Evaluation and Repair of Shear Walls of a Parking Garage

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Evaluation and Repair of Shear Walls of a Parking Garage

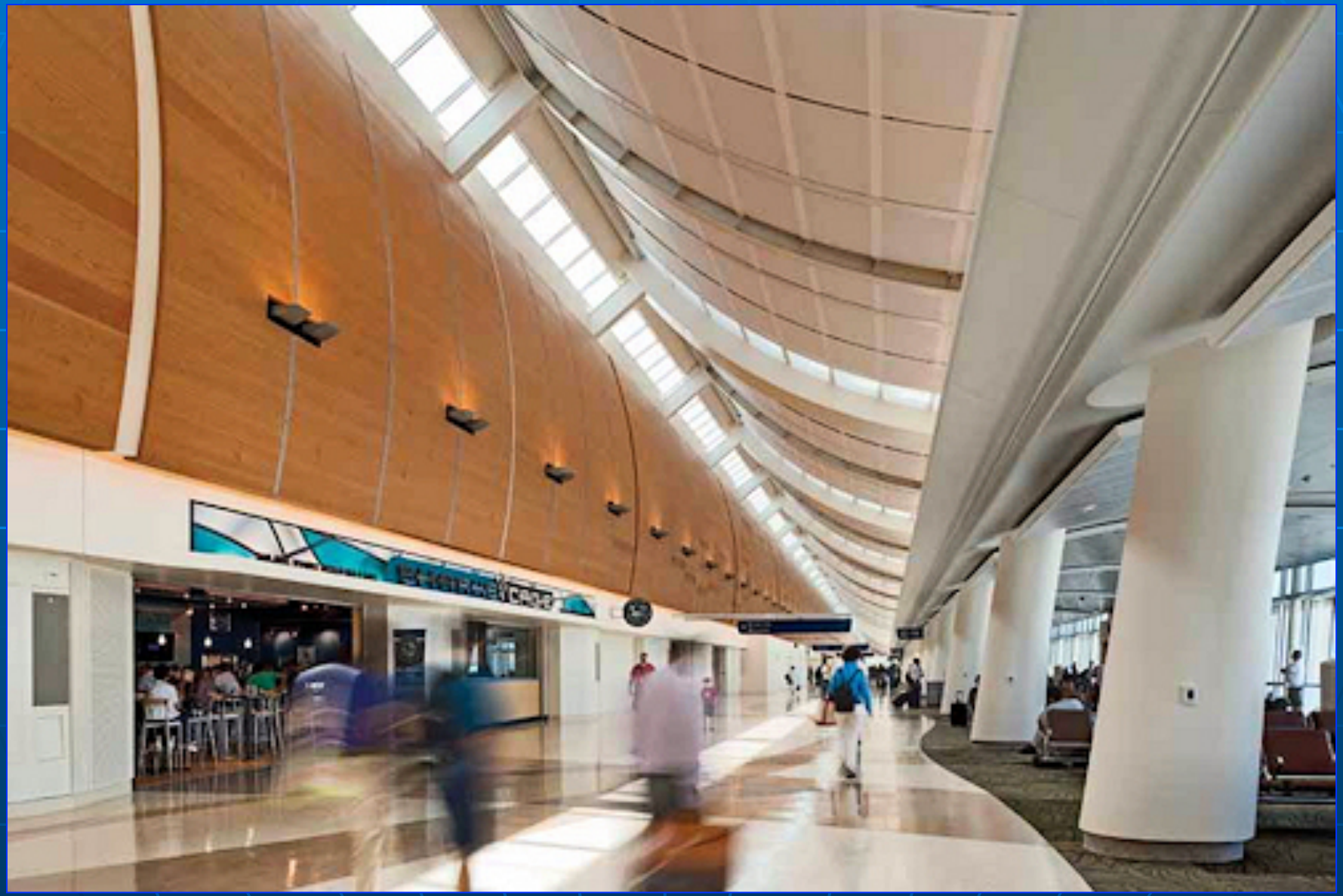
- Background
- Non-Destructive and Intrusive Testing
- Development of Repair Procedures
- Details of Repairs
- Monitoring of Repairs
- Summary

Exterior View Terminal A

Exterior View Terminal B

Exterior View Terminal B

Interior View of the Terminal



Airport Modernization Plan

- Construction of 7-Deck Consolidated Rental Car Facility (ConRAC)
- Construction & Renovation of Terminals
- $ 1.4 Billion Design-Build Project Started in 2005 on a Fast-Track Basis

ConRAC

- Rental Car Facility Across from the Terminals
- Houses Entire Rental Car Operations & Public Parking Spaces
- 3000 Parking Spaces
- Design: Precast, Pre-stressed Columns and Beams

Exterior Views of ConRAC

Exterior Views of ConRAC

Exterior Views of ConRAC

Concerns

- 32” Thick Shear Walls Between 1st & 2nd Floor
- After Removal of Forms Revealed Minor to Severe Honeycombing in some of the Walls
- At a Few Locations Unconsolidated Concrete Extended Through the Entire Depth

Contractor's Attempt for a Fix


Cement

Contractor's Trade Name

Group Meeting Recommendation

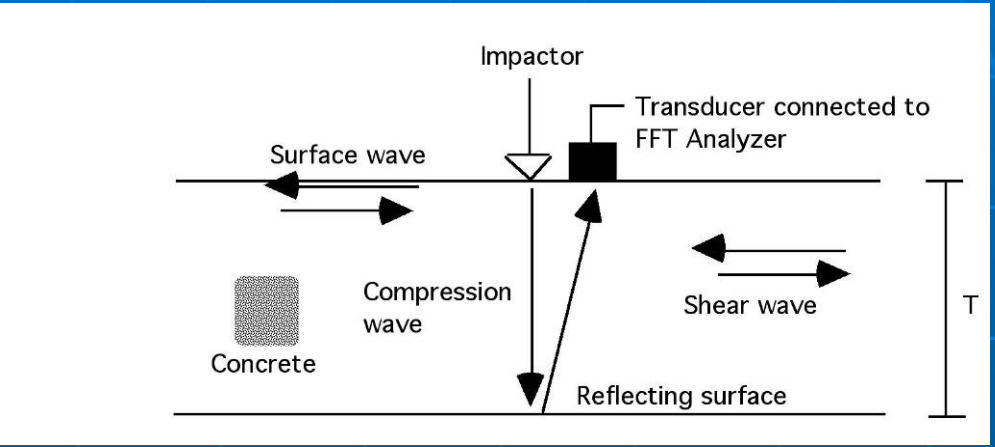
- Perform Non-Destructive Testing to Determine Extent of the Unconsolidated Concrete
- Develop Repair Procedure(s)

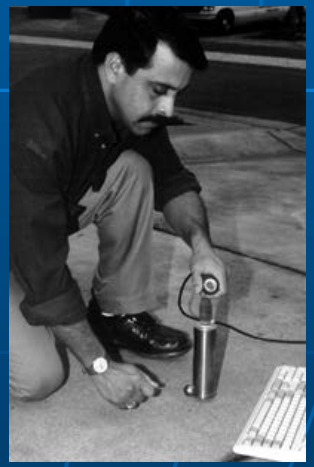
CSI's Initial Work-Scope

- Test 10 Walls at ~ 150 Locations Designated by the Engineer of Record Using Impact-Echo (IE) technique
- Locations to Include Honeycombed as well as Sound Concrete

Impact-echo Principle

- A short pulse is introduced in the structure.
- Reflected waves are analyzed with the waveform analyzer in the frequency domain.
- Dominant frequencies relate to the condition of the structure.

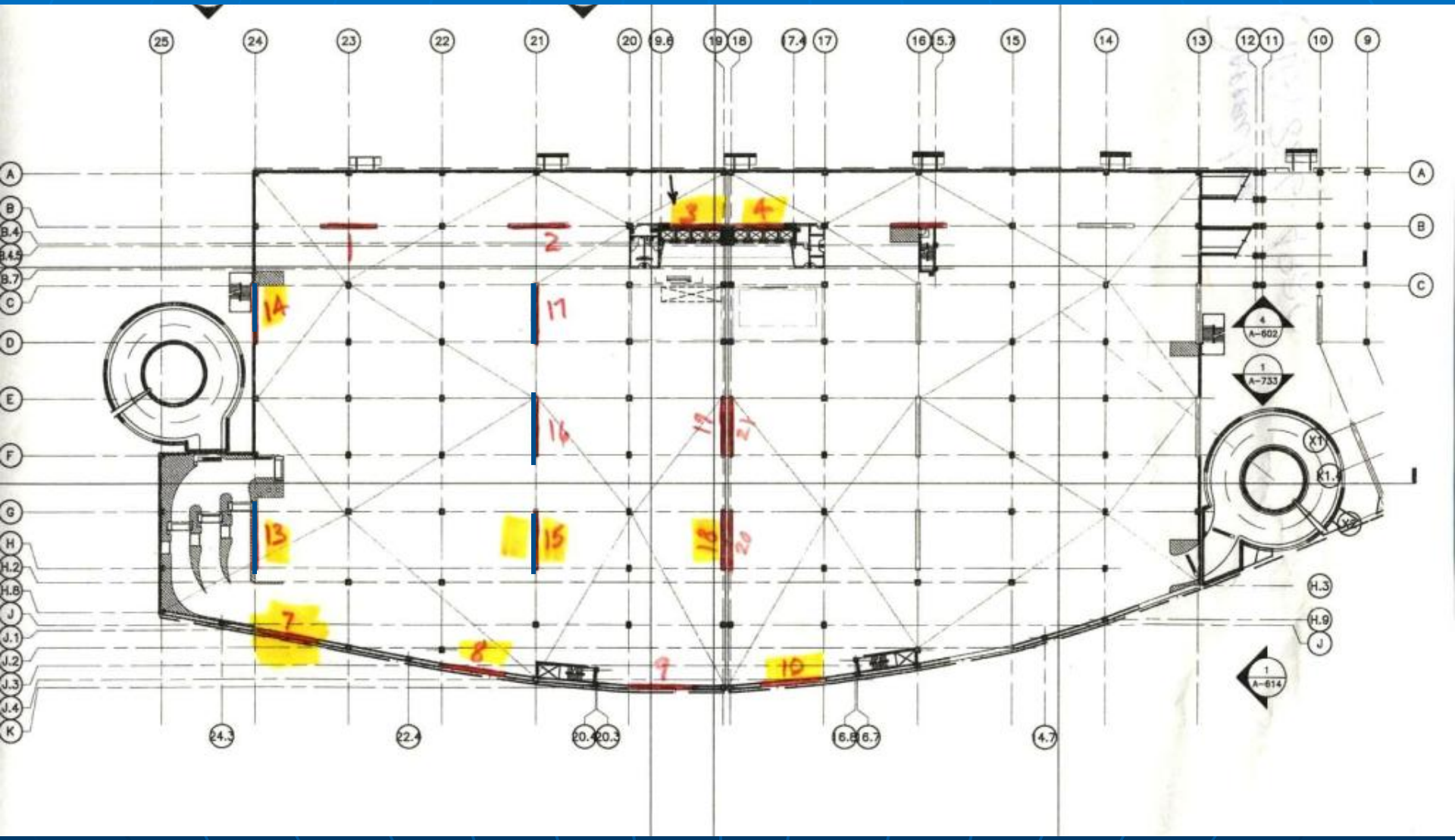




Impact-echo

- Based on propagation of a stress wave through the material.
- Needs an access from only one side to conduct the tests.
- “Local” Test
- On-site Evaluation- most often no further analysis is needed.

Plan View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A-733
1
A-614
X1
X1.1
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20.4
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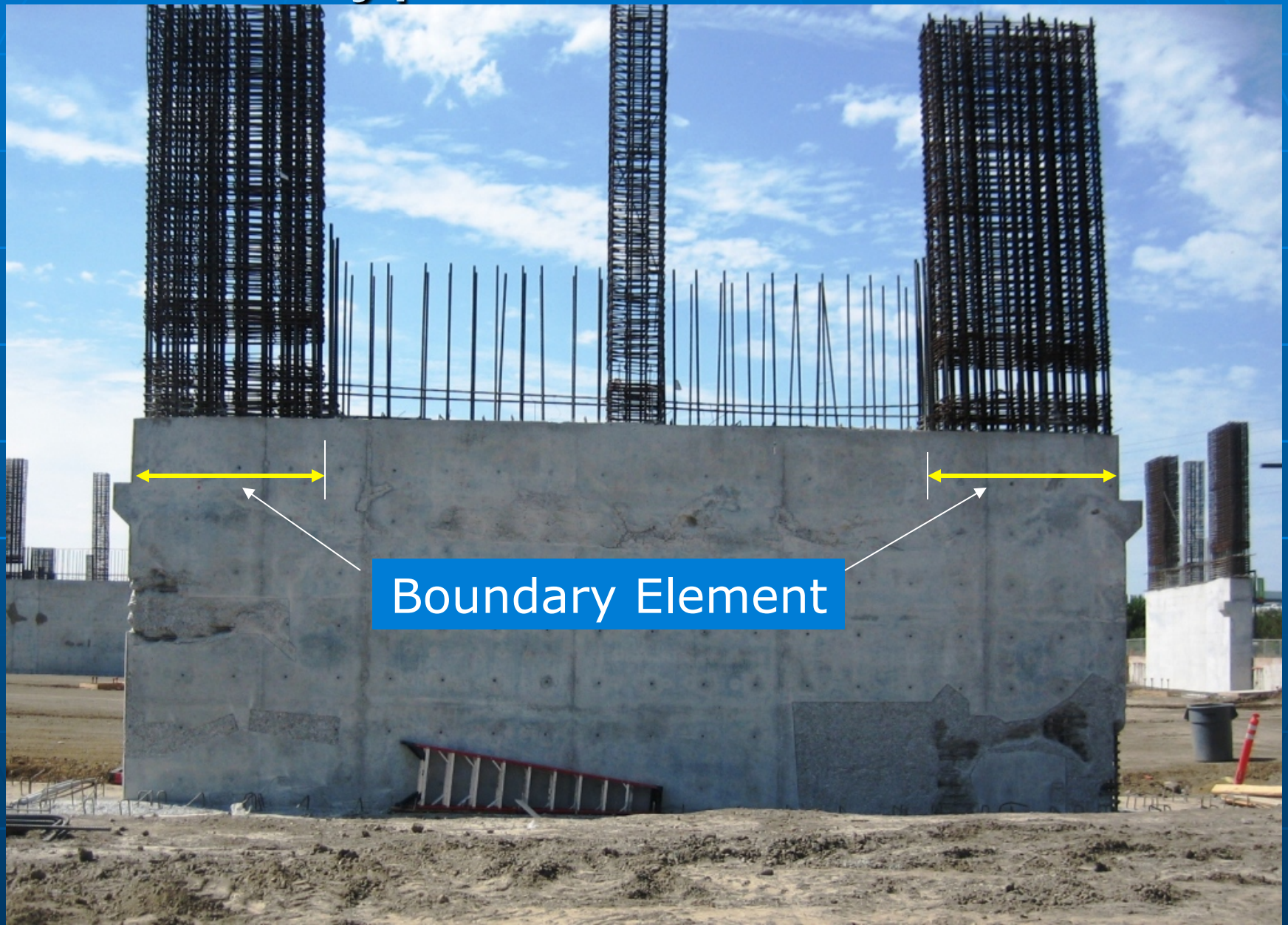
6.8
6.7
4.7

Overall View

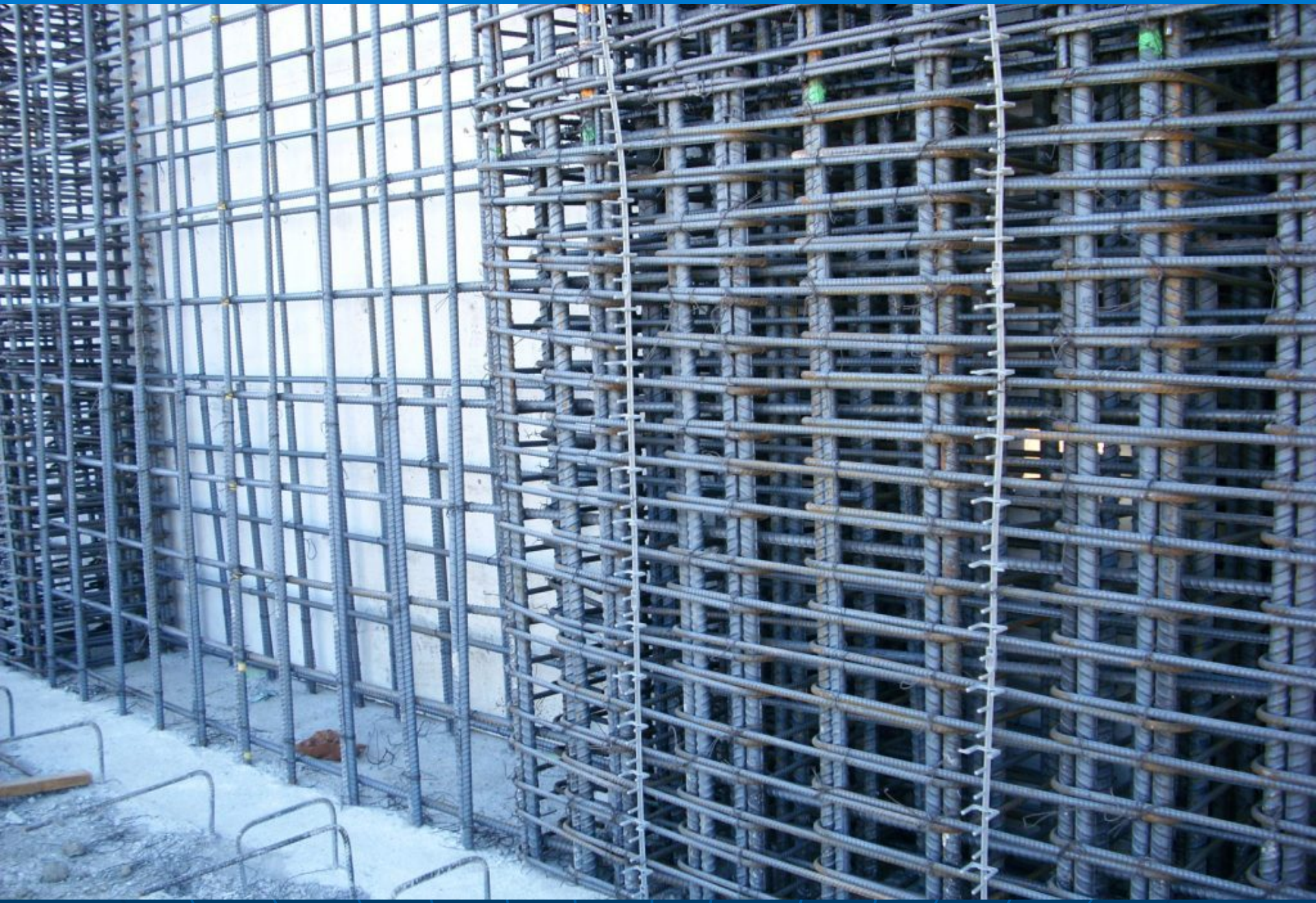
Overall View

Typical Shear Wall

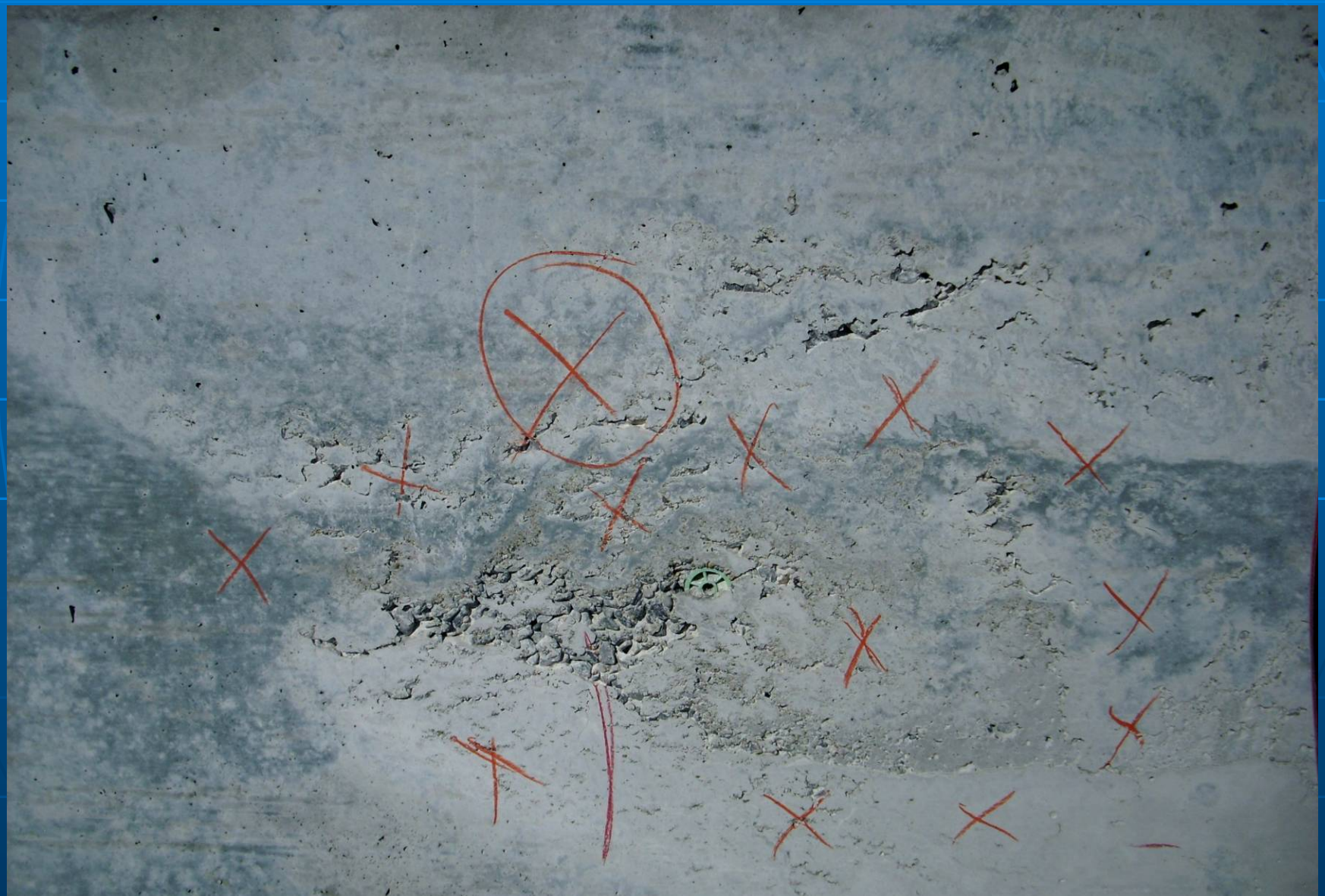


Shear Wall-Side View

Boundary Elements: Heavily Reinforced



Honeycombed Concrete

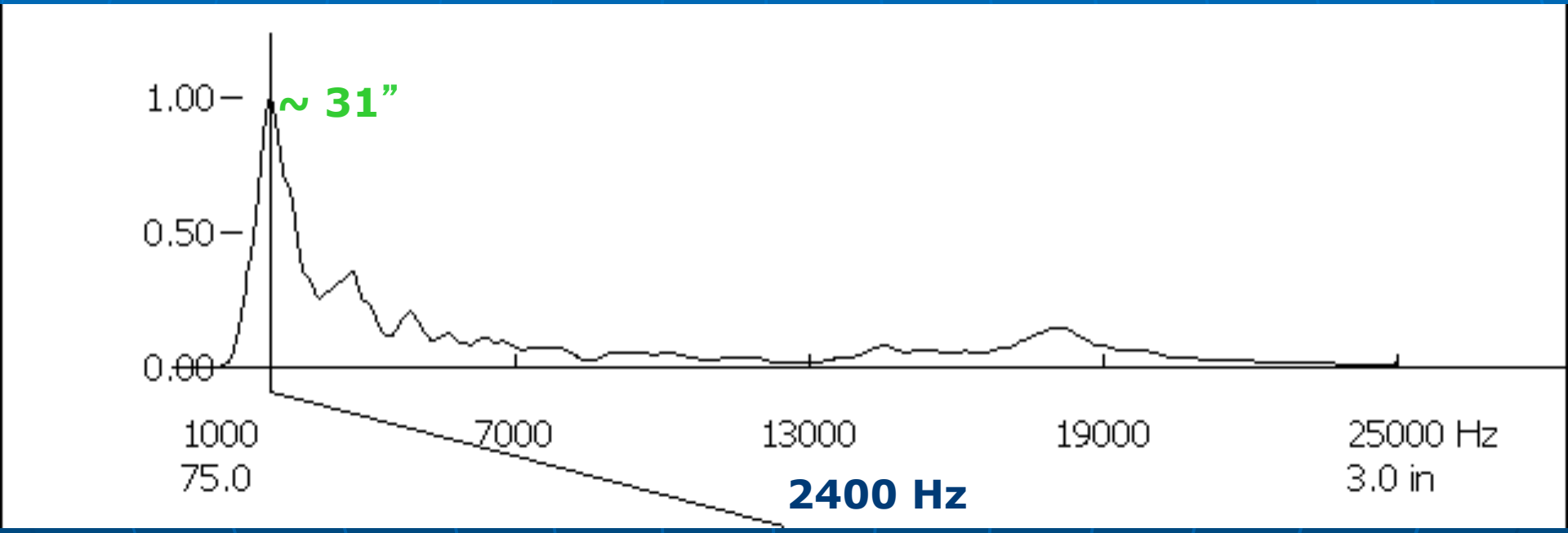



E
D
B
A

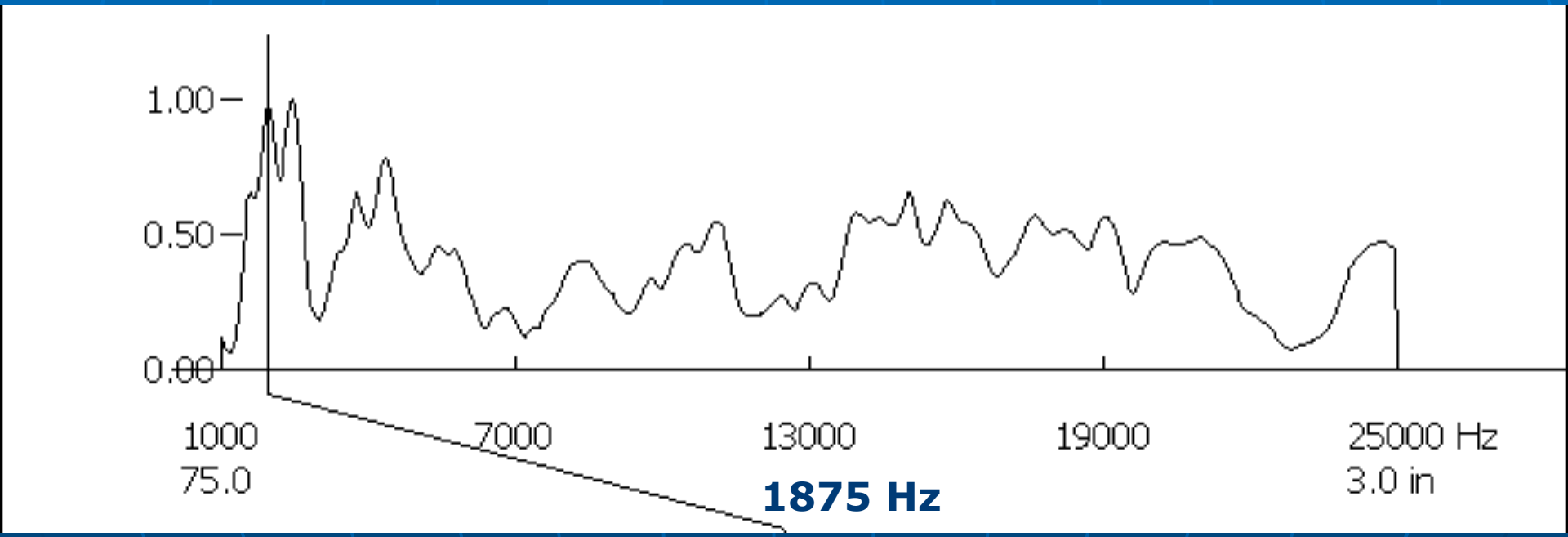
Conducting IE Tests

Conducting IE Tests

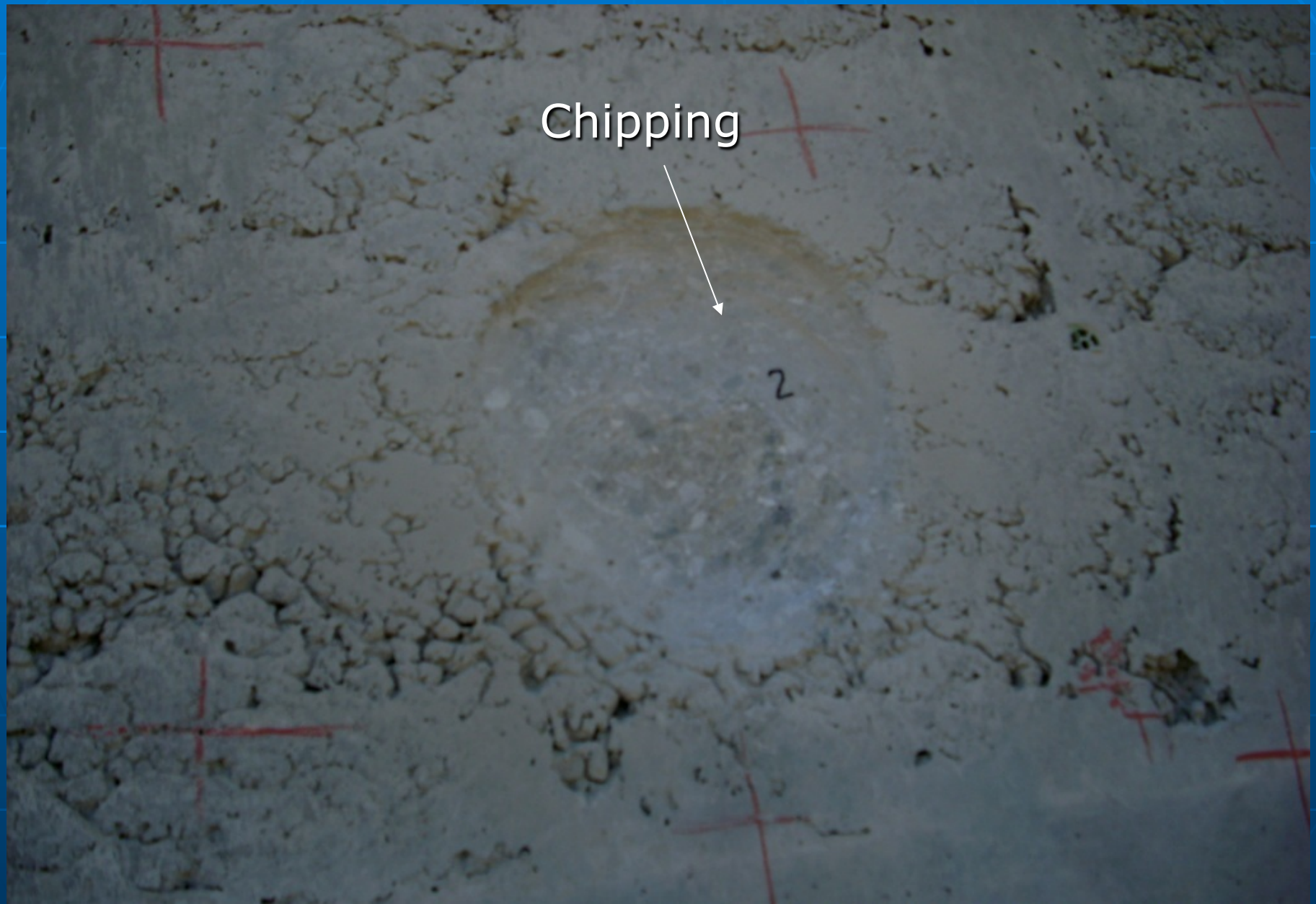
IE Results- Sound Concrete



IE Results-Honeycombed Concrete



Verification of Test Results



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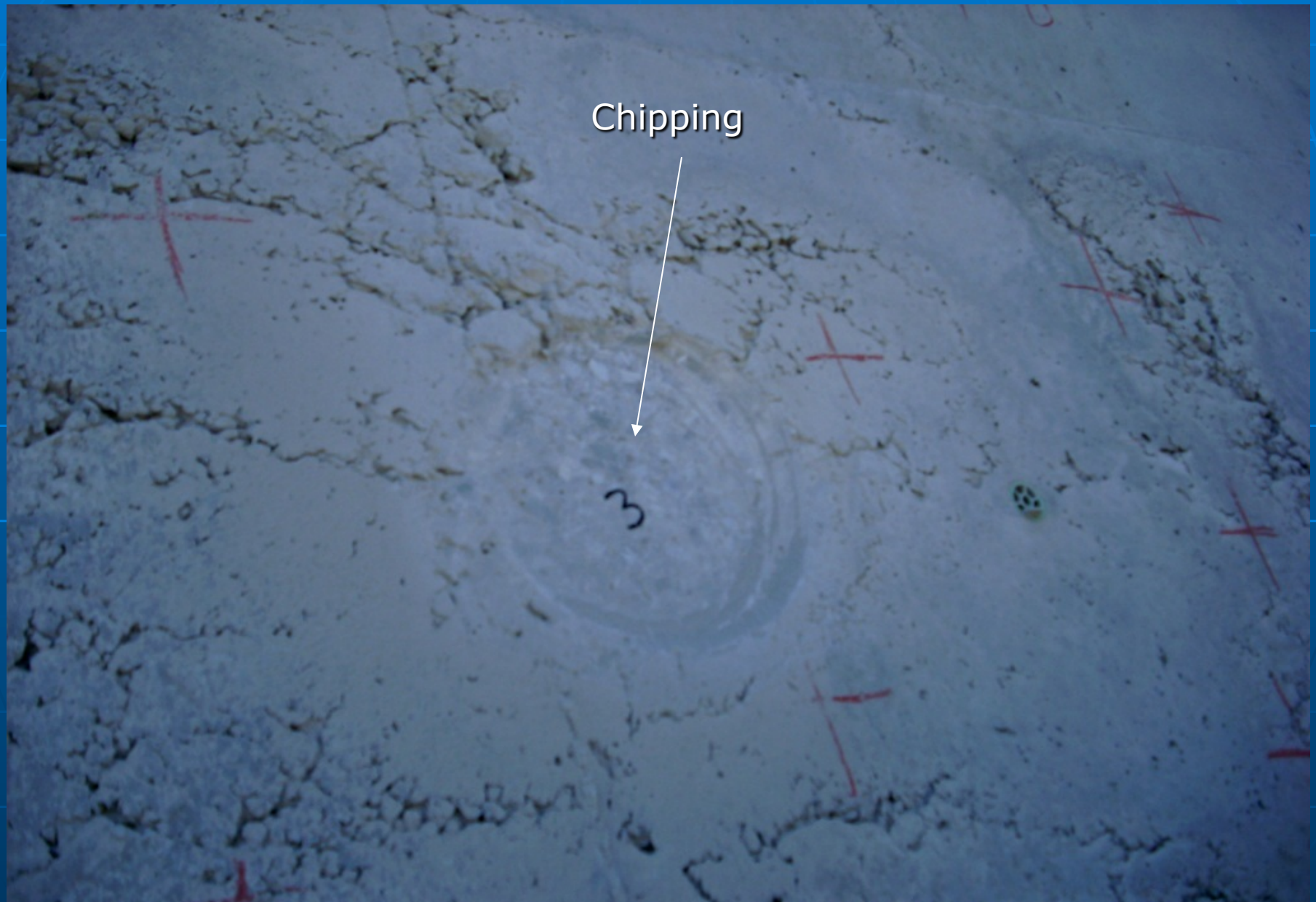


Verification of Test Results

Results Summary

- Majority of the Locations Did Not Contain Through the Depth Voids
- A Few Locations Contained Unconsolidated Concrete up to 40% of the Depth

Results Summary

ONE EXCEPTION

Shear Wall IE Results

- Showed Inconsistent, Non-Repeatable Signals at Two Adjacent Locations

Shear Wall- Add'L Work

- Chipping of the Concrete Showed Color Variation

Shear Wall- More Add'L Work

- Drilled and Removed Partial Depth, 2" dia. Cores Close to the Interior Rebar

….And then Drilled 5/8” Dia. Holes

For Borescope Observations

Borescope Observations Showed

- Interior Delamination
- Bug Holes in One Hole, Depth: 8-9”
- Crack in Another Hole; Depth: 9-10”, Color Change in Material
- Crack in Third Hole; Depth: ~8”, Color Change in Material Starting at 6.5”

Recommendations

- Perform Microscopic Examination to Characterize the Concrete
- Chip the Area Concrete to Examine the Interior Condition


Chipping of
unsound concrete


Large chunks came out easily


Significant delamination at
the rebar depth

Development of Repair Procedures

- With the Discussions Between the Engineer, Material Supplier & CSI, Repair Procedures Were Developed for Three Different Conditions Using ACI &ICRI Guidelines:
- No.1: For Defects up to 1½” Deep
- No.2: For Defects More than 1½” Deep & Rebars Are Exposed in Non-Boundary Elements

Development of Repair Procedures for Various Conditions

- No. 1: For Defects up to 1½” Deep, Minimum Rebar Exposure
- No. 2: For Defects More than 1½” Deep & Rebars Exposed in Non-Boundary Elements
- No. 3: For Defects More than 1½” Deep & Rebars Exposed in Boundary Elements

General Repair Details

- Saw-Cut Straight Edges, ¼” Deep, No Feathering
- Mechanically Remove All Honeycombed Concrete with a Fractured Aggregate Profile ~ ¼”
- Presoak Concrete Surface to Provide SSD Condition
- Mix & Apply the Repair Material
- Damp Cure for 3 Days

Differences in Procedures

- Procedure 1: Different Material for Shallow Repairs
- Procedures 2 & 3: Same Material but in Procedure 3, Repair Material to be Placed by Forming & Pumping.

Hammer Sounding

Saw Cutting the Outer Edges

Chipping the Concrete

Checking the Profile

Offering Guidance

More Chipping!

Cleaning

Cleaning

Water Supply

Spraying with Water

Spraying with Water

Checking the Depth

Checking the Depth

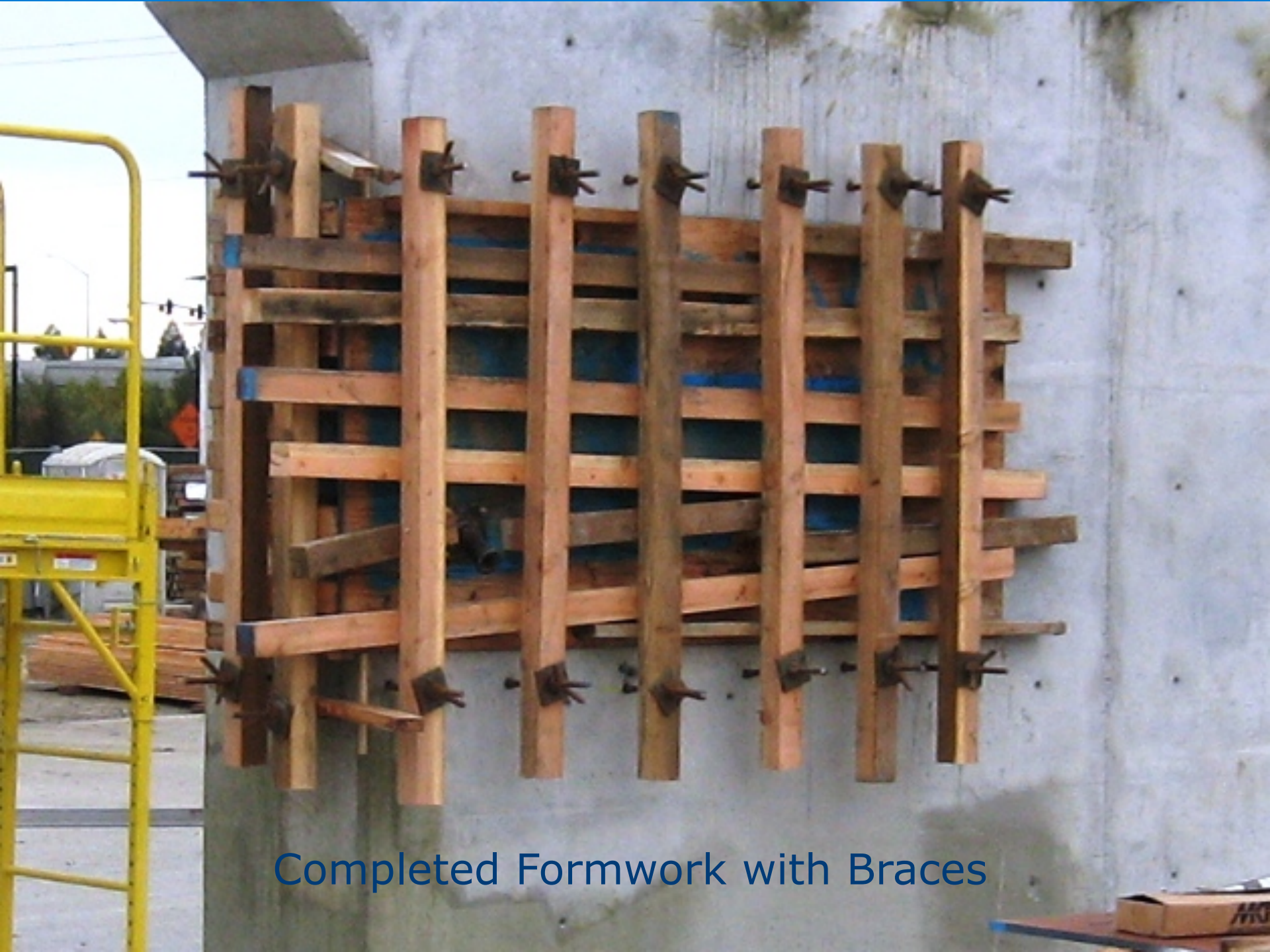

Good Chipping Work!
Condition 2

Good Chipping Work!

Condition 3

Condition 3 Repair Details

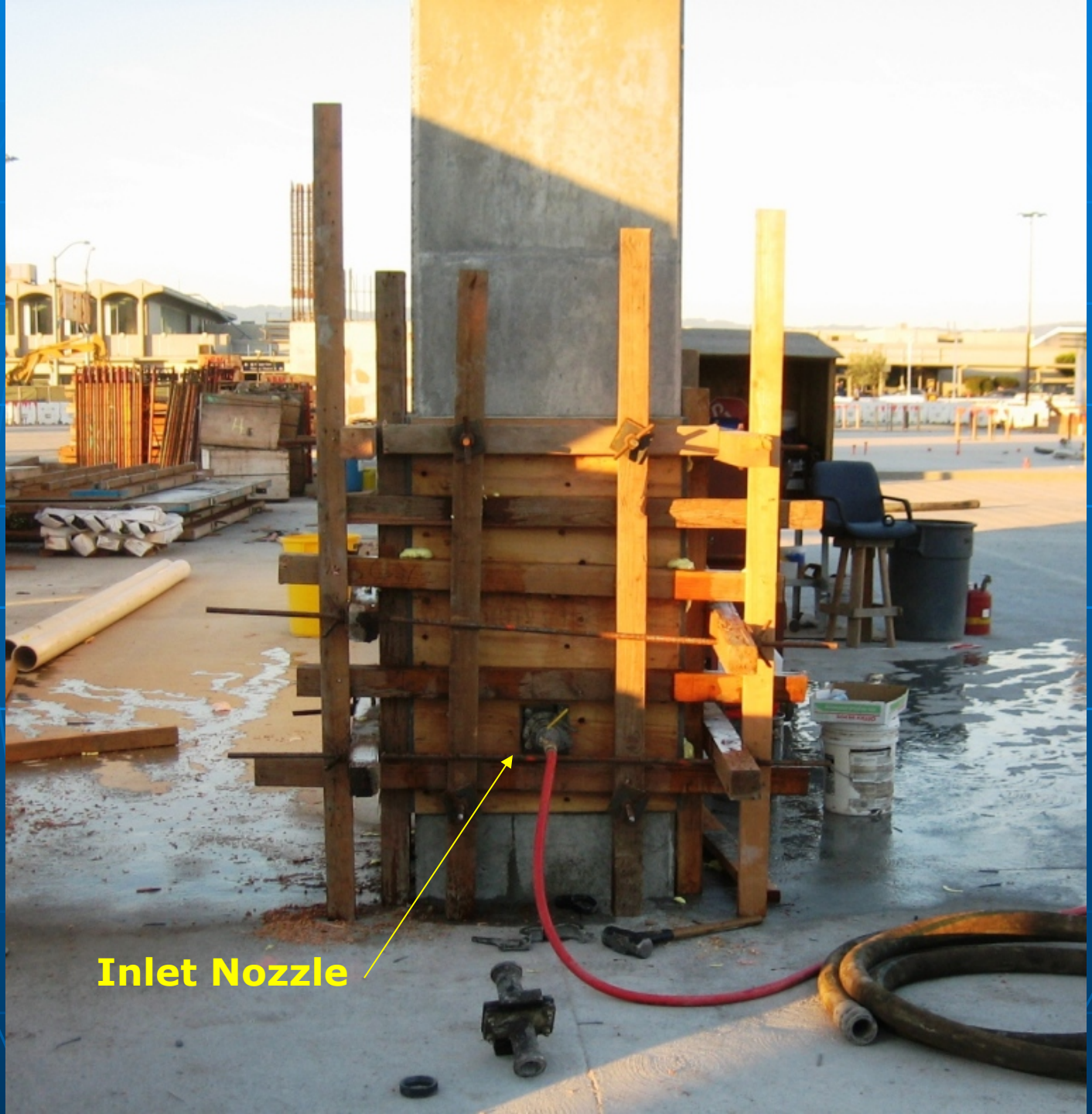

Forming



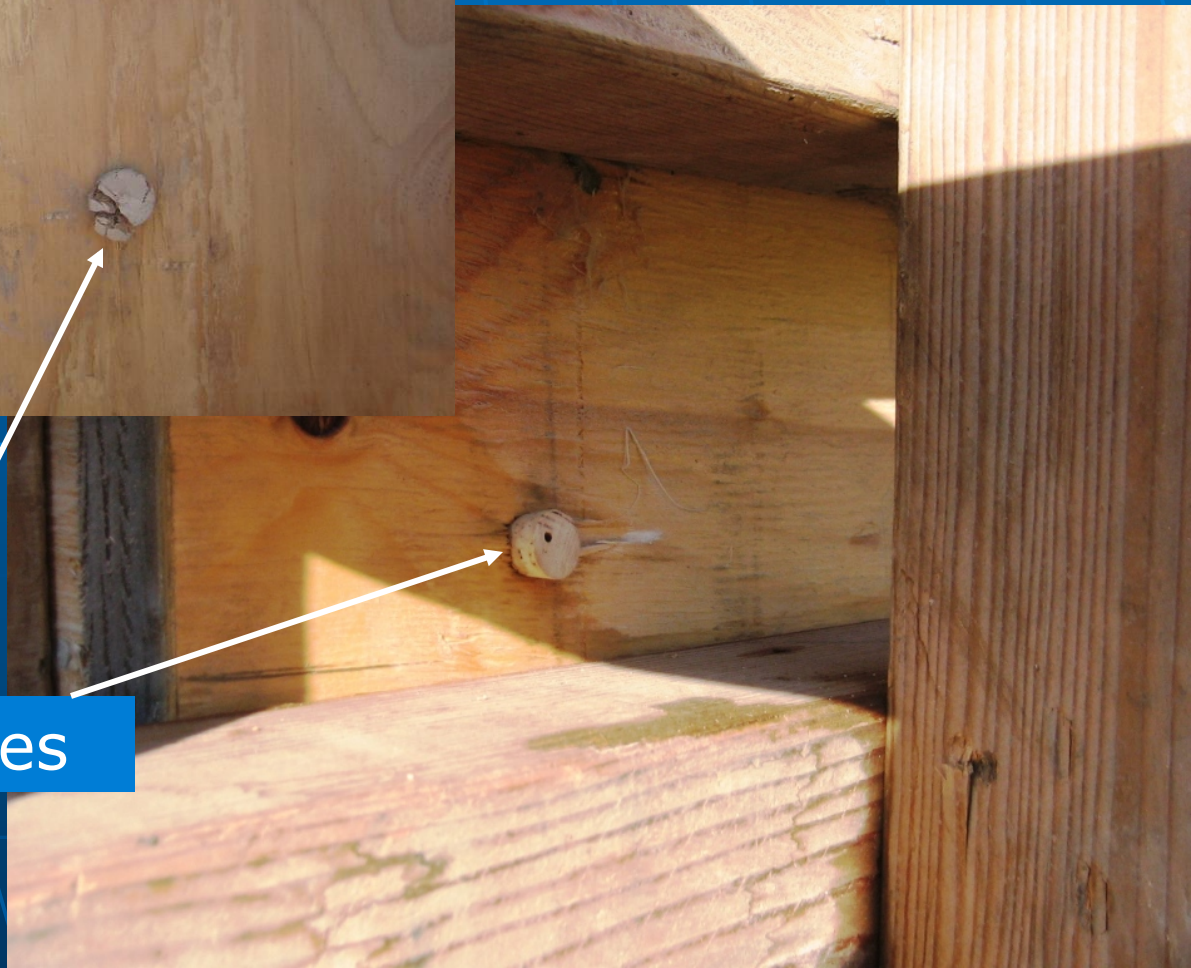
Completed Formwork with Braces

Completed Formwork- Another View


Clamps to hold the forms securely


Inlet Nozzle


Inlet Nozzle



Ventilation Holes

Achieved the SSD Condition for the Concrete by Flooding the Formed Area with Water and Emptying it.

Procedure also served to make sure that the forms were sealed properly.

Getting Ready to Mix the Material


Gel Patch
Gel Patch
Gel Patch
Gel Patch
HENRY


Brand New Pump
AIRPLACO
PumpMaster
PRO Model PE-21
CAUTION
READ INSTRUCTIONS BEFORE OPERATING
EYE PROTECTION REQUIRED
KOHLER
COMMAND PRO 20
D.O.W.

Had to get used to the new pump!


Faced a few challenges with leakages and bulging forms


Indication that the repair material has reached the level at the ventilation hole

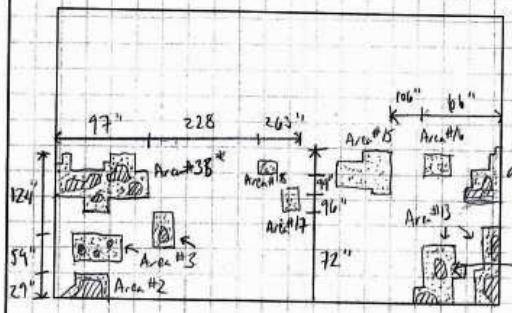
Documentation

Date: 8-16 to 8-17-06 YH Page No. 1

Project: [redacted] Airport
Rental Car Parking Structure

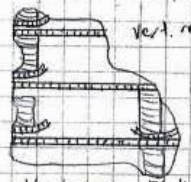
Concrete Science Inc.
Materials & Structural Engineers
Tel. (510) 581-2342
Fax. (510) 581-4178

Shear Wall No. 7 East



* Area #3B continues onto South face it until, connects to Area #4 on South
Needs more chipping done tomorrow
Area #2 chipped to a total depth of 7½" at ground level on South side.

Area #13

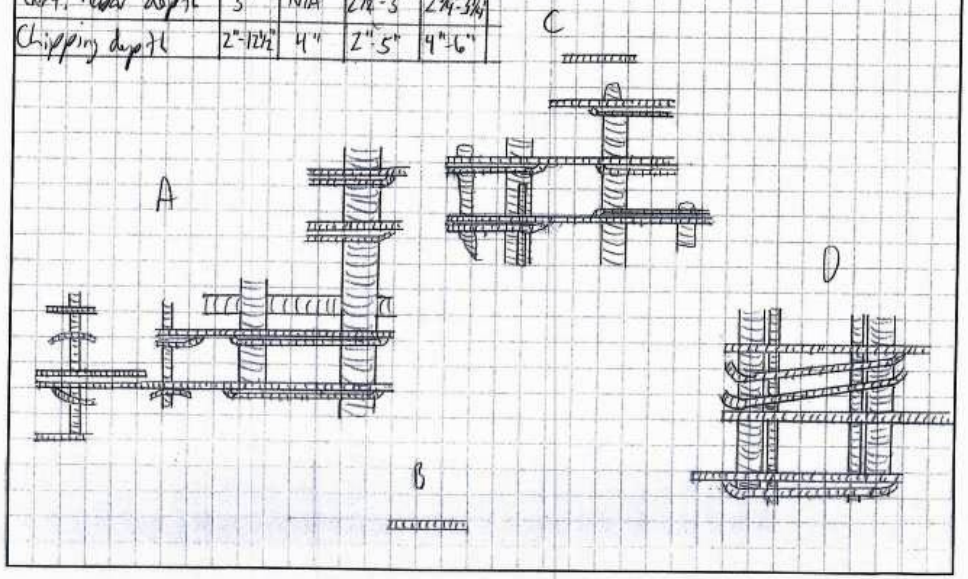


Horiz. rebar thickness = 5/8"
Horiz rebar depth = 2"
Chipping depth = 3½" - 4½"

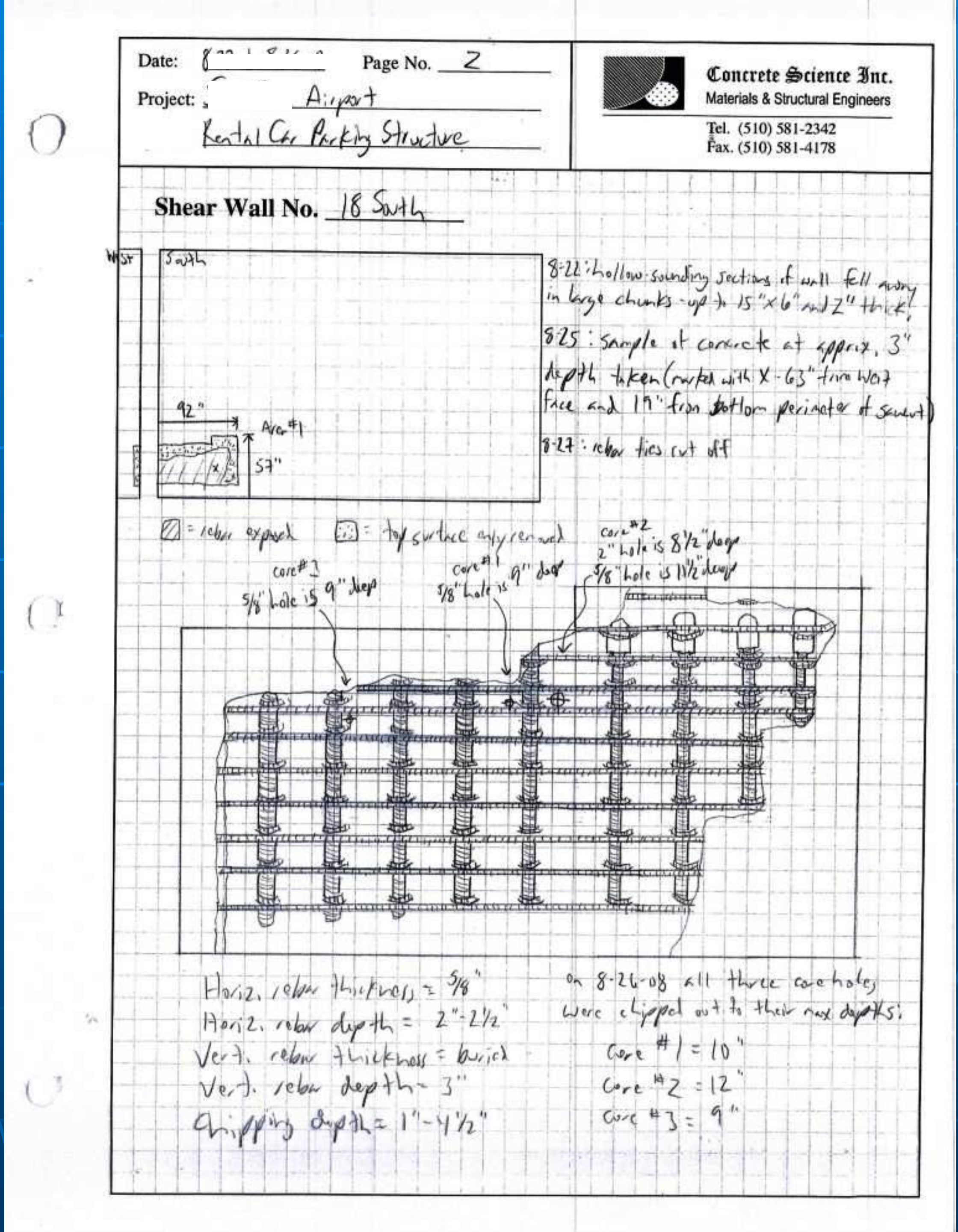
▨ = rebar exposed ▭ = top surface only removed

Area #3B

	A	B	C	D
Horiz. rebar thickness	5/8"	5/8"	5/8"	5/8"
Horiz. rebar depth	2"	2"	2"	2"
Vert. rebar thickness	5/8" 1 5/8"	N/A	5/8 1 5/8"	5/8" 1 5/8"
Vert. rebar depth	3"	N/A	2½"-3"	2¾"-3½"
Chipping depth	2"-12½"	4"	2"-5"	4"-6"



Documentation



Date: 8... Page No. 2

Project: ... Airport

Rental Car Parking Structure

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Shear Wall No. 18 South

West

South

8-22: hollow sounding sections of wall fell away in large chunks - up to 15"x6" and 2" thick!

8-25: Sample of concrete at approx. 3" depth taken (marked with X - 63" from West face and 19" from bottom perimeter of sample)

8-27: rebar ties cut off

92"

Area #1

57"

= rebar exposed

= top surface only removed

core #2
2" hole is 8½" deep
5/8" hole is 11½" deep

core #1
5/8" hole is 9" deep

core #3
5/8" hole is 9" deep

Horiz. rebar thickness = 5/8"
Horiz. rebar depth = 2"-2½"
Vert. rebar thickness = buried
Vert. rebar depth = 3"
Chipping depth = 1"-4½"

On 8-26-08 all three core holes were chipped out to their max depths:

Core #1 = 10"
Core #2 = 12"
Core #3 = 9"

Paper Work

Date: _____ Page No. _____

Project: San Jose Airport
Rental Car Parking Structure

Concrete Science Inc.
Materials & Structural Engineers
Tel. (510) 581-2342
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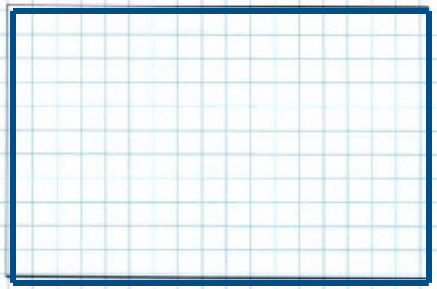
Shear Wall No. _____ **Repair Area No.** _____



Type of Repair: _____ Material Used: _____

Temperature: _____ Relative Humidity: _____ Wind: _____

Amount of Mixing Water: _____ Amount of Material: _____

Time/Mixing Start: _____ Mixing Time: _____ Time/Application: _____

Surface Condition: _____

Notes: _____

Repair Summary Table

Location		Date (Finished Chipping)	Repair		
Wall No.	Area No.		Date	Type	Material

Condition 3: Finished Repair

Condition 3: Finished Repair

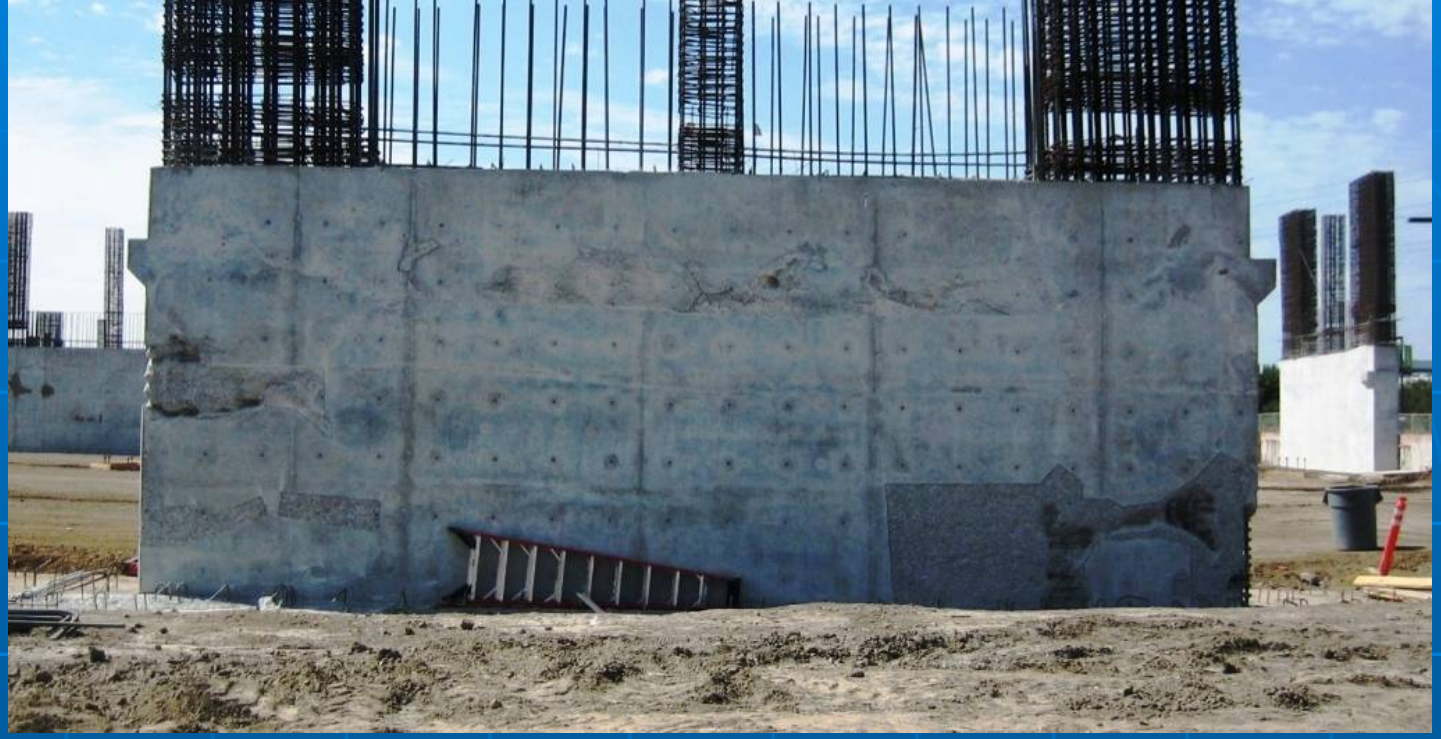
Curing Procedure

- For Conditions 1 & 2: Application of Water Based, Film Forming Curing Compound
- For Condition 3: Form Curing for 3 Days and then Application of the Curing Compound

Chipped Areas

Repaired Areas

Before



Partially Finished

Before

Partially Completed

Summary

- Honeycombed Shear Walls Were Tested with Impact-Echo.
- IE Results Indicated that at Some Locations Unconsolidated Concrete Extended up to 13-14” from the Surface.
- Repairs Were Completed with Three Procedures.
- Successful Completion with Cooperation from Everyone Involved in the Project.

Thank You !

Any Questions?