2.13 ANSS DOWNHOLE ARRAYS AT INSTRUMENTED BUILDINGS

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INTRODUCTION

Instrumented buildings are a significant component of the U.S. Geological Survey's (USGS) Advanced National Seismic System (ANSS). In order to examine the structural response, soil-structure interaction, and the effects of surface geology on the input motions to structural arrays, the ANSS program has deployed borehole instrumentation at some instrumented structures in the United States.

One of the first buildings to be fully instrumented under the ANSS program is the Robert Atwood Government Building in downtown Anchorage, Alaska, a 20-story steel-frame structure with a single-story basement and a reinforced-concrete foundation. The building instrumentation is complemented by an array of buried, three-component accelerometers in six boreholes ranging in depth from 15 to 200 ft (5-60 m), with a seventh sensor at the surface. The boreholes are located a city block from the building, sufficiently removed that the records are unaffected by the shaking of the building itself. The borehole data thus record the input signal of the seismic waves impinging on the building.

The USGS has also funded the instrumentation of a site adjacent to the Factor building on the University of California, Los Angeles (UCLA) campus. This building was densely instrumented under a National Science Foundation (NSF)-funded program for the development of sensor networks (UCLA's Center for Embedded Networked Sensing (CENS). A 100-m borehole was drilled, logged, and cased in 2004, and a three-component accelerometer is being installed at the bottom of the cased borehole. While this site is not an extensive array of borehole sensors like the Anchorage site, the single borehole sensor will provide useful information about the input motions to the Factor building, as well as other structures on campus.

The following is a photo essay of the two array sites. Details of these sites will be provided in a section of the second Geotechnical Strong-Motion Arrays workshop in fall of 2005.

THE DELANEY PARK ARRAY, ANCHORAGE, ALASKA

Downtown Anchorage sits on top of the great Alaskan subduction zone and has been subjected to large damaging earthquakes in the past. The March 27th, 1964 (Good Friday), magnitude 9.2 great Alaska

earthquake shook the ground for more than four minutes over a 50,000-square-mile region and caused 131 deaths. Figure 1 shows the Anchorage city skyline (left) and the recently instrumented Robert Atwood building as seen from Delaney Park (right), the site of the new ANSS geotechnical array.

Instrumentation

The Delaney Park Array, deployed to provide the input wavefield to the Atwood building, has three-component accelerometers at six levels (Figure 2) within the near-surface soil column and also at the surface. A soft formation called the Bootlegger Cove, is thought to be responsible for much of the damage in downtown Anchorage during the 1964 earthquake. Blow counts are down in the single digits at depths of over 100 ft in this formation, and wave velocity decreases with depth through this formation (Figure 3). The geotechnical array is deployed to sample the ground motions within this formation, as well as above and below it. Figures 4 through 7 show various steps in the geotechnical strong-motion array installation process.

Figure 1. The skyline of downtown Anchorage (top) and the Atwood building and Delaney Park geotechnical strong motion array (bottom).

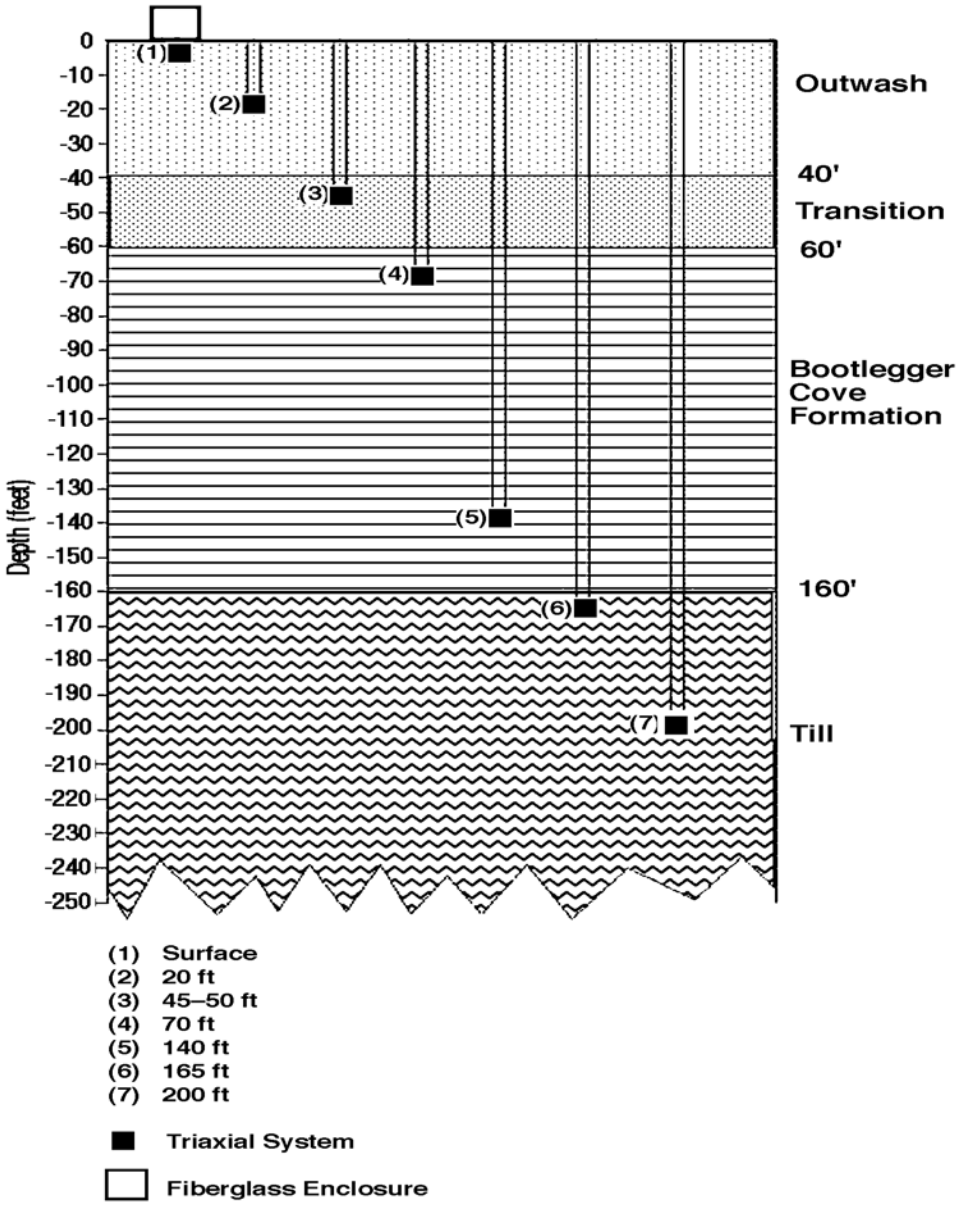

Figure 2. **Soil profile and Geotechnical Array Layout at the Delaney Park Array in downtown Anchorage, Alaska.**

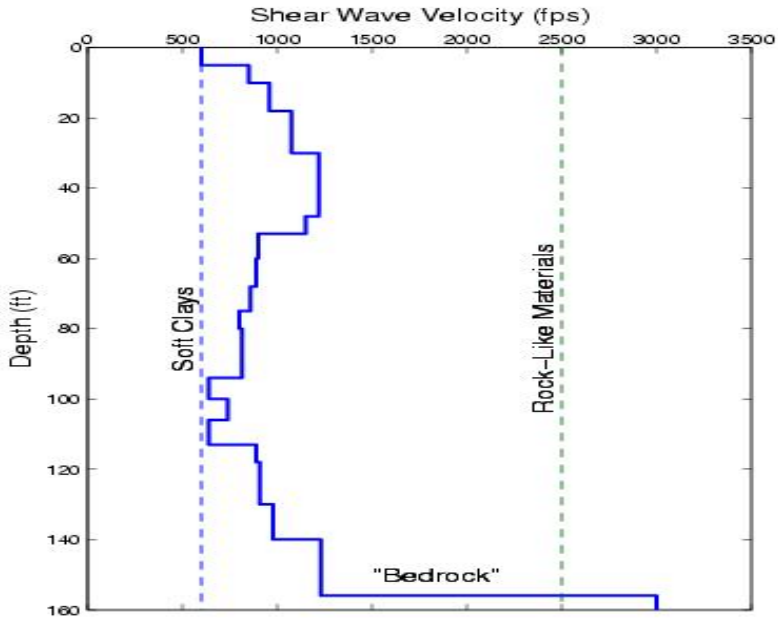

Figure 3. Shear wave velocity with depth in downtown Anchorage.

Figure 4. Delaney Park Array after drilling of six boreholes. The instrumented Atwood building can be seen in the background.

Figure 5. Installing a three-component accelerometer at the Delaney Park geotechnical strong-motion array.

Figure 6. Using glass beads to couple the borehole accelerometer to the borehole casing.

Figure 7. The completed fenced in array and recording hut (October 2003).

(a) (b)

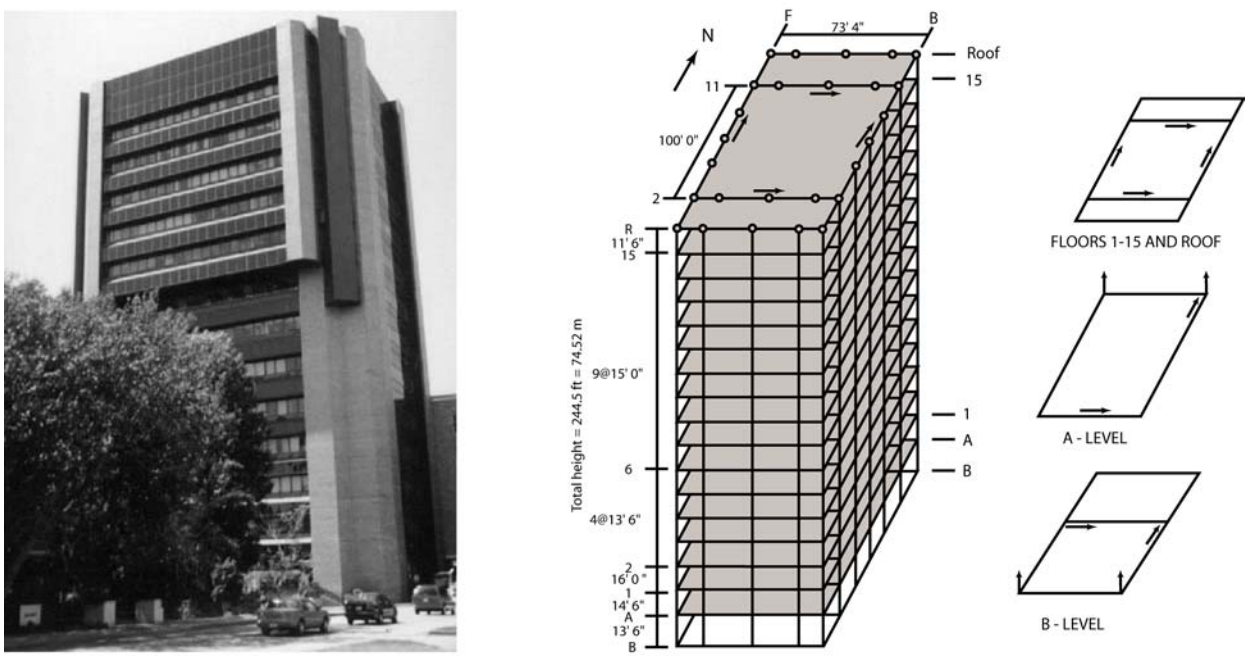

Figure 8. (a) Factor Building on the UCLA campus. (b) Schematic of the building's instrumentation system.

Figure 9. Drilling at the Botanical Gardens on the UCLA campus with the Factor Building in the background.

Data from the Delaney Park Array are telemetered in real-time from Anchorage to the USGS office in Menlo Park, California, and to the Alaska Seismic Network at the University of Alaska in Fairbanks.

THE BOREHOLE INSTALLATION AT THE FACTOR BUILDING ON THE UCLA CAMPUS

Under the CENS program, the densely instrumented 17-story Factor Building (Figure 8) on the UCLA campus was recently augmented with a downhole accelerometer at 100-m depth. The borehole had extensive geophysical and geotechnical logging conducted prior to installation of the casing so that the response of the soil column can be modeled using the data recorded at depth and at the surface. The motions recorded at depth serve as the input motions for structural response modeling of the building. Figure 9 shows the drilling that took place in 2004 to set the 100-m casing. The borehole is located within a building height of the Factor building, in the Botanical Gardens just east of the structural array.