

DRAFT REPORT

**GEOTECHNICAL
ENGINEERING STUDY**

**University of California, Berkeley
Art Museum Relocation Study
Berkeley, California**

Prepared for
University of California, Berkeley
Planning, Design and Construction
2000 Carleton Street
Berkeley, California 94720-0380

May 8, 2001

URS

500 12th Street, Suite 200
Oakland, CA 94607

5100011038.00

DRAFT REPORT

1.0 Introduction

In 1997, the University of California (U.C.) at Berkeley initiated the SAFER Program - a campus-wide inventory of the seismic reliability of its facilities. The existing University Art Museum, originally constructed in 1967, and located between Bancroft and Durant Streets in Berkeley, California, was rated as "very poor" in this inventory (U.C. Berkeley, 1997). A seismic retrofit project is presently underway to upgrade the seismic performance of this structure to preserve life safety in the event of a major earthquake. The University is now considering constructing a new Art Museum on a site at the western edge of the main campus. Such a location would have the cultural benefit of being in close proximity to the downtown Berkeley arts district. This report presents the results of our study to identify and evaluate the key geotechnical design and construction issues associated with development of a new U.C. Berkeley Art Museum at this proposed location.

2.0 Scope of Work

The scope of our study was based on our meeting with you and your architect on February 20, 2001, our proposal to you dated March 7, 2001, and your authorization of March 28, 2001. The elements of the study included:

1. Review existing geotechnical reports, as-built plans, and geologic data in the vicinity of the proposed site;
2. Develop ranges of geotechnical engineering design parameters for the project based on previous investigations in the project vicinity;
3. Identify key geotechnical design issues associated with the site development alternatives, including construction at-grade, construction with underground basement level(s), construction next to adjacent structures, and construction on top of existing foundations;
4. Evaluate the feasibility of alternate foundation systems, and any potential geotechnical constraints on the proposed construction;
5. Provide preliminary geotechnical design recommendations, as appropriate; and
6. Provide recommendations for geotechnical site investigations to supplement the existing data for final design.

3.0 Project Location and Existing Facilities

The project site is situated on two city blocks immediately west of campus in downtown Berkeley as shown on Figure 1. The site is bounded by University Avenue to the north, Oxford Avenue to the east, Center Street to the south, and Shattuck Avenue to the west.

DRAFT REPORT

The site, which is bisected by east/west trending Addison Street, can be further subdivided into three regions, discussed below.

The first parcel consists of the 1.3-acre (56,250 sq. ft.) area west of Oxford Avenue between Addison and Center Streets. Two existing structures currently occupy this area: the 250-space University Hall Parking Structure and the U.C. Printing Plant. The University Hall Parking Structure is a 3-level reinforced concrete structure with a basement level, ground floor, and roof level parking. The U.C. Press Building is a "sawtooth" shaped one-story steel structure with a partial basement beneath the southern part of the shop floor, and a 3-story portion along Oxford Street.

The second parcel consists of the 0.8-acre (36,440 sq. ft.) area northeast of the intersection of Shattuck Avenue and Center Street. This area is currently occupied by an existing one-story Bank of America branch and its adjoining parking lot.

The third parcel consists of the 0.9-acre (38,000 sq. ft.) area west of Oxford Avenue between Addison Street and University Avenue. This area is currently occupied by the western (2-story) portion of University Hall, a 19-space parking well, and a 29-space parking lot. The western portion of University Hall is a 2-story steel structure and the eastern portion is a 7-story reinforced concrete structure. Our records show that this entire structure is underlain by a basement.

4.0 Data Review

The following information was provided to us by Mr. Darril de la Torre of U.C. Berkeley Capital Projects for our review:

- Report titled "Soil Investigation for the Proposed Statewide Office Building" [a.k.a. University Hall] by Woodward, Clyde & Associates, dated March 1957.
- Foundation drawings for "The University of California Statewide Office Building" [a.k.a. University Hall] by Welton Becket and Associates, dated July 1957.
- Foundation drawings for "Statewide Office Building Parking Structure" [a.k.a. 250-Space University Hall Parking] by Anshen & Allen Architects, dated October 1959.
- Foundation drawings for "University of California Press Building" [a.k.a. U.C. Printing Plant] by Masten and Hurd Architects, dated November 1938.
- Report titled "Geotechnical Investigation, GALA Building, Berkeley, California" by Harza Engineering Company, dated November 1998. This structure is currently under construction.

URS recently completed geotechnical site investigations for the Seismic Replacement Building No. 1 and Barker Hall Seismic Upgrade projects, both located on opposite sides of the corner of Hearst and Oxford Streets. The following information from those investigations was also reviewed:

DRAFT REPORT

- Report titled "Geotechnical Engineering Study, Oxford Street Replacement Building No. 1, University of California" by URS Greiner Woodward Clyde, dated January 2000.
- Report titled "Geotechnical Engineering Study, Seismic Upgrading of Barker Hall, University of California" by Woodward Clyde Consultants, dated January 1998.

The significant pieces of information extracted from these data sources are summarized in Table 1 and are discussed in further detail in the following sections.

5.0 Previous Subsurface Investigations

Five exploratory borings were drilled at the site in February of 1957 in connection with the soil investigation for University Hall (Woodward, Clyde & Associates, 1957). The holes were advanced to a maximum depth of 75 feet using a 6-inch diameter power auger, and the samples were recovered using a Modified California sampler. Blow counts from a 140-lb hammer falling 30 inches were recorded. The laboratory testing program consisted of the following types of tests: water content, dry density, unconfined compression, gradation, plasticity, consolidation, and triaxial shear (both consolidated-drained and consolidated-undrained tests).

In December of 1998 and December of 1999, thirteen exploratory borings were drilled approximately 600 feet north of the site for the proposed Oxford Street Replacement Building No. 1 to be located north of Hearst Avenue (URS Greiner Woodward Clyde, 2000). These borings were initially advanced using rotary wash drilling methods and soil samples were recovered using split-spoon and Modified California samplers. The borings were advanced to a maximum depth of 74 feet using diamond core drilling techniques in rock, and samples were collected using a 5-foot split core barrel and a wire-line system. Laboratory tests consisted of water content, dry density, unconfined compression, plasticity, and gradation tests. Upon completion, five of the boreholes were converted into groundwater monitoring wells.

In November and December of 1997, six exploratory borings were drilled approximately 550 feet north-east of the site for the Barker Hall Seismic Upgrade investigation (Woodward Clyde, 1998). Three of these borings were advanced using rotary-wash drilling methods to refusal at bedrock depths ranging from 33 to 43 feet below grade. Soil samples were recovered from these borings using split-spoon and Modified California samplers. Three additional borings were advanced to a maximum depth of 75 feet using diamond core drilling techniques, and samples were collected using a 5-foot split core barrel and a wire-line system. Laboratory tests consisted of water content, dry density, unconfined compression, plasticity, and gradation tests.

In March of 1998, five borings were drilled approximately 300 feet south of the site for the GAIA Building currently under construction south of Allston Way (Harza, 1998). These borings were advanced to a maximum depth of 71 feet using 8-inch diameter

DRAFT REPORT

hollow-stem augers. Soil samples were recovered using split-spoon and Modified California samplers. Laboratory tests consisted of water content, dry density, unconfined compression, and plasticity tests.

6.0 Site Geology and Seismicity

The site is located on relatively flat ground west of and at the foot of the Berkeley Hills. The ground surface elevation along Oxford Street ranges from about +210 feet MSL at Hearst Street to about +200 feet MSL at Addison Street. Radbruch (1957) indicated that the site area is underlain by the Temescal formation consisting of alluvial-fan deposits with interfingered lenses of clayey gravel, sandy silty clay, and sand-silt-clay mixtures. Below the Temescal formation is Franciscan Graywacke bedrock with small amounts of shale. The Franciscan formation consists of sandstone, siltstone, shale, greenstone, and chert.

The Hayward fault is the closest known active fault and is approximately 3,000 feet (900 meters) east of the site. The potential for surface fault rupture at the site is judged to be very low. The Hayward fault is a major component of the San Andreas fault system in the San Francisco Bay Area, and has been extensively studied. It extends about 100 kilometers from Mount Misery, east of San Jose (Bryant, 1982), to San Pablo Bay (Lienkaemper, 1992). The northern portion of the Hayward fault is particularly well-expressed geomorphically where it coincides with a marked "rift" valley through the Oakland Hills. Systematic right-lateral stream offsets have been documented at several locations along the fault zone.

The Hayward fault generated a large earthquake in 1868. The earthquake has been estimated as a Richter magnitude 6.8 event. It produced several tens of kilometers of surface rupture (Lienkaemper and others, 1991). The northern end of the 1868 surface rupture is believed to be located near San Leandro, although some discontinuous ruptures may have occurred as far north as Mills College in Oakland. The California Working Group on Earthquake Probabilities (1999) estimated a 32 percent probability of a magnitude 6.7 or greater earthquake in the next 30 years on the northern segment of the Hayward fault that is closer to the site. At the present time, microseismicity is associated with much of the northern segment of the fault (Oppenheimer and others, 1992).

7.0 Anticipated Subsurface and Groundwater Conditions

In general, the subsurface conditions at the site are expected to consist of approximately 40 feet of stiff to very stiff silty and sandy clay, overlying hard clay and dense sand below depths of 40 feet. Weathered bedrock should be encountered at depths of roughly 45 to 50 feet, with rock competency and strength increasing with depth. The overlying clay is expected to exhibit low plasticity and compressibility, and to contain varying

DRAFT REPORT

amounts of rock fragments and gravel. Occasional layers of medium dense to dense clayey sands on the order of 5 to 10 feet thick may also be encountered within the clay. The bedrock at the site is part of the Franciscan formation, and should consist of a melange of siltstone, sandstone, claystone and greenstone.

It should be noted that south of the site (south of Allston Way), relatively thin deposits of clay, on the order of 8 feet thick, were encountered overlying relatively thick deposits of clayey sand and gravel, on the order of 16 to 36 feet thick. Bedrock was not encountered at that location. Conversely, bedrock was encountered at depths as shallow as 17 to 25 feet at the Seismic Replacement Building No. 1 site to the north at the corner of Hearst Avenue.

Groundwater was encountered during the 1957 site investigation at the University Hall site at depths ranging from 7 to 16 feet below ground surface. Groundwater was encountered at depths ranging from 12 to 20 feet below the ground surface at the GAIA Building site. The groundwater depths at the new Art Museum site may vary among the three parcels, but typically should exist at depths of 10 to 20 feet. The groundwater levels are expected to have seasonal variations. The anticipated subsurface and groundwater conditions are conceptually shown for a cross-section taken along Oxford Avenue in Figure 2. The stick logs shown on Figure 2 correspond to those borings from the previous investigations that are located relatively close to Oxford Avenue.

8.0 Liquefaction Potential

Liquefaction is a phenomenon during which loose, saturated, cohesionless soils (generally sands) temporarily lose shear strength during ground shaking induced by severe earthquakes. Significant factors known to affect the liquefaction potential of soils include grain size distribution, relative density, degree of saturation, the confining stresses acting on the soils, and the characteristics of the soil fines fraction. As discussed above, shallow lenses of medium dense to dense clayey sands on the order of 5 to 10 feet thick may be encountered at the site. However, these soils are unlikely to be susceptible to liquefaction due to their fines content and sufficiently dense state.

9.0 Foundation Recommendations

Based on our data review, the existing structures in the vicinity of the site are founded primarily on shallow foundation systems consisting of spread footings and slabs on grade, and most of these structures have partial or full basements. For example, University Hall consists of 1-story and 7-story concrete and steel structures founded on spread footings and grade beams located beneath a basement slab underlain by 6 inches of gravel fill. The University Hall Parking Structure is a 3-level reinforced concrete structure founded on spread footings located beneath a basement slab on grade. The U.C.

DRAFT REPORT

Printing Plant has a warehouse-type 1-story steel-framed section founded on spread footings located beneath the shop floor, and a 3-story reinforced concrete portion founded on spread footings located beneath the basement floor.

We are not aware of any reported foundation problems, building distress, or excessive settlements of these structures in the site vicinity. Because shallow foundation systems have successfully been employed in this area, the new Art Museum could likely utilize a similar foundation design, provided that it is comparable in size and loading to the existing structures. Furthermore, the site specific soil data from previous investigations imply that the site is suitable for supporting a new structure on spread footings without detrimental settlements.

If spread footing foundations allow excessive settlements under the proposed building loads, a mat foundation may be a viable alternative. If the proposed structure exerts very high column loads and/or imposes excessive settlements on both spread footings and mat foundations, drilled piers may be designed to extend to end-bearing on bedrock. This scenario would be most likely for a heavy structure designed without a basement (a basement excavation decreases the applied foundation bearing pressure, which reduces building settlements). Driven pile foundations are not considered a suitable foundation option for this site. Design for uplift forces may also be of concern, and is discussed below.

Based on the limited information available to us at this time, we are unable to provide specific recommendations for the construction of new structures to be founded on existing foundations at the site. It may be feasible, however, during the site investigation, to excavate test pits adjacent to the existing foundations to evaluate the soil bearing capacity and the structural integrity of the footings (the latter to be evaluated by a structural engineer).

10.0 Geotechnical Design Criteria

The following geotechnical design parameters have been developed based on the subsurface conditions encountered in the project vicinity and are recommended to provide a basis for conceptual-level design only. These design recommendations apply equally to development at the three parcels comprising the overall site. A site-specific geotechnical investigation should be performed to provide specific recommendations for final design of the proposed structure(s).

10.1 Shallow Foundations

Shallow spread foundations should be a minimum of 24 and 18 inches wide for square and strip footings, respectively, and should be founded at least 24 inches below the lowest adjacent finished grades. To limit differential foundation settlements, the

DRAFT REPORT

following allowable bearing pressures are recommended to determine the sizes of new footings:

Dead Load (F.S. = 3)	4000 psf
Dead and Live Load (F.S. = 2)	6000 psf
All loads, including wind or seismic (F.S. = 1.5)	8000 psf

These bearing pressures are provided for footings bearing on undisturbed native very stiff to hard clays. We expect differential settlements of less than 1/2-inch between adjacent footings designed with these bearing pressures. Total settlements will be a function of building dead and live loads, building footprint, and basement excavation depth (if any).

10.2 Mat Foundations

A mat foundation may be designed with the allowable bearing pressures provided above for shallow foundations. Estimated settlements and recommended values for modulus of subgrade reaction are a function of the specific building loading and geometry, to be determined during final design.

10.3 Drilled Piers

We do not expect that drilled piers will be required for compressive loads for the new Art Museum, unless a shallow or mat foundation system allows excessive settlements. In this case, the piers may be designed as end-bearing on bedrock. It is more likely that drilled piers would be utilized to provide uplift resistance for seismic, wind, or hydrostatic loads. We recommend that drilled piers be designed with an allowable skin friction of 1200 psf for uplift loads. This skin friction value may potentially be improved by conducting a drilled pier load test program at the site.

10.4 Uplift Anchors

Rock anchors may also be designed to provide uplift resistance, if required. The anchors should be pressure-grouted in competent bedrock to develop the design allowable adhesion (skin friction) of 17,500 psf for uplift loads. Pilot load tests should be performed to evaluate the actual rock anchor tension capacity, and the anchors should be proof tested during installation.

10.5 Seismic Site Factor

It is assumed that the seismic design of the buildings will be performed using the Uniform Building Code (UBC) standard design response spectra. In the absence of design criteria due to the preliminary nature of the project, our recommendations are