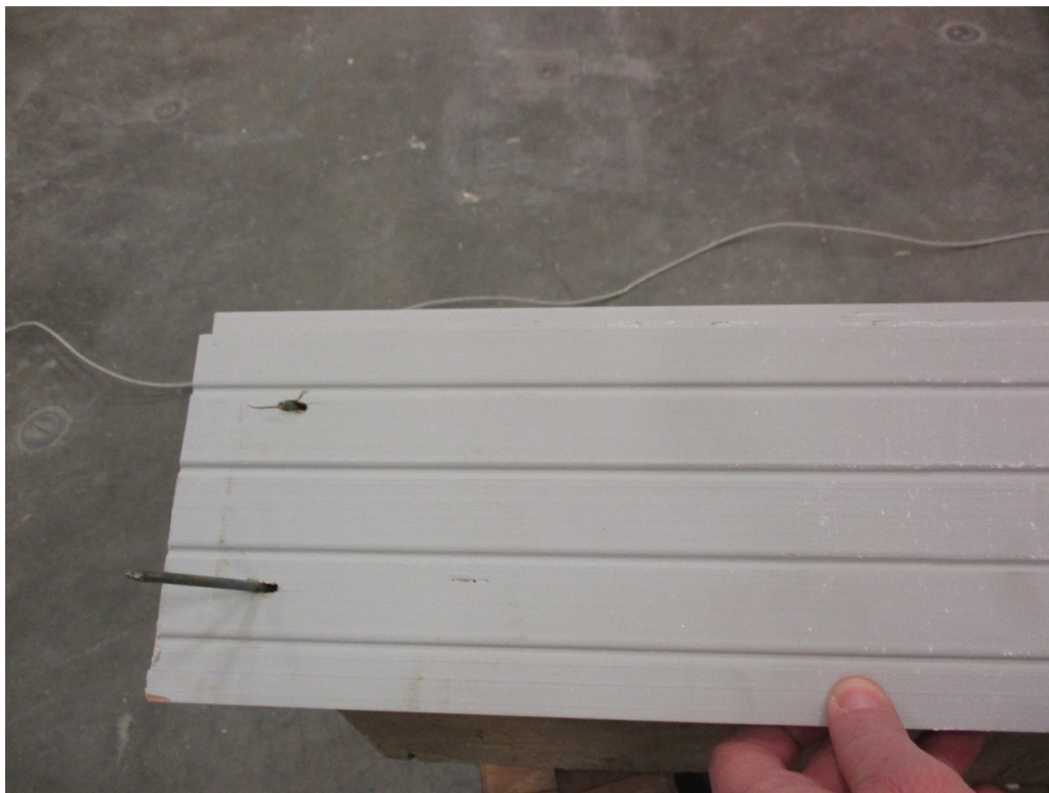


Figure D.71 Interior face of siding following removal.



Figure D.72 Interior face of siding following removal, showing nail slots in siding.



Figure D.73 Interior face of siding following removal, showing nail slots in siding.



Figure D.74 Wall framing observed after siding removal.



Figure D.75 Close-up of wall framing showing narrow splits at siding nail locations and large splits in vicinity of header.

D.4.3 Wood Lath Observations

At the conclusion of testing, as previously discussed, most all of the plaster on the north and south walls was completely detached from the wood lath and sitting on the floor of the test specimen. As the plaster finish broke off of the interior face, the plaster keys that anchored the plaster to the lath also fell down into the stud cavity. As a result, the stud cavity was filled with a significant accumulation of fallen keys; see Figures D.76 and D.77. During testing, the falling of the keys sounded similar to rain. Even after the interior face plaster and the back keys had fallen, in many locations plaster remained wedged between the lath boards; see Figure D.78. The plaster remaining between boards was fairly widespread, and is believed to have helped the wood lath contribute some strength and stiffness even after the plaster had fallen off. The back side of the wood lath (Figure D.79) and the studs where the lath was attached (Figure D.80) did not show signs of hold elongation or splitting.



Figure D.76 Piled plaster keys at the bottom of the wall stud cavity at conclusion of testing.



Figure D.77 Plaster keys still remaining in place and pile of fallen keys at conclusion of testing.



Figure D.78 Plaster keys still remaining between wood lath boards at conclusion of testing.



Figure D.79 Back side of wood lath board with nail hole showing no signs of enlargement or elongation.



Figure D.80 Studs below removed wood lath boards showing no signs of splitting or slotting at lath nail locations.

D.4.4 Building Paper Observations

It was not possible to observe the building paper until after testing was completed; it was found to be extensively torn and slotted; see Figure D.81



Figure D.81 Building paper was highly disrupted at the conclusion of testing.

D.5 Specimen C-2 Observations

The following describes observations made at the conclusion of testing Specimen C-2. Included are detailed overall observations, as well as observations following the removal of the T1-11 plywood siding and the interior gypsum wallboard.

D.5.1 Observed Conditions at End of Testing

Figure D.82 shows the overall condition of the specimen at the conclusion of testing. During testing, strapping was used around the middle wall piers to keep base of these sections of wall from moving outward and falling off of the foundation. Additional strapping at the west-end pier was also added at the conclusion of testing.

The base of the west wall is seen in Figures D.83 and D.84. Because the base of the wall both uplifted and slid to the east during testing, the T1-11 siding was crushed as the wall sat back down on the siding. In addition the base of the wall became concave because during a cycle of sliding to the east, the 2×4 bottom plate got wedged in place and did not return to its original location.

The south wall T1-11 siding remained in generally good condition; see Figures D.85 through D.88. This is in large part due to the test capacity being governed by overturning resistance rather than by the shear capacity of the wall. Only limited working of the sheathing nails limited withdrawn nails were observed. No edge tear out was seen. A small number of

flakes of the surface ply occurred; see Figure D.89. Some damage to the bottom of the T1-11 and trim were seen at the south east corner; see Figure D.90.



Figure D.82 Specimen C-2 overall view of at completion of testing.



Figure D.83 Specimen C-2 base of west end of at conclusion of testing.



Figure D.84 Specimen C-2 Base of east end of at conclusion of testing.



Figure D.85 Specimen C-2 condition of south wall at conclusion of testing.



Figure D.86 Specimen C-2 condition of south wall at conclusion of testing.



Figure D.87 Specimen C-2 condition of south wall at conclusion of testing.

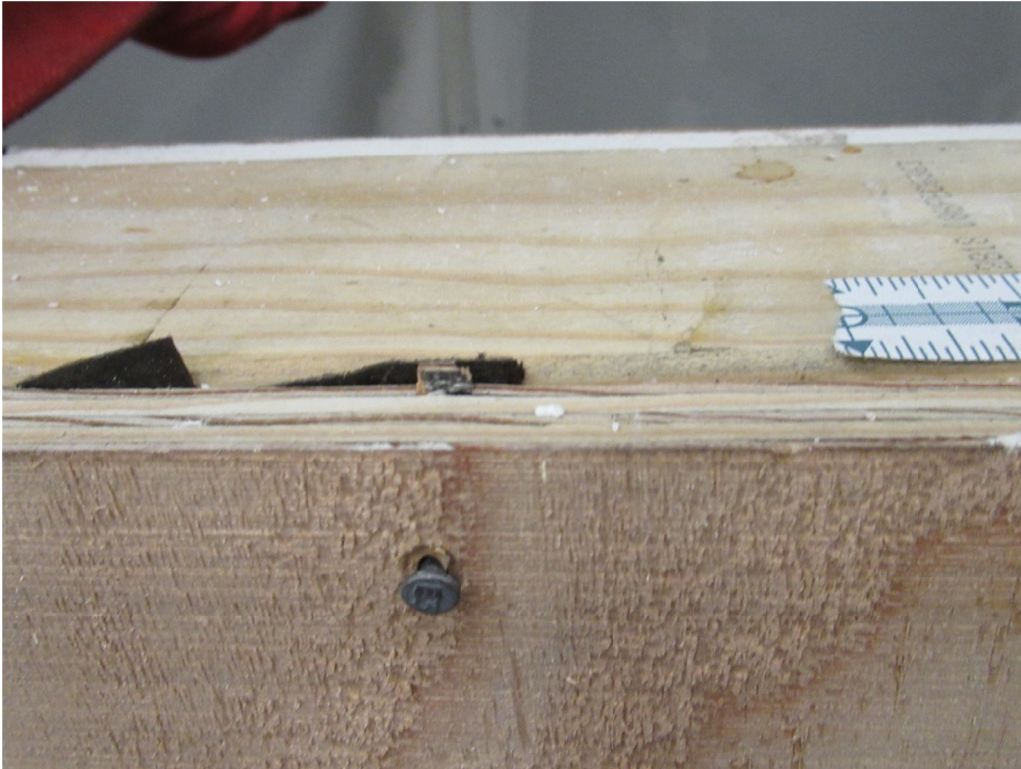


Figure D.88 Specimen C-2 condition south wall at conclusion of testing.

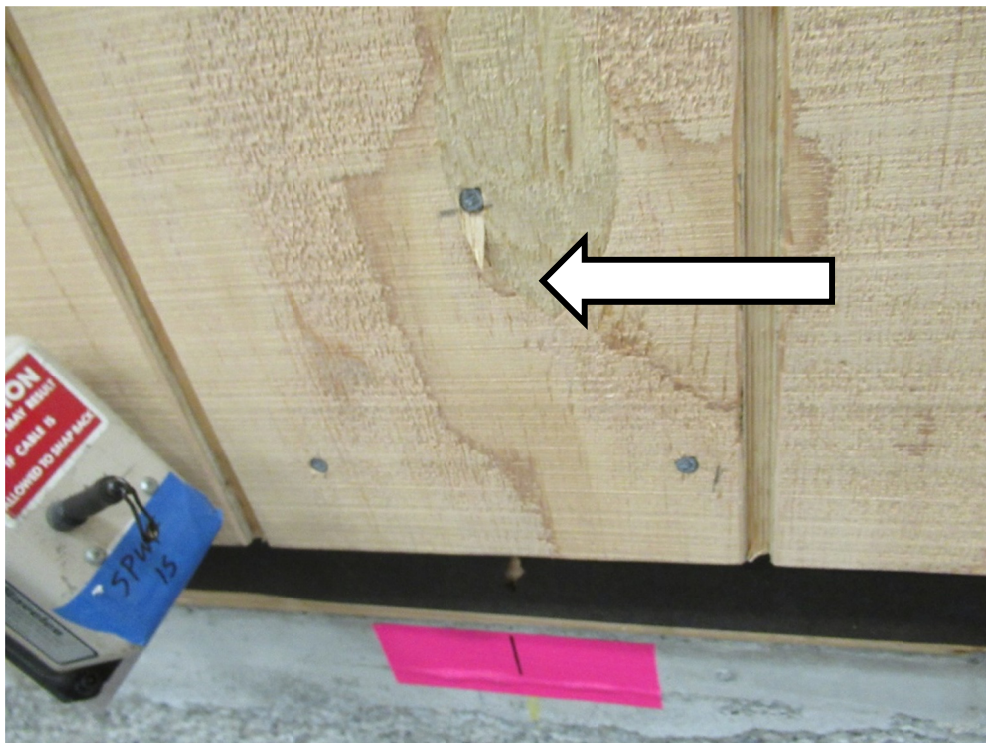


Figure D.89 Local flake in surface ply of T1-11 siding.



Figure D.90 **Fractured trim a specimen corner.**

The east wall (like the west wall) suffered significant damage, with the wall uplifting and then sitting back down on the foundation. Figures D.91 through D.93 show the damage to the siding, trim, and foundation sill plate. Building paper that was installed under the siding originally ran down the face of the wall, but tucked itself under the wall framing also.



Figure D.91 Siding damage at base on east wall.



Figure D.92 Siding damage at base on east wall.



Figure D.93 Siding damage at base on east wall.

The north wall, in addition to nail withdrawal patterns similar to the south wall, developed a fracture approximately 12 in. long from the top corner of the window and extending east (Figure D.94). A vertical offset at the T1-11 joint and nail working can be seen in Figures D.95 and D.96. Additional working of sheathing nails can be seen in Figures D.97 and D.98.



Figure D.94 Tear in siding above window in north wall.



Figure D.95 Working of edge nails at the T1-11 vertical joint.



Figure D.96 Working of edge nails at the T1-11 vertical joint.



Figure D.97 Working of edge nails at the T1-11 vertical joint.



Figure D.98 Working of edge nails at the T1-11 vertical joint.

On the interior, the west wall bottom plate that slid and got wedged against the north at south wall bottom plates can be seen in Figures D.99 and D.100. This resulted in the concave appearance at the base of this wall seen in Figure D.83. Offset of the taped gypsum wallboard joints could be seen throughout the interior; see Figures D.101 through D.103. At the edges of gypsum wallboard panels alongside the doors and windows, partial detachment of the gypsum wallboard from the framing could be seen, with some separations up to 1/2-in.; see Figures D.104 and D.105. In addition, gouging of the gypsum wallboard at the nails could be seen, and in some cases were of a fairly significant length; see Figure D.106. Over much of the floor perimeter, debris from the gypsum wallboard was observed, including flaked pieces of joint compound, and gypsum from the core of the board gouged by nails at the bottom of the walls; see Figure D.107. Also visible on the interior at a pocket in the gypsum wallboard for instrumentation, the nails holding the 2 × 4 wall bottom plate to the foundation sill plate can be seen to have significantly withdrawn and did not extend into the foundation sill plate; see Figure D.108.



Figure D.99 Base of west-end wall where bottom plate got caught on perpendicular wall framing.



Figure D.100 Close-up of west wall bottom plate to left, withdrawn bottom plate nails to right.



Figure D.101 Tearing and joint compound spalling at gypsum wallboard taped joints.



Figure D.102 Tearing and joint compound spalling at gypsum wallboard taped joints.



Figure D.103 Tearing and compound joint spalling at gypsum wallboard taped joints.



Figure D.104 Separation of the gypsum board wall panel from the wall framing.



Figure D.105 Separation of gypboard from framing.



Figure D.106 Gouging of the gypsum wallboard back face at side of door opening.



Figure D.107 Gouging of gypsum wallboard at the base of the walls.



Figure D.108 Bottom plate nails withdrawn from the bottom plate.

D.5.2 Plywood Siding (T1-11) Observations

Sections of the T1-11 siding were removed for more detailed examination. With the exception of the damage already discussed, the T1-11 siding was seen to be in good condition. At the back face of the siding the nail holes from the sheathing nails were seen to be only minimally elongated, with the only exception being the nailing from the sheathing to the header; see Figures D.109 and D.110.



Figure D.109 Slotting of back side of siding at header.



Figure D.110 Lack of nail hole enlargement or slotting, typical for inside face of siding.

D.5.3 Interior Gypsum Wallboard Observations

Sections of gypsum wallboard were taken off for more detailed inspection. On the back face of the gypsum wallboard, although there were some nail holes with minimal elongation, there were a number of instances of extensive elongation and gouging. The range can be seen in Figures D.111 through D.113. Vertical gouges were observed alongside doors and windows, with gouges tending toward diagonal at the header. Bottom nails had gouged towards the bottom edge, in some cases pulling out a plug of the gypsum core.



Figure D.111 Nail hole slotting and gouging on inside face of gypsum board panels.



Figure D.112 Nail hole slotting and gouging on inside face of gypsum board panels.



Figure D.113 Nail hole slotting and gouging on inside face of gypsum board panels.

D.5.4 Bottom Plate Observations

By the end of the test, most all of the nails fastening the 2×4 wall bottom plate to the foundation sill plate had been withdrawn. This included a number of nails that were simply withdrawn and did not re-engage (Figures D.114 and D.115); and nails that withdrew and were bent over between the 2×4 and the foundation sill plate; see Figures D.116 and D.117.



Figure D.114 Bottom plate fastening withdrawal at conclusion of testing.



Figure D.115 Bottom plate fastening withdrawal at conclusion of testing.



Figure D.116 Bottom plate fastening withdrawal at conclusion of testing. Bottom of nail is bent and point can be seen between bottom plate and 4x nailer below.



Figure D.117 Bottom plate fastening withdrawal at conclusion of testing. Bottom of nail is bent and point can be seen between bottom plate and 4× nailer below.

D.5.5 Building Paper Observations

The building paper could not be observed until the conclusion of the test. When examined, it was found to be systematically torn in the vicinity of the headers; see Figures D.118 and D.119.



Figure D.118 Torn building paper at conclusion of testing.



Figure D.119 Torn building paper at conclusion of testing.