TEST REPORT-November 1992

PHASE I RESIDENTIAL FOUNDATION ANCHORAGE

Introduction

California's active seismic activity has historically inspired the creation of numerous methods and devices that could be utilized to reduce earthquake hazard, especially for commercial, industrial, and public works projects. In the wake of these developments single-family residential projects are finally being addressed, largely because of the numerous residential structural failures due to recent seismic activity. Of particular concern are foundation failures to existing residential buildings, whereas California in general and SEAOSC and the City of LOS ANGELES in particular are now developing guidelines for the retrofit of residential foundations. One necessary aspect of the development of these guidelines is a testing program designed to cater particularly to residential foundations, developing load criteria and methods,

Consequently, this test report is a beginning towards obtaining that goal.

.Purpose

The purpose of this series of tests was to quantitatively determine the following;

(1) to determine ultimate load and deflection criteria under induced static loading for existing foundation anchors and to observe the mode of failure.

(2) to determine ultimate load and deflection criteria under induced static loading for retrofit anchor bolts and/or retrofit anchorage devices and to observe the mode of failure. Results can then be compared to each other and to the results of anchor bolts alone as determined by 1 above*

(3) To compare values of failure for anchorage both with a wall superimposed dead load (Surcharge) and with no dead load.

(4) To obtain sufficient test data in devising a simple homeowner's method to determine minimum strength foundation concrete.

TEST PROCEDURES FOR ANCHORAGE DEVICES

The following outline the test procedures;

1. The bolt and/or plate assembly are installed into the foundation
and shown with two reaction anchors.
2. The embedded (or exposed) length of the anchor is measured and recorded before torque, after torque and after test.
3. Any surcharge load is placed on top of the "sill plate".
4. The apparatus is installed as shown generally consisting of a,
sill plate and anchor bolts, with or without side plates;
5. A dial gauge is installed for measuring the displacement?
6. The hydraulic ram is placed in the test apparatus and actuated using a hand-operated jack;
7. Periodic load and displacement readings are recorded until the
system can no longer sustain an applied load.

In performing the test, one must also note other observations such as cracking of the wood, bending of the anchor bolt and/or plate assembly.

SUMMARY of PHASE I

1. The concrete compressive strength for these foundations was high, averaging 3,800 psi.

2. The sill plates loaded with surcharge performed about 11% higher on the average than those with no surcharge when comparing the loads at 1/2" displacement.

3. Loads were noticeably increased when larger washers were used (see tests 2R(1) and 2 R (2) . Field observation at the conclusion of these tests showed the smaller washer crushing the grain of the wood surrounding the anchor considerably more than the larger washers.

4. For almost all tests, the ultimate failures were wood failures. No anchor bolt failures were observed either in the chemical or the expansion anchors.

5. Comparing ultimate loads, the following conclusions are drawn:

a. average ultimate load for existing 1/2" bolts in foundation was 4.1k (tests 1 (3) & 1 (4)
b. all chemical and expansion bolts tested to ultimate in the same range as these limits (the wood was the failure mechanism)

c. the generic side plate tested to an average ultimate load of 4.6k plate. This ultimate load of 4.6k compares closely to 4.lk for 1/2" bolts embedded anchors.

Conclusion: The generic side plates could be used as a one on one trade off for 1/2" diameter anchor bolts.

The Harlen anchor plate (Retrofit Foundation System - RFS) tested to an average ultimate level of 5k/plate. This ultimate load is a little higher than the ultimate for a 1/2" anchor bolt.

Conclusion; The Harlen RFS plate could be used as a one to one trade off for 1/2" anchor bolts.

The Simpson side plate (FA6) tested to an average ultimate load of 2.6k/plate. This is less than the 4.1k ultimate load for 1/2" anchor bolts.

Conclusion*:* While the Simpson FA6 tested lower than the other devices tested in this program, the plate remains a feasible option for a substitution for 1/2" diameter anchor bolts when compared to the UBC code values of 650 lbs per anchor bolt (note: dividing the ultimate load of 2.6k by 4 gives a working value of 650 lbs per anchor).

The slant: bolts tested to an average ultimate load of 4.1k/bolt.

This ultimate load compares to 4.1k for 1/2" embedded anchors.

Conclusion; The 1/2" slant anchor could be used as a one on one trade off for 1/2" anchor bolts.

SUMMARY

A) GENERAL (PHASE II)

1. The average compressive strength of this concrete for these foudations was 1500 psi. or about what could be expected from low quality existing residential foundation

2. The sill plates loaded with a surcharge did not perform very differently from the tests with no surcharge. However, there was a noticeable difference in the stability of the sill plate - they had significant buckling without the overburden.

3. For almost all tests, the wood was the failure mechanism. There was one case (Test 5DPG (3)) where the reaction anchors failed after high loading. Also had both reaction anchor and existing anchor failure at "strong" existing concrete (Tests 1(1), 1(2) and 1(3)). Finally, in two eases 3REX(2) and 5DGP(1)) the concrete had local failure at the anchors after high loading and deflection.

4. Generally the loads at 1/2" displacement were observed to be approximately linear to the ultimate loads at failure, Therefore, usually any comparisons at 1/2" displacement will parallel any comparisons at ultimate loading.

B> ULTIMATE LOAD SUMMARY AND CONSLUSIONS (PHASE (II)

1. Average ultimate load for existing 1/2" diameter bolts in good condition was 8.1k (Tests 1(1), 1(2), and1(3)).

2. All chemical and mechanical bolts tested to ultimate at about the same range. The failure was in the wood. The average for all single chemical anchor tests and average for all single expansion bolt tests was 7.2k.

3. Mechanical anchors tested with round standard cut washers showed a significant reduction in ultimate load as compared with square plate washers. The smaller washer would bite into the wood and crush the wood locally under smsall loading and deflections. For round standard cut washers the average ultimate load was 4.9k, for square washers the average was 5.9k.

4. There was no significant difference between the tests on anchorage systems using mechanical versus chemical anchors for these static load tests, even when the mechanical anchors were placed in honeycombed concrete.

5. The ½ " chemical slant bolts had an ultimate failure average of 2.1k (Tests 4SCH(1), (2) and (3)). Failure occured at *very* small deflections (0.01% 0.03" and 0.268"), Observations during the tests showed that the chemical adhesive seeped down trough the hole in the wood to between the sill plate and the foundation, resulting in a “glued” connection. Failure occurred when the bond between

the wood sill plate and the concrete foundation broke; the slant bolt was not effective. These tests cannot be conclusive for the whole system.

6. The generic side plate system tested side plate system tested to an average ultimate of 3.3 k/plate.

7. The Harlen side plate system tested to an average ultimate of 4.3k per plate.

8, The Simpson side plate system tested to an average ultimate of 2. 3/plate.

CONCLUSION (PHASE II) All systems, the generic, the Harlen and the Simpson even in concrete of questionable strength may be used as a one-to one trade-off for the UBC proscribed ½ diameter anchor bolt.

Comparison of Phase I and Phase II

1. In phase I the f'c of the concrete averaged 3800 psi; in phase II it average 1500psi.

2, For single chemical bolts the results were; Phase I average ultimate load was 4.9k; Phase II was 5.2k.

3. For single expansion bolts the results were: Phase I average ultimate load was 4.7k;; phase II was 5.2k.

4. For the gereric side plate system the results were; Phase I average ultimage load was 4.6k/plate; Phase II was 5.4 k.

5. For the Hasten side plate system;, the results were; Phase I average ultimate load was 5.0k/plate; Phase II was 4.3k plate,

CONCLUSION (COMPARING PHASEI VERSUS PHASE II)

The difference in the strength of the concrete did not appreciably affect the performance of the foundation anchorage systems. Engineered or proscribed methods for retrofitting foundations of good concrete will also work with foundations of weaker concrete (f'c approximately 1500psi). The predominant failure mechanism in these anchorage connections was the wood sill plate in both the good and weak concrete foundations.