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TEST REPORT

**DYNAMIC OUT-OF-PLANE AND IN-PLANE TESTING OF FULL-SCALE HOLLOW
CLAY TILE INFILLED FRAMES**

FOR

MARTIN MARIETTA ENERGY SYSTEMS, INC

BY

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US ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORIES

MASTER

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1. PURPOSE

The U.S. Department of Energy (DOE) had a need for the technical support and assistance of the U.S. Army Construction Engineering Research Laboratories (USACERL) in connection with the Hollow Clay Tile Test Program.

Martin Marietta Energy Systems, Inc. (MMES), Managing Contractor for the U.S. Department of Energy's Y-12 Plant, is currently assessing the safety of the facilities at the plant. Many of the buildings are constructed of steel and concrete frames infilled with unreinforced clay tile walls. In many instances, these infill walls comprise the major lateral load resisting capacity of the structures. Due to the variability in strength and stiffness and the lack of specific engineering data for this type masonry construction, Energy Systems has begun a research program to evaluate clay tile infill behavior.

A significant portion of this focused research program has been completed. Masonry prism, unit tile, and mortar specimen tests have been performed to establish constitutive material properties. Large (half-scale) infilled steel frames have been tested using various combinations of in-plane and out-of-plane loading. A full-scale lateral air pressure test and two full-scale in-plane racking tests have also been performed. Other procedures such as in-situ bond wrench, normal, flat jack, and bed joint shear tests have been used to characterize aspects of the construction.

The purpose of this task was to complete a part of the shake table testing as defined in the Program Management Plan for the Hollow Clay Tile Wall (HCTW) Program, Y/EN-4433. This test report describes the testing performed by USACERL to accomplish this task. This project was conducted by the Structural Engineering Team which is part of the Engineering and Materials Division, Infrastructure Laboratory. All tests were performed on the Biaxial Shock Test Machine (BSTM) located at USACERL in Champaign, Illinois.

2. SCOPE OF WORK

The scope of this work encompasses shake table testing of two clay tile infilled frames connected to form a three dimensional structure as described in section 3, "Description of Specimen". USACERL constructed a total of four infilled walls. Two of the infills were used for the primary test program, and the other two were retained as backup units, in case of premature failure of one or both of the primary infills, and for possible future testing.

3. Description of Specimen

The specimen consists of a three dimensional structure as shown in Figure 1. Two hollow clay tile (HCT) infilled frames are spaced approximately 9' apart and are connected by steel trusses and a concrete roof slab. The thickness of the concrete slab is 8", providing approximately 12000 pounds of added mass to the structure. Each infilled frame structure is nominally 8' high (wall) by

11' long with the wall placed inside the column flanges and against the column web as shown in Figures 7. Both columns are W10x30 sections. The beam is a W12x40 oriented with its strong axis resisting vertical load.

The masonry panels are single wythe construction built with running bond using an equivalent type N (ASTM C 270) mortar. The clay tiles are laid with the cores horizontal using approximately 1/2 inch full width bed joints and 1/2 inch head joints with only face shell mortar. A full width mortar layer is placed between the base beam surface and the bottom course of the wall panel. The infill is bonded to the column and beam of the specimen frame by snugly packing mortar between the steel and masonry. However, no mortar is placed in the gap between the clay tile and the column flanges. No reinforcement is used in the masonry. The infill is constructed with no offset between the wall and the frame centerline.

The MMES test specifications required the ability to rotate the specimen 90 degrees in order to test it in both horizontal directions. To accomplish this the walls and columns were built on heavy steel base beam sections which are bolted to the shake table as shown in Figure 1. Beam to column connections are framed connections using double clip angles. Bolts were of the slip critical class and were tightened by the turn of the nut method. All steel is to meet the requirements of ASTM A36.

The clay tile wall weighs approximately 35 psf which leads to an approximate weight of 9000 pounds for the infill plus steel framing. Previous low amplitude vibrations tests (impact hammer and eccentric mass shaker) have indicated the first out-of-plane frequency is approximately 16 Hz. Depending on the quality of the column/infill interface, the in-plane frequency is quite higher and may exceed 40 Hz. Cyclic out-of-plane static drift (1.5% of height) tests have lowered the out-of-plane frequency by as much as 50% and the in-plane frequency by as much as 30%.

4. Test Specimen Fabrication

MMES fabricated the steel frame components and shipped them to USACERL with the clay tile units and sand in sufficient quantity to construct 4 wall specimens. MMES also supplied 3 drawings (Dwg S2E800800A008, Dwg S2E800800A008, and Dwg S2E800800A010) covering the fabrication of the steel frames, masonry infill and the concrete roof slab. These drawings also detailed the exact mix proportions for the mortar and the strength requirements for the concrete. USACERL personnel erected 4 steel frames, and poured concrete on top of the steel base beams to form a base for the masonry in July 1993. A journeyman mason who had worked on previous test projects at USACERL was hired and began building the walls on 23 Aug 1993. Mr. Dale Jones from MMES was present during this work. It was discovered that not enough clay tile units had been shipped, so only 2 walls and half of the third wall were completed. Mr. Jones made arrangements to ship additional units and the remaining walls were completed on 13-14 Sept 1993.

The walls were be constructed per Dwg S2E800800A008 with seven courses of eleven tile each. The bed joint and head joint were approximately 1/2" thick. A full bed joint was used. The

lowest course had a mortar layer between it and the concrete base. It consisted of eleven full tile. The next row up had ten full tiles, with a half-tile on each end. These courses alternated up to the top. The top row was mortared to the steel beam. The end tiles were mortared to the steel web, but no mortar was placed between the column flanges and the wall. The mason prepared 2 mortar batches per wall. Nine 2x2x2 inch mortar cubes were made from each mortar batch for a total of 18 cubes per wall. ASTM C109 was followed for the molding of the specimens. The mortar cubes were air cured in close proximity to the walls. The cubes were marked with the wall number and the batch they were taken from. Three cubes from each batch were tested at 28 days, on the day of the out-of-plane shake table test, and on the day of the in-plane shake table test. Testing procedures were in accordance with ASTM C780. The data sheets for the mortar strengths are located in Appendix A.

USACERL constructed a wooden form and installed the reinforcing steel as detailed in MMES drawing S2E800800A10. Concrete was placed in the form on 8 Sept 1993.

5. Instrumentation and Data Acquisition

Four types of instrumentation were employed during the tests to measure the shake table base input and the response of the 2 walls, including electrical resistance strain gages, accelerometers, linear variable displacement (LVDT) transducers, and linear resistive displacement transducers. Figures 2-5 show the placement of the instrumentation for both walls for both the Out-of-Plane and In-Plane tests.

A. Strain Gages:

Measurements Group type CEA-06-250UN-120 strain gages were used to measure strain in the steel frame components as shown in Figures 2 and 4. These are constantan grid gages with complete polyamide encapsulation which are temperature compensated for steel. The gage grid is 0.250 inches long by 0.120 inches wide. At each measurement location, 2 strain gages were installed and connected together to form a single measurement point as shown in Figure 6. The strain gages were connected to Vishay model 2120 signal conditioners to provide power, balancing and signal amplification.

B. Accelerometers:

Endevco model 7290-10 and 7290-30 accelerometers were used to measure acceleration on the steel and the masonry walls as shown in Figures 2-5. The accelerometers are DC powered with frequency response down to DC frequency. The accelerometers are connected to Endevco model 4476.2 and 4476.2A signal conditioners which provide power, balancing and signal amplification.

C. LVDTs:

RDP Electrosense model LDC1000A LVDTs were used to measure relative displacement between the frame and the masonry as shown in Figures 2-4, and to measure panel displacement

across the face of the walls in the In-Plane tests as shown in Figures 4-5. This transducer is a DC powered unit that provides an electrically isolated output signal. The LVDTs were connected to Endevco model 4471.1A signal conditioners which provide DC power but no signal amplification or electrical balancing. The LVDTs were electrically balanced by adjusting the physical position of sensing core as the gage is installed to produce a zero output signal. Figure 7 shows how the LVDTs were fixtured to measure relative displacement for both test orientations.

D. Absolute Displacement Transducers:

Celeco model PT101-10 and PT101-60A resistive transducers were used to measure the absolute displacement of the shake table and various locations on the walls relative to the shake table foundation floor. These transducers were mounted on a large steel reference frame on the foundation, and their sensing elements were attached to the model using stranded steel extension wires. The measurement locations are shown in Figures 2-5. These transducers were connected to Endevco model 4471.3 signal conditioners which provide DC power and electrical balancing, but no amplification.

E. Data Acquisition and Test Control:

Figure 7 is a schematic block diagram of the instrumentation, data acquisition and test control systems. There were a total of 48 transducer channels used in both the Out-of-Plane and the In-Plane tests as shown in the data acquisition channel lists in Appendix B. The 48 transducer output signals were connected to 3 Data Translation model DT2831-G 16-channel data acquisition boards. A fourth DT2831-G board was used to provide the drive signal to the BSTM for test control during the seismic tests.

6. Out-Of-Plane Testing

Walls 1 and 2 were mounted on the BSTM on 22 October 1993 in the Out-Of-Plane orientation as shown in Figure 8. Mr. Jim Kincaid from Martin Marietta determined that the original method of attaching the concrete roof slab to the walls was not going to provide sufficient clamping force to hold the slab in position. The original design had 5 bolts attaching the slab to each wall. Two of the bolts on each wall attached the slab directly to the 2 steel end columns and the remaining 3 attached the slab to the header I-beam through steel sleeve spacers. MMES made a decision to not use the spacers, but to use a quick setting grout to form a rectangular block around the center bolt on each wall. After the grouting was completed, the roof slab was bolted into place. During the period 18-27 Oct 1993, all of the transducer calibrations were performed and all instrumentation was installed on the model for the Out-of-Plane configuration in Figures 2 and 3.

A series of 4 low level random vibration tests and 3 seismic time history tests were performed in the Out-of-Plane configuration on 28-29 Oct 1993. The exact sequence of tests is shown in the test lists in Appendix C. During these tests, 12 mortar cubes for walls 1 and 2 were crushed to determine their strength as shown on the data sheets in Appendix A.

The low level random vibration tests were performed to measure the natural frequencies of the model, and to determine how much these frequencies changed as the seismic tests were performed. The random tests were performed using a Bruel & Kjaer model 2032 signal analyzer to provide a band-limited white noise signal to drive the BSTM at a vibration amplitude just sufficient to produce a noticeable response in the model. Data was acquired on all 48 data channels, and Fourier transfer functions were computed for A4/A9 (slab/base input), and A7/A9 (upper center of the wall/base input). The first 2 resonant peaks were measured and the results are tabulated in Appendix D.

The seismic tests were performed using a site specific time history record provided by MMES. The record was labeled RISKTH2. Figure 9 shows the acceleration time history and the integrated velocity and displacement records. The displacement record was used to drive the BSTM. Tests were conducted at 1, 2 and 4 times the full scale value of the reference time history as indicated in the sequence of tests in Appendix C. Results for seismic test #3 (4X full scale) are plotted in Appendix F.

7. In-Plane Testing

After completion of the Out-of-Plane tests, the model was disassembled and removed from the BSTM. The model was reinstalled on the BSTM in the In-Plane configuration as shown in Figure 9. The center bolt attaching the slab to the center of each header beam was again grouted in place. The instrumentation was reconfigured for this orientation.

Six low level random tests and 6 seismic test were conducted on 9 Nov 1993. Two low level random tests and 2 sine sweep tests were conducted on 16-17 Nov 1993 to fail the model. Testing was halted after sine sweep test 2. The exact sequence of tests is tabulated in Appendix C. The resonant frequencies measured during the random tests are shown in Appendix D. During the testing crack maps were drawn by MMES personnel as shown in Appendix E. During these tests, 12 mortar cubes for walls 1 and 2 were crushed to determine their strength as shown on the data sheets in Appendix A. The results of seismic test #9 (16X full scale) are plotted in Appendix G.

The random tests and the seismic tests were conducted in the same manner as the Out-of-Plane tests. The same seismic time history record (RISKTH2) was used for the seismic tests. The sine sweep tests were performed with a Gen Rad model 2514 test control system operating as a sine sweep control generator to drive the horizontal axis of the BSTM with a constant amplitude sinusoidal acceleration whose frequency was swept over a predetermined range. For sine sweep test #1 the control parameters were:

Frequency Range:	10-20 hz
Amplitude:	1.0 g
Sweep Rate:	1.0 octave/minute.

For sine sweep test #2 the sweep parameters were:

Frequency Range: 15-5 hz
Amplitude: 3.0 g
Sweep Rate: 1.0 octave/minute.

FIGURE 1: SHAKE TABLE TEST OF HOLLOW CLAY TILE WALL MODEL

FIGURE 2: OUT-OF-PLANE TEST INSTRUMENTATION, WALL #1

FIGURE 3: OUT-OF-PLANE TEST INSTRUMENTATION, WALL #2

FIGURE 4: IN-PLANE TEST INSTRUMENTATION, WALL #1

FIGURE 5: IN-PLANE TEST INSTRUMENTATION, WALL #2

FIGURE 6. STRAIN GAGE CABLES

FIGURE 7. LVDT MOUNTING DETAIL

FIGURE 8. INSTRUMENTATION AND CONTROL SCHEMATIC

REFERENCE FRAME

LOAD PHASE #1
- OUT-OF-PLANE TEST

DIRECTION OF
TABLE MOTION

REFERENCE FRAME

LOAD PHASE #2
IN-PLANE TEST

FIGURE 9: PLAN VIEW SHOWING TEST ORIENTATIONS

FIGURE 10. Seismic Test Reference Waveform RISKTH2

APPENDIX A

MORTAR COMPRESSIVE STRENGTH DATA SHEET

MORTAR COMPRESSIVE TESTING - ASTM C 780

Test Frame No.: 1

Specimen Data:

Date Made: 8/23/93
 Samples Made by: J.M. Gambill
 Mortar Type:
 Date Specimens put in Moist Room: Air Cured

Test Data:

	28-Day Test	Out-of- Plane	In-Plane, Failure
Date	9/20/93	10/29/93	11/9/93
Age of Samples	28 days		
Tested By	Bill Gordon	Jim Gambill	Bill Gordon
Recorded By	Bill Gordon	Jim Gambill	Bill Gordon
Batch #1: Ultimate Strength (Pounds)			
Sample #1	3.49 kip	3.82 kip	4.24 kip
Sample #2	3.48	3.99	4.12
Sample #3	3.38	3.64	—
Average	3.45 kip	3.82 kip	4.18 kip
Batch #2: Ultimate Strength (Pounds)			
Sample #1	3.14 kip	3.72 kip	3.80 kip
Sample #2	3.43	3.90	4.10
Sample #3	3.26	3.19	4.00
Average	3.28 kip	3.60 kip	3.97 kip

MORTAR COMPRESSIVE TESTING - ASTM C 780

Test Frame No.: 2

Specimen Data:

Date Made: 8/24/93

Samples Made by: Jim Gambill

Mortar Type: _____

Date Specimens put in Moist Room: Air cure

Test Data:

	28-Day Test	Out-of- Plane	In-Plane, Failure
Date	9/21/93	10/29/93	11/9/93
Age of Samples	28 days		
Tested By	Bill Gordon	Jim Gambill	Bill Gordon
Recorded By	Bill Gordon	Jim Gambill	Bill Gordon
Batch #1: Ultimate Strength (Pounds)			
Sample #1	3.96 Kip	4.75 Kip	4.90 Kip
Sample #2	3.67	4.60	5.20
Sample #3	3.73	4.05	4.85
Average	3.79 Kip	4.47 Kip	4.98 Kip
Batch #2: Ultimate Strength (Pounds)			
Sample #1	4.60 Kip	4.46 Kip	4.85 Kip
Sample #2	4.53	4.66	4.65
Sample #3	4.28	4.27	4.40
Average	4.47 Kip	4.46 Kip	4.63 Kip

APPENDIX B

DATA ACQUISITION CHANNEL NUMBERS

DATA ACQUISITION CHANNEL NUMBERS: WALL #1, OUT-OF-PLANE TESTING

Sensor, Location	Serial Number	Channel Number
SG1 - Left Column, Bottom, Front		00
SG2 - Left Column, Bottom, Back		01
SG3 - Left Column, Lower Middle, Front		02
SG4 - Left Column, Lower Middle, Back		03
SG5 - Left Column, Upper Middle, Front		04
SG6 - Left Column, Upper Middle, Back		05
SG7 - Left Column, Top, Front		06
SG8 - Left Column, Top, Back		07
SG9 - Truss, Bottom Chord, Center		08
AD1 - Left Column, Lower Middle		09
AD2 - Left Column, Upper Middle		10
AD3 - Left Column, Top		11
AD4 - Right Column, Lower Middle		12
AD5 - Right Column, Upper Middle		13
AD6 - Right Column, Top		14
AD7 - Beam, Center		15
AD8 - Panel, Upper Middle, Center		16
RD1 - Left Column, Bottom		17
RD2 - Left Column, Lower Middle		18
RD3 - Left Column, Upper Middle		19
RD4 - Right Column, Upper Middle		20
RD5 - Panel, Bottom, Middle		21
RD6 - Beam, Middle		22
A1 - Left Column, Top		23
A2 - Right Column, Top		24
A3 - Beam, Center		25
A4 - Slab, Center		26

A5 - Panel, Bottom, Center		27
A6 - Panel, Lower Middle, Center		28
A7 - Panel, Upper Middle, Center		29
A8 - Panel, Top, Center		30
A9 - Specimen Base, Center (Shake Table)		31
A10 - Panel, Top, Left		32
A11 - Panel, Upper Middle, Right		33
A12 - Panel, Top, Right		34

SG = Strain Gage

AD = Absolute Displacement

RD = Relative Displacement

A = Acceleration

DATA ACQUISITION CHANNEL NUMBERS: WALL #2, OUT-OF-PLANE TESTING

Sensor, Location	Serial Number	Channel Number
AD9 - Specimen Base, Center		35
RD7 - Left Column, Upper Middle		36
RD8 - Right Column, Upper Middle		37
A13 - Panel, Upper Middle, Center		38
A14 - Panel, Top, Left		39
A15 - Panel, Top, Right		40
A16 - Beam, Center		41
A17 - Panel, Upper Middle, Left		42
DH - Shake Table, Horizontal Displacement		43
AH - Shake Table, Horizontal Acceleration		44
DV - Shake Table, Vertical Displacement		45
AV - Shake Table, Vertical Acceleration		46
DP - Shake Table, Pitch Displacement		47

AD = Absolute Displacement

RD = Relative Displacement

A = Acceleration

DH,AH,DV,AV,DP = BSTM Parameters

DATA ACQUISITION CHANNEL NUMBERS: WALL #1, IN-PLANE TESTING

Sensor, Location	Serial Number	Channel Number
SG1 - Left Column, Bottom, Inside		00
SG2 - Left Column, Bottom, Outside		01
SG3 - Left Column, Middle, Inside		02
SG4 - Left Column, Middle, Outside		03
SG5 - Left Column, Top, Inside		04
SG6 - Left Column, Top, Outside		05
SG7 - Beam, Left, Top		06
SG8 - Beam, Left, Bottom		07
SG9 - Beam, Center, Top		08
SG10 - Beam, Center, Bottom		09
SG11 - Beam, Right, Top		10
SG12 - Beam, Right, Bottom		11
SG13 - Right Column, Bottom, Inside		12
SG14 - Right Column, Bottom, Outside		13
SG15 - Right Column, Middle, Inside		14
SG16 - Right Column, Middle, Outside		15
SG17 - Right Column, Top, Inside		16
SG18 - Right Column, Top, Outside		17
PD1 - Diagonal, Top Left - Bottom Right		18
PD2 - Diagonal, Bottom Left - Top Right		19
PD3 - Diagonal, Horizontal		20
PD4 - Diagonal, Vertical		21
AD1 - Right Column, Center		22
AD2 - Right Column, Top		23
AD3 - Beam, Right		24
A1 - Left Column, Middle		25
A2 - Left Column, Top		26

A3 - Specimen, Center		27
A4 - Right Column, Top		28
A5 - Panel, Middle, Center		29
A6 - Beam, Center		30
A7 - Slab, Center		31
RD1 - Left Column, Top		32
RD2 - Right Column, Top		33
RD3 - Beam, Right		34

SG = Strain Gage

PD = Panel Displacement

AD = Absolute Displacement

RD = Relative Displacement

A = Acceleration

DATA ACQUISITION CHANNEL NUMBERS: WALL #2, IN-PLANE TESTING

Sensor, Location	Serial Number	Channel Number
AD4 - Specimen Base, Center		35
AD5 - Right Column, Middle		36
AD6 - Beam, Right		37
PD5 - Panel Diagonal, Top Left - Bottom Right		38
PD6 - Panel Diagonal, Bottom Left - Top Right		39
A8 - Panel, Middle, Center		40
A9 - Beam, Center		41
A10 - Right Column, Middle		42
DH - Shake Table, Horizontal Displacement		43
AH - Shake Table, Horizontal Acceleration		44
DV - Shake Table, Vertical Displacement		45
AV - Shake Table, Vertical Acceleration		46
DP - Shake Table, Pitch Displacement		47

AD = Absolute Displacement

PD = Panel Displacement

A = Acceleration

DH,AH,DV,AV,DP = BSTM Parameters

APPENDIX C

TEST SEQUENCE

TEST SEQUENCE: OUT-OF-PLANE TESTING

Test Date 10/28/93 - 10/29/93
Test Frame No. 1 and 2

Test Director Jim Gambill
MM-ES Technical Contact Jim Kincaid

[illegible]

TEST SEQUENCE: IN-PLANE TESTING

Test Date 11/9/93 and 11/17/93
 Test Frame No. 1 and 2

Test Director Jim Gambill
 MM-ES Technical Contact Jim Kincaid

Test Type	Test Level	Comments
Random	1.6%	Random Test 5
seismic	Full Scale	RISKTH2 Test 4
Random	1.6%	Random Test 6
Seismic	2X F.S.	RISKTH2 Test 5
Random	1.6%	Random Test 7
seismic	4X F.S.	RISKTH2 Test 6
Random	1.6%	Random Test 8
Seismic	8X F.S.	RISKTH2 Test 7
Random	1.6%	Random Test 9
Seismic	12X F.S.	RISKTH2 Test 8
Random	1.6%	Random Test 10
seismic	16X F.S.	RISKTH2 Test 9 (slab loose)
Random	1.6%	Random Test 11, before regrouting
Random	1.6%	Random Test 12, after regrouting
Sine Sweep	1.0g	10 Hz → 20 Hz, 1.0g, 1.0 oct/min.
Sine Sweep	3.0g	15 Hz → 5 Hz, 3.0g, 1.0 oct/min.

APPENDIX D

LOW LEVEL RANDOM TEST RESULTS

**OUT-OF-PLANE RANDOM WHITE NOISE TEST RESULTS
FREQUENCY & MAGNITUDE**

Random Test Number	SLAB				WALL			
	1st Frequency		2nd Frequency		1st Frequency		2nd Frequency	
	Freq	Mag	Freq	Mag	Freq	Mag	Freq	Mag
1	7.00		33.5					
2								
3	6.5	28.4	32.75	3.3	6.63	17.8	32.8	19.9
4	6.6	27	32.4	3.5	6.5	2.6	32.5	31

**IN-PLANE RANDOM NOISE TEST RESULTS
FREQUENCY & MAGNITUDE**

Random Test Number	SLAB				WALL			
	1st Frequency		2nd Frequency		1st Frequency		2nd Frequency	
	Freq	Mag	Freq	Mag	Freq	Mag	Freq	Mag
5	16.50	7.31	55.0	0.60	16.13	2.96	55.0	2.45
6	16.38	7.37	55.0	0.71	15.88	3.02	55.0	2.63
7	16.13	6.74	54.75	0.86	15.63	3.05	54.75	2.64
8	15.88	7.30	54.50	1.23	15.63	3.08	54.50	3.07
9	14.89	7.42	53.25	0.96	15.00	2.79	53.00	1.77
10	13.50	7.81	51.60	0.56	13.65	2.69	50.25	1.82
11	14.25	7.97	51.88	0.50	14.13	2.94	51.00	1.46
12	14.75	7.72	51.5	0.72	14.88	3.44	51.50	1.59

APPENDIX E

CRACK MAPS

CRACK MAP

Test Date
Cracks Mapped By
Test Event

OCT. 27, 1993
DALE JONES
PRETEST/POST WHITE .02 RMS / POST EARTHQUAKE/POST #2
WALL 1 - INSIDE

Test Frame No.

COMMENT - SMALL HAIRLINE SHRINKAGE CRACKS

MARTIN
FOR
82

OCT 27 1993

CRACK MAP

Test Date
Cracks Mapped By
Test Event

OCT. 27, 1993 / 10/28/93 / 10/28/93
DALE JONES
PRETEST / POST WHITE .02 RMS / POST EARTHQUAKE / POST X 2 /

Test Frame No.

WALL 2 - INSIDE

COMMENT: SMALL HAIRLINE SHRINKAGE CRACKS

CRACK MAP

Test Date
Cracks Mapped By
Test Event

OCT. 27, 1993

DALE JONES

PRETEST / POST WHITE .02 RMS / POST EARTHQUAKE / POST x 2
POST x 4

Test Frame No.

WALL 2 - OUTSIDE

1	2	3	4	5	6	7	8	9	10	11
12	13	14	15	16	17	18	19	20	21	22
24	25	26	27	28	29	30	31	32	33	34
35	36	37	38	39	40	41	42	43	44	45
47	48	49	50	51	52	53	54	55	56	57
58	59	60	61	62	63	64	65	66	67	68
70	71	72	73	74	75	76	77	78	79	80

COMMENT:

SMALL HAIRLINE SHRINTAGE

CRACK MAP

Test Date
Cracks Mapped By
Test Event

Oct. 27, 1993

Dale Jones

pretest / Post WHITE .02 RMS / Post EARTHQUAKE / Post x 2 "" /
Post x 4

Test Frame No.

Wall 2 - outside

COMMENT: Small hairline shrinkage

CRACK MAP

Test Date

11/9/93

Cracks Mapped By

Test Event

IN-PLANE TEST

Test Frame No.

WALL 1 - OUTSIDE

~~8~~ - ON RIDGE EQ.

1	2	3	4	5	6	7	8	9	10	11	
12	13	14	15	16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31	32	33	34	
35	36	37	38	39	40	41	42	43	44	45	46
47	48	49	50	51	52	53	54	55	56	57	
58	59	60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79	80	

NO CRACKS

CRACK MAP

Test Date
Cracks Mapped By
Test Event

11/9/93
IN-PLANE TEST

Test Frame No.

WALL 1 - INSIDE

8 - OAK RIDGE F6

11	10	9	8	7	6	5	4	3	2	1
23	22	21	20	19	18	17	16	15	14	13
34	33	32	31	30	29	28	27	26	25	24
46	45	44	43	42	41	40	39	38	37	36
57	56	55	54	53	52	51	50	49	48	47
69	68	67	66	65	64	63	62	61	60	59
80	79	78	77	76	75	74	73	72	71	70

6 bleed thru - NO CRACK

CRACK MAP

Test Date
Cracks Mapped By
Test Event

11/9/93

IN PLANE TEST

Test Frame No.

WALL 2 - OUTSIDE

1	2	3	4	5	6	7	8	9	10	11	
12	13	14	15	16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31	32	33	34	
35	36	37	38	39	40	41	42	43	44	45	46
47	48	49	50	51	52	53	54	55	56	57	
58	59	60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79	80	

8 O.R. EARTHQUAKES

CRACK MAP

Test Date
Cracks Mapped By
Test Event

11/9/93
IN-PLANE TEST
WALL 2 INSIDE

Test Frame No.

8 O.R. EARTHQUAKES

APPENDIX F

OUT-OF-PLANE SEISMIC TEST DATA

Seismic Test 3, Out-of-Plane

SG1 - Left Column, Bottom Front, Wall 1

Seismic Test 3, Out-of-Plane

SG2 - Left Column, Bottom Back, Wall 1

Seismic Test 3, Out-of-Plane
SG3 - Left Column, Lower Middle Front, Wall 1

Seismic Test 3, Out-of-Plane

SG4 - Left Column, Lower Middle Back, Wall 1

Seismic Test 3, out-of-Plane
SG5 - Left Column, Upper Middle Front, Wall 1

Seismic Test 3, Out-of-Plane

SG6 - Left Column, Upper Middle Back, Wall 1

Seismic Test 3, Out-of-Plane

SG7 - Left Column, Top Front, Wall 1

Seismic Test 3, Out-of-Plane

SG8 - Left Column, Top Back, Wall 1

Seismic Test 3, Out-of-Plane

SG9 - Truss, Bottom Cord, Center

Seismic Test 3, Out-of-Plane

AD1 - Left Column, Lower Middle, Wall 1

Seismic Test 3, Out-of-Plane

AD2 - Left Column, Upper Middle, Wall 1

Seismic Test 3, Out-of-Plane

AD3 - Left Column, Top, Wall 1

Seismic Test 3, Out-of-Plane
AD4 - Right Column, Lower Middle, Wall 1

Seismic Test 3, Out-of-Plane

AD5 - Right Column, Upper Middle, Wall 1

Seismic Test 3, Out-of-Plane

AD6 - Right Column, Top, Wall 1

Seismic Test 3, Out-of-Plane

AD7 - Beam, Center, Wall 1

Seismic Test 3, Out-of-Plane

AD8 - Panel, Upper Middle Center, Wall 1

Seismic Test 3, Out-of-Plane

RD1 - Left Column Bottom, Wall 1

Seismic Test 3, Out-of-Plane

RD2 - Left Column, Lower Middle, Wall 1

Seismic Test 3, Out-of-Plane

RD3 - Left Column, Upper Middle, Wall 1

Seismic Test 3, Out-of-Plane
RD4 - Right Column, Upper Middle, Wall 1

Seismic Test 3, Out-of-Plane

RD5 - Panel, Bottom Middle, Wall 1

Seismic Test 3, Out-of-Plane

RD6 - Beam, Middle, Wall 1

Seismic Test 3, Out-of-Plane

A1 - Left Column Top, Wall 1

Seismic Test 3, Out-of-Plane

A2 - Right Column Top, Wall 1

Seismic Test 3, Out-of-Plane

A3 - Beam Center, Wall 1

Seismic Test 3, Out-of-Plane

A4 - Slab Center

Seismic Test 3, Out-of-Plane

A5 - Panel Bottom Center, Wall 1

Seismic Test 3, Out-of-Plane

A6 - Panel, Lower Middle Center, Wall 1

Seismic Test 3, Out-of-Plane

A7 - Panel, Upper Middle Center, Wall 1

Seismic Test 3, Out-of-Plane

A8 - Panel, Top Center, Wall 1

Seismic Test 3, Out-of-Plane

A9 - Shake Table, Center

Seismic Test 3, Out-of-Plane

A10 - Panel Top Left, Wall 1

Seismic Test 3, Out-of-Plane

A11 - Panel, Upper Middle Right, Wall 1

Seismic Test 3, Out-of-Plane

A12 - Panel, Top Right, Wall 1

Seismic Test 3, Out-of-Plane

AD9 - Shake Table, Center

Seismic Test 3, Out-of-Plane RD7 - Left Column, Upper Middle, Wall 2

Seismic Test 3, Out-of-Plane RD8 - Right Column, Upper Middle, Wall 2

Seismic Test 3, Out-of-Plane A13 - Panel, Upper Middle Center, Wall 2

Seismic Test 3, out-of-Plane A14 - Panel, Top Left, Wall 2

Seismic Test 3, Out-of-Plane A15 - Panel Top Right, Wall 2

Seismic Test 3, Out-of-Plane

A16 - Beam, Center, Wall 2

Seismic Test 3, Out-of-Plane A17 - Panel, Upper Middle Left, Wall 1

Seismic Test 3, Out-of-Plane DH - Shake Table, Horizontal

Seismic Test 3, Out-of-Plane

AH - Shake Table, Horizontal

Seismic Test 3, Out-of-Plane

DV - Shake Table Vertical

Seismic Test 3, Out-of-Plane

AV - Shake Table, Vertical

Seismic Test 3, Out-of-Plane

DP - Shake Table Pitch Displacement

APPENDIX G

IN-PLANE SEISMIC TEST DATA

Seismic Test 9, In-Plane

SG1 - Left Column, Bottom Inside, Wall 1

Seismic Test 9, In-Plane

SG2 - Left Column, Bottom Outside, Wall 1

Seismic Test 9, In-Plane

SG3 - Left Column, Middle Inside, Wall 1

Seismic Test, In-Plane

SG4 - Left Column, Middle Outside, Wall 1

Seismic Test 9, In-Plane

SG5 - Left Column, Top Inside, Wall 1

Seismic Test 9, In-Plane

SG6 - Left Column, Top Outside, Wall 1

Seismic Test 9, In-Plane

SG7 - Beam, Left Top, Wall 1

Seismic Test 9, In-Plane

SG8 - Beam, Left Bottom, Wall 1

Seismic Test 9, In-Plane

SG9 - Beam, Center Top, Wall 1

Seismic Test 9, In-Plane

SG10 - Beam, Center Bottom

Seismic Test 9, In-Plane

SG11 - Beam, Right Top, Wall 1

Sesimic Test 9, In-Plane

SG12 - Beam, Right Bottom, Wall 1

Seismic Test 9, In-Plane

SG13 - Right Column, Bottom Inside, Wall 1

Seismic test 9, In-Plane
SG14 - Right Column, Bottom Outside, Wall 1

Seismic Test 9, In-Plane
SG15 - Right Column, Middle Inside, Wall 1

Seismic Test 9, In-Plane

SG16 - Right Column, Middle Outside, Wall 1

Seismic Test 9, In-Plane

SG17 - Right Column, Top Inside, Wall 1

Seismic Test 9, In-Plane

SG18 - Right Column, Top Outside, Wall 1

Seismic Test 9, In-Plane

PD1 - Panel, Top Left-Bottom Right, Wall 1

Seismic Test 9, In-Plane

PD2 - Panel, Bottom Left-Top Right, Wall 1

Seismic Test 9, In-Plane

PD3 - Panel, Horizontal, Wall 1

Seismic Test 9, In-Plane

PD4 - Panel, Vertical, Wall 1

Seismic Test 8, in-Plane

AD1 - Right Column, Center, Wall 1

Seismic Test 8, in-Plane

AD2 - Right Column, Top, Wall 1

Seismic test 8, In-Plane

AD3 - Beam, Right, Wall 1

Seismic Test 8, In-Plane

A1 - Left Column, Middle, Wall 1

Seismic Test 8, In-Plane

A2 - Left Column, Top, Wall 1

Seismic Test 8, In-Plane

A3 - Shake Table, Center, Horizontal

Seismic Test 8, In-Plane

A4 - Right Column, Top, Wall 1

Seismic Test 8, In-Plane

A5 - Panel, Middle Center, Wall 1

Seismic Test 8, In-Plane

A6 - Beam, Center, Wall 1

Seismic Test 8, In-Plane

A7 - Slab, Center

Seismic Test 9, In-Plane

RD1 - Left Column, Top, Wall 1

Seismic Test 9, In-Plane

RD2 - Right Column, Top, Wall 1

Seismic Test 9, In-Plane

RD3 - Beam, Right, Wall 1

Seismic Test 8, In-Plane

AD4 - Shake table, Center, Horizontal

Seismic Test 8, In-Plane

AD5 - Right Column, Middle, Wall 2

Seismic Test 8, In-Plane

AD6 - Beam, Right, Wall 2

Seismic Test 9, In-Plane

PD5 - Panel, Top Left-Bottom Right, Wall 2

Seismic Test 9, In-Plane

PD6 - Panel, Bottom Left-Top Right, Wall 2

Seismic Test 8, In-Plane
A8 - Panel, Middle Center, Wall 2

Seismic Test 8, In-Plane

A9 - Beam, Center, Wall 2

Seismic Test 8, In-Plane

A10 - Right Column, Middle, Wall 1

Seismic Test 8, In-Plane

DH - Shake Table, Horizontal

Seismic Test 8, In-Plane

AH - Shake Table, Horizontal

Seismic Test 9, In-Plane

DV - Shake Table Displacement, Vertical

Seismic Test 8, In-Plane

AV - Shake table, Vertical

Seismic Test 9, In-Plane

DP - Shake Table Displacement, Pitch