GEOTECHNICAL ENGINEERING REPORT

FOR

SANTA BARBARA ZOOLOGICAL GARDENS

PROPOSED SUMATRAN TIGER EXHIBIT,

WAVE FACILITY, AND SERVICE YARD

SANTA BARBARA, CALIFORNIA

VT-22503-02

DECEMBER 20, 2001

PREPARED FOR

TYNANGROUP, INC.

BY

EARTH SYSTEMS

SOUTHERN CALIFORNIA

1731-A WALTER STREET

VENTURA, CALIFORNIA

Earth Systems
Southern California

1731-A Walter Street
Ventura, CA 93003
(805) 642-6727
FAX (805) 642-1325

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TynanGroup, Inc.
Attention: Cameron Carey
2927 De La Vina
Santa Barbara, CA 93105

Project: Santa Barbara Zoological Gardens
Proposed Sumatran Tiger Exhibit, Wave Facility, and Service Yard
Santa Barbara, California

As authorized, we have performed a geotechnical study for the proposed Sumatran Tiger Exhibit, Wave Facility, and Service Yard structures to be located at the Santa Barbara Zoological Gardens in Santa Barbara, California. The accompanying Geotechnical Engineering Report presents the results of our subsurface exploration and laboratory testing programs, as well as our conclusions and recommendations pertaining to geotechnical aspects of project design.

We have appreciated the opportunity to be of service to you on this project. Please call if you have any questions, or if we can be of further service.

Respectfully submitted,

EARTH SYSTEMS SOUTHERN CALIFORNIA

Reviewed and Approved

TODD J. TRANBY
No. 2078
CERTIFIED
ENGINEERING
GEOLOGIST

Todd J. Tranby
Engineering Geologist

Richard M. Beard
Geotechnical Engineer

REGISTERED PROFESSIONAL ENGINEER
RICHARD MICHAEL BEARD
GE128
Exp. 12-31-05
GEOTECHNICAL
STATE OF CALIFORNIA

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INTRODUCTION

A. Project Description

This report presents results of a Geotechnical Engineering study performed for the proposed Sumatran Tiger Exhibit, Wave facility, and Service Yard structures to be located at the Santa Barbara Zoological Gardens in Santa Barbara, California. It is assumed herein that the proposed Sumatran Tiger Exhibit will be a one-to two-story masonry structure with slab-on-grade floors and a water feature with glass for viewing. It is assumed herein that the proposed Wave facility will be a one-story masonry structure that will replace the existing one-story structure. It is assumed herein that the proposed Service Yard structures will be one-story masonry structures with slab-on-grade floors. Structural considerations for building column loads of up to 50 kips with maximum wall loads of 2 kips per lineal foot were used as estimates for the recommendations of this report. If actual loads vary significantly from these assumed loads, Earth Systems Southern California should be notified since reevaluation of the recommendations contained in this report may be required.

B. Purpose and Scope of Work

The purpose of the geotechnical study that led to this report was to evaluate the soil conditions of the site with respect to design and construction of the proposed structures. These conditions include surface and subsurface soil types, expansion potential, settlement potential, bearing capacity, the presence or absence of subsurface water, and liquefaction potential. The scope of our work included:

1. Reconnaissance of the site and review of past geotechnical report by Earth Systems Southern California.
2. Hand augering, sampling and logging of eight continuous borings to study soil and groundwater conditions.
3. Laboratory testing of soil samples obtained from the subsurface exploration to determine their physical and engineering properties.
4. Analyzing the geotechnical data obtained.
5. Consulting with owner representatives.
6. Preparing this report.

Contained in this report are:

1. Descriptions and results of field and laboratory tests that were performed.
2. Discussions pertaining to the local soil and groundwater conditions.
3. Conclusions and recommendations pertaining to site grading and structural design.

C. Site Setting

The Santa Barbara Zoological Gardens is located south of U.S. Route 101 Freeway, north of Cabrillo Boulevard, west of Andree Clark Bird Refuge, and east of Ninos Drive in Santa Barbara, California (see attached Vicinity Map). The site lies on an east-west trending ridgeline with very gently sloping flanks. The elevation of the top of the ridegline is approximately 62 feet above mean sea level. The elevation near the toe of the ridegeline flanks is approximately 13 feet above mean sea level.

The proposed Sumatran Tiger exhibit will be located approximately mid-slope height, on the northern side of the gently sloping ridgeline. An existing bird avery and reptile exhibit occupy the area where the proposed exhibit will be located. Prior to the proposed construction, the existing structures in the area will be demolished.

The proposed Wave facility will be located near the top of the ridgeline where the original estate house was located. The site is currently occupied by a small one-story kitchen, an arbor, several masonry barbeques, and picnic tables. The site lies on a relatively flat area that increases in slope gradient near the northeast side of the proposed construction. Prior to the proposed construction, the existing structures and tables will be removed and/or demolished.

The proposed Service Yard structures will be located near the southwest portion of the zoo. The proposed Service Yard structures will include several modular building and concrete bins for materials storage. The site is currently occupied by small one-story structures and various equipment that will be removed.

SEISMICITY

Although the site is not within a State-designated "fault rupture hazard zone", it is located in an active seismic region where large numbers of earthquakes are recorded each year. Historically, major earthquakes felt in the vicinity of the subject site include the December 21, 1812 "Santa Barbara Region" earthquake, that was presumably centered in the Santa Barbara Channel (CDMG, 1975), the 1857 Fort Tejon earthquake, the 1872 Owens Valley earthquake, and the 1952 Arvin-Tehachapi earthquake.

It is the standard of practice when evaluating the seismicity to consider the design basis (10% probability of exceedance in 50 years) accelerations. The California Division of Mines and Geology, in concert with the U.S. Geological Survey and the scientific community, has recently presented results of a statewide probabilistic seismic hazard assessment (CDMG, Seismic Shaking Map Sheets, Map Sheet 48, 1999). The focus of the assessment was to generate a seismic hazard map showing zones of estimated peak ground accelerations at a hazard level of 10% probability of exceedance in 50 years. The site location plots between 0.60 g to 0.70 g acceleration potential. A contour map of the estimated magnitude of earthquake that causes the dominant hazard for peak ground acceleration at 10% probability of exceedance in 50 years with alluvial site conditions was also prepared as part of the statewide seismic hazard assessment survey. The site location plots within a zone of magnitude 6.5 to 7.0. The structure should be designed for UBC Zone 4 requirements; however, the project Structural Engineer should be made aware of the design basis acceleration.

For the project site the 1997 UBC Seismic Design Parameters are:

Parameter	Table No.	Value
Seismic Zone Factor (Z)	16-I	0.40
Soil Type Profile	16-J	S_D
Seismic Coefficient (C_a)	16-Q	$0.44N_a$
Seismic Coefficient (C_v)	16-R	$0.64N_v$
Near Source Factor (N_a)	16-S	1.3
Near Source Factor (N_v)	16-T	1.6
Seismic Source Type	16-U	B

These values area based on a distance of less than 2 kilometers from the Red Mountain Fault as determined from the UBC Maps of Known Active Fault Near-Source Zones in California and Adjacent Portions of Nevada.

The structural designs for the building in this project should at minimum conform to the UBC requirements. The project Structural Engineer should be made aware of the probabilistically estimated peak horizontal accelerations (0.60 to 0.70 g) to determine if any additional strengthening is warranted.

SOIL CONDITIONS

Evaluation of the subsurface indicates that soils beneath the Sumatran Tiger Exhibit site generally consist of medium dense, interbedded, clays to silts to silty sands to sand (CL, ML, SM, and SP soil types as defined by the Unified Soil Classification System).

Evaluation of the subsurface indicates that soils near the proposed Wave facility site generally consists of medium dense, interbedded, clays to silts to silty sands to sand (CL, ML, SM, and SP soil types as defined by the Unified Soil Classification System). There appears to be at least 4 to 5 feet of fill located on the northeast side of the proposed structure. This fill appears to be loose to moderately dense.

Evaluation of the subsurface indicates that soils near the proposed Service Yard structures facility generally consists of medium dense to stiff, interbedded, clays silty sands (CL, and SM soil types as defined by the Unified Soil Classification System). There appears to be at least 4 to 5 feet of fill located on the west sides of the proposed structures. This fill appears to be loose to moderately dense.

Soils encountered at approximate bearing depths (upper 5 feet) at the proposed building locations are characterized by relatively low blow counts and relatively low in-place densities. In some areas fill was encountered. Testing indicates that anticipated bearing soils at the proposed structures lie in the "medium" expansion range of Table 18-I-b of the 1997 Uniform Building Code.

The proposed building sites are underlain primarily by Older Alluvial Deposits as indicated on the Regional Geology Map (Dibblee, Geologic Map of the Santa Barbara Quadrangle, 1986) included in Appendix A of this Report.

Groundwater was not encountered in any of the borings. Groundwater was encountered at a depth of approximately 13 feet below existing ground surface during a previous geotechnical study for the proposed Discovery Pavilion and proposed Cats of Africa Exhibit. The groundwater at the Cats of Africa Exhibit was probably perched within the interbedded Older Alluvial units.

Samples for near-surface soils were tested for pH, resistivity, soluble sulfates and soluble chlorides. The test results provided in Appendix B should be provided to the project designers for their interpretations pertaining to the corrosivity or reactivity of various construction materials (such as concrete and piping) with the soils.

LIQUEFACTION

A major cause of damage during earthquakes is a significant reduction of soil strength or stiffness, generally referred to as liquefaction. Liquefaction can cause translational instability, bearing failure, settlement, ground loss, and other related phenomena. Translational instabilities can be slope failures or lateral spreading. Bearing failure can occur when soil strength loss is near a foundation. Settlement can occur when bearing failure is precluded, but volumetric compression occurs. Ground loss results from sand boils and is usually very localized. Liquefaction is typically a design problem only if it occurs in the upper 50 feet of the subsurface soils. However, on sloping ground or when foundations reach beyond that depth, liquefaction should be considered to a greater depth.

The soils most susceptible to liquefaction are sandy soils and silty soils of low plasticity. Cohesive soils with fines content greater than 30% are generally not susceptible to liquefaction if their fines classify as clays, or they have a plasticity index greater than 30%. Generally, if a soil has a clay content greater than 15%, or the water content is less than 0.9 times the liquid limit, liquefaction can be a ruled out. However, cohesive soils, if sensitive, can lose significant strength even if they cannot liquefy, and there may be a need to address this problem. Although widely believed to be non-liquefiable, gravelly soils can be susceptible to liquefaction if internal drainage is impeded.

In order for liquefaction to occur, a potentially liquefiable soil must be saturated and subjected to rapid cyclic loading that is sufficiently intense to overcome a soil's internal resistance to liquefaction.

Liquefaction analyses were performed during the preparation of a Geotechnical Engineering Report (Earth Systems Southern California, 2001) for the proposed Cats of Africa Exhibit and the proposed Discovery Pavilion. The liquefaction analysis indicates that the proposed Discovery Pavilion site, which lies on younger alluvial deposits, has a total estimated liquefaction induced settlement of about 2 inches. The liquefaction analyses indicated no liquefaction potential at the proposed Cats of Africa Exhibit which lies on older alluvial deposits. The older alluvial deposits below the proposed structures are similar to the older alluvial deposits encountered below the proposed Cats of Africa Exhibit. Because the older alluvial deposits below the proposed Cats of Africa Exhibit were considered non-liquefiable, it is also assumed that the older alluvial deposits below the proposed structures are non-liquefiable.

CONCLUSIONS AND RECOMMENDATIONS

The site is suitable for the proposed development from a Geotechnical Engineering standpoint provided that the recommendations contained in this report are successfully implemented into the project. Because uncertified fill and variable expansive soils were encountered below the proposed structures, overexcavation below the proposed building sites will be required in order to minimize differential settlement and differential expansion.

A. Grading

1. Pre-Grading Considerations

   a. Grading at a minimum should conform to Chapter 33 of the 1997 California Building Code.

   b. The existing ground surface should be initially prepared for structures and other improvements by removing all vegetation, debris piles, large roots, any other organics, and any noncomplying fill. Voids created by removing such material should be properly backfilled and compacted. No compacted fill should be placed unless a representative of the Geotechnical Engineer has observed the underlying soil.

   c. Fill and backfill placed at near optimum moisture in layers with loose thickness not greater than 8 inches should be compacted to a minimum of 90% of the maximum dry density obtainable by the ASTM D 1557 test method unless otherwise recommended or specified. Random compaction tests by Earth Systems Southern California can assist the Grading Contractor in evaluating whether the Grading Contractor is meeting compaction requirements. Compaction tests pertain only to a specific location, however, and do not guaranty that all fill has been compacted to the prescribed percentage of maximum density. It is the ultimate responsibility of the Grading Contractor to achieve uniform compaction in accordance with the requirements of this report and the grading ordinance.

d. Shrinkage of soils affected by compaction is estimated to be about 15%.

e. Import soils used to raise site grade should be equal to, or better than, on-site soils in strength, expansion, and compressibility characteristics. Import soil can be evaluated, but will not be prequalified by the Geotechnical Engineer. Final comments on the characteristics of the import will be given after the material is at the project site.

f. Roof draining systems should be designed so that water is not discharged into bearing soils or near the structure. Final site grade could be such that all water is diverted away from the structure, and is not allowed to pond. In landscape areas adjacent to the building we recommend a minimum gradient of 2% toward either hardscapes or drain inlets.

g. Earth Systems Southern California should be retained to provide Geotechnical Engineering services during site development and grading, and foundation construction phases of the work to observe compliance with the design concepts, specifications and recommendations. This will allow for timely design changes in the event that subsurface conditions differ from those anticipated prior to the start of construction.

h. Plans and specifications should be provided to Earth Systems Southern California prior to grading. Plans should include the grading plans, foundation plans, and foundation details. Earth Systems Southern California will review these plans only for conformity with geotechnical parameters not including drainage. It is the responsibility of the Client and other Engineers to review and approve designs and plans for conformity with all engineering and design requirements necessary to the proper function and performance of the structure.

2. <u>Rough Grading/Areas of Development</u>

a. Because of the presence of variable density soils, variable expansive soils, and uncertified fill at the bearing depth, overexcavation and recompaction of soils in the building areas will be necessary to decrease the potential for differential settlement and provide more uniform bearing conditions. Soils should be overexcavated to the deeper depth of either: 1) 2 foot below the bottom of the footings, 2) to a depth of 5 feet below the existing ground surface, 3) to a depth of 4 feet below the finish pad grade, or 4) through any uncertified fill throughout the entire building areas, and to a distance of 5 feet beyond the perimeter of the buildings. The resulting surfaces should then be scarified an additional 1 foot, moisture conditioned and recompacted to at least 90% of maximum density. The intent of these recommendations is to have a minimum of 3 feet of compacted soil below the bottoms of all footings and the removal of all uncertified fill and loose soils.

b. Areas outside of the building areas to receive fill, exterior slabs-on-grade, sidewalks or paving should be overexcavated through any uncertified fill and loose soils. The resulting surface should then be scarified an additional 1 foot, moisture conditioned and recompacted.

c. The bottom of all excavations should be observed by a representative of this firm prior to processing or placing fill.

d. Voids created by dislodging cobbles and boulders during scarification should be backfilled and recompacted, and the dislodged cobbles larger than 8 inches in diameter should be removed from the subgrade.

e. On-site soils may be used for fill once they are cleaned of all organic material, rock, debris and irreducible material larger than 8 inches.

f. Fill and backfill placed at near optimum moisture in layers with loose thickness not greater than 8 inches should be compacted to a minimum of 90% of the maximum dry density obtainable by the ASTM D 1557 test method.

g. Import soils used to raise site grade should be equal to, or better than, on-site soils in strength, expansion, and compressibility characteristics. Import soil can be evaluated, but will not be prequalified by the Geotechnical Engineer. Final comments on the characteristics of the import will be given after the material is at the project site.

h. If pumping soils or otherwise unstable soils are encountered during the overexcavation, stabilization of the excavation bottom will be required prior to placing fill. This can be accomplished by various means. One method would be drying the soils by aeration. Another would be working thin lifts of one and one-half inch (minimum size) float rock into the excavation bottom until stabilization is achieved. Use of a geotextile fabric such as Mirafi 500X, or the equivalent, is another possible means of stabilizing the bottom. If this material is used, it should be laid on the excavation bottom and covered with approximately 6 to 12 inches of float rock prior to placing of fill materials derived from on-site soils. It is anticipated that pumping soils will be encountered during grading and utility placement in isolated areas.

3. Utility Trenches
   a. Utility trench backfill should be governed by the provisions of this report relating to minimum compaction standards. In general, on-site service lines may be backfilled with native soils compacted to 90% of maximum density. Backfill of offsite service lines will be subject to the specifications of the jurisdictional agency or this report, whichever are greater.
   b. Backfill operations should be observed and tested by the Geotechnical Engineer to monitor compliance with these recommendations.
   c. Jetting should not be utilized for compaction in utility trenches.

B. Structural Design

The recommendations that follow are in part based upon the expansion index (in the "medium" expansion range) measured as part of our laboratory testing and the soils encountered in our field study. The expansion potential should be re-evaluated at the completion of grading. To the extent that expansion indices are determined to be above the "medium" expansion range, some of the recommendations of the sections that follow may need to be changed.

1. Foundations
   a. Conventional continuous footings and/or isolated pad footings may be used to support structures.
   b. Footings should bear into firm recompacted soils as recommended elsewhere in this report. Foundation excavations should be observed by a representative of Earth Systems Southern California after excavation, but prior to placing of reinforcing steel or concrete, to verify bearing conditions.
   c. Conventional continuous footings may be designed based on an allowable bearing value of 1,000 psf for an assumed minimum footing size of 12 inches wide and 21 inches deep.
   d. Isolated pad footings may be designed based on an allowable bearing value of 1,500 psf for an assumed minimum square footing size of 24 inches by 24 inches by 21 inches deep.
   e. Allowable bearing values are net (weight of footing and soil surcharge may be neglected) and are applicable for dead plus reasonable live loads.

f. Bearing values may be increased by one-third when transient loads such as wind and/or seismicity are included.

g. Lateral loads may be resisted by soil friction on floor slabs and foundations and by passive resistance of the soils acting on foundation stem walls. Lateral capacity is based on the assumption that any required backfill adjacent to foundations and grade beams is properly compacted.

h. Actual footing designs should be provided by the Structural Engineer, but the dimensions and reinforcement recommended should not be less than that for the appropriate expansion range.

i. Continuous footings bottomed in soils in the "medium" expansion range should be reinforced, at a minimum, with one No. 4 bar along the bottom and one No. 4 bar along the top.

j. Bearing soils in the "medium" expansion range should be premoistened to 130% of optimum moisture content to a depth of 27 inches below lowest adjacent grade. Premoistening should be confirmed by testing.

2. <u>Slabs-on-Grade</u>

a. Concrete slabs should be supported by compacted structural fill as recommended elsewhere in this report.

b. It is recommended that perimeter slabs (walks, patios, etc.) be designed relatively independent of footing stems (i.e., free floating) so foundation adjustment will be less likely to cause cracking.

c. Actual slab designs should be provided by the Structural Engineer, but the reinforcement and slab thickness recommended should not be less than that for the appropriate expansion range.

d. Slabs bottomed on soils in the "medium" expansion range should be underlain with a minimum of 4 inches of sand. Areas where floor wetness would be undesirable should be underlain with a vapor barrier (as specified by the project Architect or Civil Engineer) to reduce moisture transmission from the subgrade soils to the slab. The barrier should be laid on the subgrade and covered with the sand. The sand above the vapor barrier should be lightly moistened just prior to placing concrete.

e. Slabs bottomed on soils in the "medium" expansion range should at a minimum be reinforced at mid-slab with No. 3 bars on 24 inch centers, each way.

f. Slab subgrade soils in the "medium" expansion range should be premoistened to 130% of optimum moisture content to a depth of 27 inches below lowest adjacent grade. Premoistening should be confirmed by testing.

3. Frictional and Lateral Coefficients

a. Resistance to lateral loading may be provided by friction acting on the base of foundations. A coefficient of friction of 0.30 may be applied to dead load forces. This value does not include a factor of safety.

b. Passive resistance acting on the sides of foundation stems equal to 206 pcf of equivalent fluid weight may be included for resistance to lateral load. This value does not include a factor of safety.

c. A one-third increase in the quoted passive value may be used when considering transient loads such as wind and seismicity.

d. Passive resistance may be combined with frictional resistance provided that a one-third reduction in the coefficient of friction is used.

4. Retaining Walls

a. Conventional cantilever retaining walls backfilled with compacted on-site soils may be designed for active pressures of 70 pcf of equivalent fluid weight for well-drained, level backfill. Alternatively, a free draining granular material may be used for retaining wall backfill and designed for active pressures of 35 pcf of equivalent fluid weight.

b. The pressures listed above were based on the assumption that backfill soils will be compacted to 90% of maximum dry density as determined by the ASTM D 1557 Test Method.

c. The lateral earth pressure to be resisted by the retaining walls or similar structures should be increased to allow for surcharge loads. The surcharge considered should include the loads from any structures or temporary loads that would influence the wall design.

d. A system of backfill drainage and waterproofing should be incorporated into the retaining wall designs. Backfill comprising the drainage system immediately behind the retaining structures should be a free-draining granular material with a filter fabric between it and the rest of the backfill soils. As an alternative, the back of the wall could be lined with a geodrain system. The backdrain should extend from the bottom of the wall to about 18 inches from finished backfill grade. Waterproofing of exterior retaining walls should be considered to help mitigate efflorescence on wall faces.

e. Compaction on the uphill side of the wall within a horizontal distance equal to one wall height should be performed by hand-operated or other light weight compaction equipment. This is intended to reduce potential "locked-in" lateral pressures caused by compaction with heavy grading equipment.

f. Water should not be allowed to pond near the top of the wall. To accomplish this the final backfill site grade should be such that all water is diverted away from the retaining wall.

5. Settlement Considerations

Static settlement is estimated to be about 0.5 inch assuming the proposed structures will be founded onto firm, recompacted soils. Differential settlement for static loads is estimated to be approximately 0.25 inch.

ADDITIONAL SERVICES

This report is based on the assumption that an adequate program of monitoring and testing will be performed by Earth Systems Southern California during construction to check compliance with the recommendations given in this report. The recommended tests and observations include, but are not necessarily limited to the following:

1. Review of the building and grading plans during the design phase of the project.
2. Observation and testing during site preparation, grading, placing of engineered fill, and foundation construction.
3. Consultation as required during construction.

LIMITATIONS AND UNIFORMITY OF CONDITIONS

The analysis and recommendations submitted in this report are based in part upon the data obtained from the borings hand augered on the site. The nature and extent of variations between and beyond the borings may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.

The scope of our services did not include any environmental assessment or investigation for the presence or absence of wetlands, hazardous or toxic materials in the soil, surface water, groundwater or air, on, below, or around this site. Any statements in this report or on the soil boring logs regarding odors noted, unusual or suspicious items or conditions observed, are strictly for the information of our client.

Findings of this report are valid as of this date; however, changes in conditions of a property can occur with passage of time whether they be due to natural processes or works of man on this or adjacent properties. In addition, changes in applicable or appropriate standards may occur whether they result from legislation or broadening of knowledge. Accordingly, findings of this report may be invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and should not be relied upon after a period of 1 year.

In the event that any changes in the nature, design, or location of the structure and other improvements are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing.

This report is issued with the understanding that it is the responsibility of the Owner, or of his representative to insure that the information and recommendations contained herein are called to the attention of the Architect and Engineers for the project and incorporated into the plan and that the necessary steps are taken to see that the Contractor and Subcontractors carry out such recommendations in the field.

As the Geotechnical Engineers for this project, Earth Systems Southern California (ESSC) strives to provide our services in accordance with the generally accepted geotechnical engineering practices in this community at this time. No warranty or guarantee is expressed or implied. This report was prepared for the exclusive use of TynanGroup and their authorized agents.

It is recommended that ESSC be provided the opportunity for a general review of final design and specifications in order that earthwork and foundation recommendations may be properly interpreted and implemented in the design and specifications. If ESSC is not accorded the privilege of making this recommended review, we can assume no responsibility for misinterpretation of our recommendations.

REFERENCES

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