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June 2, 2004

Arup
901 Market Street, Suite 260
San Francisco, CA 94703

Attention: Demetrious C. Koutsoftas
Associate Principal

Dear Mr. Koutsoftas:

Re: Predicted Settlement of 80 Natoma Building

This letter report summarizes the results of the settlement analyses for the proposed construction of the 80 Natoma building in downtown San Francisco. The facility consists of a 52-story Tower supported on a piled mat foundation that is surrounded on three sides by two levels of underground garage and a two story building. The site is underlain by a 100-foot-thick clay deposit, called the Old Bay Clay (OBC), located 90 feet below ground surface. The piles for the mat foundation terminate above the OBC and transfer significant stresses to this layer. There is considerable concern as to the amount of settlement that would develop due to compression of the OBC under the stresses imposed by the 80 Natoma building.

The writer was asked for an independent assessment of the likely settlement of the Tower due to the proposed construction. This assessment adopted two methods of analysis, one based on hand calculations by the writer and the other using finite element analyses with the PLAXIS program. The latter were performed by Professor Andrew Whittle of MIT, whose expertise is in theoretical soil mechanics and numerical techniques. He also conducts courses for users of the PLAXIS program. We were furnished with plans and cross-sections of the proposed construction, typical soil profiles (including one deep boring log at the site), and results of laboratory classification, strength, and consolidation tests run on the OBC for prior projects in the area. Mr. Koutsoftas also provided information regarding the likely construction sequence and time schedule.

EXHIBIT C

This report presents a summary of the selected soil profile and the settlement characteristics of the OBC layer, how the proposed construction was modeled, results of analyses to predict stress changes within the OBC during construction, and estimates of the resulting vertical movements. To facilitate the calculations, the analysis is divided into two steps to estimate: (1) settlements resulting from incremental stresses above the in situ stresses due to the weight of the structure; and (2) settlements resulting from initial heave during excavation, followed by subsequent loading during construction when the building loads restore the in situ stresses to their preconstruction levels.

SOIL PROFILE AND PROPOSED CONSTRUCTION

Figure 1(a) shows the selected initial soil profile, the location of the water table, and the total unit weights of the soil strata for conditions below the center of the Tower. The relative thicknesses of the soft Bay Mud and dense Colma Sand vary across the site, whereas the depth and thickness of the OBC was assumed to be constant (i.e., average thickness of 100 feet, between depths of 90 feet and 190 feet), because there is only one deep borehole at this site and there is not sufficient information to assess the likely variations in clay thickness across the site. The essential features of the proposed construction are summarized in Figure 1(b).

The total vertical stress from the Tower and the mat foundation is 13,200 psf and is supported by piles that transfer the load to a dense sand layer known as Colma Sand. The mat has approximate plan dimensions of 120 feet × 130 feet. In the area of the parking garage and podium, there is a net reduction in stresses because the weight of the excavated soil is greater than the load imposed by the structure. For the purposes of my settlement analyses, a net stress reduction of 1,700 psf was applied at a depth of 26 feet, the bottom of the garage slab. In order to facilitate the planned construction, the groundwater table was assumed to be lowered from the current depth of 15 feet to 45 feet. This groundwater lowering causes a loss of buoyancy equivalent to 1,872 psf.

The changes in stresses in the OBC layer were calculated using two different methods. The first method uses the numerical program PLAXIS, which models the foundation as a two-dimensional structure, in order to simplify the analysis and reduce the conceptual effort to a manageable level. The main advantage of the PLAXIS model is its ability to model in a realistic fashion the rigidity of the piled mat foundation. The second method, which is intended as a check on the more complex numerical model, uses simple charts that can account for the actual three-dimensional stress conditions, but cannot model the stiffness of the building foundation. In addition, the PLAXIS program can simulate the sequence of the various construction processes (i.e., excavation, dewatering, and loading due to building construction).

The results of the two stress analyses show incremental stresses in the OBC layer that range from 5.5 to 8 kips per square foot (ksf) near the top of the layer and 2.5 to 3.5 ksf at the bottom later. The results from the two methods of analyses are reasonably consistent, given the differences in the modeling assumptions. At depths greater than 130 feet, the final stresses calculated from the two methods are within 10 percent of each other.

CONSOLIDATION PROPERTIES OF OLD BAY CLAY

No consolidation tests were performed on the OBC at the site, which is surprising given the size of the project and the large stresses imposed by the 80 Natoma Tower. Mr. Koutsoftas furnished detailed results of eight consolidation tests: five from boring B-7 at 101 Second Street (very near this site) and three from boring B-9 at 55 Second Street. All eight tests were of exceptionally high quality. From my detailed review and evaluation of the results of the eight consolidation tests, I was able to determine the preconsolidation stresses in the OBC and their variation with depth and the compressibility characteristics of the clay. Based on my evaluation of the in situ preconstruction stresses and the incremental stresses imposed by the proposed building construction, it is anticipated that the final effective stresses in the OBC at the end of consolidation will be below the preconsolidation stress, although near the top of the layer they are close to the preconsolidation stress. This means that the OBC will be loaded entirely in recompression. The compressibility of the OBC in the recompression zone is represented by the recompression ratio, which is the amount of strain induced by a tenfold increase in effective stress. Values of recompression ratio (RR) in the range of 0.02 to 0.04 were estimated from the eight consolidation tests. The larger values of RR correspond to conditions where the final effective stress approaches the preconsolidation stress.

PREDICTED SETTLEMENT OF THE TOWER MAT

The settlements resulting from recompression of the OBC were estimated based on one-dimensional compression theory and consideration of the stress changes from the initial (preconstruction) in situ stresses to the final stresses after completion of consolidation under the building loads. In addition, there are settlements caused by the unloading process, resulting from excavation and subsequent reloading as the stresses are restored to the preconstruction condition.

The results of the analyses, considering the stress changes from the preconstruction condition to the final condition (i.e., ignoring the unloading-reloading effects of excavation and subsequent loading), indicate a total settlement of 7.8 inches estimated for the incremental stresses calculated from the 3-dimensional analysis, and using a value of recompression ratio (RR) of 0.03. Based on the results of the PLAXIS analysis, a settlement value of 6.6 inches was calculated. The settlements from the two methods differ by less than 10 percent from their average value of 7.2 inches. For the range of RR values indicated from the results of the eight consolidation tests (RR values of 0.02 to 0.04), the corresponding range of settlements would be about 5.5 to 9.5 inches. Based on these analyses, I estimate a total settlement of 7.5 ±2.0 inches.

The process of unloading during excavation and reloading to the point of restoring the initial (preconstruction) stresses will result in additional settlements. My calculations indicate an additional settlement in the range of 1 to 2 inches, with an average value of 1.5 inches.

Therefore, based on the data presented above, it is estimated that the mat foundation would experience a total settlement of 8.5 ±2.5 inches.

The above analyses address the estimated magnitude of total settlement under the center of the mat foundation. The settlements will be significantly smaller under the edges of the mat, and hence will result in differential settlements. Given that there is no information regarding variations in the thickness of the OBC under this site, it is not possible to provide a realistic estimate of differential settlements without additional boreholes and soil testing. Nevertheless, the results of the analyses presented in this letter lead me to conclude that the maximum settlement of the building will be very large, and therefore it is reasonable to expect that significant differential settlements are also likely to develop.

Sincerely yours,

Charles C. Ladd

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Attachments:
Figure 1
One-page CV

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JOB Transbay - Natoma Building
SHEET NO. 1 OF 1
CALCULATED BY CCL DATE 5/29/04
CHECKED BY ______ DATE ______
SCALE ______

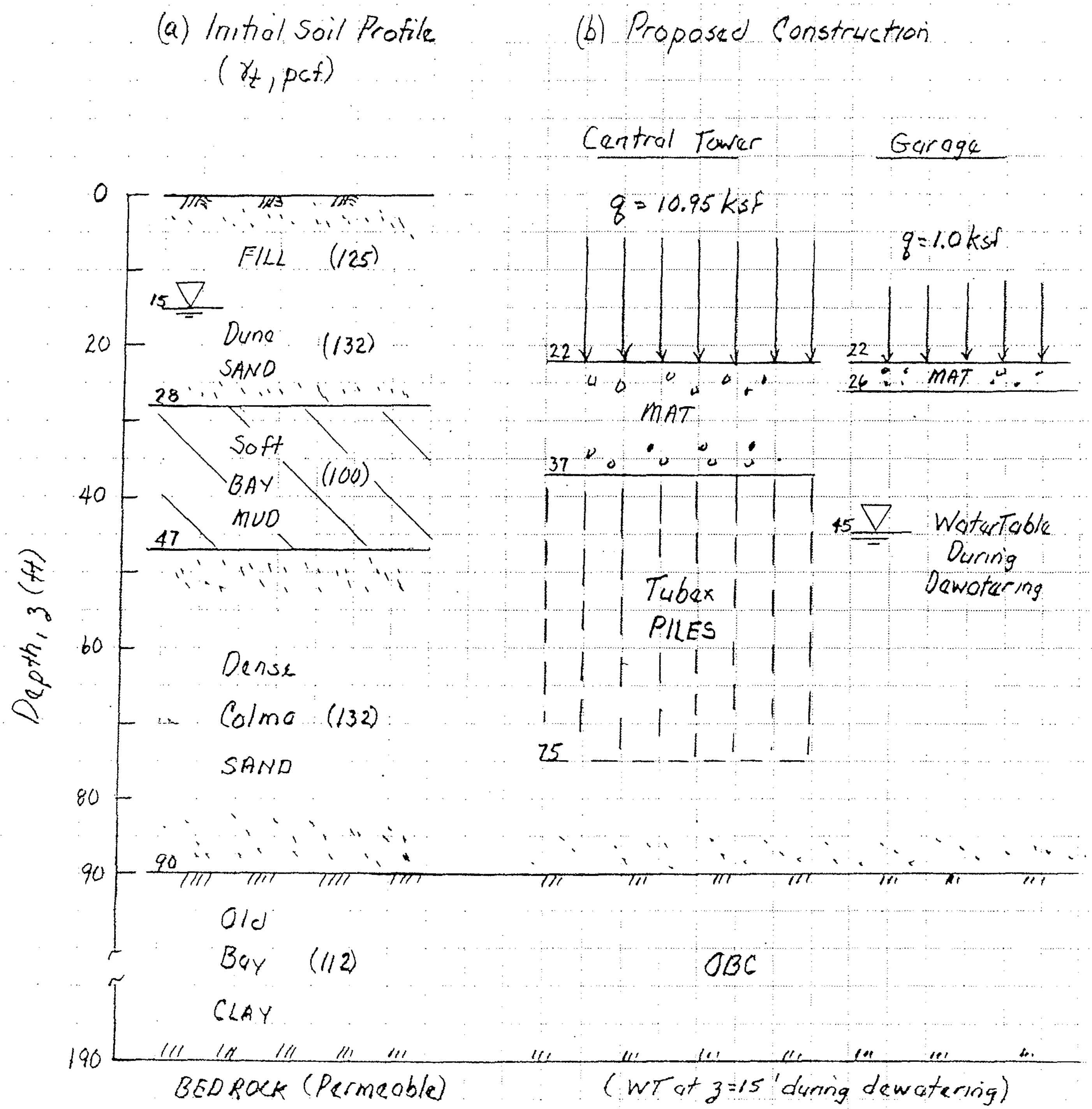

Fig. 1 Soil Profile and Proposed Construction: 80 Natoma Building

CCL 5/28/04

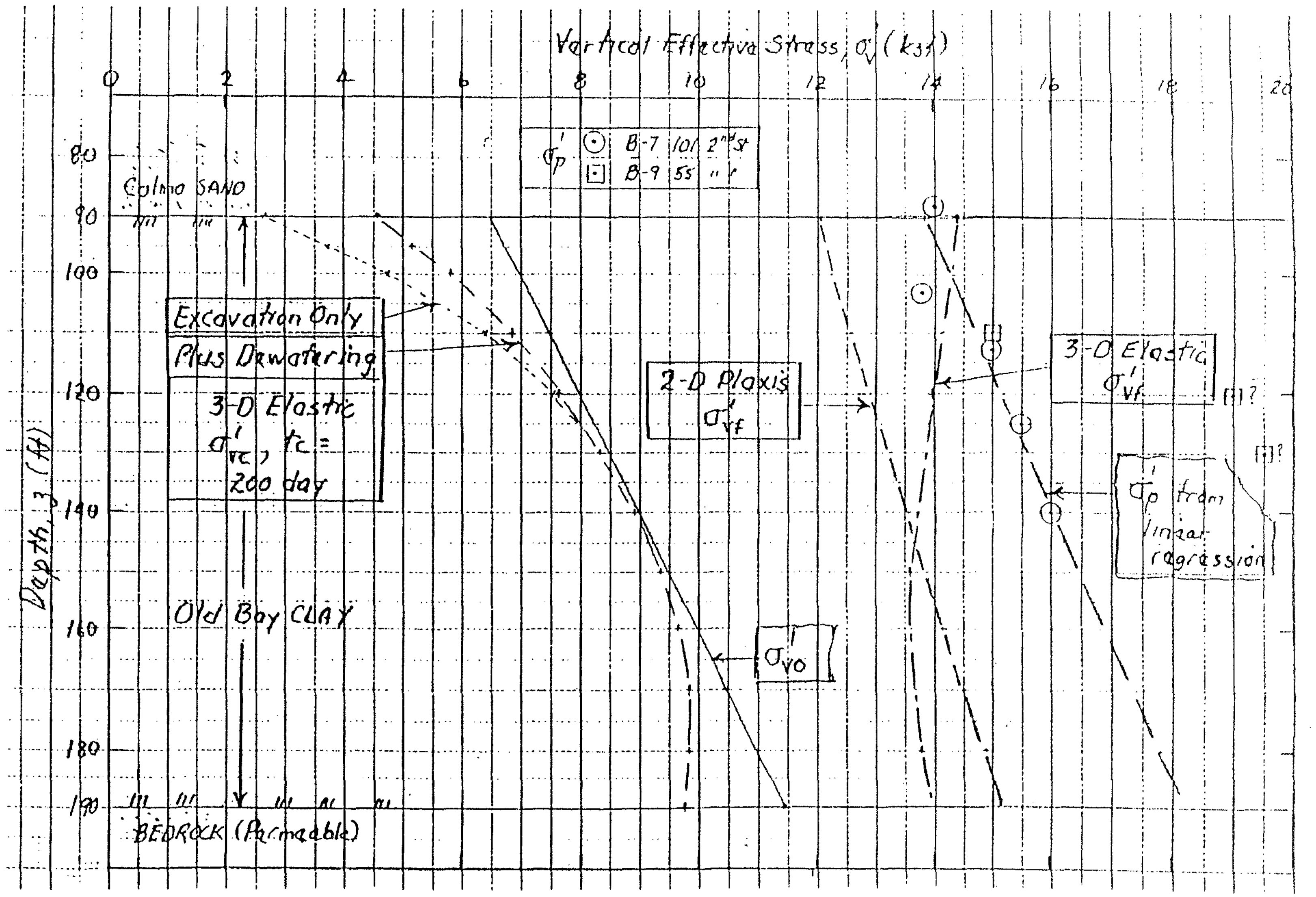

Fig. 2 Vertical Effective Stresses in Old Bay CLAY: Initial Stress History and Predicted Changes Under Centerline of Natoma Tower

BIOGRAPHY

NAME CHARLES CUSHING LADD, III

EDUCATION
A.B. (*cum laude*), Math and Physics, Bowdoin College, 1955
S.B., Building Engineering and Construction, MIT, 1955
S.M., Civil Engineering, MIT, 1957
Sc.D., Soil Engineering, MIT, 1961

PROFESSIONAL CAREER

1957	Department of Civil and Environmental Engineering, MIT Instructor (1957-61), Asst. Prof. (1961-64), Assoc. Prof. (1964-70), Prof. (1970-94), Edmund K. Turner Prof. (1994 -96), Prof. (1996-2001), MIT
1967-68	Visiting Consultant, Haley and Aldrich, Inc.
1983	Visiting Senior Scientist, Norwegian Geotechnical Institute
1983-94	Director, Center for Scientific Excellence in Offshore Engineering, MIT
2001	Edmund K. Turner Prof. of Civil and Environmental Engineering, Emeritus, MIT

PROFESSIONAL ACHIEVEMENTS
Professor Ladd is internationally known for his contributions to geotechnical engineering, teaching, research and practice. Over the years, he has worked on *in situ* and laboratory testing, soil stabilization, soft-ground construction, foundation stabilization, risk analysis, and offshore engineering. A major focus of his research has been the effort to understand the behavior of soft cohesive soils and to describe that behavior in terms that are useful in practice. He is a member of the National Academy of Engineering and recipient of numerous ASCE honors, including the Croes and Norman Medals, Terzaghi Lecture, Honorary Member and Karl Terzaghi Award.

ENGINEERING ACTIVITIES
American Society of Civil Engineers
- Professional Activities Committee (1982-86)
- Committee on Curricula and Accreditation (Chair, 1981-82)
- Geotechnical Engineering Division
  - Publications Committee (1969-84); Awards Committee (1975-82; Chair, 1984-88);
  - Past Chair, Soil Properties Committee; Executive Committee (1989-96; Chair, 1993-94)
- Geo-Institute, Bd. of Governors (1996-98); Technical Publications Committee (1996-)

American Society for Engineering Education
American Society for Testing and Materials
Boston Society of Civil Engineers Section of ASCE
- President, Board of Government (1977-78); Past Chair, Geotechnical and Structural Groups

British Geotechnical Society
Canadian Geotechnical Society
International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE)
National Society of Professional Engineers
Transportation Research Board
Board of Commissioners, Department of Public Works, Concord, MA (1965-78)
Geotechnical Consultant on 90 Projects (65 in the U.S., 25 outside the U.S.)

PUBLICATIONS
Over 90 publications in ASCE, ASTM, *CGJ*, *Geotechnique*, etc.

HONORS AND AWARDS
Chi Epsilon, Phi Beta Kappa, Sigma Xi, Tau Beta Pi
Walter L. Huber Civil Engineering Research Prize of ASCE (1969)
Croes Medal of ASCE (1973)
Norman Medal of ASCE (1976)
General Reporter, Session I, 9th ICSMFE, Tokyo (1977)
Effective Teaching Award, Dept. of Civil and Environmental Engineering, MIT (1980)
National Academy of Engineering (1983)
Co-Reporter, Session II, 11th ICSMFE, San Francisco (1985)
Karl Terzaghi Lecture of ASCE (1986)
Hogentogler Award of ASTM (1990)
Samuel M. Seegal Prize, School of Engineering, MIT (1994)
Honorary Member of ASCE (1995)
Middlebrooks Award of ASCE (1996, 2002)
Karl Terzaghi Award of ASCE (1999)
Arthur Casagrande Memorial Lecture of BSCES (2000)
Arthur Casagrance Lecture, 12th Panamerican Conf. SMGE, MIT (2003)
Who's Who in America