

PART 1 GENERAL**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General Conditions and Division 1 Specification Sections, apply to this Section.
- B. Geotechnical reference documents
 - * 1. "Transbay Tower Geotechnical Data Report," dated June 17, 2013.
 - 2. "Transbay Tower – Lateral Earth Pressures for Shoring Design" prepared by Arup dated March 8, 2013

1.2 SUMMARY

- A. Section includes specifications for designing, furnishing, installing, maintaining, and removing excavation support systems as indicated and required to protect existing structures, personnel, general public, utilities, streets, sidewalks and adjacent earth against cave-ins, excessive settlement, or other hazards to persons or property.
- B. Contractor shall select the type and method of excavation support system appropriate for the project and meeting the design and performance criteria described herein.
- C. Contractor shall provide all ancillary work necessary to complete the excavation support system including, but not limited to, obtaining permits, pre-trenching for removal of drilling obstructions, and construction of equipment pads and platforms.
- D. Related Sections:
 - 1. Section 31 00 00 "Earthwork" for excavating and backfilling and for controlling surface-water runoff and ponding.
 - 2. Section 31 23 19 "Dewatering" for dewatering excavations.
- E. Exclusions
 - 1. Excavation support associated with utility trenches

1.3 QUALITY ASSURANCE

- A. Shoring design shall be performed by an engineering firm or individual (also referred to as the Engineer of Record) employed by the Contractor with experience in designing shoring systems. The firm or individual designer shall have not less than ten years experience in providing this type of engineering. The engineer responsible for the design of the shoring system shall provide references for a minimum of 3 shoring design projects of similar depth or scope in dense urban settings within the past 10 years.
- B. Regulatory Requirements:
 - 1. California Building Code, 2010 Edition (CBC) with San Francisco Amendments
 - 2. California Code of Regulations, Title 8, Chapter 4, Subchapter 4 – Construction Safety Orders, and Subchapter 19 – Trench Construction Safety Orders
 - 3. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 33 and Appendix Chapter 33, and Structural Chapters 18 and 18A
 - a. Excavations, regardless of depth, shall comply fully with the requirements of Sections 3301.2, 3301.2a and 3301.3 of California Building Code

1.4 DEFINITIONS

- A. Dewatering: Outside the construction site: A process used to remove ground water from a site prior to its entry into the excavation. Inside the construction site: A process used to remove the ground water only from within the boundaries of the construction site after the installation of a barrier wall. Barrier walls may consist of slurry walls, secant pile walls or sheet pilings.
- B. Engineer of Record (EOR): The term Engineer of Record for the excavation support system, or, the EOR for the excavation support system, as used in this specification section is defined as a professional Civil or Structural Engineer currently registered in the State of California with the specified qualifications and experience, retained by the excavation support system trade contractor to provide engineering design and structural observations for the excavation support system.

- C. Internal Bracing: A system of supports consisting of walers, bracing elements functioning as compression members providing reaction points to the perimeter walls which may occur as cross lot elements, corner elements, and or other geometry as designed. The internal bracing system includes all connections and miscellaneous metal components to provide a complete and functioning system providing support to the exterior shoring wall or to the perimeter concrete basement wall.
- D. Lagging: Temporary excavation support structure consisting of heavy timber boards, planking, sheathing, or reinforced precast concrete planks secured in place by steel H-piles
- E. Proof load: An applied load greater than the design load, imposed by load test.
- F. Secant Wall: An excavation support system consisting of a series of drilled, spaced soldier piles and intersecting, unreinforced concrete drilled piers or drilled shafts arranged in an arched configuration, filled with a lean concrete-mix cement and sand grout.
- G. Sheet Piling: Interlocking steel sheet piling installed vertically to hold back earth or retain soil. May be a temporary or permanent structure.
- H. Slurry Wall: A reinforced concrete wall constructed by filling a trench with tremie concrete. Tremie concrete displaces the bentonite slurry already in the trench, forming a concrete barrier, when set, which retains the earth or soil on the exterior side of the slurry wall, and permits excavation and removal of the soil on the interior side of the wall
- I. Soil Anchor: A pre-stressed frictional anchorage device, consisting of a high-strength steel tendon, fitted with a stressing anchor at one end and an anchor device, permitting force transfer to the soil, at the other end, installed in a prepared hole that is drilled or driven into the ground
- J. Soil Mix Wall: A multiple-augered, cement-grout reinforced earth technique, incorporating steel H-beam reinforcement, whereby existing soils are mixed in place with cement grout, forming a row of overlapped soil cement columns, creating a reinforced earth wall excavation support system
- K. Soldier Piles: Vertical steel H-piles installed to take the side thrust of horizontal lagging. Also called soldier beams
- L. Strut: A brace or supporting member which resists thrusts in the direction of its own length; may be vertical, diagonal, or horizontal
- M. Tie-Backs: An excavation-face support obtained by grouted steel bars, wire strands, or tendons, with or without a dead-man, in combination with face-retaining or bearing steel plates, board timbers, or shotcrete reinforcement
- N. Tremie Concrete: Concrete placed by means of tremie equipment, for depositing concrete under water and thereby displacing bentonite slurry in a slurry-wall trench or excavation
- O. Waler: A horizontal beam used to brace or support vertical sheeting or sheet piling
- P. Watertight: No continuous running or seeping water from the shoring wall. Stationary droplets are acceptable; flowing, dripping or streaming water is not.

1.5 DESIGN

- A. Basic unit stresses for design shall be taken from the following references. All design shall comply with loadings and allowable stresses and or ultimate stresses as compliant with requirements for permanent facilities. Use of larger basic unit stresses due to a limited duration of service life is not acceptable. Use of reduced loading due to a limited duration of service life is not acceptable.
 - 1. Structural Steel: Manual of Steel Construction, American Institute of Steel Construction (AISC), 13th edition
 - 2. Reinforced Concrete: Building Code Requirements for Structural Concrete, American Concrete Institute, (ACI 318).
 - 3. Timber: California Building Code
 - 4. Welding: American Welding Society, AWS D1.1-06 "Structural Welding Code".
- B. Design excavation support systems to support earth pressures, utility loads, equipment, applicable traffic and construction loads, and other surcharge loads in a manner which will allow the safe and expeditious construction of permanent structures without movement or settlement of the ground and in a manner which will prevent settlement of and damage to, or movement of, adjacent buildings, streets and sidewalks, structures, utilities, or other facilities during the various stages of construction. Include evaluation of the effects of dewatering and flooding of excavation.

- C. Design each component to support the maximum loads which may occur during various stages of construction.
- D. Support of excavation structures shall be analyzed for all conditions which may occur during the various stages of construction. Among others, these conditions include: installation, relocation and removal of struts; flooding and dewatering of excavations; and concreting of excavation bottom. The loading conditions on opposite sides of a cut may not be equal. In this case, both sides shall be designed for and be compatible with the larger loading. The conditions to which the design applies shall be indicated on the shop drawings.
- E. The shoring wall shall be watertight.
1. Soil mix walls shall achieve a maximum permeability of 3×10^{-6} cm per second at 28 days and 1×10^{-6} cm per second, or less at 90 days. Permeability tests shall be performed by the Contractor on selected core samples in accordance with ASTM D5084-90 method.
- F. Excavation support system shall be designed for loads in accordance with the following. Where contradictory requirements occur, the more conservative or more restrictive provision shall govern:
1. Contract documents including geotechnical reference documents and this specification
 2. American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures (ASCE Standard 7-05) for Non-Building Structures
 3. Include incidental loads for stair towers, temporary generators, man-lifts, dewatering systems, etc., as defined by the Contractor
 4. As would be prudent and ordinarily as considered to be recommended practice for an excavation support system of this size and extent in the San Francisco Bay Area
- G. Interface with Transbay Transit Center (TTC) excavation support system:
1. Movement of the existing TTC shoring wall shall be limited to a magnitude of 1.0 inches horizontally in any direction at the top of the soldier piles and at the top bracing level. Movement of the existing TTC shoring wall shall be limited to a magnitude of 1.5 inches horizontally in any direction at depths below the top bracing level.
 2. The Contractor shall instrument the following strut numbers on all four bracing levels of the TTC internal bracing system: 37, 38, 42, 44, 46, 48, 52, and 53. It should be noted that struts 40, 45, and 50 are currently monitored by the TTC contractor and this information will be made available to the Transbay Tower contractor.
 3. The Contractor shall monitor the reduction of stress in the struts for the TTC excavation. If the TTC strut forces decrease, the Contractor shall preload struts or have other means to restore the forces in the TTC struts to a minimum of 90% of the original load in the struts. The force in the struts will be the average of the strut forces over a 48 hour period of typical weather. Non-typical weather would be considered daytime high temperature of less than 50 or higher than 80 degrees F.
 4. The Contractor shall not increase the forces in the TTC struts by more than 10% of the current strut loads. If diagonal internal bracing is used for the excavation support system, loads parallel to the shoring wall along the First Street shoring wall and the intermediate shoring wall shall not impose any additional forces into the TTC shoring system. The strut loads will be evaluated based on the criteria described in article 1.5 H 3.
 5. The TTC shoring wall that separates the two sites shall not receive any in-plane loads from the Transbay Tower excavation shoring system.
 6. Heave of the TTC shoring wall is anticipated as the Tower excavation proceeds. The internal bracing system shall be designed to withstand a vertical displacement of 3" or shall incorporate details to accommodate it
 7. The internal bracing elements of the TTC excavation support system have been designed to withstand seismic loading corresponding to a probabilistic ground motion with a 10% probability of exceedence in 50 years (475-year earthquake). Seismic load reactions acting on the shoring wall that separates the two sites shall be transferred to the surrounding soil.
- H. Seismic Design for Connections, Primary Bracing, and Secondary Bracing shall include seismic loads based on the following:
1. Seismic loading due to soil applied to the excavation support system and to the concrete basement walls is included within the loading provided in the geotechnical reference documents.
 2. Seismic loading applied to elements of the bracing system components shall be included in the design of internal bracing components

3. A probabilistic ground motion with a 10% probability of exceedence in 50 years (475-year earthquake) times a factor equal to 0.2 shall be used as the design earthquake for determination of seismic loading due to earthquake ground motion acting upon the self-weight of internal bracing system components
 4. Seismic Parameters SD1 and SDS shall be determined by use of the United States Geologic Survey National Seismic Hazard Mapping Project Seismic Hazard Curves (Java Applet available at USGS Web website <http://earthquake.usgs.gov/hazards/designmaps/index.php>)
- I. Where additional excavation is carried below the main excavation, provide means to prevent movement of the main excavation supports.
 - J. Design the excavation support system to allow the required free excavated space for workers, dewatering system, concrete work, wall waterproofing, and drainage systems.
 - K. Design excavation support systems for staged installation and removal to conform to construction and backfill sequences and logistics.
 - L. Employ walers, struts, and tieback anchors for horizontal support as required for excavation faces to be retained by soldier piles and lagging, sheet piles, concrete slurry walls or by soil mix walls. Provide struts with intermediate vertical and horizontal supports as required to prevent buckling. Struts shall be preloaded by wedging or jacking.
 - M. Internal bracing design shall include excavation sequence drawings indicating sequence of excavation lifts over a spatial area and corresponding installation of bracing prior to additional excavation.
 - N. Internal bracing design shall include P Delta effects, including effects from strut dead loads, bowing, or curvature of struts, eccentric loading and vertical displacement of the supporting piles caused by heave.
 - O. Provide diagonal bracing where needed for stability of the system.
 - P. Design piles or other vertical support members to be incorporated in a system employing tiebacks or soil anchors to have the capability of resisting vertical components of tieback loads without significant settlement during any stage of excavation and construction.
 - Q. Timber support systems, including lagging, shall be employed only for utilities and minor structures. Timber supporting members and lagging to be left in place shall be pressure- treated with wood preservative.
 - R. Provide a 6" (nominal) diameter steel pipe for installation of inclinometers at eight soldier piles located intermittently around the excavation. Each pipe shall extend the full length of the soldier pile, spliced as necessary, and shall be welded to the soldier pile. Cap the ends with wood plugs. Exact locations of pipes will be provided by the Owner's Representative. The inclinometers will be installed by the Owner's Representative.
 - S. Provisions shall be made to protect struts from excessive deformations and stress variations induced by temperature fluctuations. Effects from temperature fluctuations shall be accounted for in the internal bracing design and these effects will not be grounds for variance from the performance criteria listed in this specification section.
 - T. For excavations with an internal bracing system, the contractor shall coordinate rebracing reactions with design loading and reinforcement provided for the permanent foundation wall to assure reactions applied to the permanent foundation wall are within the design limitations of the permanent foundation wall. The permanent basement walls are not designed to cantilever.
 - U. All reaction plates used for rebracing shall be placed on grout pads on the permanent foundation wall, with anchorage of the plate to the permanent foundation wall provided by bolts. Bolts, plates, and grout pads shall be detailed and installed to allow complete removal following removal of rebracing. Extension of any items for anchorage of rebracing connections shall not extend beyond 18" from the face of wall, and in no case shall penetrate the permanent foundation wall waterproof membrane. All metal items providing connection for rebracing shall be detailed to result in no metal products remaining within 2 inches of the finish concrete surface following removal. Following removal, all concrete surfaces impacted by rebracing operations shall be fully restored to match color, texture, finish, structural integrity, and other architectural requirements, including water tightness, of the adjacent permanent foundation wall.

1.6 SUBMITTALS

- A. Submit the following according to Conditions of the Construction Contract and Division 1 Specification Sections.
- B. Qualifications
 1. Name, qualifications, and experience of the person who will be the Engineer of Record (EOR) for the design of the excavation support system

2. Name, qualifications, and experience of the firm(s) that will perform the excavation support work, including names and qualifying experience of key personnel.
- C. Excavation Support System Program: Prepare and submit a written schedule and procedure, along with detailed drawings, of the proposed excavations and excavation support systems. Include the following:
1. Summary of the proposed excavation support systems describing the major elements employed to hold back earth and to keep water out of the excavation.
 2. Summary of sequencing and timing requirements for coordination of construction operations with installation of the bracing system
 3. Summary of how bracing locations have been coordinated with construction operations to allow installation of permanent structure
 4. Installation procedures including methods of material placement and field quality control procedures
 5. Excavation sequence
 6. Details of preloading including sequence, timing, schedule of preloading forces and inspections, and complete details of the method to be utilized for locking load in strut element following application of preload
 7. Protection measures for existing structures, facilities, streets and sidewalks
 8. Instrumentation and monitoring procedures to determine that the performance of the excavation support system is in compliance with the requirements
 - a. Monitoring procedures shall be established by the EOR.
 - b. Procedures shall establish monitoring locations at distances appropriate to allow measurements to verify performance of the excavation support system. The timing of measurements to provide monitoring shall be established to occur at intervals as appropriate to monitor performance of the excavation support system
 9. Removal sequencing and timing coordinated with permanent structure construction
 10. Contingency plans for excessive wall or foundation movements including procedures identifying specifics (chain of command/decisions/implementation of actions) of contingency plans for mitigation of excessive shoring wall or ground movements specified in the Contract Documents or if mitigation is directed by the Owner's Representatives during construction
 11. Special testing and inspection services to be performed
 12. The program shall take into account that excavations cannot extend beyond the project limits into adjacent properties above or below grade, unless otherwise indicated. Where tie-backs, soil anchors, soil nailing or similar support systems are required, the Contractor shall be solely responsible for securing permission from adjacent property owners to install such temporary and permanent systems. If the Contractor is unable to secure such permission, support systems shall be installed completely within the project limits.
 - a. Any such permission from adjacent property owners shall be in writing, and the owner's signature, granting such permission, shall be witnessed and properly notarized. Certified copies of all such permissions shall be submitted to the Owner's Representative for record purposes.
- D. Shop Drawings: Submit Shop Drawings and specifications for support systems, lagging, tie-back anchors, and internal bracing. Include the following:
1. Specific description of field quality control measures
 2. Details of interface with permanent structures
 3. Detailed description of tie-back soil anchors, soil nailing, and walers, if used, and the proposed installation procedure, including method of grouting anchors, grout type, and mix proportions.
 4. Details of bracing struts and walers, if used, and the proposed installation procedures, including method and sequence of preloading.
 5. Details of required preloading systems, pre-stressing systems, load measuring facilities, systematic schedule of preloading and pre-stressing operations, and sequence of construction
 6. Method and details for securing lagging in support system openings
 7. Proposed method of providing for utility penetrations

8. Assembly and erection details of members and connections for the system
- E. Basis of Design Summary Document: Prior to submitting calculations, submit Basis of Design Summary Document as a separate submission package. Include the following:
 1. The interpretation of design criteria extracted from Construction Documents and any other documents including loading, allowable displacements, and monitoring requirements.
 2. Identification of all loading to be applied to bracing elements
 3. Identification of locations where these loads are resisted by the bracing system
- F. Calculations: Submit appropriate design calculations to support Shop Drawings. Include theoretical deflections of supporting members. Include calculations indicating the expected magnitude of vertical and lateral movement
- G. Professional Engineer's Certification: The excavation support systems program, Shop Drawings, calculations, and test reports shall be prepared, sealed, and signed by a professional civil or structural engineer currently registered in the State of California.
- H. Calibration Charts: Submit certified calibration charts for each jack-gage unit used for preloading.
- I. Proof Loading Test Reports: Submit reports of performance tests and proof loading tests of soil anchors, certified by a professional civil or structural engineer currently registered in the State of California.
- J. Material test reports from tests arranged and paid for by the Contractor:
 1. Concrete:
 - a. Slump: slump test in accordance with ASTM C143/C143M
 - b. Strength: 28 day compressive strength tests of cored samples in accordance with ASTM D2166
 2. Soil-cement:
 - a. Permeability: 28 day tests of cored samples in accordance with ASTM D5084-90 method;
 - b. Strength: 28 day compressive strength tests in accordance with ASTM C39.
 3. Steel:
 - a. Mill certifications or coupon testing. Submit certifications or coupon testing for all structural steel w-flange, pipe and plate where the relied upon strength corresponds to a steel materials with a yield strength greater than 30,000 psi ($f_y > 30\text{ksi}$).
- K. AWS prequalified welding procedures, or documentation of qualification performed for project specific welding procedures in accordance with AWS D1.1 requirements.
- L. Current AWS welder certifications. It is acceptable to provide current AWS certifications to the welding special inspector in the field at first day for each welder. Copies of these certifications shall be provided to the Owner's Representative
- M. Submit a plan for repairing and making watertight leaks in the shoring wall due to cracks, joints, fractures, or other flaw or defect that allows water through the shoring wall during construction.
- N. Written response providing satisfactory explanation or revisions with regard to written comments stemming from review of the submittal, or inquires, from the owner, Owner's Representative(s), governmental agency, Architect, Structural Engineer, Geotechnical Engineer or other members of the design team.
- O. Quality Control and Construction Plan. This plan shall as a minimum include the following:
 1. Identification of intervals for performance of surveying to monitor position of the excavation support system. Coordinate monitoring of shoring system by Contractor and excavation support trade contractor with overall monitoring plan.
 2. Methods of survey and alignment control for placement of excavation support and verification of position and clearance of bracing elements from other planned construction elements or operations. Clearly identify coordination activities that have either occurred or are planned to occur and to establish the basis for positioning of excavation support system assemblies.
 3. Detailed inspection procedures and identification of responsible individuals to provide inspection services and other measures as may be required to ensure the excavation support system is performing in compliance with all project requirements. Special attention shall be addressed toward verification of all aspects of the work

to provide for control of displacements of the shoring wall and bracing system at all stages of construction. The plan shall include provision for installation of discontinuous (stepping) rows of walers and struts as necessary to coordinate with construction operations.

4. Coordination with construction operations during excavation including accommodations for types of excavation equipment. Coordination shall include locations of proposed temporary soil slopes, bench widths, and maximum duration of exposure of such items and their impacts on installation of excavation support components.
- P. In reviewing submittals, the Owner's Representative will use the criteria and loads for structures indicated on the Contract Drawings. The conditions to which the design applies shall be indicated on the Shop Drawings.
- 1.7 MEETINGS**
- A. Division 1 - Project Meetings: Meeting requirements.
 - B. Convene pre-installation meeting minimum two weeks prior to commencing work of this section.
- 1.8 PROJECT CONDITIONS**
- A. Contractor shall verify the location of existing structures, improvements and utilities.

PART 2 PRODUCTS

2.1 UNAUTHORIZED MATERIALS

- A. Materials and products required for work of this section shall not contain asbestos, polychlorinated biphenyls (PCB) or other hazardous materials identified by the Owner.

2.2 GENERAL

- A. Materials shall be free from strength-impairing defects and in accordance with Contract Documents and applicable specifications for individual components.

2.3 MATERIALS

- A. Steel, new material: Where new materials are to be used, submit manufacturer certifications of mechanical and chemical properties.
- B. Steel, salvage material: Salvage materials shall be free of defects. Note that defects include, but are not limited to, excessive rust, pitting, holes, uninspected or undocumented splices or welds, or other prior service or prior fabrication which has resulted in loss of strength or loss of reliability of structural properties. For steel materials which are recycled from prior projects (salvaged materials) and are to be incorporated into the work, testing to determine mechanical properties and chemical composition for determination of weldability shall be performed on a random sampling basis as follows:
 1. For soldier piles and primary strut members, 100% of elements to be utilized shall be tested. Where strut elements are fabricated by joining multiple elements, the 100% testing requirement applies to each component joined to result in the final member
 2. For other element types, testing frequency is as follows:
 - a. Where material properties relied upon for design corresponding to minimum yield strength $f_y=30,000$ psi, sampling shall be performed on 5% of each major series of structure element type
 - b. Where material properties corresponding to minimum yield strength $f_y=36,000$ psi, sampling shall be performed on 10% of each major series of structure element type.
 - c. Where material properties corresponding to minimum yield strength $f_y=42,000$ psi or 50,000 psi is used, sampling shall be performed on 20% of each major series of structure element type.
 - d. Testing performed per subparagraphs above at sampling rates of 5%, 10%, and 20% respectively shall be reported to the Owner's Representative in writing. Testing results must satisfy all samples meeting 100% of materials strength requirements for acceptance of salvage materials. If less than 100% of materials tested meet this requirement, then the sampling rate shall be increased. In this event, the sampling rate for retesting shall be subject to review and approval by the Owner's Representative.
- C. Steel, sheet piling: ASTM A328, continuous interlocking type, of sizes indicated on approved Shop Drawings, with suitable handling holes.

D. Concrete

1. Submit mix design prepared by a Professional Engineer registered in the State of California regularly engaged in providing concrete mix design services. Concrete for any use shall be proportioned with a minimum 28 day compressive strength equal to 3,000 psi ($f'_c=3,000$ psi), and shall be proportioned with a maximum water cement ratio, $W/C=0.50$. All concrete shall be batched, delivered, and placed in accordance with ACI 301 and ASTM C94.
2. Submit certificates for cement, all admixtures, and gradations of all aggregates indicated as components of the concrete mix design.

E. Controlled Low Strength Material (CLSM)

1. Submit mix design prepared by a Professional Engineer registered in the State of California regularly engaged in providing concrete mix design services. CLSM shall be proportioned with a minimum 28 day compressive strength equal to 300 psi ($f'_c=300$ psi). All concrete shall be batched, delivered, and placed in accordance with ACI 301 and ASTM C94.
2. Submit certificates for cement, all admixtures, and gradations of all aggregates indicated as components of the CLSM mix design.

F. Reinforcing steel for use with concrete

1. All reinforcement shall be new steel and shall comply with ASTM A615 or ASTM A706 corresponding to the grade and type relied upon in design calculations.
2. Submit manufacturer certificates for reinforcement.

G. Bentonite Slurry: Natural Wyoming type granular bentonite, graded so that 90 percent will pass a 20 mesh sieve and less than 10 percent will pass a 200 mesh sieve, mixed with water. Bentonite slurry shall be a stable suspension of powdered bentonite with a minimum density of 65 pcf and a maximum density of 85 pcf.

H. Grout for soil mix walls: The material added to the blended in situ soils shall be a water-based Portland cement grout. The purposes of the grout are to assist in loosening the soils for penetration and optimum mixing, and upon setting, to strengthen the in situ soils. The grout shall be premixed in a mixing plant, which combines dry materials and water in predetermined proportions.

I. Tiebacks

1. Steel Bars or Rods: ASTM A615, Grade 60, threaded steel bars or bars conforming to requirements of ASTM A722 or ASTM F432, as applicable of sizes indicated on approved Shop Drawings. Provide complete with header or face plates conforming to ASTM A36 where required, nuts conforming to ASTM A563, and washers conforming to ASTM F436, as indicated or required
2. Wire Strands: Single-strand or multiple-strand galvanized steel wire conforming to ASTM A416 or ASTM A586, as appropriate
3. Grout: Pumpable concrete, with minimum compressive strength at 28 days of 4,000 psi. Concrete mix shall contain 6.5, 94-pound sacks of cement per cubic yard minimum. Aggregate size shall be commensurate with the space being filled.

J. Timber: Structural grade lumber with a minimum fiber stress in bending of 1100 psi

1. Lagging: Heavy timber boards or planking of sizes indicated on approved Shop Drawings.
2. Posts, Struts, and Walers: Heavy timber posts, beams, stringers, and planking, as required, of sizes indicated on Shop Drawings.
3. Preservative Treatment: Wood members required to be left permanently in place shall be pressure-treated with preservative material in accordance with AWPA C3.

2.4 EQUIPMENT AND FACILITIES

- A. Contractor shall furnish all tools, equipment, devices, appurtenances, facilities, and services for the construction and removal of excavation support systems as indicated or required.

PART 3 EXECUTION**3.1 GENERAL**

- A. Install excavation support systems for safety and preservation of existing improvements. Excavation support systems shall consist of structures designed by the Contractor to support the various excavations.
- B. Construct support systems in accordance with approved Shop Drawings and in a manner that will ensure that supported faces will be stabilized. Provide for additional soil pressure caused by adjacent surcharge loads.
- C. Install lagging members as indicated and in a manner which will prevent loss of soil. Wedge lagging members against undisturbed earth or place compacted fill or slurry fill into voids behind lagging.
- D. The contractor, free of cost to the Owner, shall remove or apply additional concrete, shotcrete or other approved material to the excavated face of the shoring to make the excavated face smooth, straight, vertical and ready to accept waterproofing. The waterproofing substrate shall be regular and smooth with no gaps or voids greater than 0.5 in.

3.2 DETECTION OF MOVEMENT

- A. Establish horizontal and vertical optical survey monitoring points on the excavation support system including, but not limited to, vertical members against the excavated face and vertical and horizontal members of the internal bracing system, and take and record readings of all monitoring points as required by the EOR's Shop Drawings and Specifications.
- B. Provide strut-monitoring devices, installed in accordance with the manufacturer's instructions, at locations indicated or required by the EOR's Shop Drawings and specifications.
- C. During shoring and new construction the Contractor shall visually observe the shoring system and nearby exterior improvements on a frequent basis for indications of movement. Such observations shall occur daily during performance of excavation and installation of bracing systems. The Contractor shall stop excavation operations if deflection or distress at or above the action trigger level is observed and shall immediately notify the Owner's Representative, the EOR.
- D. Have materials and equipment available to implement the Contractor's contingency plan

3.3 TOLERANCES

- A. No part of the excavation support systems that will remain permanently in place shall be placed or allowed to deflect within the limits of permanent structures.
- B. Shores, shoring, secant pile walls, slurry walls and sheet piles shall be installed straight, true and vertical with an allowable tolerance into the excavation of zero (0) inches and an allowable tolerance out of the excavation of two (2) inches.

3.4 EXCAVATION SUPPORT SYSTEM CONSTRUCTION

- A. Excavation support system construction shall be in accordance with the requirements of the Contract Documents; the approved Shop Drawings, Notes, procedures and specifications prepared by the EOR and the Contractor's Quality Control and Construction Plan.

3.5 FIELD QUALITY CONTROL

- A. Refer to Division 1 - Quality Control, for general requirements
- B. Unless otherwise noted, field inspection and testing shall be performed by the Contractor.

3.6 PERFORMANCE REQUIREMENTS

- A. The Contractor shall design and construct the shoring wall and the internal bracing system to meet the following maximum allowable movement performance criteria as stated below.
- B. Maximum allowable movements and corrective action trigger levels are specified in the table below.

Type of Instrumentation	Action Trigger Level	Maximum Allowable Movement
Monitoring Point on Adjacent Building	3/4 inch	1.0 inch
Survey Target at Top of Shoring Wall and at Top Level of Bracing (Horizontal – Perpendicular to the Shoring Wall)	3/4 inch	1.0 inch
Inclinometer, Below Top Level of Bracing (Horizontal – Perpendicular to the Shoring Wall)	1.0 inch	1.5 inch
Survey Target on at Top of TTC Shoring Wall and at Top Level of Bracing (Horizontal – All Directions)	3/4 inch	1.0 inch
Survey Target on TTC Shoring Wall Below Top Level of Bracing (Horizontal – All Directions)	1.0 inch	1.5 inch

- C. The Contractor shall submit proposed mitigation methods during the design phase. The Contractor shall implement the proposed mitigation methods when the Action Trigger Levels are reached.
- D. If movement is detected which does not meet the maximum allowable movement the following is required:
 - (1) All work shall be immediately stopped.
 - (2) A soil berm shall be placed against all portions of the exposed shoring unsupported by internal bracing. The berm shall be placed 25 feet wide to a height of the next highest bracing element. The berm shall slope down at a 3:1 slope.
 - (3) The Contractor shall submit additional mitigation methods.
 - (4) Approved mitigation methods shall be implemented immediately.

3.7 UNACCEPTABLE WORK

- A. Excavation support system elements that fail, are placed out of position, exceed allowable tolerances, exceed allowable design stresses, have defect inclusions, or are damaged.
- B. Shoring wall which is not watertight.
 - 1. Repair leaks in the shoring wall due to cracks, joints, fractures, or other flaw or defect that allows water through the shoring wall during construction

3.8 REMOVAL OF EXCAVATION SUPPORT SYSTEM

- A. If removal is required wholly or in part, perform such removal in a manner that will not disturb or damage adjacent buildings, structures, streets, sidewalks, construction, utilities or elements of the excavation support system which are to remain. Fill voids immediately with lean concrete or with approved backfill compacted to the relative compaction for the location as specified in Section 31 00 00 - Earthwork
- B. Excavation support systems shall be left in place until the concrete walls and structures to receive the transferred loading from the removed support system have reached 100 percent of the specified compressive strength at 28 days. Demonstrate with strength test results that the concrete has reached the specified strength before load transfer from the support system to the concrete structure may be performed.
- C. Secant walls and soil-mix walls shall be left in place except as noted herein.
- D. Remove from the site all elements of excavation support systems to an elevation below the finished level of streets and sidewalks in accordance with the requirements of the City and County of San Francisco.
- E. All excavation support system materials remain property of the Bracing System trade contractor and shall be fully removed from the site following completion of work. All handling and disposition of materials shall be performed in accordance with all State and Federal laws and regulations.
- F. All materials resulting from performance of this work for disposal are property of the Bracing System trade contractor and shall be removed from the project site. All handling and disposal shall be performed in accordance with all State and Federal laws and regulations.
- G. Repair damage to properties resulting from removal work.

END OF SECTION