Summary of Woodstock Barn Engineering Assessments to Date

VECO report of Sept 15 2005 (attached)

Conclusions and recommendations in brief:

- Excessive lateral loading of south wall due to hydrostatic pressure
- Author thought south wall cracks were active and moving.
- South wall deflected up to 3" at top in certain locations.
- Overall barn structure racked 2" to north due to south wall movement
- South wall will fail at some point; not properly braced at top by floor
- Wall assumed to be unreinforced based on measured distortion and crack inspection

- Park vehicles 7 feet back
- Clean catch basin system to creek; appeared not to work
- Don't occupy the structure due to actively moving cracks/wall
- Provide trench drain and rerouting of downspouts
- Expose all south wall and install buried perimeter drain at footing daylighting to west
- Build new rather than retrofit old

April 2006 Inspection by Kris Hamilton of Geiger Engineering

- Provided and installed crack monitors
- Saw no evidence of wall recently moving.
- Denis Bailey, long term resident, said no wall movement for a decade or so and that failure occurred in one creek overflow event
- Engineer saw no reason not to use the building unless the wall were documented to have moved recently. He felt monitoring was most important and that there was insufficient evidence of recent wall movement.

Summer 2008: Park Operations crew cleans catch basins and tight line to creek to working order

- Denis Bailey says it was never known that this system could work; he did not know of it being maintained or functional

Crack monitors do not indicate any movement of wall since April of 2006

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CITY OF BELLINGHAM PARKS AND RECREATION DEPARTMENT

WOODSTOCK FARM BUILDING FOUNDATION

REPORT FOR STRUCTURAL CONDITION ASSESSMENT

VECO Document No.: 1000-10-100-01

VECO Project No.: 251174-1000

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1. INTRODUCTION

1.1 Purpose of Assessment

Perform a preliminary investigation into the cracking in foundation wall and provide recommendations for repair.

2. SCOPE OF INVESTIGATION AND ASSESSMENT

2.1 Inspection

The inspection consisted of an interior and exterior visual inspection. Crack location and widths were noted and a map is included in the appendix

A camera was used to take digital photos and selected pictures are included in the Appendix.

A level and plum bob were used to check the wall deflection.

3. DESCRIPTION OF STRUCTURE

3.1 General

The 40x35 foot building consists of a day light basement with wood framed floor and walls. The east portion is used for an apartment and has a second story loft. The west section is largely unoccupied and is used for miscellaneous storage.

The east and south walls are 7-foot high 8-inch thick unreinforced concrete walls that retain up to 7 feet of soil. The basement consists of a 4-inch thick unreinforced concrete slab with interior wood columns. This space is used for storage and a workbench area.

3.2 History

Based on discussions with Tim Hall the original house was built in 1912 and other additions were made in 1923. The actual construction date is unknown; however the original use of the structure was a barn.

4. COLLECTED DATA

The following methods were used in the assessment of the foundation.

- Photos of the structure.
- Crack measurements.
- Wall and column deflections.
- RISA3D computer program.

5. DISCUSSION FROM SITE VISITS

5.1 Wall failure

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The south concrete basement wall has failed structurally as evidenced by the vertical cracks through the wall and the horizontal crack located about 18 inches above the floor. A full inspection of the wall was not possible due to the items stored in the southwest end of the basement.

Fresh spalling of the concrete would indicate that these cracks are active.

Measurements indicate that the wall has deflected at the top up to 3 inches. In addition the interior columns have deflected up to 2 inches. This indicates that the entire building has racked about 2 inches to the north.

Inspection of the top plate did not reveal any bolts that would brace the wall at the top and gaps between the plate and the wall on the west side indicate around ¾" of settlement. It is assumed that this wall is unreinforced based on the measured distortion and crack inspection.

The floor slab braces the wall at the bottom and is cracked starting at about the midpoint of the south wall indicating presence of significant lateral loads.

It is our opinion that this wall failed due to hydrostatic pressure that built up behind the wall from surface water. Furthermore the wall was not properly braced at the top by the floor and thus acted like a cantilevered wall once the friction between the wall and the top plate was overcome. A cantilever wall will see about 2.5 times the stresses than a braced wall.

A failed cantilevered wall would exhibit horizontal cracks on the soil side whereas a braced wall would begin cracking on the inside. It appears that the wall started in the later condition as indicated by the interior crack and then overcame friction and failed on the outside. These interior cracks are quite subtle since the wall has rotated north and compressed the cracks.

Computer calculations confirm that the tensile stresses in the wall would be roughly 1.5 times the cracking stress during a hydrostatic condition, assuming the concrete compressive strength of 4000 psi and no support from the floor.

5.2 Drainage/Grading

The paving on the south side is cracked and slopes toward the building draining into large cracks along the wall. A fairly large area of paving drains toward the building and may be compounded if the existing catch basin along the road is plugged.

Settlement due to the wall rotation and erosion of the soil along the wall have caused the paving to settle and compound the problem.

Attempts to seal the cracks have been previously performed, but additional wall movement and slab settlement have made these repairs ineffective.

6. CODE COMPLIANCE

6.1 Wall

Although an 8-inch unreinforced wall 7 feet tall with proper top bracing and a drainage system would be allowed per the 2003 IRC for residential construction. However, this wall does not meet these criteria.

7. RECOMMENDATIONS

7.1 Repairs/Recommendations

Our preliminary survey suggested that the cracks were caused by footing settlement from water erosion. After gathering additional data on wall deflections, performing calculations of the wall based on this deflection and then completing additional surveys: it is apparent the wall has failed from excessive lateral load. Footing settlement is likely a contributor to the failure as indicated by the gap under the plate on the southwest corner.

Many options for repair were considered for restoring the wall capacity; these included epoxy injection, installation of tiebacks, and installation of interior counterforts or bracing. However since this unreinforced wall has cracked both vertically and horizontally, continuity no longer exists making these repairs difficult, expensive and their effectiveness questionable.

Do to the complexity of the failure and the design effort required to detail a suitable fix we offer the following general recommendations at this stage.

1. Replace existing paving so the water is directed away from the building. A conceptual plan was discussed with Tom Slack and Carl Clark of the Parks Department. This plan included installation of a trench drain, rerouting of the downspouts and inspection of the existing catch basins and drains for functionality.

2. After the paving is removed on the south side, excavate to expose the south wall down to the footing to allow inspection of the wall and installation of a perimeter drain consisting of a 4 inch perforated pvc pipe encapsulated in pea gravel and wrapped with a geotextile. The drain should be daylighted on the west side of the building directing the water away from the foundation.

3. Until the wall is repaired/replaced vehicles it would be prudent to keep parked vehicles 7 feet from the edge of the building to prevent additional loading on the wall.

4. Based on the condition of the wall and the indications of recent movement, it is our opinion that this building should only be used as an unoccupied building until the wall is stabilized/ replaced.

5. It is our opinion that replacing the wall is the option of choice. Many options exist including installing the new wall on the interior of the building to simplify construction. However this will require some engineering effort to develop a workable, cost effective design that can be installed without compromising the integrity of the existing wall during construction. This work should be coordinated with the installation of the paving and perimeter drain.

   This may dictate that temporary grading and crack sealing be performed before the rainy season to allow time for design of the new wall.

8. CONCLUSIONS

Although this building has been functional for as much as 90 years, signs of active cracking in the wall and slab indicate structural failure of the basement wall.

Due to the uncertainty of the overall integrity we recommend that a new wall be installed to stabilize the structure. We feel that attempts to retrofit the wall would be more expensive and risky.

Elimination of potential hydrostatic conditions must be completed to prevent further failures. Regrading the site, installing surface drains and a wall perimeter drain system should be sufficient to alleviate hydrostatic pressure behind the wall.

9. APPENDIX A

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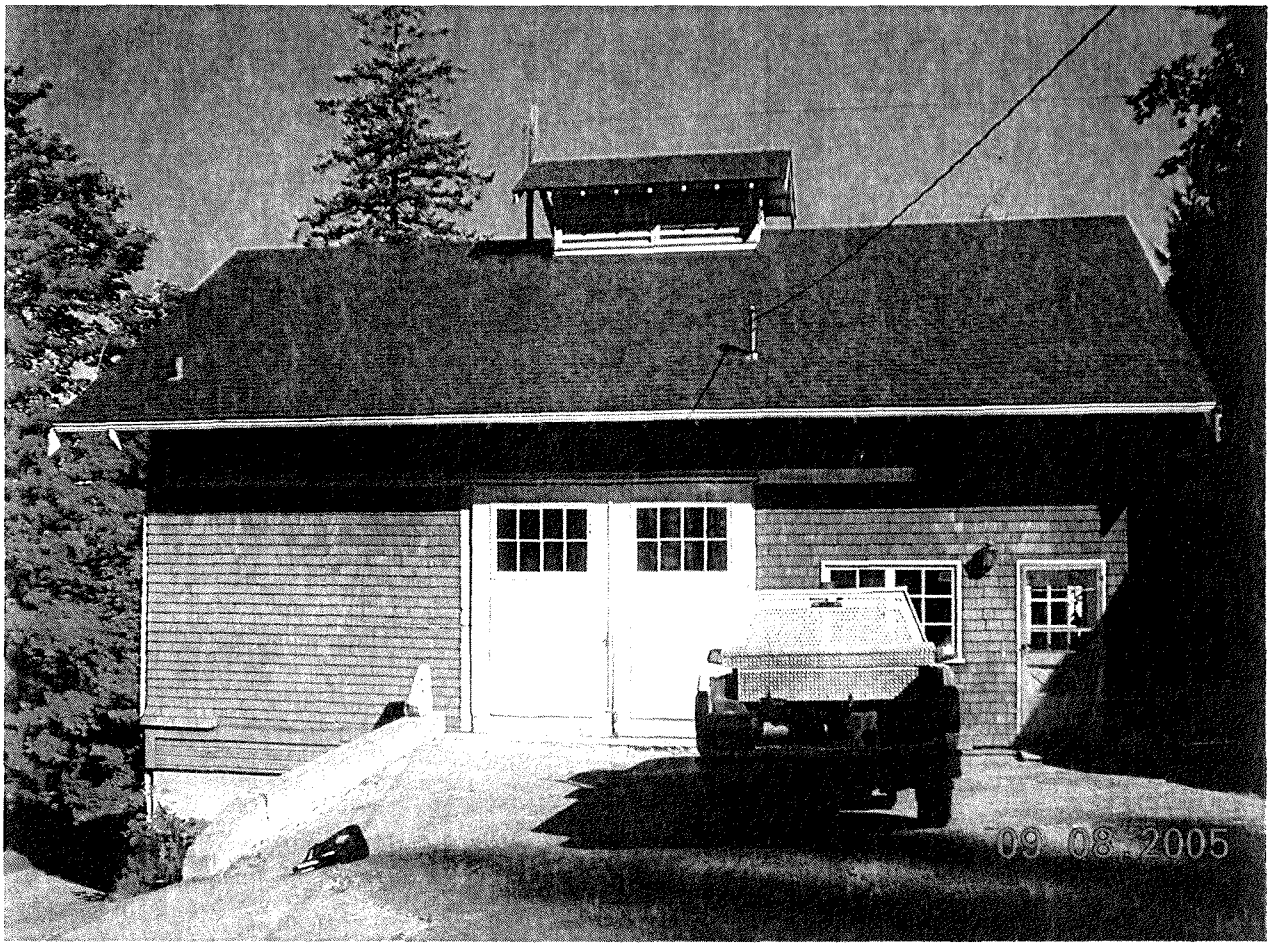
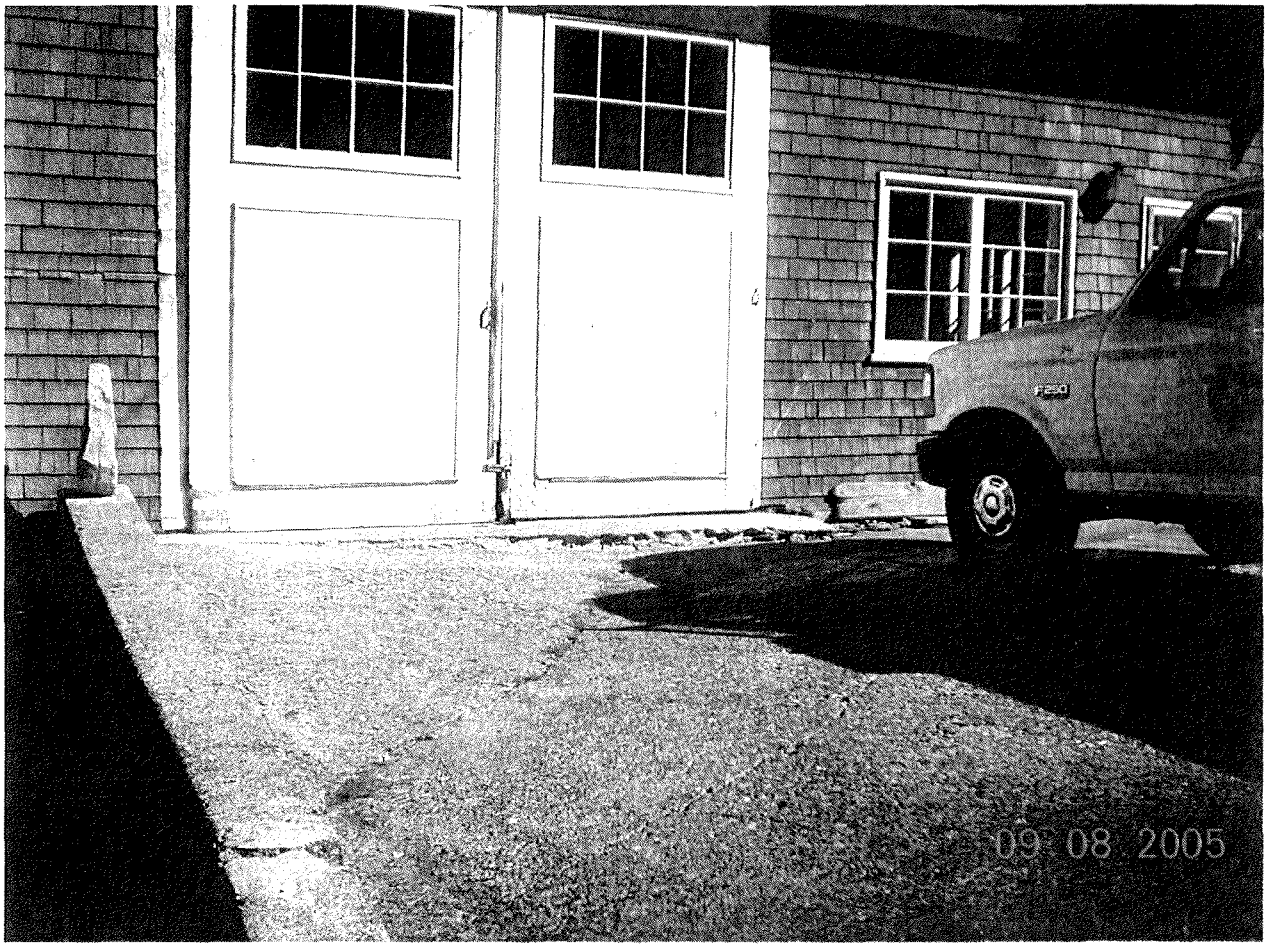
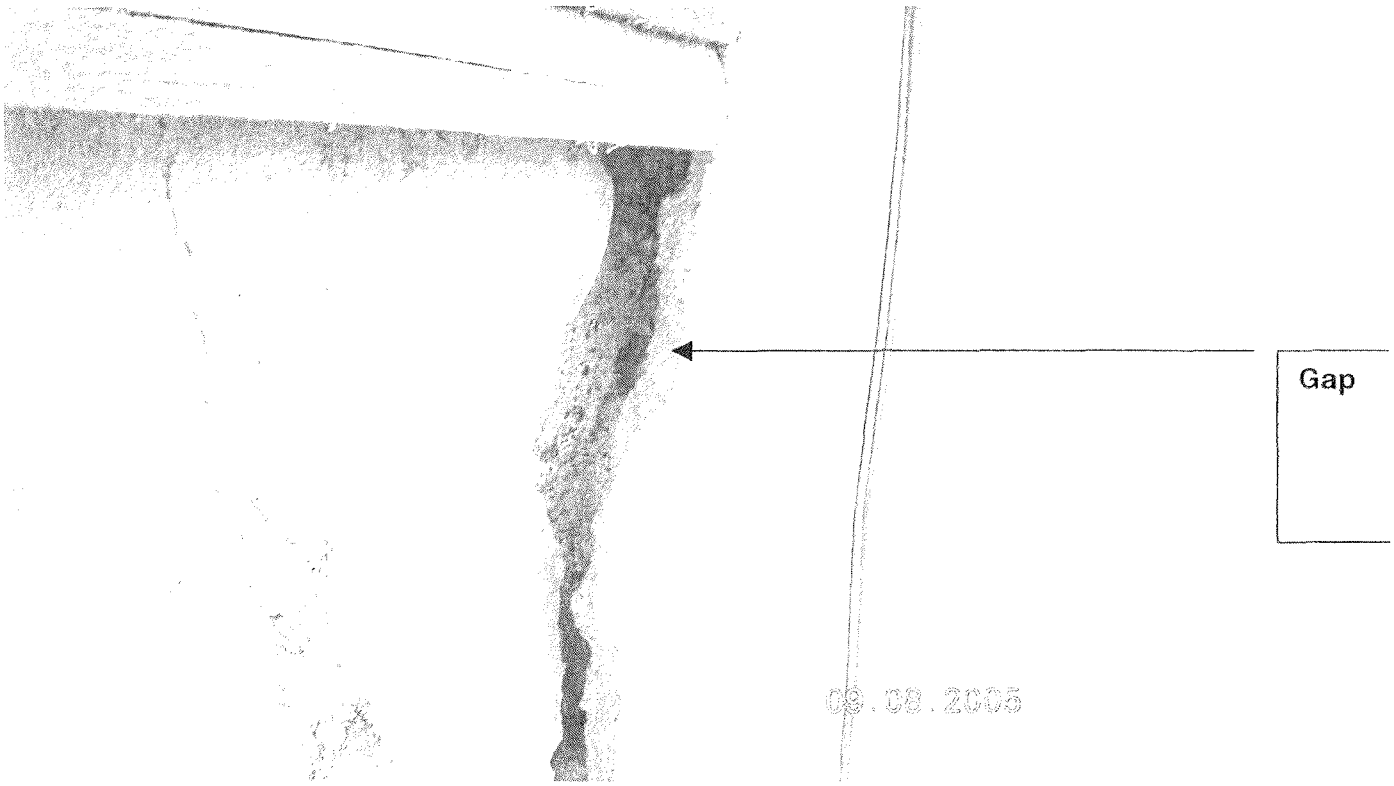


South Wall Elevation



Cracked paving and opening below door.



Crack in basement wall with gap where wall has pulled away from the retaining wall.

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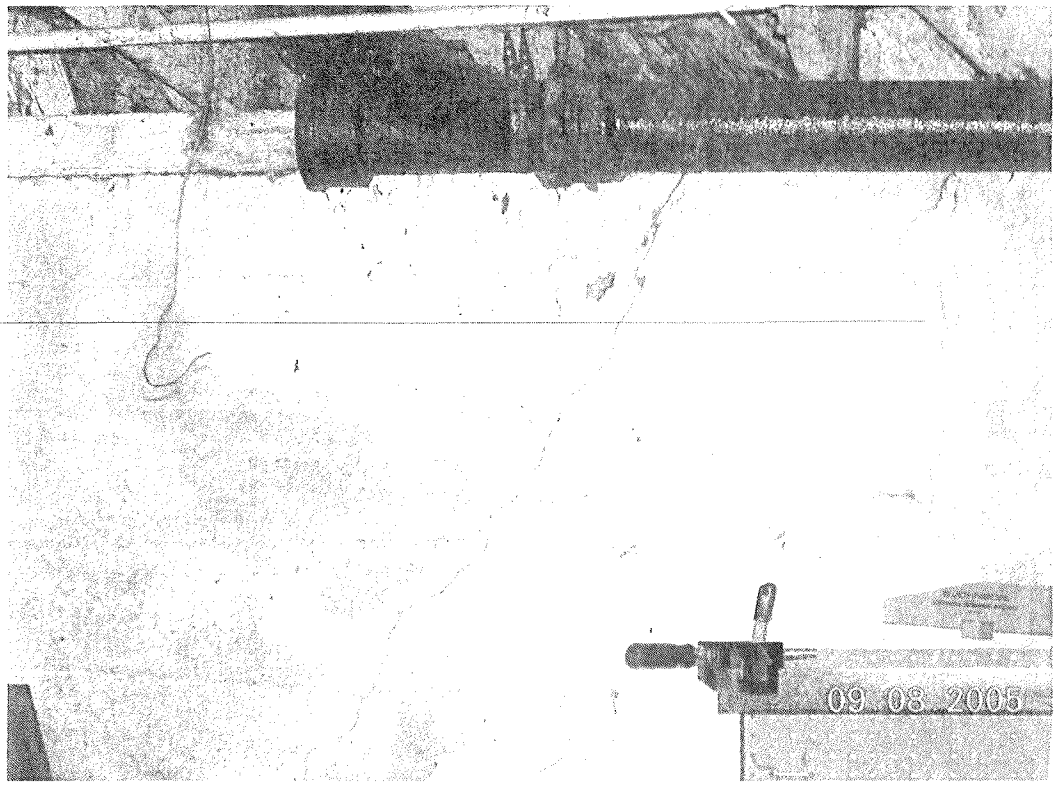
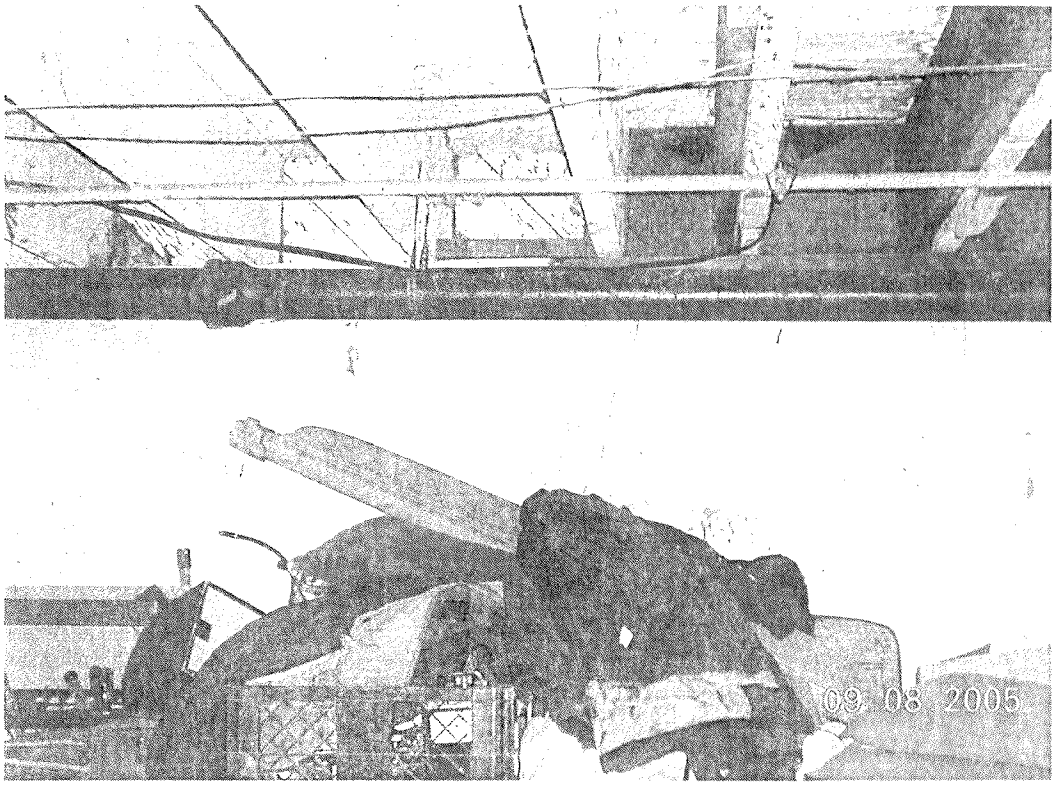


Crack located in the middle of the wall.



Crack at the east end. Note that top plate on the right has been replaced.

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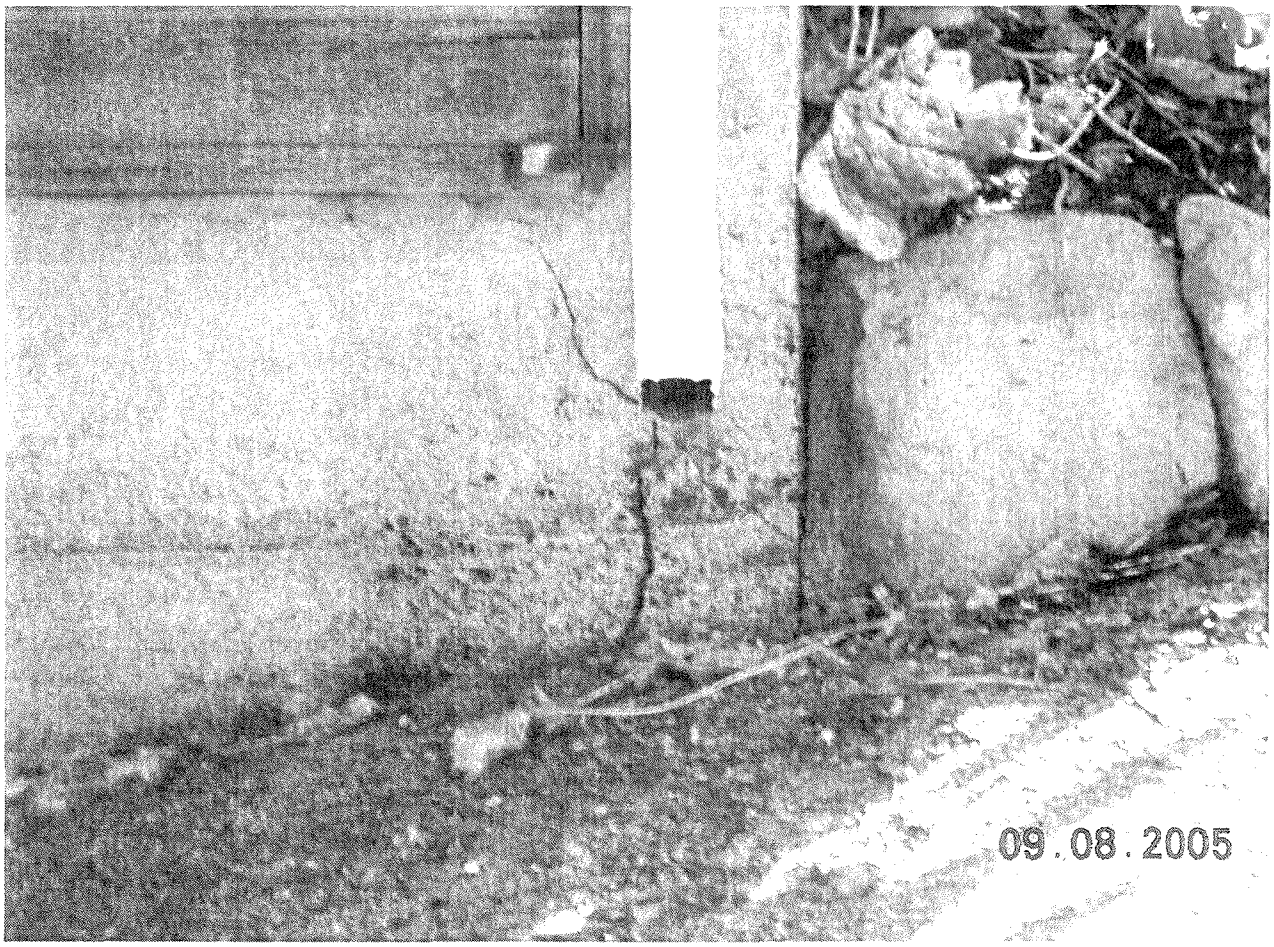
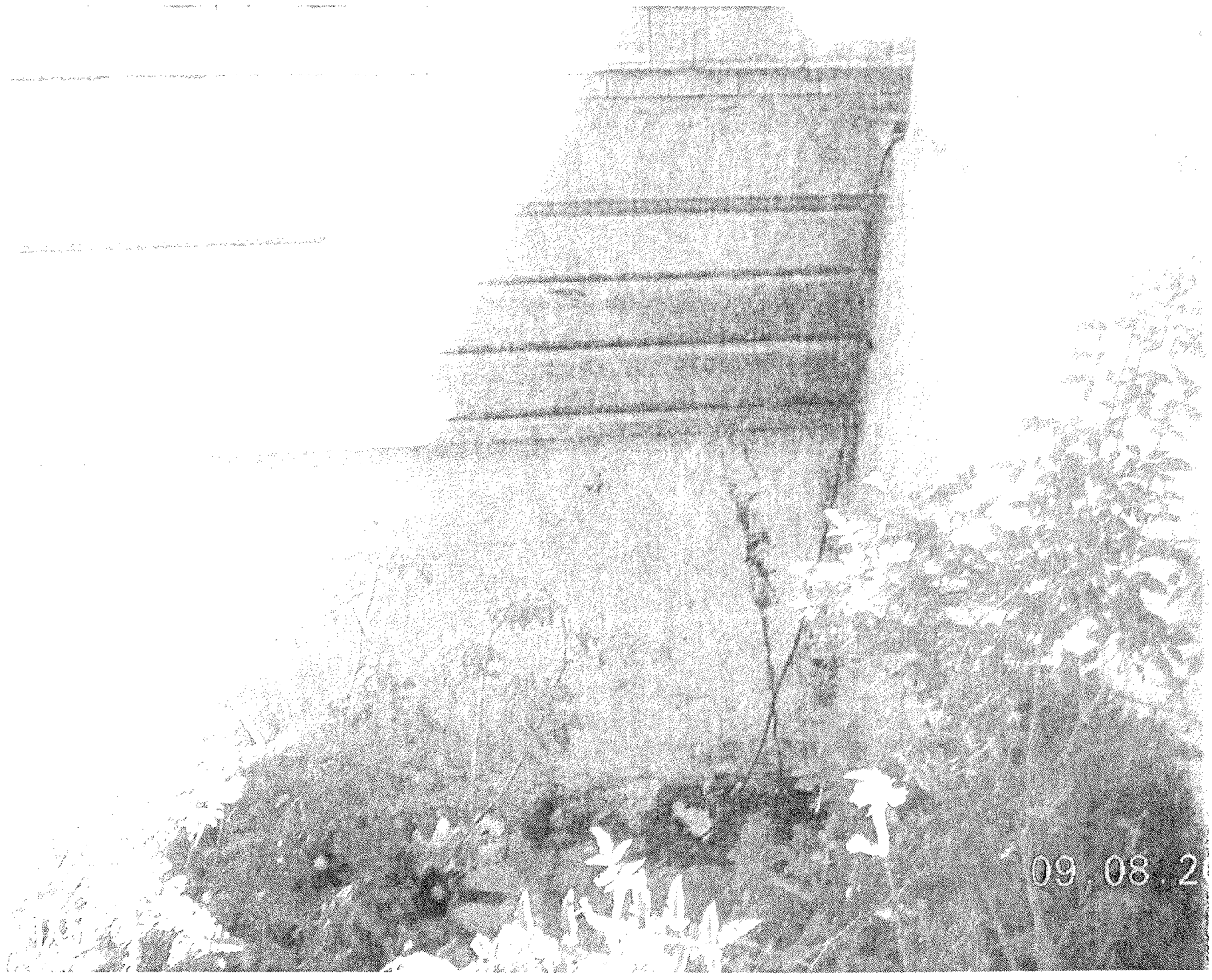
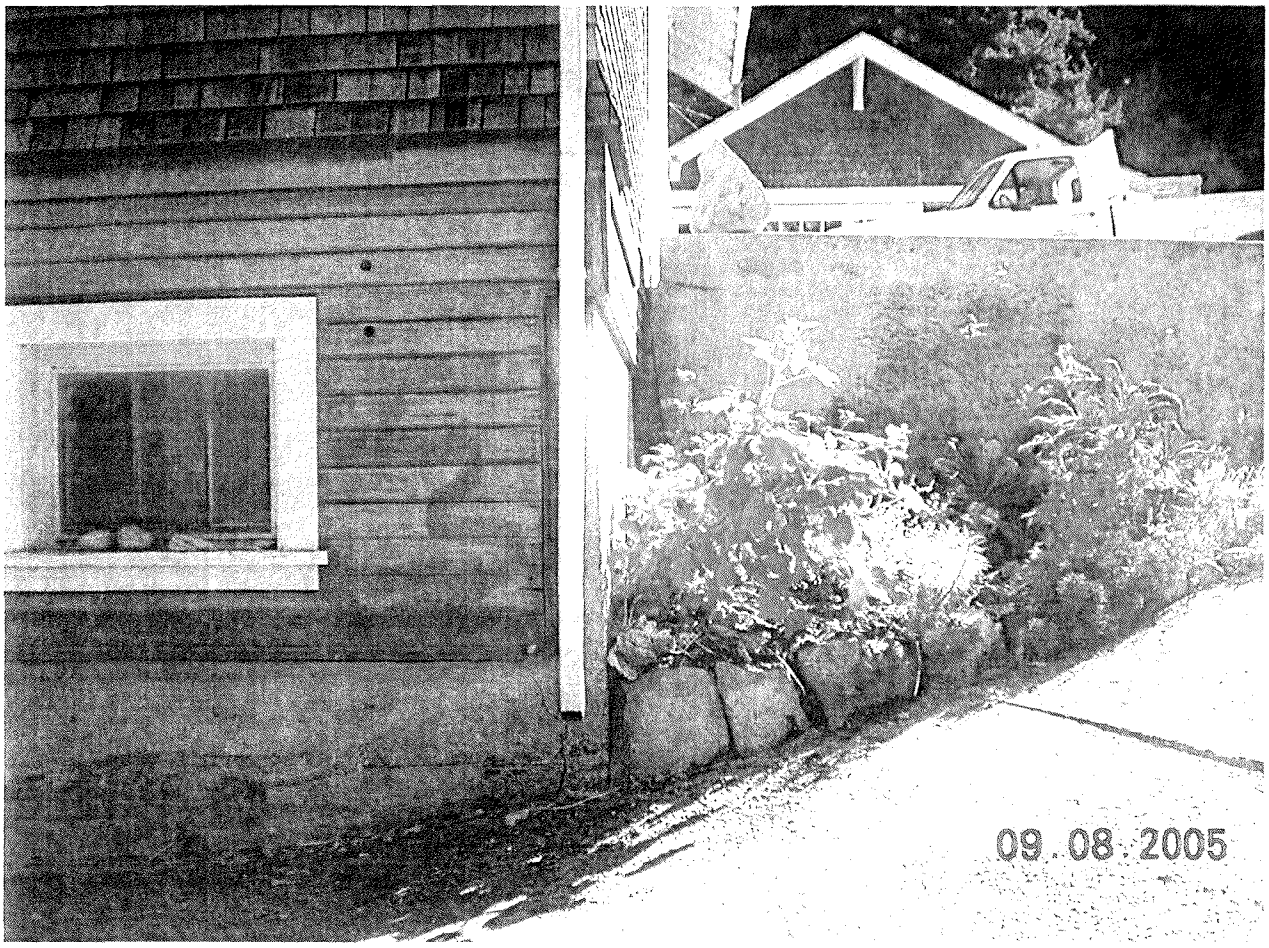


SW corner. Vertical crack in foundation from wall rotation. Note horizontal crack turns the corner and heads south. Elevation lines up with interior horizontal crack.



Another shot of exterior crack and driveway retaining wall.



West elevation.

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More cracks in paving at SE corner looking north.

Looking south. Note driveway slope to the front of the building.

REFERENCES

1. ASCE 11-90, *Guideline for the Structural Condition Assessment of Existing Buildings.*
2. 2003 *International Residential Code.*

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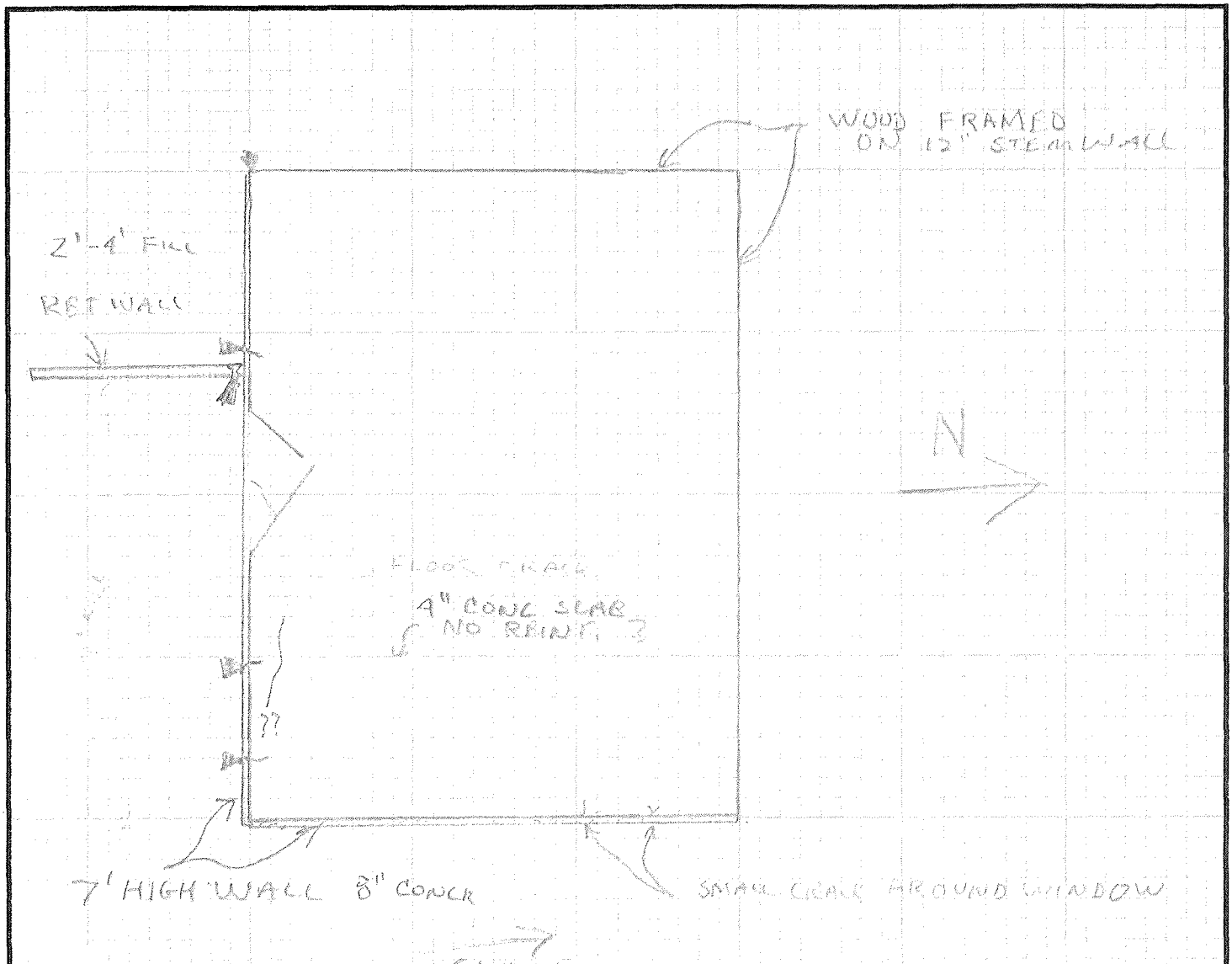

PLAN

▶ : MAJOR CRACKS (VERTICAL)

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CHKD. ____ DATE ____ CRACK MAP & NOTES JOB NO. ____