

31 71 00 TUNNEL CONSTRUCTION

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31 71 00 TUNNEL CONSTRUCTION

REVISION INDEX

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31 71 00 TUNNEL CONSTRUCTION

TABLE OF CONTENTS

	PAGES
REVISION INDEX	2
TABLE OF CONTENTS	3
PART 1 - GENERAL	4
1.1 SUMMARY	4
1.2 DEFINITIONS	4
1.3 RELATED SECTIONS	4
1.4 REFERENCES STANDARDS	5
1.5 SUBMITTALS	5
1.6 QUALITY	7
1.7 SITE CONDITIONS	7
PART 2 - PRODUCTS	7
2.1 Grout Materials	7
2.2 PERFORMANCE AND DESIGN CRITERIA	7
2.3 EQUIPMENT	8
PART 3 - EXECUTION	8
3.1 GENERAL	8
3.2 EXCAVATION METHODS	8
3.3 DRILLING AND BLASTING	9
3.4 MECHANICAL EXCAVATION	9
3.5 ROCK SUPPORT	10
3.6 TUNNEL LINING	10
3.7 GROUTING	10
3.8 DISPOSAL OF EXCAVATION MATERIAL	10
3.9 FIELD QUALITY CONTROL	11
3.10 TOLERANCES	11
3.11 PROTECTION AND CLEANUP	11

31 71 00 TUNNEL CONSTRUCTION

SECTION 31 71 00 – TUNNEL CONSTRUCTION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Work specified in this Section describes underground tunnel construction and improvements as indicated on the Drawings.
- B. The work includes:
 - 1. The excavation required to advance and modify tunnels and adits.
 - 2. Contractor designed and construction of support systems.
 - 3. Construction of tunnel linings.

1.2 DEFINITIONS

- A. **Blasting Specialist** – Approved blasting designer with experience in the design and/or construction of underground excavations as required for the Work.

1.3 RELATED SECTIONS

- A. 02 41 00 – Demolition and Facility Removal.
- B. 03 10 00 – Concrete Forms and Accessories.
- C. 03 20 00 – Concrete Reinforcing.
- D. 03 30 00 – Cast-In-Place Concrete.
- E. 03 60 00 – Grouting.
- F. 31 23 00 – Excavation and Fill Placement.
- G. 31 25 00 – Erosion and Sedimentation Controls.

31 71 00 TUNNEL CONSTRUCTION

1.4 REFERENCES STANDARDS

- A. California Code of Regulations, Title 8, Chapter 4, Division of Industrial Safety – Subchapter 20, Tunnel Safety Orders.
- B. California Department of Industrial Relations: Division of Occupational Safety and Health (DOSH) – Cal/OSHA:
 - 1. Title 8, Division 1. Department of Industrial Relations, Chapter 4. Division of Industrial Safety Subchapter 20. Tunnel Safety Orders.
- C. International Society of Explosives Engineer (ISEE):
 - 1. ISEE - Blaster's Handbook.
- D. National Fire Protection Association (NFPA):
 - 1. NFPA 495 - Explosive Materials Code.
- E. Occupational Safety and Health Standards for Construction Industry (OSHA) 29 Code of Federal Regulations (CFR) Part 1926 Subpart S – Underground Construction.
- F. Vibration Subcommittee of the International Society of Explosive Engineers (ISEE), blast monitoring equipment operation standards (1999).

1.5 SUBMITTALS

- A. Items listed in this section are to be submitted to the Engineer for information prior to the start of any Works.
- B. Work Plan: method statement, equipment, indicate proposed method including descriptions and sequence of construction in accordance with the California Code of Regulations Subchapter 20 and OSHA 29 CFR, tunnel surveying plan including method for alignment and grade control.
- C. Survey Report including Photos/Documentation on conditions of structures, buildings, equipment near locations of the Work.
- D. Probe Hole Survey: include procedures for alignment and grade control and frequency of verification.
- E. Daily logs and shift report of Work during tunnel construction.
- F. Blasting Specialist:

31 71 00 TUNNEL CONSTRUCTION

1. If using drilling and blasting methods, the Contractor shall retain a Professional Engineer who will be responsible for developing the complete designs, drawings, directing the Work, monitoring the performance of the Work, and making adjustments to the blast design as required during construction. Submit for review the name, qualifications, and reference of the Blasting Specialist.
 2. The Blasting Specialist shall be experience in the design of (if required):
 - a. Blasting services near operational water retaining structures including dams and hydrotechnical equipment.
 - b. "Lake Tap" blasting method.
- G. Drilling and Blasting, submit the following:
1. Blasting plans are to be submitted to DSOD for review and approval at least two weeks in advance of desired approval date.
 2. Blasting plans in accordance with the applicable federal, State, and local codes and regulations, indicating the following:
 - a. Name, qualification, and references of the proposed Blasting Specialist, blaster-in-charge, and personnel responsible for blast design.
 - b. Method and mitigation to control noise, air blast, ground vibration, fly rock, and dust control.
 - c. Explosives transportation plan including handling, storage, and security.
 - d. Procedures for conducting blasting operations including Safety plan and fire prevention plan.
 3. Controls for blasting near structures including design peak vibration limits and frequency and the proposed blast monitoring program.
 4. Submit for review any proposed modifications to the drilling and blasting plan.
 5. Blasting Report - Submit a blasting report detailing the blast outcome within 48 hours of each blast. Include in the report the following:
 - a. Drill logs and notes regarding conditions encountered in the drill holes, including:
 - 1) Description of encountered subsurface conditions such as open joints, soft or fractured rock zones, groundwater conditions, hole alignment, probing ahead of excavation face and drilling problems.
 - b. Any variations from the submitted Blasting Plan, including any changes to explosives type or amount, loading dimensions, hole spacing, and initiation sequence and delay times.
 - c. Blast monitoring documentation in accordance with ISEE.
 - d. A comment section that includes the Contractor's evaluation of the blast performance, any unusual conditions or situations during the blast, and any misfires.
 - e. Details of any other information.

31 71 00 TUNNEL CONSTRUCTION

H. Blasting of the Copco No. 1 Dam Low Level Outlet:

1. The Blasting Specialist shall submit the Blasting Plan to the Engineer for review and approval before blasting.

1.6 QUALITY

- A. Work shall be in conformance with the Drawings, submittals, and other project documents.
- B. Temporary Bracing:
 1. Design tunnel support, initial support, and temporary bracing system.
 2. Provide temporary ground support structures and rock surface protection as required.

1.7 SITE CONDITIONS

- A. Provide lighting of the worksite.
- B. Employ measures to mitigate dust, noise/ vibration, water, and other pollution created by the Work.

PART 2 - PRODUCTS

2.1 GROUT MATERIALS

- A. Water, Portland cement (Type II, meeting ASTM C150), and Sand - Conform to requirements specified in Section 03 31 00, Portland Cement Concrete, except 100 percent of sand to pass a No. 8 sieve.
- B. Ingredients of Grout Mix – Non-corrosive to steel and free from calcium chloride.

2.2 PERFORMANCE AND DESIGN CRITERIA

- A. Design, engineer, and perform tunnel excavation according to the Drawings to achieve the excavation shapes, roughness and dimensions as indicated on the drawings.

31 71 00 TUNNEL CONSTRUCTION

- B. If drilling and blasting method is selected, design blasting to achieve the project requirements, obtain necessary permits.

2.3 EQUIPMENT

- A. Use equipment that comply with the California Code of Regulations Orders and OSHA CFR.
- B. Grouting Equipment - Capable of developing in a continuous, uniform manner desired pressure at grout hole connection up to the maximum pressure required.
- C. Seismographs: shall comply with the ISEE Blaster's Handbook.

PART 3 - EXECUTION

3.1 GENERAL

- A. Take precautions to not damage structure or equipment near the excavation. This includes direct damage (fly rock) or indirect (vibrations).
- B. Follow the safe work procedures detailed within the Work Plan.
- C. Provide, operate, and maintain ventilation system as required.
- D. Provide dust suppression methods and system to control dust and operate such methods and system from tunnel excavation work.

3.2 EXCAVATION METHODS

- A. Tunnel excavation method, techniques and procedure is at the discretion of the Contractor. The selected method shall be submitted for review, no work shall be performed until the Engineer has reviewed and approved the proposed method, materials, and equipment.
- B. The excavation method, techniques and procedure shall be capable of removing all material to the minimum line of excavation and surface roughness.
- C. Probe drilling for determining rock and upstream hydrostatic conditions shall be accomplished with equipment capable of pre-grouting above the maximum upstream hydrostatic pressure condition.

31 71 00 TUNNEL CONSTRUCTION

- D. Probe drilling for determining the rock mass conditions shall be accomplished with rotary core drilling rigs, as indicated by the Blasting Specialist.

3.3 DRILLING AND BLASTING

- A. Follow a blast design, prepared by the Blasting Specialist and the monitoring plan.
- B. Drill blasting holes as required to complete desired construction results. Review the blasting performance and adjust the blast design to achieve the requirements as per the Drawings.
- C. Blasting to be performed using the perimeter-controlled blasting techniques including presplitting and trim (cushion) blasting adjacent to the minimum line of excavation.
- D. Take necessary precautions to protect the structures, buildings and equipment not intended to be removed with the drilling and blasting from blast induced damage, including protection from fly rock, protection from vibrations due to blasting or air blasts.
- E. The Contractor is responsible to coordinate blasting and notify the Owner, and Other Contractor's and personnel working on site or near site.
- F. Design the blast to comply with safe peak particle velocity (PPV) for all structures within and the vicinity of the blast area and other locations.
- G. Remove loose material and scale to sound unshattered base surface and to the lines and grades as per the Drawings or beyond as required to provide a stable surface.
- H. Limit damage to adjacent structures by preventing flyrock and limiting blast vibration, vibration frequency and overpressure as required.
- I. Drill test (probe) holes ahead of the excavation face as required by CAL/OSHA and minimum requirements specified. Test holes within tunnel plugs to be grouted to prevent water leakage.

3.4 MECHANICAL EXCAVATION

- A. Underground excavation by mechanical methods may include hydraulic impact hammer, drilling and expansion methods and saw cutting.
- B. The mechanical excavation methods shall be compatible with the requirement and scheduling of the Work and nature of the material to be removed.

31 71 00 TUNNEL CONSTRUCTION

- C. Obtain the Engineer's acceptance of the excavated surfaces before placement of concrete.

3.5 ROCK SUPPORT

- A. Provide any rock support, including rock bolts, rock dowels immediately after material has been removed from the excavation.
- B. In accordance with Section 03 20 00 – Concrete Reinforcing and Section 03 60 00 – Grouting.

3.6 TUNNEL LINING

- A. Cast-In-Place Concrete Lining:
 - 1. In accordance with Section 03 30 00 – Cast-In-Place Concrete.
 - 2. Provide provision to purge air from the formwork and falsework from the tunnel crown or interior of the formwork.

3.7 GROUTING

- A. Clean out grout holes.
- B. Operate and control grout pumps to deliver grout uniformly and steadily until completed.
- C. Stop injection when no more grout, of required mix and consistency, can be injected under maximum pressure as accepted in submitted procedures.
- D. Perform grouting at pressures that will not cause damage to the existing surfaces.

3.8 DISPOSAL OF EXCAVATION MATERIAL

- A. Waste material created by tunnel construction Work shall be disposed at the disposal sites in accordance with Section 02 41 00 – Demolition and Facility removal.

31 71 00 TUNNEL CONSTRUCTION

3.9 FIELD QUALITY CONTROL

- A. The Contractor shall make access to the excavated area available to the Engineer for inspections. Inspections will be carried out area after mucking, scaling and cleaning has been completed. The inspections are for purposes of geological mapping and inspections of the excavated surfaces in preparation for passage of water within the tunnel.

3.10 TOLERANCES

- A. Variation on drilling from the design grade and alignment:
 - 1. Tunnel Excavation: grade \pm 3 inch.
 - 2. Tunnel Excavation: alignment \pm 8 inch.
- B. Tunnel linings: in accordance with Section 03 30 00 – Cast-in-Place Concrete or Section 05 12 00 – Structural Steel as applicable.

3.11 PROTECTION AND CLEANUP

- A. At completion and during progress of the Work maintain premises in a neat and orderly manner. Dispose of rubbish, construction debris and surplus materials at least on a weekly basis.
- B. Cover and protect the work from damage by Work of other sections or other contractors.
- C. Protect the Work of other sections from damage resulting from the work of this section.

END OF SECTION 31 71 00