Geotechnical Engineering Report

Fletcher Building Loading Dock Expansion
San Antonio College Campus
San Antonio, Texas

October 25, 2011
Terracon Project Nº 90115202

Prepared For:
Alamo Community College District
Live Oak, Texas

Prepared By:
Terracon Consultants, Inc.
San Antonio, Texas

October 25, 2011

Alamo Community College District
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SUBJECT:
Geotechnical Engineering Report
Fletcher Building Loading Dock Expansion
San Antonio College Campus
San Antonio, Texas
Terracon Project No. 90115202

Dear Mr. Strybos:

Terracon Consultants, Inc. (Terracon) is pleased to submit our Geotechnical Engineering Report for the above referenced project. We trust that this report is responsive to your project needs. Please contact us if you have any questions or if we can be of further assistance.

We appreciate the opportunity to work with you on this project and look forward to providing additional Geotechnical Engineering and Construction Materials Testing services in the future.

Sincerely,
Terracon Consultants, Inc.
(Firm Registration: TX F3272)

Dustin G. Smyth, P.G.
Project Geologist
Geotechnical Services

Mike Ghazawi, P.E.
Principal

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DGS/MTG/njf – 90115202

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GEOTECHNICAL ENGINEERING REPORT
FLETCHER BUILDING LOADING DOCK EXPANSION
SAN ANTONIO COLLEGE CAMPUS
SAN ANTONIO, TEXAS

Terracon Project Nº 90115202
October 25, 2011

EXECUTIVE SUMMARY

This geotechnical executive summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled General Comments should be read for an understanding of the report limitations.

A geotechnical exploration has been performed for the proposed Fletcher Building Loading Dock Expansion to be located at the existing San Antonio College Campus in San Antonio, Texas. Terracon's geotechnical scope of work included the advancement of one test boring to about 35 feet below existing site grades.

Based on the information obtained from our subsurface exploration, the site is geotechnically suitable for development of the proposed project. Pertinent findings and recommendations generated from this study include those summarized below:

Subsurface Conditions: About 2½ inches of asphalt was observed at the ground surface. No crushed limestone base was observed. The site surface soils generally consisted of a CLAYEY GRAVEL (GC) FILL material. The underlying subsurface soils generally consisted of CLAY (CH). Subsurface water was not encountered during drilling operations.

Foundations: A drilled pier foundation system with a suspended floor slab may be used to support the proposed loading dock addition.

Earthwork: Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during construction.

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1.0 INTRODUCTION

Terracon Consultants Inc. (Terracon) is pleased to submit this document which presents the results of our geotechnical engineering services performed for this project. The project involves the design and construction of a new loading dock expansion at the existing Fletcher Administration Building at San Antonio College in San Antonio, Texas.

This project was authorized by Alamo Community College District's (ACCD) Purchase Order No. B1250126 dated October 7, 2011. The scope of services for this project is outlined in Proposal No P90110939 dated September 28, 2011.

The purpose of this report is to describe the subsurface conditions observed at the boring drilled for this study, analyze and evaluate the test data, and provide recommendations with respect to:

- subsurface soil conditions
- earthwork
- seismic considerations
- groundwater conditions
- foundation design and construction

Our geotechnical engineering scope of work for this project included the advancement of one boring at the project site to a depth of about 35 feet below the existing site grades. Logs of the boring along with a Site Location Plan and Bore Location Plan are included at the end of this report. The results of laboratory tests are shown on the boring log adjacent to the respective sample location. Descriptions of the field exploration and laboratory testing are included in their respective appendices.

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site layout	Refer to the Site Location Plan and Bore Location Plan (Figures 1 and 2 in the Illustrations section).

ITEM	DESCRIPTION
Structures	We understand that an approximately 11 feet by 24 feet loading dock addition will be constructed. An approximately 23,000 pound generator will be housed partially on the existing loading dock structure and partially on the proposed loading dock addition.
Finished Floor Elevation	Will match existing.
Grading	The site grading was not available at the time of this report. However, because the site is developed, we anticipate that the structure will be at or near existing grades.
Construction	The existing loading dock is supported by a drilled pier foundation system and is structurally suspended. The loading dock addition will be constructed with a similar foundation system. Additionally, the new loading dock area will be doweled into the existing structure.

2.2 Site Location and Description

ITEM	DESCRIPTION
Location	This project will be located on the San Antonio College Campus in San Antonio, Texas.
Existing improvements	Buildings, access drives, flatwork, and landscaping.
Current ground cover	Asphalt, flatwork, landscaping.
Existing topography	Relatively flat and level, based on visual observations.

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

The San Antonio Sheet (1983) of the Geologic Atlas of Texas published by the Bureau of Economic Geology of the University of Texas at Austin has mapped the Pecan Gap Chalk (Kpg) and the undivided Navarro Group and Marlbrook Marl (Kknm) of the Cretaceous Geologic Period at this site. The Pecan Gap Chalk primarily consists of chalk and chalky marl which forms a deep weathering profile of soil. The Navarro Group consists primarily of highly expansive clay. The soils at this site seem to be consistent with the Navarro Group.

3.2 Typical Subsurface Profile

Description	Approximate Depth of Stratum (feet)	Material Encountered	Consistency/Density
---	0 to ½	2½ inches of Asphalt; No Crushed Limestone Base material observed.	---

Description	Approximate Depth of Stratum (feet)	Material Encountered	Consistency/Density
Stratum I	0 to 6½	FILL: CLAYEY GRAVEL (GC)[1]; light grayish brown and yellowish brown, sandy.	Loose to Medium Dense
Stratum II	6½ to 35	FAT CLAY (CH)[2]; yellowish brown and gray to dark yellowish brown and grayish brown, with gypsum seams and oxide staining.	Very Stiff to Hard

[1] The FILL: CLAYEY GRAVEL (GC) materials encountered are not expected to experience volumetric changes (shrink/swell) with fluctuations in moisture content. These materials are considered stable due to their granular nature.

[2] The CLAY (CH) soils could undergo high volumetric changes (shrink/swell) should it experience changes in its in-place moisture content.

Conditions encountered at the boring location are indicated on the boring log. Stratification boundaries on the boring log represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Details for of the boring can be found on the boring log in Appendix A of this report.

3.3 Subsurface Water Conditions

Groundwater or subsurface water generally appears as either a permanent or temporary water source. Permanent subsurface water is generally present year round and fluctuates seasonally with climatic changes. Temporary subsurface water is also referred to as a “perched” water source, which generally develops as a result of seasonal and climatic conditions. For the purposes of this report, we will simply refer to groundwater as subsurface water.

The borings were drilled to their full depths using dry drilling techniques to aid in the observation of subsurface water. Subsurface water was not encountered during drilling operations. The borings were backfilled with soil cuttings and patched with asphalt cold patch after the drilling operations and subsurface water observations were completed.

As previously noted, subsurface water levels are influenced by seasonal and climatic conditions, which generally result in fluctuations in the elevation of the subsurface water level over time. After periods of heavy rain, subsurface water may be encountered at the fill soil interface and within gypsum seams such as those encountered at this site.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Grading for the proposed site development was not available at the time of this report. The FFE was also not available. Accordingly our recommendations are based on assuming a FFE to match the existing structure. If this information changes, we should be contacted to review and revise our recommendations as appropriate. We understand that a drilled pier foundation system with a suspended slab may be considered to support the loading dock addition at this site.

The foundation being considered to provide support for the planned structure must satisfy two independent engineering criteria with respect to the subsurface conditions encountered at this site. One criterion is the foundation system must be designed with an appropriate factor of safety to reduce the possibility of a bearing capacity failure of the soils underlying the foundation when subjected to axial and lateral load conditions. The other criterion is movement of the foundation system due to compression (consolidation or shrinkage) or expansion (swell) of the underlying soils must be within tolerable limits for the structures. The field data acquired during this study indicate that the soils at this site have competent strength characteristics. However, the onsite soil has moderate to high expansion potential. The proposed drilled pier foundation system with a structurally suspended slab should not be affected by the expansive soils.

4.2 Potential Vertical Rise

Highly expansive soils were encountered at this site. Based upon the results of our field and laboratory programs, we estimate that the subsurface soil in the upper 15 feet within the area of the proposed structure exhibits a Potential Vertical Rise (PVR) of about 2 inches in its present condition. The PVR was determined using the Texas Department of Transportation (TxDOT) Method TEX-124-E. However, since the structure will be supported by drilled piers suspended above grade, no special pad preparation will be required. If these assumptions change, please contact our office to provide additional recommendations as needed.

4.3 Drilled Pier Foundations

4.3.1 General

Drilled piers may be considered to support the proposed loading dock addition and suspended slab at this site. Recommendations for straight-sided piers and underreamed piers are presented below.

4.3.2 Straight-Sided Piers

The proposed structure and suspended slab may be supported on drilled straight-sided piers that bear at least 25 feet below existing grades at the time of our geotechnical drilling. This depth was chosen as a result of the uplift forces anticipated from the clayey soil encountered during our subsurface exploration and to bear the piers below the anticipated zone of seasonal

moisture variation. The piers may be designed for a net allowable bearing pressure of 13,500 psf based on total load or 9,000 psf based on dead load plus long-term live load, whichever results in a larger bearing surface. These bearing pressures include factors of safety against a bearing capacity failure of approximately 2 and 3, respectively.

Allowable side shear value of 600 psf with an assumed factor of safety of at least 2 may be used to aid in resisting axial compressive loads on the piers. The side shear should be neglected for and fill material, the upper 5 feet of soil in contact with the pier shaft, and within 1 pier diameter of the bottom of the shaft. Piers should not extend deeper than 30 feet below existing grade at the time that soil borings were drilled without contacting our office.

In addition to the axial compressive loads on the piers, these piers will also be subjected to axial tension loads due to expansive clay soils and possibly due to other induced structural loading conditions. To compute the axial tension force due to the swelling soils along the pier shaft, the following equation may be used.

$$Q_u = 52 \cdot d$$

Where:
Q_u = Uplift force due to expansive soil conditions in kips (k)
d = Diameter of pier shaft in feet (ft)

This calculated force can be used to compute the longitudinal reinforcing steel required in the pier to resist the uplift force induced by the swelling clays. However, the cross-sectional area of the reinforcing steel should not be less than ½ percent of the gross cross-sectional area of the drilled pier shaft. The reinforcing steel should extend from the top to the bottom of the shaft to resist this potential uplift force.

The ultimate uplift resistance of the straight-sided drilled piers can be evaluated using the following equation:

$$Q_r = 3.1 \cdot d \cdot D_p + W_p + P_{DL}$$

Where:
Q_r = Ultimate uplift resistance of pier in kips (k)
d = Diameter of pier shaft in feet (ft)
D_p = Founding depth of pier in natural soils minus the upper 10 feet of shaft in contact with the soil in feet (ft)
W_p = Weight of the drilled pier in kips (k)
P_{DL} = Dead Load acting on the drilled pier in kips (k)

We recommend that a factor of safety of at least 1.5 be applied to the computed ultimate uplift force.

4.3.3 Underreamed Piers

The proposed structure and suspended slab may be supported on drilled underreamed piers that bear at least 20 feet below existing grades at the time of our geotechnical drilling. This depth was chosen as a result of the uplift forces anticipated from the clayey soil encountered during our subsurface exploration and to bear the piers below the anticipated zone of seasonal moisture variation. The piers may be designed for a net allowable bearing pressure of 13,500 psf based on total load or 9,000 psf based on dead load plus long-term live load, whichever results in a larger bearing surface. These bearing pressures include factors of safety against a bearing capacity failure of approximately 2 and 3, respectively.

Allowable side shear value of 600 psf with an assumed factor of safety of at least 2 may be used to aid in resisting axial compressive loads on the piers. The side shear should be neglected for any fill material, the upper 5 feet of natural soil in contact with the pier shaft, since it is possible that the clay soils may dry and shrink away from the pier shaft, and within 1 underream diameter of the bottom of the shaft. Piers should not extend deeper than 30 feet below the existing grades at the time of our geotechnical drilling without contacting our office.

These piers will also be subjected to axial tension loads due to the expansive soil conditions and possibly due to other induced structural loading conditions. To compute the axial tension force due to the swelling soils along the pier shaft, the following equation may be used.

$$Q_u = 52 \cdot d$$

Where:
Q_u = Uplift force due to expansive soil conditions in kips (k)
d = Diameter of pier shaft in feet (ft)

This calculated force may be used to compute the longitudinal reinforcing steel required in the pier to resist the uplift force induced by the swelling clays. However, the cross sectional area of the reinforcing steel should not be less than one-half percent of the gross cross-sectional area of the drilled pier shaft. The reinforcing steel should extend from the top of the shaft to the bottom of the underream to resist this potential uplift force.

The uplift force due to swelling soils and any other axial tension forces due to structural loading conditions can be resisted by the underreamed portion of the drilled pier. The ultimate uplift resistance of the underreamed pier may be evaluated using the following equation:

$$Q_r = 16 (D^2 - d^2) + W_p + P_{DL}$$

Where:
Q_r = Ultimate uplift resistance of underreamed pier in kips (k)
D = Diameter of underream in feet (ft)
d = Diameter of pier shaft in feet (ft)
W_p = Weight of the drilled pier in kips (k)
P_{DL} = Dead Load acting on the drilled pier in kips (k)

We recommend that a factor of safety of at least 1.5 be applied to the computed ultimate uplift force. We should note that the diameter of the underream should be large enough to overcome the uplift forces induced on the pier without causing a localized soil failure to the soils immediately overlying the underream.

We recommend that the ratio of underream diameter to shaft diameter be larger than 2:1 but in no case should this ratio exceed 3:1 to reduce the likelihood of problems developing during construction. However, if a ratio less than 3:1 is used, it may be difficult to effectively remove all of the loose material from the underream bottom.

4.3.4 Pier Spacing

The piers for the addition should be designed so that proper spacing is maintained between the proposed piers and the existing piers. For straight shaft piers, maintain at least 2 pier diameter from edge to edge, or 3 pier diameters center-to-center, based on the larger diameter of the two adjacent piers. For underreamed piers, maintain 2 underream diameter from edge to edge, or 3 underream diameters center-to-center, based on the larger of the two underreams. Closer drilled shaft/underream spacing should be evaluated to determine if reductions in the allowable bearing pressures should be made to control settlement.

4.3.5 Settlement Considerations

Total settlements, based on the indicated bearing pressures, should be about 1 inch or less for properly designed and constructed drilled piers. Settlement beneath individual piers will be primarily elastic with most of the settlement occurring during construction. Differential settlement may also occur between adjacent piers. The amount of differential settlement could approach 50 to 75 percent of the total pier settlement. For properly designed and constructed piers, differential settlement between adjacent piers is estimated to be less than ¾ of an inch. Settlement response of drilled piers is impacted more by the quality of construction than by soil-structure interaction.

Improper pier installation could result in differential settlements significantly greater than we have estimated. In addition, larger magnitudes of settlement should be expected if the soil is subjected to bearing pressures higher than the allowable values presented in this report.

4.4 Construction Considerations

The pier excavations should be augered and constructed in a continuous manner. Steel and concrete should be placed in the pier excavations immediately following drilling and evaluation for proper bearing stratum, embedment, and cleanliness. In no circumstances should the pier excavations remain open overnight.

Subsurface water was not encountered during the field activities. However, water may be encountered during construction or after periods of wet weather. Therefore, the contractor should be prepared to use temporary casing to reduce the water flow into the excavation and/or sloughing of the excavation sidewalls should this occur. The casing method is discussed in the following paragraphs.

Casing will provide stability of the excavation walls and will reduce water influx; however, casing may not completely eliminate subsurface water influx. In order for the casing to be effective, a "water tight" seal must be achieved between the casing and surrounding soils. The drilling subcontractor should determine casing depths and casing procedures. Water that accumulates in excess of 3 inches in the bottom of the pier excavation should be pumped out prior to steel and concrete placement. If the water is not pumped out, a closed-end tremie should be used to place the concrete completely to the bottom of the pier excavation in a controlled manner to effectively displace the water during concrete placement. If water is not a factor, concrete should be placed with a short tremie so the concrete is directed to the bottom of the pier excavation. The concrete should not be allowed to ricochet off the walls of the pier excavation nor off the reinforcing steel. If this operation is not successful or to the satisfaction of the foundation contractor, the pier excavation should be flooded with fresh water to offset the differential water pressure caused by the unbalanced water levels inside and outside of the casing. The concrete should be tremied completely to the bottom of the excavation with a closed-end tremie.

Removal of casing should be performed with extreme care and under proper supervision to minimize mixing of the surrounding soil and water with the fresh concrete. Rapid withdrawal of casing or the auger may develop suction that could cause the soil to intrude into the excavation. An insufficient head of concrete in the casing during its withdrawal could also allow the soils to intrude into the wet concrete. Both of these conditions may induce "necking", a section of reduced diameter, in the pier.

All aspects of concrete design and placement should comply with the American Concrete Institute (ACI) 318-99 Code Building Code Requirements for Structural Concrete, ACI 336.1-98 Standard Specification for the Construction of Drilled Piers, and ACI 336.3R-93 entitled Suggested Design and Construction Procedures for Pier Foundations. Concrete should be designed to achieve the specified minimum 28-day compressive strength when placed at a 7 inch slump with a ±1 inch tolerance. Adding water to a mix designed for a lower slump does not meet the intent of this recommendation. If a high range water reducer is used to achieve this slump, the span of slump retention for the specific admixture under consideration should be thoroughly investigated. Compatibility with other concrete admixtures should also be considered. A technical representative of the admixture supplier should be consulted on these matters.

Successful installation of drilled piers is a coordinated effort involving the general contractor, design consultants, subcontractors, and suppliers. Each must be properly equipped and prepared to provide their services in a timely fashion. Several key items of major concern are:

- Proper drilling rig with proper equipment (including casing, augers, underreaming tools, and cleanout buckets);

- Reinforcing steel cages tied to meet project specifications;

- Proper scheduling and ordering of concrete for the piers; and
- Monitoring of installation by design professionals.

Pier construction should be carefully monitored to assure compliance of construction activities with the appropriate specifications. A number of items of concern for pier installation include those listed below.

- Pier locations
- Vertical alignment
- Competent bearing
- Casing removal (if needed)
- Concrete properties and placement
- Steel placement
- Proper casing seal for subsurface water control (if needed)

If the contractor has to deviate from the recommended foundations, Terracon should be notified immediately so additional engineering recommendations can be provided for an appropriate foundation type.

4.5 Structurally Suspended Floor Slab System

For a structurally suspended floor slab system at this site, a minimum 12-inch void should be established beneath the floor slab and grade beams. Typically, the void beneath suspended floor systems is greater than 12 inches due to the nature of the construction section. It may be advantageous to create a crawl space several feet high beneath the floor slab in order to access plumbing lines and other elements beneath the slab.

Options to create the recommended void or crawl space include the use of void boxes, appropriate formwork, and/or soil retainer blocks. If void boxes are used to create the void beneath the floor slab or grade beams, care must be taken not to damage the boxes prior to concrete placement. The void boxes must retain their dimensional integrity during concrete placement if they are to serve their intended purpose. The void boxes should have an intimate fit to excavations. The void boxes, formwork, and soil retainers should be situated so that concrete is not allowed to spill substantially over the sides, into, or beneath the void boxes during concrete placement. Filling of this space with concrete will reduce the effectiveness of the void boxes. Additionally, the sides of the voids beneath the grade beams should be protected so that the soil will not slough beneath the grade beams and thus fill the void. If a cardboard carton system is used on this project, we recommend that the carton form supplier provide, during initial concrete operations, a representative to instruct the work force on proper installation methods for both the forms and concrete.

Provisions should be made to collect and dispose of any water that may enter in the void or crawl space beneath the floor slab. This may include: (1) sloping the subgrade of the crawl space to appropriate drainage outlets (which may require a sump/pump system), and (2) the construction of an unreinforced concrete "mud" slab to help facilitate drainage. In addition, measures should be implemented to provide proper surface drainage away from the building to reduce the potential for water to drain into the crawl space. Please refer to the "Expansive Soil Considerations" section of this report for additional discussion on providing proper drainage around the structure.

In addition, proper ventilation should be provided to reduce the possibility of a high humidity environment developing in the crawl space. Mold growth and possibly even foundation movements may occur if the crawl space is not adequately ventilated and/or if sufficient moisture is allowed to collect in the crawl space. Roof downspouts should not be located near perimeter vents.

In a crawl space, plumbing lines are typically hung from the fixed support of the suspended slab. However, where the plumbing lines exit the crawl space, typically through the grade beams, they come into contact with the onsite soils that can experience varying degrees of expansive soil movements depending on site and pad preparation. Thus, the plumbing lines are expected to experience differential movement outside of the grade beams. Accordingly, they must be designed with a degree of flexibility (and may require to be double-sleeved) to accommodate the differential movements that may be experienced.

Backfill along the perimeter of the exterior beams should receive special attention. The backfill should consist of lean clay (CL) soil having: (1) a Plasticity Index (PI) between 15 and 25 percent, (2) at least 65 percent passing the No. 200 Sieve, and (3) no more than 15 percent retained on the No. 4 Sieve. The onsite soils may be considered for this material provided that they meet the noted criteria. The backfill should be placed in maximum 8-inch loose lifts that are moisture conditioned to between optimum and +4 percentage points of optimum moisture content and compacted to at least 95 percent of the maximum dry density as determined by ASTM D 698. Proper compaction of the backfill will reduce the potential for future settlement. Excessive settlement of the backfill soils may change drainage patterns and direct water toward the structure and may also result in distress to overlying flatwork.

4.6 Interaction with Existing Structures

The construction of additions to an existing structure can often create a situation that leads to the formation of distress in both structures if both structures are connected to each other. Typically, such distress occurs due to the use of different foundations and as a result of the structures having different framing stiffness. These differences often lead to dissimilar performances between the addition and existing structure. Such performance dissimilarities typically manifest themselves as differential movements and can cause significant amounts of

distress. The risks associated with dissimilar performances between the addition and existing structure may be reduced by the following:

- Design the foundation of the addition using the type and geometry similar to the existing foundation system (when appropriate);
- Dowel the addition and existing foundations slabs together to prevent differential vertical movements across the joint; and
- Construct an expansion joint between the new and existing structure to allow for differential horizontal movement between the addition and existing structure.

Excavating adjacent to the existing foundation should be performed with care. Excavations adjacent to the existing structure could cause the foundation to become undermined and the foundation or structure could suffer damages. We recommended that the contractor monitor the existing foundation carefully during construction and be prepared to brace the existing foundation if necessary.

4.7 Seismic Considerations

Description	Value
2009 International Building Code Site Classification (IBC) [1]	D [2]
GPS Coordinates: Latitude	29.445337°
Longitude	-97.497667°
Maximum Considered Earthquake 0.2 second Spectral (S_S) Acceleration	0.107 g
Maximum Considered Earthquake 1.0 second Spectral Acceleration (S_1)	0.029 g

[1] The site class definition was determined using SPT N-values in conjunction with Table 1613.5.5 in the 2009 IBC. The Spectral Acceleration values were determined using publicly available information provided on the United States Geological Survey (USGS) website. The above criteria can be used to determine the Seismic Design Category using Tables 1613.5.6 (1) and 1613.5.6 (2) in the 2009 IBC.

[2] Note: The 2009 International Building Code (IBC) requires a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope does not include the required 100 foot soil profile determination. Borings extended to a maximum depth of 35 feet, and this seismic site class definition considers that stiff soil continues below the maximum depth of the subsurface exploration. Additional exploration to deeper depths would be required to confirm the conditions below the current depth of exploration.

4.8 Earthwork

The comments and suggestions in this section are provided for planning and informational purposes so project specifications can be prepared and to indicate conventional methods to achieve the intent of our design recommendations. Details regarding excavation, dewatering, selection of equipment/machinery, trafficability, project site safety, shoring, and other similar construction techniques that require “means and methods” to accomplish the work is the sole

responsibility of the project contractor. It should be recognized that the comments contained in this report are based on the observations of small diameter boreholes and the performance of larger excavations may differ significantly as a result of the differences in excavation sizes. Construction means and methods selected by the contractor may differ from those described in this report. Any variations may significantly impact the anticipated behavior of the subsurface conditions during the construction process.

4.8.1 Site Access

Proper site drainage should be maintained during the entire construction phase so ponding of surface runoff does not occur and cause construction delays and/or inhibit site access, particularly in cut areas. During construction, it is possible the surficial soils may become excessively wet as a result of inclement weather conditions. When the moisture content of these soils elevates above what is considered to be the optimum range of moisture for compaction operations, they can become difficult to handle and compact. If such conditions create a hindrance to compaction operations or site access, lime or portland cement may be mixed with these soils to improve their workability. However, due to the possibility of adverse reactions between lime and sulfate-bearing soils; we recommend that the sulfate tests be performed prior to lime treatment. A sulfate test is currently in progress. Once the testing is complete the results will be forwarded. The modifier can be mixed in general accordance with TxDOT Items 260 and 275. However, the purpose of the modifier is to dry out the subgrade and allow site workability. The strict requirements for curing and the actual modifier percentage can and should be at the discretion of the contractor. The modified subgrade, however, should be compacted to at least 95 percent of the maximum dry density as evaluated by ASTM D 698 at moisture contents between optimum to +4 percentage points of the optimum moisture content.

4.8.2 General Site Preparation

Construction areas within the site should be stripped of existing vegetation, loose topsoil, asphalt, concrete, crushed limestone base material, and any other deleterious material. After site stripping and excavating to the desired elevations, the exposed subgrade should be proofrolled with appropriate construction equipment weighing at least 20 tons. The purpose of this recommendation is to check the subgrade for weak, loose, or soft areas prior to fill placement and compaction. This operation should be observed and evaluated by Terracon's qualified geotechnical personnel experienced in earthwork operations.

Placement and compaction of soil is discussed below:

- Structure Areas and General and Common Areas (not requiring structural support): For clayey subgrade compact to at least 95 percent of the maximum dry density as evaluated by ASTM D 698 (Standard Compaction) at compaction moisture contents between optimum and +4 percentage points of optimum moisture content. For granular subgrade compact to at least 95 percent of the maximum dry density as evaluated by ASTM D 698 (Standard Compaction) at compaction moisture contents between -2 and +3 percentage points of optimum moisture content.

- Utility Trenches: Compact clayey soil to at least 95 percent of the maximum dry density as evaluated by ASTM D 698 (Standard Compaction) at compaction moisture contents between optimum and +4 percentage points of optimum moisture content. The use of flowable fill can also be considered as utility backfill. When properly designed, this material can be excavated easily at a later date if required. While the material costs may be higher than other backfill soils, the use of flowable fill is usually quicker, requires no compaction and no testing when used for this purpose.

4.8.3 Select Fill Materials

If grades are to be raised, onsite soil or select fill may be used. Select fill should consist of non-expansive (inert) materials such as a low plasticity silty or sandy clay soil, clayey sand, or granular material such as clayey gravel, caliche, crushed limestone base material, or crushed concrete. All select fill soils should have a Plasticity Index (PI) between 7 and 20 percent. The select fill materials should be relatively free and clean of organic material and debris, and should not contain stones larger than 3 inches in maximum dimension.

To provide a more "all-weather" working surface, consideration can be given to using a granular base material in the upper 6 inches of the select fill, meeting the requirements of 2004 TxDOT Item 247, Type A or B, Grade 1 or 2 crushed limestone or gravel base material. Granular base material can also consist of crushed concrete meeting the criteria specified in the 2004 TxDOT Item 247, Type D, Grade 1 or 2. Grade 1 or 2 materials are generally more resistant to the effects of hard rain during construction than a non-processed material.

All select fill should be placed in loose lifts of no more than 8 inches, moisture conditioned between -2 and +3 percentage points of the optimum moisture content, and compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698.

4.8.4 Preconstruction Meeting

Every project and construction site is unique, making it vitally important that all construction drawings, specifications, change orders, and related documents be reviewed by the respective design professionals participating in the project. The performance of the foundations for this project will depend on correct interpretation of our geotechnical engineering report and proper compliance of construction activities with regard to our geotechnical recommendations and to the construction drawings and specifications. We highly recommend that a preconstruction meeting be conducted. One of the purposes of the meeting is to discuss the Special Inspections required on the plan documents.

The following are among those that should be discussed at the meeting:

- Lines of Communication/Authority;
- Reporting (both verbal and written); and

- Special Inspections. In particular; what is required; who will perform the inspections; what are the specified frequencies; how should the inspections be scheduled; and, reporting requirements.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

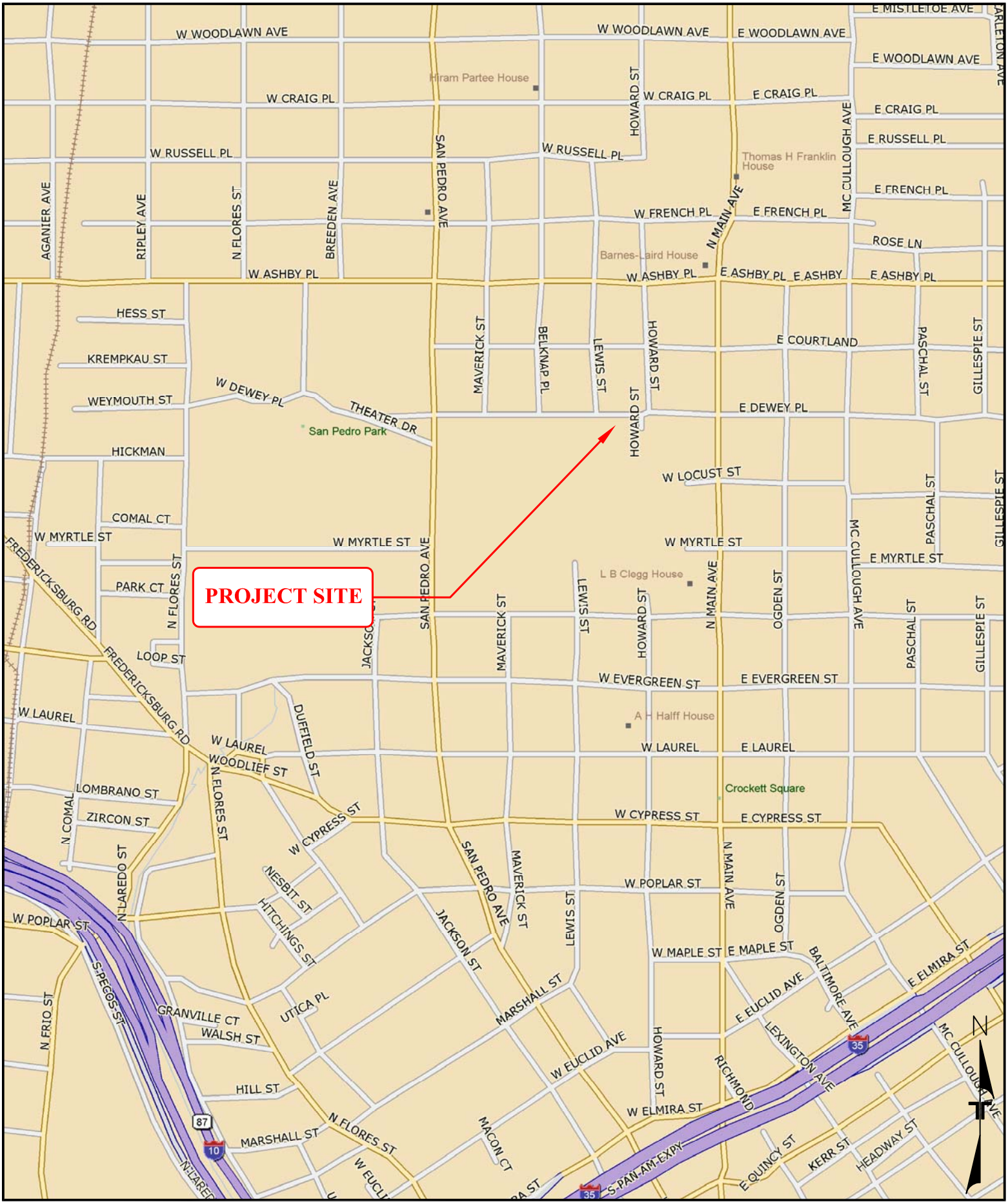
The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur away from our boring, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided. Prospective contractors should familiarize themselves with the conditions at the site and retain their own experts to interpret the data in this report and perform additional testing and/or inspection as they deem necessary prior to bidding.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

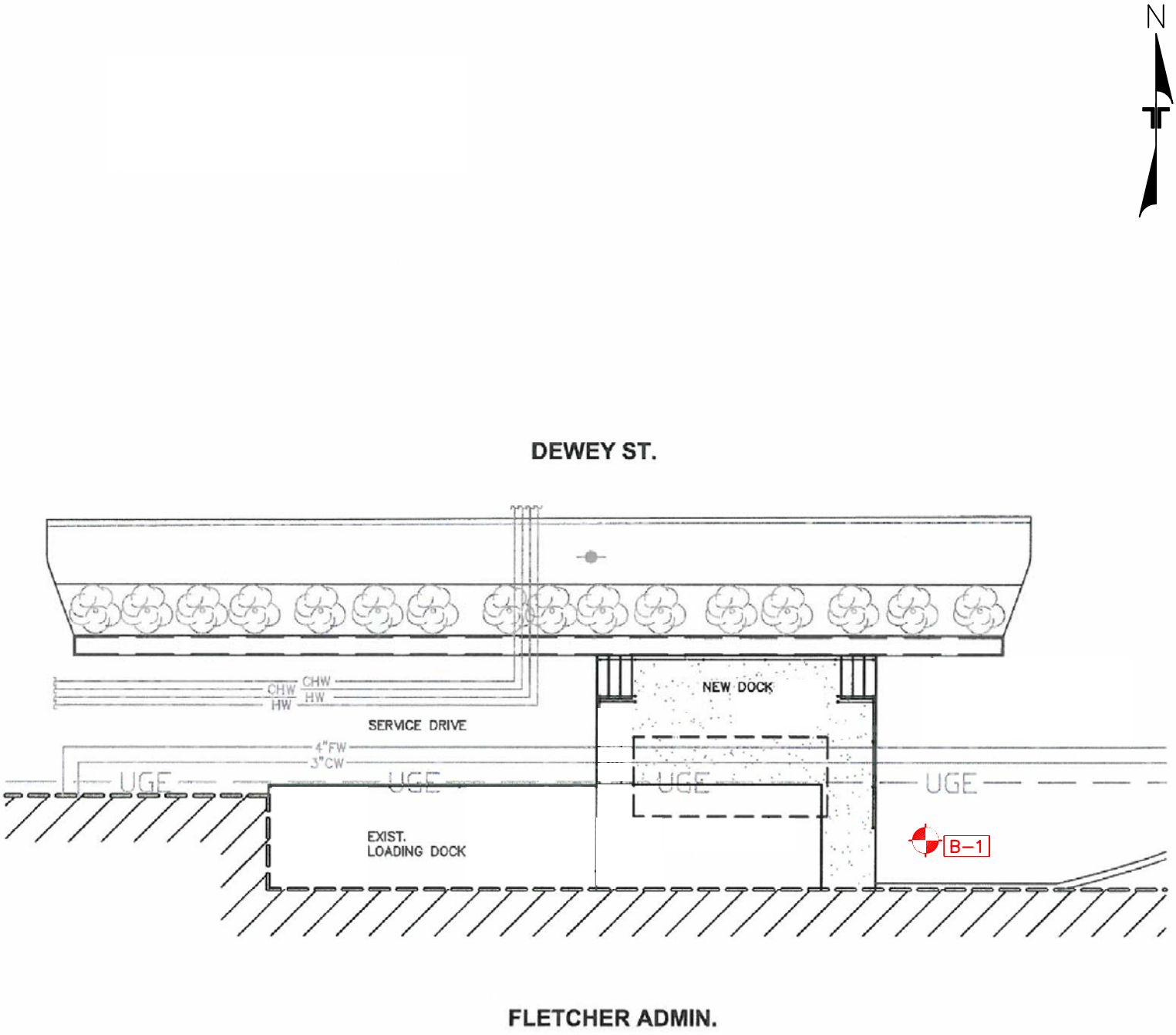
This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

ILLUSTRATIONS

Site Location Plan
Bore Location Plan



Project Mngr: DGS	Project No. 90115202	Terracon Consulting Engineers and Scientists	SITE LOCATION PLAN
Drawn By: LS(90)	Scale: NTS	6911 BLANCO ROAD SAN ANTONIO, TX 78216	Fletcher Building Loading Dock Expansion Dewey Street, San Antonio College San Antonio, Texas
Checked By: DGS	File No. 90115202	PH. (210) 641-2112 FAX. (210) 641-2124	FIGURE 1
Approved By: DGS	Date: 10-11-11		



LEGEND:

- APPROXIMATE BORE LOCATION

Project Mngr:	DGS
Drawn By:	LS(90)
Checked By:	DGS
Approved By:	DGS

Project No.	90115202
Scale:	NTS
File No.	90115202
Date:	10-11-11

Terracon
Consulting Engineers and Scientists
6911 BLANCO ROAD SAN ANTONIO, TX 78216
PH. (210) 641-2112 FAX. (210) 641-2124

BORE LOCATION PLAN

Fletcher Building Loading Dock Expansion
Dewey Street, San Antonio College
San Antonio, Texas

FIGURE

2

APPENDIX A – FIELD EXPLORATION

Field Exploration Description
Boring Log
General Notes
Unified Soil Classification System

Field Exploration Description

One test boring was drilled at the site on October 10, 2011. The boring was drilled to a depth of about 35 feet below the ground surface at the approximate location shown on the attached Bore Location Plan, Figure 2.

Terracon personnel used the site plan provided by Alamo Community College District to establish the bore locations in the field. Locations of the borings are shown on the attached "Bore Location Plan." Soil samples were obtained by both thin-walled tube and split-barrel sampling procedures. In the thin-walled tube sampling procedure, a thin-walled, seamless tube with a sharp cutting edge is pushed hydraulically into the ground to obtain relatively undisturbed samples of cohesive or moderately cohesive soils. In the split-barrel sampling procedure, a standard 2-inch O.D. split-barrel sampling spoon is driven into the ground with a 140-pound hammer falling a distance of 30 inches.

The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the standard penetration resistance value. These values are indicated on the borings logs at the depths of occurrence. If the sampler was driven less than the final 12 inches, the N value is recorded on the logs as the number of blows and amount of penetration. However, if the sampler was not driven the initial 6-inch seating increment with 50 hammer blows, refusal (i.e. "ref) is recorded along with the inches driven on the logs. The samples were sealed and transported to the laboratory for testing and classification.

Our field representative/driller prepared the field logs as part of the drilling operations. The boring logs included visual classifications of the materials encountered during drilling and our field representative interpretation of the subsurface conditions between samples. Each boring log included with this report represents the engineer's/geologist's interpretation of the field logs and include modifications based on visual observations and testing of the samples in the laboratory.

LOG OF BORING NO. B-1

CLIENT: **Alamo Colleges**
San Antonio, Texas

PROJECT: **Fletcher Building Loading Dock Expansion**

BORING LOCATION: **See Bore Location Plan**

SITE: **Dewey Street, San Antonio College**
San Antonio, Texas

Graphic Log	DESCRIPTION	DEPTH, FEET	USCS SYMBOL	SAMPLES TYPE	SAMPLES N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT	TESTS MOISTURE CONTENT, %	DRY DENSITY, PCF	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	MINUS #200 SIEVE, %	COMPRESSIVE STRENGTH, TSF	FAILURE STRAIN, %	CONFINING PRESSURE, PSI
	Approx. Surface Elevation: Existing Grade													
	0.5 2.5 inches of Asphalt, no Crushed Limestone Base material observed in the boring.			SS	N=9	13		40	19	21	29			
	STRATUM I			SS	N=21	6								
	FILL: CLAYEY GRAVEL; light grayish brown, loose to medium dense.		GC	SS	N=16	8					19			
	6.5 - yellowish brown, sandy.	5		SS	N=16	32								
	STRATUM I			ST	P=2.5	40		82	33	49				
	FAT CLAY; yellowish brown and gray, very stiff to hard.													
	- dark yellowish brown and grayish brown with oxide staining below 8 feet.	10												
				ST	P=3.5	43	77	84	30	54		3.1	3	
		15												
				ST	P=3.5	32								
		20	CH											
	- with gypsum seams below 23 feet.			ST	P=4.5+	33	88	75	31	44		3.0	2	
		25												
				ST	P=4.5+	32								
		30												
				SS	N=46	34								
	35.0	35												
	Boring Terminated at about 35 feet.													

This Log is not valid if seperated from original report.

STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES. IN SITU, THE TRANSITION BETWEEN STRATA MAY BE MORE GRADUAL.

Remarks - Dry augered to final depth. Subsurface water was not encountered during the drilling. The boring was backfilled with cuttings and capped with asphalt patch after the subsurface water observations.

WATER LEVEL OBSERVATIONS

▽ ▼

▼ ▼

FREE WATER WAS NOT OBSERVED DURING OUR DRILLING OPERATIONS

Terracon

DATE DRILLED
10/10/2011

PROJECT NUMBER
90115202

EXHIBIT

A-1

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon – 1-$^3/_8$" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube - 2" O.D., unless otherwise noted	PA:	Power Auger
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	N/E:	Not Encountered
WCI:	Wet Cave in	WD:	While Drilling		
DCI:	Dry Cave in	BCR:	Before Casing Removal		
AB:	After Boring	ACR:	After Casing Removal		

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	<2	Very Soft
500 – 1,000	2-3	Soft
1,001 – 2,000	4-6	Medium Stiff
2,001 – 4,000	7-12	Stiff
4,001 – 8,000	13-26	Very Stiff
8,000+	26+	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Ring Sampler (RS) Blows/Ft.	Relative Density
0 – 3	0-6	Very Loose
4 – 9	7-18	Loose
10 – 29	19-58	Medium Dense
30 – 49	59-98	Dense
50+	99+	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other Constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other Constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	30+

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]		GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]		GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel[F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]		SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]		SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]		CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]		ML	Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit - not dried			Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line		CH	Fat clay[K,L,M]
			PI plots below "A" line		MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried			Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

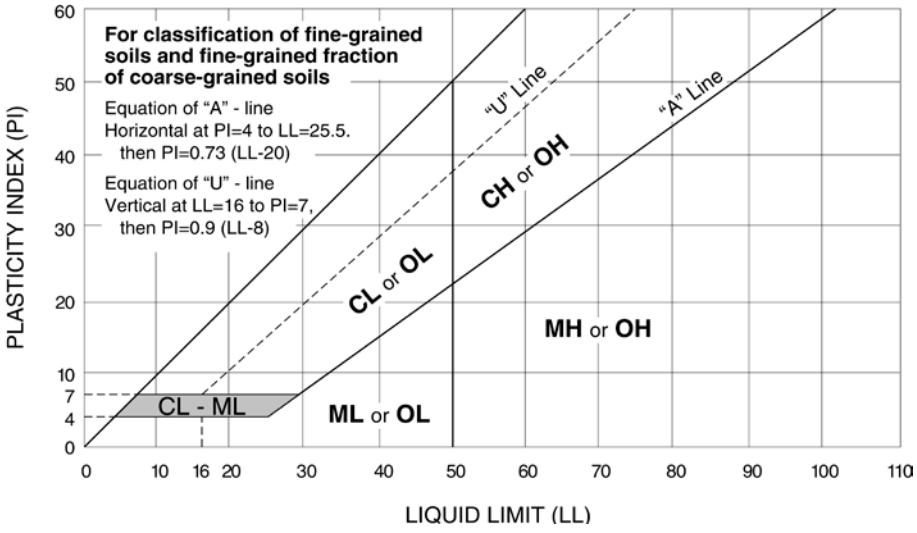
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



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APPENDIX B – LABORATORY TESTING

Laboratory Test Description

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer/geologist and were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix A. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

The laboratory test results were used for the geotechnical engineering analyses, and the development of foundation and earthwork recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local, or other accepted standards.

Selected soil samples obtained from the site were tested for the following engineering properties:

- Moisture Content
- Atterberg Limits
- Dry Unit Weight
- Percent passing the No. 200 Sieve
- Unconfined Compressive Strength
- Sulfate in soil (in progress)

The laboratory test results are tabulated either adjacent to the corresponding sample depths on the individual boring logs in Appendix A or on attached sheets that may be provided in this Appendix.

Sample Disposal

All samples were returned to our laboratory. The samples not tested in the laboratory will be stored for a period of 30 days subsequent to submittal of this report and will be discarded after this period, unless other arrangements are made prior to the disposal period.

APPENDIX C

ASFE INFORMATION

Important Information About Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. *No one except you* should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one—not even you*—should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, *do not rely on a geotechnical engineering report* that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions *only* at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an *opinion* about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final*, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject To Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce such risks, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations", many of these provisions indicate where geotechnical engineers responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Rely on Your Geotechnical Engineer for Additional Assistance

Membership in ASFE exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE
8811 Colesville Road Suite G106 Silver Spring, MD 20910
Telephone: 301-565-2733 Facsimile: 301-589-2017
email: info@asfe.org www.asfe.org

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SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section specifies cast-in place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes, for the following:

1. Slabs-on-grade.
2. Concrete Grade Beams.
3. Concrete Cast-In-Place Walls.

1.03 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Design Mixtures: For each concrete mixture submitted in the form provided at the end of this section. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1. Indicate amounts of mixing water to be withheld for later addition at Project site.

C. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.

D. Samples: For waterstops and vapor retarder as requested.

E. Welding certificates.

F. Qualification Data: For Installer and manufacturer as requested.

G. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
1. Aggregates.
2. Chloride ion content testing for the aggregates per ACI 222
3. Chloride ion content testing for each design mix per ACI 222

H. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.
2. Admixtures.

3. Form materials and form-release agents.
4. Steel reinforcement and accessories.
5. Fiber reinforcement.
6. Waterstops.
7. Curing compounds.
8. Floor and slab treatments.
9. Bonding agents.
10. Adhesives.
11. Vapor retarders.
12. Semirigid joint filler.
13. Joint-filler strips.
14. Repair materials.

I. Floor surface flatness and levelness measurements to determine compliance with specified tolerances.

J. Field quality-control test and inspection reports.

K. Minutes of preinstallation conference.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs on Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.

B. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

C. Testing Agency Qualifications: An independent agency, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.
2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from one source, and obtain admixtures through one source from a single manufacturer.

E. Welding: Qualify procedures and personnel according to AWS D1.4, "Structural Welding Code--Reinforcing Steel."

F. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:

1. ACI 301, "Specification for Structural Concrete," Sections 1 through 5.
2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

G. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures and to provide concrete testing necessary for evaluation of form removal.

H. Mockups: Cast concrete formed-surface panels to demonstrate typical joints, surface finish, texture, tolerances, and standard of workmanship as required by the Architect.

1. Build panel approximately to the size specified by the Architect in the location as directed by Architect.
2. Approved panels may become part of the completed Work if undisturbed at time of Substantial Completion.
3. Mock ups shall be provided for but not limited to the following:
    a. Exposed rectangular concrete columns with chamfers
    b. Typical floor framing indicated to be exposed to view in final condition.
4. Mock ups shall be individual concrete placements made on separate days. Mock ups shall be made side by side and demonstrate that the surface color and finish can be made uniform between the separate elements.
5. Do not proceed with construction of concrete members without approval of mockup by Architect. Approved mockup will be set as the standard of workmanship required for the concrete construction at the building. Work that does not this standard shall be repaired to the satisfaction of the Architect or removed and reconstructed to the standard established by the approved mockup.
6. Mockups that do not become part of the final building construction shall be removed and disposed legally off site after substantial completion for concrete work has been given by the Architect.

I. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:

    a. Contractor's superintendent.
    b. Independent testing agency responsible for concrete design mixtures.
    c. Ready-mix concrete manufacturer.
    d. Concrete subcontractor.

2. Review testing and inspecting agency procedures for field quality control, concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction contraction and isolation joints, and joint-filler strips, semirigid joint fillers, forms and form removal limitations, shoring and reshoring procedures, vapor-retarder installation, anchor rod and anchorage device installation tolerances, steel reinforcement installation, floor and slab flatness and levelness measurement, concrete repair procedures, and concrete protection.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.

B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
2. Products: Subject to compliance with requirements, provide one of the products specified.
3. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
4. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 FORM-FACING MATERIALS

A. Smooth-Formed Finished Concrete: (All exposed, formed finishes shall comply with this paragraph and the approved mock up) Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.

1. Plywood, metal, or other approved panel materials.
2. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:

a. High-density overlay, Class 1 or better.
b. Medium-density overlay, Class 1 or better; mill-release agent treated and edge sealed.
c. Structural 1, B-B or better; mill oiled and edge sealed.
d. B-B (Concrete Form), Class 1 or better; mill oiled and edge sealed.

B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.

C. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that will produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.

D. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation. Where framing is indicated to be exposed to view in final condition, pan-type forms shall be new (not re-used).

E. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

F. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch (19 by 19 mm), minimum.

G. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

H. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

2. Form release agent shall not be sprayed where it will come in contact with reinforcing steel.

I. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

1. Furnish units that will leave no corrodible metal closer than 1 inch (25 mm) to the plane of exposed concrete surface.
2. Furnish ties that, when removed, will leave holes no larger than 1 inch (25 mm) in diameter in concrete surface.
3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

2.03 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.

B. Plain-Steel Wire: ASTM A 82, as drawn.

C. Deformed-Steel Wire: ASTM A 496.

D. Plain-Steel Welded Wire Reinforcement: ASTM A 185, plain, fabricated from as-drawn steel wire into flat sheets.

E. Deformed-Steel Welded Wire Reinforcement: ASTM A 497, flat sheet.

2.04 REINFORCEMENT ACCESSORIES

A. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain-steel bars, cut bars true to length with ends square and free of burrs.

B. Zinc Repair Material: ASTM A 780, zinc-based solder, paint containing zinc dust, or sprayed zinc.

C. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.

2.05 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:

1. Portland Cement: ASTM C 150, Type I/II. Supplement with the following:

a. Fly Ash: ASTM C 618, Class C or F.

B. Silica Fume: ASTM C 1240, amorphous silica.

C. Normal-Weight Aggregates: ASTM C 33, Class 1N coarse aggregate or better, graded. Provide aggregates from a single source.

1. Maximum Coarse-Aggregate Size: See structural notes
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

D. Water: ASTM C 94/C 94M[and potable].

2.06 ADMIXTURES

A. Air-Entraining Admixture: ASTM C 260.

B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

C. Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete and complying with ASTM C 494/C 494M, Type C.

1. Available Products:

a. Boral Material Technologies, Inc.; Boral BCN.
b. Euclid Chemical Company (The); Eucon CIA.
c. Grace Construction Products, W. R. Grace & Co.; DCI.
d. Master Builders, Inc.; Rheocrete CNI.
e. Sika Corporation; Sika CNI.

D. Non-Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, non-set-accelerating, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.

1. Available Products:

a. Axim Concrete Technologies; Catexol 1000CI.
b. Boral Material Technologies, Inc.; Boral BCN2.
c. Cortec Corporation; MCI [2000] [2005NS].
d. Grace Construction Products, W. R. Grace & Co.; DCI-S.
e. Master Builders, Inc.; Rheocrete 222+.
f. Sika Corporation; FerroGard-901.

E. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.

1. Manufacturers:

a. Bayer Corporation.
b. ChemMasters.
c. Conspec Marketing & Manufacturing Co., Inc.; a Dayton Superior Company.
d. Davis Colors.
e. Elementis Pigments, Inc.
f. Hoover Color Corporation.
g. Lambert Corporation.
h. Scofield, L. M. Company.
i. Solomon Colors.

2. Color: Color shall be the natural concrete color as approved by the Architect in the mock ups unless indicated to receive pigment in the architectural drawings.

Color for concrete indicated to receive pigments shall be as selected by Architect from manufacturer's full range.

2.07 WATERSTOPS

A. Flexible Rubber Waterstops: CE CRD-C 513, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.

1. Available Manufacturers:

a. Greenstreak.
b. Progress Unlimited, Inc.
c. Williams Products, Inc.

2. Profile: Flat, dumbbell with center bulb.
3. Dimensions: 6 inches by 3/8 inch thick (150 mm by 10 mm thick); nontapered.

B. Flexible PVC Waterstops: CE CRD-C 572, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.

1. Available Manufacturers:

a. Bometals, Inc.
b. Greenstreak.
c. Meadows, W. R., Inc.
d. Murphy, Paul Plastics Co.
e. Progress Unlimited, Inc.
f. Tamms Industries, Inc.
g. Vinylex Corp.

2. Profile: Flat, dumbbell with center bulb.
3. Dimensions: 6 inches by 3/8 inch thick (150 mm by 10 mm thick); nontapered.

2.08 VAPOR RETARDERS

A. Vapor Retarder (Under Slab as indicated on the Drawings): Shall conform to ASTM E1745, Class C or better and shall have a maximum water vapor permeance of 0.04 perms when tested in accordance with ASTM E96. Vapor retarder component no less than 10 mils thick in accordance with ACI 302.1R-96.

1. Available Products:
a. Stego Wrap Vapor Barrier (10 mil) by Stego Industries LLC.
b. Griffolyn T-85 by Reef Industries.
c. SOCO-Shield VB-15

B. Vapor Barrier for critically moisture vapor sensitive floor coverings applications, such as rubber, vinyl, epoxy, urethane, methyl methacrylate, wood (gym floors), shall comply with ASTM E1745 Class A, maximum WVTR 0.008, minimum 15 mils thick.

1. Available Products:
a. Stego Wrap Vapor Barrier (15 mil) by Stego Industries LLC.
b. Premolded Membrane with Plasmatic Core by W.R. Meadows
c. Zero-Perm by Alumiseal.

2.09 FLOOR AND SLAB TREATMENTS

A. Slip-Resistive Emery Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive, crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials with 100 percent passing 3/8-inch (9.5-mm) sieve.

1. Available Products:

a. Anti-Hydro International, Inc.; Emery.
b. Dayton Superior Corporation; Emery Non-Slip.
c. Emeri-Crete, Inc.; Emeri-Topcrete.
d. Lambert Corporation; EMAG-20.
e. L&M Construction Chemicals, Inc.; Grip It.
f. Metalcrete Industries; Metco Anti-Skid Aggregate.

B. Slip-Resistive Aluminum Granule Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of not less than 95 percent fused aluminum-oxide granules.

1. Available Products:

a. Anti-Hydro International, Inc.; A-H Alox.
b. L&M Construction Chemicals, Inc.; Grip It AO.
c. Sonneborn, Div. of ChemRex; Frictex NS.

2.10 CURING MATERIALS

A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

1. Available Products:

a. Axim Concrete Technologies; Cimfilm.
b. Burke by Edoco; BurkeFilm.
c. ChemMasters; Spray-Film.
d. Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company; Aquafilm.
e. Dayton Superior Corporation; Sure Film.
f. Euclid Chemical Company (The); Eucobar.
g. Kaufman Products, Inc.; Vapor Aid.
h. Lambert Corporation; Lambco Skin.
i. L&M Construction Chemicals, Inc.; E-Con.
j. MBT Protection and Repair, Div. of ChemRex; Confilm.
k. Meadows, W. R., Inc.; Sealtight Evapre.
l. Metalcrete Industries; Waterhold.
m. Nox-Crete Products Group, Kinsman Corporation; Monofilm.
n. Sika Corporation, Inc.; SikaFilm.
o. Symons Corporation, a Dayton Superior Company; Finishing Aid.
p. Unitex; Pro-Film.
q. US Mix Products Company; US Spec Monofilm ER.
r. Vexcon Chemicals, Inc.; Certi-Vex EnvioAssist.

B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry.

C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

D. Water: Potable.

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

1. Available Products:

a. Anti-Hydro International, Inc.; AH Curing Compound #2 DR WB.
b. Burke by Edoco; Aqua Resin Cure.
c. ChemMasters; Safe-Cure Clear.
d. Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company; W.B. Resin Cure.
e. Dayton Superior Corporation; Day Chem Rez Cure (J-11-W).
f. Euclid Chemical Company (The); Kurez DR VOX.
g. Kaufman Products, Inc.; Thinfilm 420.
h. Lambert Corporation; Aqua Kure-Clear.
i. L&M Construction Chemicals, Inc.; L&M Cure R.
j. Meadows, W. R., Inc.; 1100 Clear.
k. Nox-Crete Products Group, Kinsman Corporation; Resin Cure E.
l. Symons Corporation, a Dayton Superior Company; Resi-Chem Clear Cure.
m. Tamms Industries, Inc.; Horncure WB 30.
n. Unitex; Hydro Cure 309.
o. US Mix Products Company; US Spec Maxcure Resin Clear.
p. Vexcon Chemicals, Inc.; Certi-Vex Enviocure 100.

F. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

1. Available Products:

a. Burke by Edoco; Cureseal 1315.
b. ChemMasters; Spray-Cure & Seal Plus.
c. Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company; Sealcure 1315.
d. Dayton Superior Corporation; Day-Chem Cure and Seal (J-22UV).
e. Euclid Chemical Company (The); Super Diamond Clear.
f. Kaufman Products, Inc.; Sure Cure 25.
g. Lambert Corporation; UV Super Seal.
h. L&M Construction Chemicals, Inc.; Lumiseal Plus.
i. Meadows, W. R., Inc.; CS-309/30.
j. Metalcrete Industries; Seal N Kure 0.
k. Sonneborn, Div. of ChemRex; Kure-N-Seal 5.
l. Tamms Industries, Inc.; LusterSeal 300.
m. Unitex; Solvent Seal 1315.
n. US Mix Products Company; US Spec CS-25
o. Vexcon Chemicals, Inc.; Certi-Vex AC 1315

G. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

1. Available Products:

a. Burke by Edoco; Cureseal 1315 WB.
b. ChemMasters; Polyseal WB.
c. Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company; Sealcure 1315 WB.

d. Euclid Chemical Company (The); Super Diamond Clear VOX.
e. Kaufman Products, Inc.; Sure Cure 25 Emulsion.
f. Lambert Corporation; UV Safe Seal.
g. L&M Construction Chemicals, Inc.; Lumiseal WB Plus.
h. Meadows, W. R., Inc.; Vocomp-30.
i. Metalcrete Industries; Metcure 30.
j. Symons Corporation, a Dayton Superior Company; Cure & Seal 31 Percent E.
k. Tamms Industries, Inc.; LusterSeal WB 300.
l. Unitex; Hydro Seal 25.
m. US Mix Products Company; US Spec Radiance UV-25.
n. Vexcon Chemicals, Inc.; Vexcon Starseal 1315.

2.11 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

B. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 per ASTM D 2240.

C. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

D. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:

1. Types I and II, non-load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

E. Reglets: Fabricate reglets of not less than 0.0217-inch- (0.55-mm-) thick, galvanized steel sheet. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.

F. Dovetail Anchor Slots: Hot-dip galvanized steel sheet, not less than 0.0336 inch (0.85 mm) thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

2.12 REPAIR MATERIALS

A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch (3.2 mm) and that can be feathered at edges to match adjacent floor elevations.

1. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3.2 to 6 mm) or coarse sand as recommended by underlayment manufacturer.
4. Compressive Strength: Not less than 4100 psi (29 MPa) at 28 days when tested according to ASTM C 109/C 109M.

B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch (3.2 mm) and that can be feathered at edges to match adjacent floor elevations.

1. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3.2 to 6 mm) or coarse sand as recommended by topping manufacturer.
4. Compressive Strength: Not less than 5000 psi (34.5 MPa) at 28 days when tested according to ASTM C 109/C 109M.

2.13 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of concrete and submitted in the form provided at the end of this section, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Fly Ash: 20 percent.

C. Limit water-soluble, chloride-ion content in hardened concrete in accordance with ACI 222.

D. Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing, high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.
2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.
4. Use corrosion-inhibiting admixture in concrete mixtures where indicated.

E. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

2.14 CONCRETE MIXTURES FOR BUILDING ELEMENTS

A. Slab on grade and concrete grade beams: Proportion normal-weight concrete mixture as follows:

1. Minimum Compressive Strength: As specified in structural notes
2. Minimum cement/water ratio: As specified in structural notes
3. Slump Limit: As specified in structural notes
4. Air Content: As specified in structural notes

B. Concrete Toppings: Proportion normal-weight concrete mixture as follows:

1. Minimum Compressive Strength: As specified in structural notes
2. Minimum cement/water ratio: As specified in structural notes
3. Slump Limit: As specified in structural notes
4. Air Content: As specified in structural notes
5. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.5 lb/cu. yd. (0.90 kg/cu. m).

2.15 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.16 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.

1.Batch tickets shall indicated amount of water with held at batching plant to be added at the site. No additional water shall be added unless indicated on the batch ticket. Batch tickets shall accompany the trucks and submitted to the Testing Agency for comparison to the approved mix design. Any discrepancies shall be immediately reported to the Architect and Engineer.

2.When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.01 FORMWORK

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.

B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

C. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:

1. Class A, 1/8 inch (3.2 mm) for smooth-formed finished surfaces and surfaces exposed to view in final condition.
2. Class B, 1/4 inch (6 mm) for rough-formed finished surfaces.

D. Construct forms tight enough to prevent loss of concrete mortar.

E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.

1. Install keyways, reglets, recesses, and the like, for easy removal.
2. Do not use rust-stained steel form-facing material.

F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

H. Chamfer exterior corners and edges of permanently exposed concrete.

I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.02 EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."
2. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.
3. Install dovetail anchor slots in concrete structures as indicated.

3.03 REMOVING AND REUSING FORMS

A. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F (10 deg C) for 24 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.

1. Leave formwork for beam soffits, joists, slabs, and other structural elements that supports weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.
2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.

C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not reuse forms for concrete surfaces that are exposed to view in the final condition.

3.04 SHORES AND RESHORES

A. Comply with ACI 318 (ACI 318M) and ACI 301 for design, installation, and removal of shoring and reshoring.

1. Do not remove shoring or reshoring until measurement of slab tolerances is complete.

B. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.

C. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

3.05 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.

1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

1. Weld reinforcing bars according to AWS D1.4, where indicated.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

E. Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.

3.06 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Engineer. Indicate proposed construction joints in reinforcing steel shop drawing submittals.

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.
3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
6. As directed by engineer, use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

C. Contraction Joints (as indicated): Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness as follows:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch (3.2 mm). Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3.2-mm-) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

D. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.

3.07 WATERSTOPS

E. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.

3.08 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect.

C. Before test sampling and placing concrete, water may be added at Project site, subject to the amount withheld at the batch plant as documented on the batch ticket and to the limitations of ACI 301.

1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

2. Slump tests shall be performed before the addition of high range water reducers.

D. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.

1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

E. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
2. Maintain reinforcement in position on chairs during concrete placement.
3. Screed slab surfaces with a straightedge and strike off to correct elevations.
4. Slope surfaces uniformly to drains where required.
5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

F. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When average high and low temperature is expected to fall below 40 deg F (4.4 deg C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

G. Hot-Weather Placement: Comply with ACI 301 and as follows:

1. Maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

3.09 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces not exposed to public view.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces as indicated to be exposed to public view, to receive a rubbed finish or to be covered with a coating or covering material applied directly to concrete.

C. Rubbed Finish: Apply the following to smooth-formed finished as-cast concrete where indicated:

1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and

water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.

3. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one part portland cement and one part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

3.10 FINISHING FLOORS AND SLABS

A. General: Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Scratch Finish: While still plastic, texture concrete surface that has been screeded and bull-floated or darbied. Use stiff brushes, brooms, or rakes to produce a profile amplitude of 1/4 inch (6 mm) in 1 direction.

1. Apply scratch finish to surfaces indicated and to receive concrete floor toppings.

C. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture.

1. Apply float finish to surfaces as indicated to receive trowel finish .

D. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.

1. Apply a trowel finish to surfaces as indicated, exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
2. Finish surfaces to the following tolerances, according to ASTM E 1155 (ASTM E 1155M), for a randomly trafficked floor surface:
   a. Specified overall values of flatness, F(F) 30; and of levelness, F(L) 20; with minimum local values of flatness, F(F) 24; and of levelness, F(L) 15; for suspended slabs.

E. Trowel and Fine-Broom Finish: Apply a first trowel finish to surfaces as indicated. While concrete is still plastic, slightly scarify surface with a fine broom.

1. Comply with flatness and levelness tolerances for trowel finished floor surfaces.

F. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, and ramps, and elsewhere as indicated.

1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.

G. Slip-Resistive Finish: Before final floating, apply slip-resistive aggregate finish where indicated and to concrete stair treads, platforms, and ramps. Apply according to manufacturer's written instructions and as follows:

1. Uniformly spread 25 lb/100 sq. ft. (12 kg/10 sq. m) of dampened slip-resistive aggregate over surface in 1 or 2 applications. Tamp aggregate flush with surface, but do not force below surface.
2. After broadcasting and tamping, apply float finish.
3. After curing, lightly work surface with a steel wire brush or an abrasive stone and water to expose slip-resistive aggregate.

3.11 MISCELLANEOUS CONCRETE ITEMS

A. Filling In: Fill in holes and openings left in concrete structures, unless otherwise indicated, after work of other trades is in place. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.

B. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates from manufacturer furnishing machines and equipment.

C. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on Drawings. Screed, tamp, and trowel-finish concrete surfaces.

3.12 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.

D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.

E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

a. Water.
b. Continuous water-fog spray.
c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

    a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
    b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
    c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on Project..

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

    a. After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project.

4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

3.13 JOINT FILLING

A. Prepare, clean, and install joint filler according to manufacturer's written instructions.

    1. Defer joint filling until concrete has aged at least one month. Do not fill joints until construction traffic has permanently ceased.

B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.

C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches (50 mm) deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.14 CONCRETE SURFACE REPAIRS

A. Defective Concrete: Repair and patch defective areas when approved by Architect. Remove and replace concrete that cannot be repaired and patched to Architect's approval.

B. Patching Mortar: Mix dry-pack patching mortar, consisting of one part portland cement to two and one-half parts fine aggregate passing a No. 16 (1.18-mm) sieve, using only enough water for handling and placing.

C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.

1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch (13 mm) in any dimension in solid concrete, but not less than 1 inch (25 mm) in depth. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Architect.

D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch (0.25 mm) wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
2. After concrete has cured at least 14 days, correct high areas by grinding.
3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
4. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.
5. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch (6 mm) to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
6. Repair defective areas, except random cracks and single holes 1 inch (25 mm) or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
7. Repair random cracks and single holes 1 inch (25 mm) or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.15 FIELD QUALITY CONTROL

A. Testing and Inspecting: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Inspections:

1. Steel reinforcement placement.
2. Steel reinforcement welding.
3. Headed bolts and studs.
4. Verification of use of required design mixture.
5. Concrete placement, including conveying and depositing.
6. Curing procedures and maintenance of curing temperature.
7. Verification of concrete strength before removal of shores and forms from beams and slabs.

C. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. (76 cu. m) or fraction thereof of each concrete mixture placed each day.

    a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method, for normal-weight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each composite sample.
5. Unit Weight: ASTM C 567, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
6. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test, unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens, unless field-cured test specimens are required.
7. Compressive-Strength Tests: ASTM C 39; one set for each drilled pier, but not more than one set for each truck load. One specimen will be tested at 7 days, 2 specimens will be tested at 28 days, and one specimen will be retained in reserve for later testing if required.
8. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
9. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).
10. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of

concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

11. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
12. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by Architect.
13. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
14. Correct deficiencies in the Work that test reports and inspections indicate dos not comply with the Contract Documents.

END OF SECTION 03 30 00

MIX DESIGN SUBMITTAL FORM

Project: _____

Method used to select proportions (ACI 318, Sect. 5.3): ___ field experience or ___ trial mixture

Person that prepared the submittal: _____

Signed: _____ Date: _____

Person selecting the mixture proportions:

_____

Ready-Mix Supplier Company: _____

Contact Person: _____ Phone Number: _____ Date: _____

Main Plant Location: _____ Miles from Project: ____

Secondary Plant Location: _____ Miles from Project: ____

SELECTION OF CONCRETE MIX PROPORTIONS

1. CEMENTITIOUS MATERIALS

Cement: ____(lbs) ____(cu.ft.) Type: _____ Source: _____ Manufacturer _____

Fly Ash: ____(lbs) ____(cu.ft.) Type: _____ Source: _____ Manufacturer _____

Other: ____(lbs) ____(cu.ft.) Type: _____ Source: _____ Manufacturer _____

Fly ash replacement: _____ %

2. AGGREGATES

Fine: ____(lbs) ____(cu.ft.) Size: _____ Type: _____ Source: _____

Coarse: ____(lbs) ____(cu.ft.) Size: _____ Type: _____ Source: _____

Total:____(lbs) ____(cu.ft.)Size: _____ Type: _____ Source: _____

3. WATER

Water: ____(lbs) ____(cu.ft.) Source: _____

4. ADMIXTURES

HRWR_____ oz. per 100# cement dosage range

Non-Corrosive Accelerator _____ oz. per 100# Cement

W.R._____ oz. per 100# Cement

A.E.A._____ oz. per 100# Cement

Fibers or color pigments or other additions_____ oz. per 100# Cement

FRESHLY MIXED CONCRETE PROPERTIES

Slump before additive =_____ in.Air Content = _____ %

Final Slump after additive =_____ in.Unit Dry Wt. = _____ pcf

Unit Wet Wt. =_____ pcf

Placement Method = _____

DOCUMENTATION OF COMPRESSIVE STRENGTH AND REQUIRED STRENGTH ON THE BASIS OF FIELD EXPERIENCE

Check one, complete blanks and attach historical data used for these calculations:

oRecords attached represent 30 or more consecutive, recent tests of concrete within 1000 psi of the required, which was produced with similar materials and procedures, and under similar conditions, per ACI 318, paragraph 5.3.1.

S= _____, f'c = _____, f'cr= _____, f'c(avg) = _____

oRecords attached represent two groups totaling 30 or more consecutive, recent tests of concrete within 1000 psi of the required, which was produced with similar materials and procedures, and under similar conditions, per ACI 318, paragraph 5.3.1

S(avg)= _____, f'c = _____, f'cr= _____, f'c(avg) = _____

oRecords attached represent 15-29 consecutive, recent tests of concrete within 1000 psi of the required, which was produced with similar materials and procedures, and under similar conditions per ACI 318, paragraph 5.3.1.2, spanning a period of not less than 45 days.

S(mod)=_____, f'c = _____, f'cr= _____, f'c(avg) = _____

oRecords attached represent 10-15 recent tests of concrete with similar materials and conditions, per ACI 318, paragraphs 5.3.2.2 and 5.3.3.1, spanning a period of not less than 45 days.

f'c = _____, f'cr= _____, f'c(avg) = _____

DOCUMENTATION OF COMPRESSIVE STRENGTH AND REQUIRED STRENGTH ON THE BASIS OF TRIAL MIXTURES

Age (days)	Mix #1 (f'c. – W/C ratio)	Mix #2 (f'c. – W/C ratio)	Mix #3 (f'c – W/C ratio)
28	_____	_____	
28	_____	_____	
28	_____	_____	

Attach a water cement ratio vs. f'c graph.

Show W/C ratio selected based on f'c & f'cr from T5.3.2.2

Show mix design proportioned to achieve f'cr = f'c + 1200 psi (1400 psi for strength higher than 5000 psi at 28 days)

ATTACHMENTS

Manufacturers certification of cement materials
Grading chart of Aggregate
Admixture certification
Water cement ratio vs. f'c graph
Past performance record submittals

SECTION 05 52 00

HANDRAILS AND RAILINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes steel pipe railings, guardrails, balusters, fittings and handrails.

1. Provide mechanical fasteners at connections and structural adhesive for splices.

B. Related Sections:

1. Section 03 30 00 – Cast-In-Place Concrete: Execution requirements for placement of anchors specified in this section in concrete.

1.02 REFERENCES

A. ASTM International:

1. ASTM A53/A53M – Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc-Coated, Welded and Seamless.

2. ASTM A123/A123M – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

3. ASTM A500 – Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

4. ASTM E894 (Reapproved 2004) – Test Method for Anchorage of Permanent Metal Railing Systems and Rails for Buildings.

5. ASTM E935 – Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings.

6. ASTM E985 – Standard Specification for Permanent Metal Railing Systems and Rails for Buildings.

B. National Ornamental & Miscellaneous Metals Association:

1. NOMMA Guideline 1 – Joint Finishes.

C. SSPC: The Society for Protective Coatings:

1. SSPC – Steel Structures Painting Manual.

2. SSPC Paint 15 – Steel Joist Shop Primer/Metal Building Primer.

3. SSPC Paint 20 – Zinc-Rich Coating, Type I – Inorganic and Type II – Organic.

1.03 DESIGN REQUIREMENTS

A. Structural Performance: Engineer, fabricate and install handrails, guardrails and railing systems to withstand, when tested per ASTM E985, for structural performance based on the following:

1. Testing performed according to ASTM E894 and E935.

B. Structural Performance: Engineer, fabricate and install handrails and railing systems to withstand the following structural loads without exceeding the allowable design working stress of the materials involved, including anchors and connections. Apply each load to produce the maximum stress in each of the respective components of each metal fabrication.

1. Guards: Capable of withstanding the following loads applied as indicated.

a. Concentrated Load: Single concentrated load of 200 lbs applied in any direction at any point along the top, and have attachment devices and supporting structure to transfer this loading to appropriate structural elements of the building.
b. Uniform load of 50 lbs per linear foot applied in any direction at the top and to transfer this load through the supports to the structure.
c. Concentrated and uniform loads above need not be assumed to act concurrently.

2. Handrails: Capable of withstanding the following loads applied as indicated.

a. Concentrated Load: Single concentrated load of 200 lbs applied in any direction at any point along the top, and have attachment devices and supporting structure to transfer this loading to appropriate structural elements of the building.
b. Uniform load of 50 lbs per linear foot applied in any direction at the top and to transfer this load through the support to the structure.
c. Concentrated and uniform loads above need not be assumed to act concurrently.

3. Components: Intermediate rails (all those except the handrail), balusters and panel fillers shall be designed to withstand a horizontal applied normal load of 50 pounds on an area equal to one square foot, including openings and space between rails.

a. Reactions due to this loading are not required to be superimposed with those of either B1 or B2 above.

1.04 SUBMITTALS

A. Section 01 33 00 – Submittal Procedures: Submittal requirements.

B. Shop Drawings: Indicate profiles, sizes, connection attachments, anchorage, size and type of fasteners and accessories.

1.05 QUALITY ASSURANCE

A. Finish joints in accordance with NOMMA Guideline 1.

1.06 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 PRODUCTS

2.01 STEEL RAILING SYSTEM COMPONENTS

A. Pipe: ASTM A53, Grade B, Standard Weight (Schedule 40)

1. Size: 1 1/4 inches iron pipe size, outside diameter 1.66 inches, unless otherwise noted on the Drawings.

B. Exposed Fasteners: Flush countersunk screws or bolts; consistent with design of railing.

C. Splice Connectors: Steel concealed spigots.

D. Galvanizing: All exterior handrails, guardrails and railings shall be hot-dip galvanized per ASTM A123/A123M; galvanize after fabrication.

F. Non-Shrink, Non-Metallic Grouts:

1. Euco N-S Grout; Euclid Chemical Co.

2. Crystex; L & M Construction Chemicals, Inc.

3. 588 Grout; W.R. Meadows, Inc.

4. Sonogrout 10K; Sonneborn Building Products – ChemRex, Inc.

H. Erosion-Resistant Anchoring Cement:

1. Commercial Anchor Cement; W.R. Bonsal Co.

2. Super Por-Rok;CGM Incorporated.

3. Thorogrip; Thoro Systems Products.

I. Touch-Up Primer for Galvanized Surfaces: SSPC Paint 20, Type II Organic zinc rich.

1. ZRC Galvilite galvanizing repair compound as manufactured by ZRC Worldwide.

2.02 FABRICATION

A. Fit and shop assemble components in largest practical sizes for delivery to site.

B. Fabricate components with joints tightly fitted and secured. Furnish spigots and sleeves to accommodate site assembly and installation.

C. Exposed Mechanical Fastenings: Flush countersunk screws or bolts; unobtrusively located; consistent with design of component, except where specifically noted otherwise.

D. Supply components required for anchorage of fabrications. Fabricate anchors and related components of same material and finish as fabrication, except where specifically noted otherwise.

E. Exterior Components: Continuously seal joined pieces by continuous welds. Drill condensate drainage holes at bottom of members at locations not encouraging water intrusion.

F. Interior Components: Continuously seal joined pieces by continuous welds.

G. Exposed Welded Joints: NOMMA Guideline 1 Joint Finish 1.

H. Accurately form components to suit stairs and landings, to each other and to building structure.

I. Accommodate for expansion and contraction of members and building movement without damage to connections or members.

J. Provide inserts and other anchorage devices to connect handrails and railing systems to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by handrails and railing systems. Coordinate anchorage devices with supporting structure.

K. For railing posts set in concrete, provide preset sleeves of steel, not less than 6 inches long with inside dimensions not less than 1/2 inch greater than outside dimensions of post, and steel plate forming bottom closure.

1. In lieu of setting railing posts in preset sleeves, contractor may core drill concrete, minimum 6 iches deep with inside dimensions of not less than 1/2 inch greater than outside dimensions of post.

PART 3 EXECUTION

3.01 EXAMINATION

A. Section 01 30 00 – Administrative Requirements: Coordination and Project Conditions.

B. Verify field conditions are acceptable and are ready to receive work.

3.02 PREPARATION

A. Supply items required to be cast into concrete with setting templates, to appropriate sections.

3.03 INSTALLATION

A. Install components plumb and level, accurately fitted, free from distortion or defects.

B. Anchor railings to structure with anchors, plates or angles.

C. Field weld anchors as indicated on Drawings. Touch up welds with primer. Grind welds smooth.

D. Conceal bolts and screws whenever possible. Where not concealed, use flush countersunk fastenings.

E. Assemble with spigots and sleeves to accommodate tight joints and secure installation.

F. Unless otherwise noted on the Drawings, install wall brackets at maximum 5’-0” on center.

G. Anchor posts in concrete by forming or core-drilling holes not less than 6 inches deep and 1/2 inch greater than outside diameter of post. Set the centerline of the posts a minimum of 4 inches away from the vertical edge of concrete walks, ramps or steps. Clean holes of all loose material, insert posts, and fill annular space between post and concrete with the following anchoring material, mixed and placed to comply with anchoring material manufacturer's directions.

1. Non-shrink, non-metallic grout or anchoring cement.

3.04 ERECTION TOLERANCES

A. Section 01 40 00 – Quality Requirements: Tolerances.

B. Maximum Offset From Alignment: 1/4 inch.

C. Maximum Out-of-Position: 1/4 inch.

END OF SECTION

SECTION 26 28 26

ENCLOSED TRANSFER SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes transfer switches in individual enclosures.

1.02 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA ICS 10 - Industrial Control and Systems: AC Transfer Switch Equipment.

B. Underwriters Laboratories Inc.:

1. UL 1008 - Transfer Switch Equipment.

1.03 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures.

B. Product Data: Submit catalog sheets showing voltage, switch size, ratings and size of switching and overcurrent protective devices, operating logic, short circuit ratings, dimensions and enclosure details.

1.04 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Closeout procedures.

B. Project Record Documents: Record actual locations of enclosed transfer switches.

C. Operation and Maintenance Data: Submit routine preventative maintenance and lubrication schedule. List special tools, maintenance materials, and replacement parts.

1.05 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years experience with service facilities within 100 miles of Project.

B. Supplier: Authorized distributor of specified manufacturer with minimum five years of documented experience.

1.06 MAINTENANCE SERVICE

A. Section 01 70 00 - Execution and Closeout Requirements: Maintenance service.

B. Furnish service and maintenance of transfer switches for two years from Date of Substantial Completion.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers are listed alphabetically below:

1. ASCO

2. Cummins

3. Russellectric.

4. Substitutions: Section 01 60 00 - Product Requirements

2.02 PRODUCT DESCRIPTION – AUTOMATIC TRANSFER SWITCHES

A. NEMA ICS 10, automatic transfer switch.

B. Configuration: Electrically operated, mechanically held transfer switch.

2.03 RATINGS AND FEATURES – AUTOMATIC TRANSFER SWITCHES

A. All project specific performance requirements shall be in accordance with schedule titled “AUTOMATIC TRANSFER SWITCH SCHEDULE.”

B. Withstand Current Rating: 65,000 rms symmetrical amperes when used with a UL 489 listed molded case circuit breaker, or 200,000 rms symmetrical amperes when used with a Class J, K1 or L current limiting fuse.

C. Service Conditions: NEMA ICS 10.

1. Temperature: 105 degrees F maximum.

2. Altitude: 3,300 maximum feet (1000 m) above sea level.

D. Product Features:

1. Indicating Lights: Mount in cover of enclosure to indicate NORMAL SOURCE AVAILABLE, ALTERNATE SOURCE AVAILABLE, switch position.

2. Test Switch: Mount in cover of enclosure to simulate failure of normal source.

3. Test Mode Switch: Mount in cover of enclosure to inhibit or allow transfer of load to alternate source during engine exercising period.

4. Return to Normal Switch: Mount in cover of enclosure to initiate transfer from alternate source to normal source.

5. Engine Switch: Mount in cover of enclosure. Provide LOCKOUT, NORMAL AND RUN positions.

6. Transfer Switch Auxiliary Contacts: 2 normally open; 2 normally closed.

7. Elevator pre-transfer contacts. Provide quantity as/if scheduled.

8. Normal Source Monitor: Monitor each phase of normal source voltage and frequency; initiate transfer when voltage or frequency falls beyond limits scheduled on the plans.

9. Alternate Source Monitor: Monitor each phase of alternate source voltage and frequency; inhibit re-transfer voltage or frequency is below the minimum limits scheduled on the plans.

10. Where scheduled, provide transition to allow transfer switch to be delayed in the neutral position between normal and alternate sources. In-phase monitoring is NOT ACCEPTABLE.

11. Switched Neutral: When scheduled, switched neutrals shall utilize non-overlapping contacts.

12. Automatic Sequence of Operation: Provide adjustable time delays as follow:

    a. TDES – Time Delay Engine Start: Time delay before engine start after sensing of under voltage/frequency by normal source monitor.
    b. TDNE – Time Delay Normal to Emergency (Transfer): Time delay after alternate source stabilizes before beginning transfer to alternate source.
    c. TDPT: Time Delay Programmed Transition: Time delay in neutral position between normal and alternate sources during either transfer or retransfer.
    d. TDEN – Time Delay Emergency to Normal (Re-transfer): Time delay after normal source stabilizes before beginning re-transfer to normal; bypass time delay in event of alternate source failure.
    e. TDEC – Time Delay Engine Cooling: Time delay for unloaded engine operation after re-transfer to normal.
    f. TDPT – Time Delay Pre-Transfer Signal (when scheduled): Time delay in advance of normal to alternate transfers during tests, or any retransfers from alternate to normal.

13. Engine Exerciser: Bypass exerciser control when normal source fails during exercising period.

14. Enclosure: Enclosure: NEMA enclosure, type as scheduled

15. Finish: Manufacturer's standard enamel.

16. When switch is scheduled to be provided with bypass/isolation capability, provide with the following additional features.

    a. Product Description: NEMA ICS 10, automatic transfer switch with manual bypass switch.
    b. Configuration: Drawout type electrically-operated, mechanically-held transfer switch with manually-operated CONNECTED, TEST AND DISCONNECTED drawout positions, and with mechanically operated, mechanically held transfer switch connected to bypass automatic switch in both NORMAL and EMERGENCY positions.
    c. Bypass Switch Ratings: Match automatic transfer switch for electrical ratings.
    d. Indicating Lights: Mount in cover of enclosure to indicate NORMAL SOURCE AVAILABLE, ALTERNATE SOURCE AVAILABLE, automatic SWITCH POSITION, NORMAL BYPASS and ALTERNATE SOURCE BYPASS.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install housekeeping pads in accordance with Section 03 30 00.

B. Install engraved plastic nameplates in accordance with Section 26 05 53.

3.02 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements - Execution and Closeout Requirements: Field inspecting, testing, adjusting and balancing.

3.03 MANUFACTURER'S FIELD SERVICES

A. Section 01 40 00 - Quality Requirements: Manufacturers' field services.

B. Check out transfer switch connections and operations and place in service.

3.04 ADJUSTING

A. Section 01 70 00 - Execution and Closeout Requirements: Testing, adjusting and balancing.

B. Adjust control and sensing devices to achieve specified sequence of operation.

3.05 DEMONSTRATION AND TRAINING

A. Demonstrate operation of transfer switch in normal, emergency modes, and bypass (if applicable) modes.

END OF SECTION

SECTION 26 32 13

PACKAGED ENGINE GENERATOR SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Packaged engine generator set.

B. Exhaust silencer and fittings.

C. Batteries and charger.

D. Miscellaneous accessories.

1.02 RELATED SECTIONS

A. Section 26 36 23 – Automatic Transfer and Bypass Isolation Switches.

1.03 REFERENCES

A. NEMA AB1 - Molded Case Circuit Breakers.

B. NEMA MG1 - Motors and Generators.

C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum.)

D. NFPA 30 – Flammable and Combustible Liquids Code.

E. NFPA 70 - National Electrical Code.

F. NFPA 110 – Emergency and Standby Power Systems.

1.04 SYSTEM DESCRIPTION

A. Description: Engine generator assembly and accessories to provide source of power for Level 1 applications in accordance with NFPA 110.

B. Capable of continuous standby operation at site conditions while meeting all performance requirements as stated on the drawings and as described in this specification.

1.05 SUBMITTALS

A. Submit under provisions of Section 01 30 00.

B. Shop Drawings:

1. Provide electrical diagrams including schematic and interconnection diagrams for all components. Indicate electrical characteristics and all connection requirements.

2. Provide Drawings of each major component assembly and accessory.

3. In addition to component Drawings, submit plan and elevation views with overall dimensions for a complete assembly of all major components. Indicate rough in dimensions for all connection points and weight bearing points on the overall views. Submittals consisting of individual component Drawings, without overall plans and elevations for the complete unit as finally assembled, will be rejected.

C. Product Data: Provide data showing the following.

1. Weights.

2. Fuel consumption at full load.

3. Free field sound pressure levels in dBA at eight lateral points 3 meters from center of unit.

4. Exhaust silencer data.

5. Ventilation air requirements.

6. Combustion air requirements.

7. Radiated heat in BTU per minute

8. Exhaust flow rate and temperature.

9. Radiator fan capabilities in CFM with 0.5 in water total flow restriction.

10. Provide data sufficient to determine maximum instantaneous voltage drop for various inrush KVA's, up to and including the maximum inrush KVA scheduled on the plans. The data shall include the combined effects of both subtransient reactance and torque matching features of the governor system. Instantaneous voltage dip shall be determined in accordance with the definition in the NEMA MG1 Standard.

11. Provide the maximum inrush KVA for which the excitation support system and engine will provide sustained recovery, to 90% of rated output voltage within 250 msec, while remaining within a +/- 10% of rated voltage band.

12. Provide data showing that maximum alternator winding temperature rise will not exceed the value specified in Paragraph 2.05D.

13. Provide a certification from the manufacturer certifying that the maximum alternator winding operating temperature will meet the requirements specified in Paragraph 2.05E. Note that a factory certification is required – statements from the supplier are not acceptable.

14. Prototype Testing Summary Report. Indicate results of performance testing. Prototype tests shall have been done on a complete and functional unit, component level type tests will not substitute for this requirement. The prototype test report shall indicate the engine model number and alternator model number of the prototype unit on which the report was based. Provide justification for extrapolation of prototype test results if model number of proposed engine or alternator do not match those of the prototype test.

D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation and starting of Product.

E. Manufacturer's Certificate: Certify that products meet or exceed all specified requirements, including confirmation that the manufacturer has done a line-by-line review of this entire specification section.

F. Manufacturer's Field Reports: Indicate procedures and findings. Submit to engineer for review within 10 days of completion of testing.

1.06 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 01 70 00.

B. Operation Data: Include instructions for normal operation.

C. Maintenance Data: Include instructions for routine maintenance requirements, service manuals for engine, alternator, and all accessories, oil sampling and analysis for engine wear, and emergency maintenance procedures.

1.07 QUALITY ASSURANCE

A. Perform Work in accordance with NFPA 110.

1.08 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum twenty years of documented experience, and with service facilities within 100 miles of project.

B. Supplier: Authorized distributor of specified manufacturer with minimum five years of documented experience.

1.09 WARRANTY

A. Furnish a two-year manufacturer warranty.

1.10 MAINTENANCE SERVICE

A. Furnish service and maintenance of engine generator through and including the second annual maintenance and inspection, from Date of Substantial Completion. Provide all recommended quarterly, semi-annual, and annual maintenance activities as recommended in Table A-6-3.1(a) of NFPA 110.

1.11 REGULATORY REQUIREMENTS

A. Conform to requirements of the Reference Standards.

B. Furnish products listed and classified by Underwriters Laboratories as suitable for purpose specified and indicated.

C. Comply with all emission standards for continuous standby service applicable to the project site. Provide a unit complying with both current standards and those if any scheduled for implementation within one year of bid date.

1.12 PRE-INSTALLATION CONFERENCE

A. Convene one week prior to commencing work of this Section, under provisions of Section 01 30 00.

1.13 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Section 01 60 00.

B. Accept unit on site on skids. Inspect for damage.

C. Protect equipment from dirt and moisture by securely wrapping in heavy plastic.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Caterpillar.

B. Cummins.

C. Generac.

D. Baldor

E. Substitutions: Under provisions of Section 01 60 00.

2.02 SERVICE CONDITIONS

A. Elevation: 3,300 feet maximum unless noted otherwise on the drawings.

B. Temperature: Outdoor units: 110°F ambient dry bulb temperature measured outside of engine housing at air intake. Indoor units: 125°F room temperature, measured at alternator air intake screen with generator set running at full load.

2.03 PERFORMANCE

A. All project-specific performance requirements shall be in accordance with schedule titled “ENGINE GENERATOR SET SCHEDULE.”

B. The system shall be capable of continuous standby operation at site conditions while operating the maximum scheduled load.

C. The installed system shall be capable of successfully starting and running the scheduled loads.

D. The system shall meet all scheduled performance criteria.

E. The system shall comply with all other requirements for this specification.

F. The engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature, in accordance with NFPA 110-1993, 5-13.2.6.

G. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 1.0 percent.

H. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Frequency drop and skew rate during starting any scheduled load step, or during restarting of cyclical loads, shall not exceed the values scheduled on the plans and shall return to steady state within two seconds. For purposes of determining compliance with this requirement, all cyclical loads scheduled shall be assumed to be restarted simultaneously.

I. Instantaneous voltage drop shall not exceed the value scheduled on the plans when starting any scheduled load step, or when restarting individual cyclical loads, shall not exceed the value scheduled on the plans. The maximum instantaneous voltage drop shall be measured as specified and defined in the NEMA MG1 standard, and shall include the effects of both subtransient reactance and torque matching features of the governor system (torque rolloff).

J. The exicitation system and engine shall be capable of sustained recovery to 90% of rated output voltage while supplying the greater of a) the maximum inrush KVA for any load step scheduled on the plans, or b) the sum of the scheduled inrush KVA's of all cyclical loads, and for a duration sufficient to successfully start the loads.

K. The alternator shall produce an AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic. Telephone influence factor shall be less than 40.

2.04 ENGINE

A. Engine speed: 1800 rpm.

B. Governor: Electronic isochronous type, as manufactured by Barber-Coleman or Woodward.

C. Safety Devices: Engine shutdown on high water temperature, low oil pressure, overspeed, and engine overcrank. Limits as selected by manufacturer. Alarm sensors and limits shall match control panel functions, providing all devices necessary for control panel displayed parameters.

D. Engine Starting: DC starting system with positive engagement, number and voltage of starter motors in accordance with manufacturer's instructions. Include remote starting control circuit, with MANUAL-OFF-REMOTE selector switch on engine-generator control panel.

E. Engine Jacket Heaters: Provide thermal circulation type water heater with integral thermostatic control, sized to maintain engine jacket water at 90 degrees F (32 degrees C) at ambient conditions 10° F below ASHRAE 99% winter design conditions for the site, and suitable for operation at the voltage as scheduled.

F. Radiator: Radiator using glycol coolant, with blower type fan, sized to maintain safe engine temperature while operating in the Service Conditions as specified under Paragraph 2.03 above and with an external air flow restriction of 0.5 inches of water (1.25 Pa) maximum.

G. Engine Accessories: Fuel filter, lube oil filter, intake air filter, lube oil cooler, fuel transfer pump, fuel priming pump, gear-driven water pump. Include fuel pressure gauge, water temperature gauge, and lube oil pressure gauge on engine/generator control panel.

H. Mounting: Provide unit with suitable vibration isolation and mount on structural steel base.

2.05 ALTERNATOR

A. Alternator: NEMA MG1, three-phase, four-pole, 2/3 pitch, reconnectable brushless synchronous generator with brushless exciter.

B. Rating: Oversized as required to meet all specified and scheduled performance requirements.

C. Insulation Class: H, vacuum pressure impregnated.

D. Rated Winding Temperature Rise: The rated winding temperature rise shall not exceed 105° C when operating a resistive load at the alternator nameplate rating.

E. Actual Winding Operating Temperature: The maximum winding operating temperature, including the heating effects of harmonic currents and as determined by the resistance method, shall not exceed 165°C while operating the loads scheduled on the Drawings under the Service Conditions specified in Paragraph 2.02.

F. Enclosure: NEMA MG1, open drip-proof.

G. Voltage Regulation: Include generator-mounted volts per hertz exciter-regulator to match engine and generator characteristics, and to meet the Performance Requirements in Paragraph 2.03. Include manual controls to adjust voltage droop, voltage level (plus or minus 5 percent) and voltage gain. Manufacturer’s standard excitation system shall be provided. Voltage regulation shall be immune from misoperation due to load-induced voltage wave form distortion. A permanent magnet generator (PMG) shall provide excitation power to the automatic voltage regulator.

2.06 ACCESSORIES

A. Fuel Tank: Generator set sub-base-mounted dual wall steel fuel tank with fill and vent. Size as scheduled on the plans. Fuel pump shall be mechanical type. Install equipment and wiring to provide visual and audible “low fuel” and “leak detector” alarms at the remote annunciator panel location. Conform to UL 142.

B. Exhaust Silencer: Critical type silencer, with muffler companion flanges and flexible stainless steel exhaust fitting, sized in accordance with engine manufacturer's instructions.

C. Batteries: Heavy-duty, diesel starting type lead-acid storage batteries. Match battery voltage to starting system and capacity to engine requirements and size to provide three full cranking cycles. Include necessary cables.

D. Battery Tray: Treated for electrolyte resistance, constructed to contain spillage.

E. Battery Charger: Current limiting type designed to float at 2.17 volts per cell and equalize at 2.33 volts per cell. Include overload protection, full wave rectifier, DC voltmeter and ammeter, and 120 volts AC fused input. Mount within generator housing and provide with vibration isolation.

F. Line Circuit Breaker(s): NEMA AB 1, UL Listed, 3P, molded case circuit breaker on generator output with integral thermal and instantaneous magnetic trip in each pole, sized in accordance with NFPA 70. Unit mount in enclosure to meet NEMA 250, Type 1 requirements.

G. Engine-Generator Control Panel: NEMA Type 1 gasketed generator-mounted control panel enclosure with illuminated engine and generator controls and indicators. Include provision for padlock and the following equipment and features:

1. Frequency Meter: 45-65 Hz. range.

2. AC Output Voltmeter: 2 percent minimum accuracy, with phase selector switch.

3. AC Output Ammeter: 2 percent minimum accuracy, with phase selector switch.

4. Output voltage adjustment.

5. Push-to-test indicator lamps, one each for low oil pressure, high water temperature, overspeed, and overcrank.

6. Engine start/stop selector switch.

7. Engine running time meter.

8. Oil pressure gauge.

9. Water temperature gauge.

10. Auxiliary Relay: 3PDT, to operate when engine runs, with contact terminals prewired to terminal strip.

11. Additional visual indicators and alarms as required by NFPA 110.

12. Remote Alarm Contacts: Pre-wire SPDT contacts to terminal strip for remote alarm functions required by NFPA 110.

H. Remote Annunciator Panel: Surface-mounted panel with brushed stainless steel finish. Provide audible and visible indicators and alarms required by NFPA 110. Include annunciation of position of each transfer switch, leak detection alarm, each other alarm point scheduled, and a minimum of four additional spare points.

I. Provide manual emergency stop station per NFPA 110-3-5.5.6.

J. Miscellaneous Heaters: Control panel heater, generator heater and battery heaters, all suitable for operation at 120 volts. All heaters shall be automatically disconnected when prime mover is running.

K. Weather-Protective Enclosure: Provide a reinforced steel housing allowing access to control panel and service points, with lockable doors and panels. Include fuel tank, battery rack, and silencer.

L. Provide a reinforced steel housing allowing access to control panel and service points, with lockable doors and panels. Include fuel tank, battery rack, and silencer. Provide sound control measures as required to meet the maximum sound pressure level as scheduled on the Drawings. Sound pressure levels shall be free field levels as measured in any lateral position 7 meters from set.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.02 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 01 40 00.

B. Provide full load test utilizing portable test bank, for four hours minimum. Simulate power failure including operation of transfer switch, automatic starting cycle, and automatic shutdown and return to normal. Demonstrate compliance with NFPA 110-1993, 5-13 “Installation Acceptance.”

C. Record in 5-minute intervals for the first 15 minutes and in 15-minute intervals thereafter during overall four-hour test:

1. Kilowatts.

2. Amperes.

3. Voltage.

4. Coolant temperature.

5. Room temperature.

6. Frequency.

7. Oil pressure.

D. Test alarm and shutdown circuits by simulating conditions.

3.03 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under provisions of Section 01 40 00.

3.04 ADJUSTING

A. Adjust work under provisions of Section 01 70 00.

B. Adjust generator output voltage and engine speed.

3.05 CLEANING

A. Clean work under provisions of 01 70 00.

B. Clean engine and generator surfaces. Replace oil and fuel filters.

3.06 DEMONSTRATION

A. Provide systems demonstration under provisions of Section 01 70 00.

B. Describe loads connected to emergency system and restrictions for future load additions.

C. Simulate power outage by interrupting normal source, and demonstrate that system operates to provide emergency power.

END OF SECTION

SECTION 31 63 29

DRILLED CONCRETE PIERS AND SHAFTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Dry-installed drilled piers.
2. Slurry displacement-installed drilled piers.
3. Dry-installed or slurry displacement-installed drilled piers at Contractor's choice.

B. Related Sections:

1. Division 01 Section "Temporary Facilities and Controls."
2. Division 31 Section "Site Clearing" for preparation of subgrade for drilled-pier operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface.

1.03 UNIT PRICES

A. Unit prices are included in Division 01 Section 01 20 00 "Unit Prices."

B. Drilled Piers: Actual net volume of drilled piers in place and approved. Actual length, shaft diameter, and bell diameter if applicable, may vary, to coincide with elevations where satisfactory bearing strata are encountered. These dimensions may also vary with actual bearing value of bearing strata determined by an independent testing and inspecting agency. Adjustments will be made on net variation of total quantities, based on design dimensions for shafts and bells.

1. Base bids on indicated number of straight shaft drilled piers and, for each pier, the design length from top elevation to bottom of shaft, include steel casing as part of base bid. Provide deduct unit cost if casing is not required.
2. Alternate bids on indicated number of belled drilled piers and, for each pier, the design length from top elevation to bottom of shaft, extended through the bell, and the diameter of shaft and bell, include steel casing as part of alternate bid. Provide deduct unit cost if casing is not required.
3. Unit prices include labor, materials, tools, equipment, and incidentals required for excavation, trimming, shoring, casings, dewatering, reinforcement, concrete fill, testing and inspecting, and other items for complete drilled-pier installation.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1. Indicate amounts of mixing water to be withheld for later addition at Project site.

C. Shop Drawings: For concrete reinforcement detailing fabricating, bending, supporting, and placing.

D. Qualification Data: For qualified Installer and land surveyor.

E. Welding certificates.

F. Material Certificates: For the following, from manufacturer:

1. Cementitious materials.
2. Admixtures.
3. Steel reinforcement and accessories.

G. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:

1. Aggregates

H. Field quality-control reports.

I. Other Informational Submittals:

1. Record drawings.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in drilled-pier work.

B. Testing Agency Qualifications: Qualified according to ASTM C 1077, ASTM D 3740, and ASTM E 329 for testing indicated.

C. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.4, "Structural Welding Code - Reinforcing Steel."

D. Drilled-Pier Standard: Comply with ACI 336.1 unless modified in this Section.

E. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to drilled piers including, but not limited to, the following:

a. Review geotechnical report.

b. Discuss existing utilities and subsurface conditions.
c. Review coordination with temporary controls and protections.

1.06 PROJECT CONDITIONS

A. Existing Utilities: Locate existing underground utilities before excavating drilled piers. If utilities are to remain in place, provide protection from damage during drilled-pier operations.

1. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, adapt drilling procedure if necessary to prevent damage to utilities. Cooperate with Owner and utility companies in keeping services and facilities in operation without interruption. Repair damaged utilities to satisfaction of utility owner.

B. Interruption of Existing Utilities: Do not interrupt any utility to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:

1. Notify Architect, Construction Manager and Owner no fewer than two days in advance of proposed interruption of utility.
2. Do not proceed with interruption of utility without Construction Manager's and Owner's written permission.

C. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for drilled piers.
2. The geotechnical report is included elsewhere in the Project Manual.

D. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for drilled piers. Before excavating, lay out each drilled pier to lines and levels required. Record actual measurements of each drilled pier's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.

1. Record and maintain information pertinent to each drilled pier and cooperate with Owner's testing and inspecting agency to provide data for required reports.

PART 2 - PRODUCTS

2.01 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

B. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 , plain. Cut bars true to length with ends square and free of burrs.

2.02 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source, throughout Project:

1. Portland Cement: ASTM C 150, Type I

a. Fly Ash: ASTM C 618, Class F
b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregate: ASTM C 33, graded, 1-inch- nominal maximum coarse-aggregate size. Provide aggregate from a single source[with documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials].

1. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: ASTM C 94/C 94M[and potable].

D. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
3. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
4. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

E. Sand-Cement Grout: Portland cement, ASTM C 150, Type II; clean natural sand, ASTM C 404; and water to result in grout with a minimum 28-day compressive strength of 1000 psi (6.9 MPa), of consistency required for application.

2.03 STEEL CASINGS

A. Steel Pipe Casings: ASTM A 283/A 283M, Grade C, or ASTM A 36/A 36M, carbon-steel plate, with joints full-penetration welded according to AWS D1.1/D1.1M.

B. Corrugated-Steel Pipe Casings: ASTM A 929/A 929M, steel sheet, zinc coated.

2.04 CONCRETE MIXTURES

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 limits as if concrete were exposed to deicing chemicals.

C. Proportion normal-weight concrete mixture as follows:

1. Compressive Strength (28 Days): 3000 psi .
2. Maximum Water-Cementitious Materials Ratio: 0.50

3. Minimum Slump: Capable of maintaining the following slump until completion of placement:
   a. 7 inches for slurry displacement method.

4. Air Content: Do not air entrain concrete.

2.05 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.06 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.

1. When air temperature is between 85 and 90 deg F , reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F , reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.01 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by drilled-pier operations.

3.02 EXCAVATION

A. Unclassified Excavation: Excavate to bearing elevations regardless of character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.

1. Obstructions: Unclassified excavation may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. No changes in the Contract Sum or the Contract Time will be authorized for removal of obstructions.
2. Obstructions: Unclassified excavated materials may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. Payment for removing obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work will be according to Contract provisions for changes in the Work.

B. Classified Excavation: Excavation is classified as standard excavation, special excavation, and obstruction removal and includes excavation to bearing elevations as follows:

1. Standard excavation includes excavation accomplished with conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work.
2. Special excavation includes excavation that requires special equipment or procedures above or below indicated depth of drilled piers where drilled-pier excavation equipment

used in standard excavation, operating at maximum power, torque, and downthrust, cannot advance the shaft.

a. Special excavation requires use of special rock augers, core barrels, air tools, blasting, or other methods of hand excavation.
b. Earth seams, rock fragments, and voids included in rock excavation area will be considered rock for full volume of shaft from initial contact with rock.

3. Obstructions: Payment for removing unanticipated boulders, concrete, masonry, or other subsurface obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work will be according to Contract provisions for changes in the Work.

C. Prevent surface water from entering excavated shafts. Conduct water to site drainage facilities.

D. Excavate shafts for drilled piers to indicated elevations. Remove loose material from bottom of excavation.

1. Excavate bottom of drilled piers to level plane within 1:12 tolerance.
2. Remove water from excavated shafts before concreting.

E. Notify and allow testing and inspecting agency to test and inspect bottom of excavation. If unsuitable bearing stratum is encountered, make adjustments to drilled piers as determined by Architect.

1. Do not excavate shafts deeper than elevations indicated unless approved by Architect.
2. Payment for additional authorized excavation will be according to Contract provisions for changes in the Work.

F. Excavate shafts for closely spaced drilled piers and for drilled piers occurring in fragile or sand strata only after adjacent drilled piers are filled with concrete and allowed to set.

G. Slurry Displacement Method: Stabilize excavation with slurry maintained a minimum of 60 inches above ground-water level and above unstable soil strata to prevent caving or sloughing of shaft. Maintain slurry properties before concreting.

1. Excavate and complete concreting of drilled pier on same day if possible, or redrill, clean, and test slurry in excavation before concreting.
2. Clean bottom of each shaft before concreting.

H. Temporary Casings: Install watertight steel casings of sufficient length and thickness to prevent water seepage into shaft; to withstand compressive, displacement, and withdrawal stresses; and to maintain stability of shaft walls.

1. Remove temporary casings, maintained in plumb position, during concrete placement and before initial set of concrete[, or leave temporary casings in place].

I. Bells: Excavate bells for drilled piers to shape, base thickness, and slope angle indicated. Excavate bottom of bells to level plane and remove loose material before placing concrete.

1. Shore bells in unstable soil conditions to prevent cave-in during excavation, inspection, and concreting.

J. Tolerances: Construct drilled piers to remain within ACI 336.1 tolerances.

1. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit design and construction proposals to Architect for review before proceeding.

3.03 STEEL REINFORCEMENT

A. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.

C. Fabricate and install reinforcing cages symmetrically about axis of shafts in a single unit.

D. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover over reinforcement.

E. Use templates to set anchor bolts, leveling plates, and other accessories furnished in work of other Sections. Provide blocking and holding devices to maintain required position during final concrete placement.

F. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.

3.04 CONCRETE PLACEMENT

A. Place concrete in continuous operation and without segregation immediately after inspection and approval of shaft by Owner's independent testing and inspecting agency.

1. Construct a construction joint if concrete placement is delayed more than one hour. Level top surface of concrete[and insert joint dowel bars]. Before placing remainder of concrete, clean surface laitance, roughen, and slush concrete with commercial bonding agent or with sand-cement grout mixed at ratio of 1:1.

B. Dry Method: Place concrete to fall vertically down the center of drilled pier without striking sides of shaft or steel reinforcement.

1. Where concrete cannot be directed down shaft without striking reinforcement, place concrete with chutes, tremies, or pumps.
2. Vibrate top 60 inches of concrete.

C. Slurry Displacement Method: Place concrete in slurry-filled shafts by tremie methods or pumping. Control placement operations to ensure that tremie or pump pipe is embedded no fewer than 60 inches into concrete and that flow of concrete is continuous from bottom to top of drilled pier.

D. Coordinate withdrawal of temporary casings with concrete placement to maintain at least a 60-inch head of concrete above bottom of casing.

1. Vibrate top 60 inches of concrete after withdrawal of temporary casing.

E. Screed concrete at cutoff elevation level and apply scoured, rough finish. Where cutoff elevation is above the ground elevation, form top section above grade and extend shaft to required elevation.

F. Protect concrete work, according to ACI 301, from frost, freezing, or low temperatures that could cause physical damage or reduced strength.

1. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
2. Do not use calcium chloride, salt, or other mineral-containing antifreeze agents or chemical accelerators.

G. If hot-weather conditions exist that would seriously impair quality and strength of concrete, place concrete according to ACI 301 to maintain delivered temperature of concrete at no more than 90 deg F .

1. Place concrete immediately on delivery. Keep exposed concrete surfaces and formed shaft extensions moist by fog sprays, wet burlap, or other effective means for a minimum of seven days.

3.05 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:

1. Drilled piers.
2. Excavation.
3. Concrete.

B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

C. Concrete Tests and Inspections: ASTM C 172 except modified for slump to comply with ASTM C 94/C 94M.

1. Slump: ASTM C 143/C 143M; one test at point of placement for each compressive-strength test but no fewer than one test for each concrete load.
2. Concrete Temperature: ASTM C 1064/C 1064M; 1 test hourly when air temperature is 40 deg F and below and 80 deg F and above, and 1 test for each set of compressive-strength specimens.
3. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.
4. Compressive-Strength Tests: ASTM C 39; one set for each drilled pier but not more than one set for each truck load. One specimen will be tested at 7 days, 2 specimens will be tested at 28 days, and 1 specimen will be retained in reserve for later testing if required.
5. If frequency of testing will provide fewer than five strength tests for a given class of concrete, testing will be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
6. If strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
7. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi .
8. Report test results in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. List Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in

Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests in reports of compressive-strength tests.

9. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
10. Additional Tests: Testing and inspecting agency will make additional tests of concrete if test results indicate that slump, compressive strengths, or other requirements have not been met, as directed by Architect.

    a. Continuous coring of drilled piers may be required, at Contractor's expense, if temporary casings have not been withdrawn within specified time limits or if observations of placement operations indicate deficient concrete quality, presence of voids, segregation, or other possible defects.

11. Perform additional testing and inspecting, at Contractor's expense, to determine compliance of replaced or additional work with specified requirements.
12. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

D. An excavation, concrete, or a drilled pier will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports for each drilled pier as follows:

1. Actual top and bottom elevations.
2. Actual drilled-pier diameter at top, bottom, and bell.
3. Description of soil materials.
4. Description, location, and dimensions of obstructions.
5. Final top centerline location and deviations from requirements.
6. Variation of shaft from plumb.
7. Shaft excavating method.
8. Levelness of bottom and adequacy of cleanout.
9. Properties of slurry and slurry test results at time of slurry placement and at time of concrete placement.
10. Ground-water conditions and water-infiltration rate, depth, and pumping.
11. Description, purpose, length, wall thickness, diameter, tip, and top and bottom elevations of temporary or permanent casings. Include anchorage and sealing methods used and condition and weather tightness of splices if any.
12. Description of soil or water movement, sidewall stability, loss of ground, and means of control.
13. Bell dimensions and variations from original design.
14. Date and time of starting and completing excavation.
15. Inspection report.
16. Condition of reinforcing steel and splices.
17. Position of reinforcing steel.
18. Concrete placing method, including elevation of consolidation and delays.
19. Elevation of concrete during removal of casings.
20. Locations of construction joints.
21. Concrete volume.
22. Concrete testing results.
23. Remarks, unusual conditions encountered, and deviations from requirements.

3.06 DISPOSAL OF SURPLUS AND WASTE MATERIALS

F. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION