APPENDIX

D Pier Column & Type I Pile Shaft

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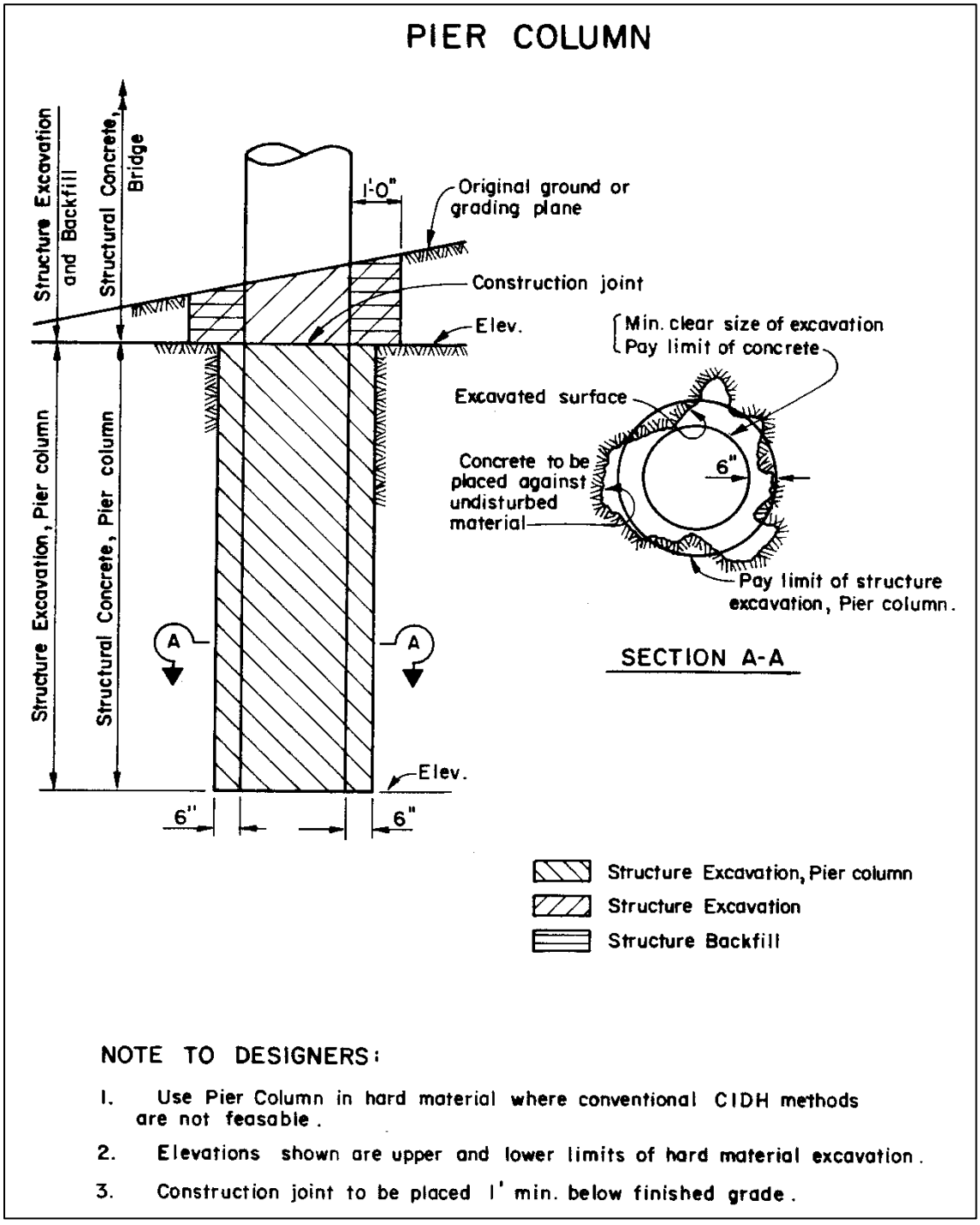


Figure D-1. Pier Column - Caltrans Bridge Design Details, page 7-20.

Blasting Example & Sample Special Provisions

What follows is an example of how Caltrans uses blasting in the construction of bridge foundations. In the past, blasting has been performed to facilitate the construction of spread footings and pier columns. The photograph below is an example of what can be considered a hybrid of the two. Pier W2 of the San Francisco-Oakland Bay Bridge East Span Construction project uses blasting to construct a foundation in rock. The foundation is in excess of 60' deep and 80' square.

Pier W2, part of the E2-T1 project (EA 04-0120L4) is part of the new San Francisco Oakland Bay Bridge. Blasting was used for structure excavation of these piers. Construction of W2 structures was complete in September 2004 at a cost of $24.1 million.

Figure D-2. SFOBB East Span Pier W2 Footing Excavations.

Special Provisions – EA 04-0120C4

The following specification was taken from the Special provisions of the above referenced contract. It is understood that projects of this type are unique and extreme in their application of engineering principles, but still utilize construction operations utilized on projects throughout the State. Note that special provisions are unique to each contract; and as such may vary from what is presented below. In some geologic regions blasting may be the only option, however Industry continues to implement new technologies. In some cases, new tools such as the rotator and/or oscillator (refer to Chapter 6, *Cast-In-Drilled-Hole Piles*) may be more appropriate and more environmentally considerate.

BLASTING

Attention is directed to, "Project Information," and "Photo Survey of Existing Facilities," of these special provisions, regarding the Blasting Demonstration Report, and photo survey of the existing facilities.

Attention is directed to "Order of Work," of these special provisions regarding transportation and use of explosives.

If the Contractor elects to use blasting for structure excavation (bridge) at Piers W2, project blasting shall conform to Sections 7-1.10, "Use of Explosives," and 19-2.03, "Blasting," of the Standard Specifications and these special provisions.

The Contractor shall control project blasting effects (fly rock, ground motion, and air noise levels) within the safe limits so as not to cause damage to neighboring improvements.

Blasting Plan Submittal

The Contractor shall submit a blasting plan to the Engineer detailing how he proposes to control fly rock, air noise level, and ground motion peak particle velocity. No blasting operations, including drilling, shall start until the Engineer has reviewed and approved the blasting plan.

The Contractor shall submit the blasting plan in accordance with the provisions in "Working Drawings," of the special provisions not less than 30 working days before commencing blasting activity or at any time the Contractor proposes to change the drilling and blasting methods. The Contractor shall provide 10 working days for the Engineer to complete the review of the blasting plan. In the event that additional blasting plans are required, the Contractor shall provide 5 working days for the review of each additional plan.

The blasting plan shall provide for limiting ground motion to a maximum peak particle of 100 mm/sec at the existing E1 Pier of the San Francisco Oakland Bay Bridge (Bridge No. 33-0025), and 50 mm/sec at the Torpedo Building (Building 262). Controlling fly rock, air noise levels, and ground motor peak particle velocities as specified herein shall not relieve the Contractor of his responsibility for assuring the complete safety of his operation.

The blasting plan shall indicate the type and method of instrumentation proposed by the Contractor to determine air noise levels, and ground motion peak particle velocity at the nearest improvements. The blasting plan shall also provide for a pre-blast reconnaissance survey of all adjacent improvements.

Approval of the Contractor's blasting plan or blasting procedures shall not relieve the Contractor of any of his responsibility under the contract for assuring the complete safety of his operations with respect to neighboring improvements, or for the successful completion of the work in conformance with the requirements of the plans and specifications.

If the Engineer fails to complete the review within the time allowed, and if, in the opinion of the Engineer, the Contractor's controlling operations are delayed or interfered with by reason of the delay, an extension of time commensurate with the delay will be granted as provided in Section 8-1.07, "Liquidated Damages," of the Standard Specifications.

Qualifications

The blasting supervisors (blaster in charge) shall have a minimum of 10 years experience, directly related to the specific types of blasting they are supervising.

All blasters and supervisors shall be properly qualified and licensed in accordance with applicable federal, State, and local government regulations.

The Contractor shall retain the services of an experienced seismologist or engineering consultant with at least 10 years experience in monitoring blasting operations and interpreting ground vibration, air overpressure, and water pressure amplitudes for similar construction projects.

The Contractor shall retain the services of an experienced specialist who will conduct the pre-blast inspections of private properties as specified herein. The specialist shall have performed similar pre-construction survey services on at least three projects of similar scope and complexity.

Pre-Blast Condition Survey

The Contractor shall perform a pre-blast survey of specified buildings and structures, and utilities within 100 meters or which may potentially be at risk from blasting damage. The survey method used shall be acceptable to the Contractor's insurance company. The Contractor shall perform the pre-blast survey within 30 working days in advance of the planned commencement or resumption of blasting operations and pre-blast records shall be made available to the Engineer for review. The Contractor prior to the beginning of the blast shall notify occupants of the local buildings. The pre-blast survey shall, as a minimum, contain the following:

A. The name of the person making the inspection.
B. The names of the property owner and occupants, the addresses of the property, the date and time of the inspection.

C. A complete description of the structure(s) or other improvement(s) including culverts and bridges.

D. A detailed interior inspection with each interior room (including attic and basement spaces) designated and described. All existing conditions of the walls, ceiling and floor such as cracks, holes and separations shall be noted.

E. A detailed exterior inspection fully describing the existing conditions of all foundations, walls, roofs, doors, windows, and porches.

F. A detailed listing, inspection and documentation of existing conditions of garages, outbuildings, sidewalks and driveways.

G. A detailed listing of highway signposts, light fixtures and overhead power lines.

H. A survey of any wells or other private water supplies including total depth and existing water surface levels.

The Contractor shall perform a re-survey of all locations whenever blasting operations are either terminated or suspended for a period in excess of 30 working days. The documentation may consist of either a written report, or videotape with voice narration. The videotape, if used, must include date and time displayed on the image. The Contractor shall provide copies of the pre-blast inspection report or videotape documentation to the Engineer at the time that the blasting plan is submitted.

The Contractor shall control project blasting so that vibration, flyrock, ground and vibration motion, and air noise levels do not cause damage to nearby structures including highway sign posts, light fixtures and parked vehicles, undue annoyance to nearby residents, or danger to employees on the project. The Contractor shall use controlled blasting techniques and designs and shall coordinate the traffic control during blasting operation. The Contractor shall be responsible for all damage resulting from blasting.

Vibration Control and Monitoring

When blasting within proximity of buildings, structures, or utilities that may be subject to damage from blast-induced ground vibrations, the Contractor shall control ground vibrations by the use of properly designed delay sequences and allowable charge weights per delay. Allowable charge weights per delay shall be based on vibration levels that will not cause damage. The Contractor shall perform trial blasts to select allowable charge weights per delay by measuring vibration levels. The Contractor shall select proper control method to limit over break. The trial blasts shall be carried out in conformance with the blasting test section requirements, modified as required to limit ground vibrations to a level which will not cause damage. The blasting test section requirements require that two seismographs be used, one placed on the end of the shot and one placed at 90 degrees behind the shot to establish vibration levels and their relation to the measurement location. The Contractor shall have full responsibility to control over break.

Whenever vibration damage to adjacent structures is possible, the Contractor shall monitor each blast with an approved seismograph located, as

approved, between the blast area and the structures subject to the blast site. The seismograph used shall be capable of recording particle velocities for three mutually perpendicular components of vibration in the range generally found with controlled blasting.

The Contractor shall employ a qualified vibration specialist to establish safe vibration limits. The vibration specialist shall also interpret the seismograph records to ensure that the seismograph data are utilized effectively in the control of the blasting operations with respect to the existing structures. The vibration specialist used shall be subject to the Engineer's approval.

The Contractor shall provide vibration monitoring at the following locations:

A. Existing E1 pier of San Francisco-Oakland Bay Bridge.
B. Torpedo Building (Building 262).
C. Navy Building 1.
D. Coast Guard Building 27.

The measuring devices should be positioned at the closest face of structure or body of water to the blast site.

Data recorded for each shot shall be furnished to the Engineer prior to the next blast and shall include the following information:

A. Identification of instrument used.
B. Name of qualified observer and interpreter.
C. Distance and direction of recording station from blast area.
D. Type of ground at recording station and material on which instrument is sitting.
E. Maximum particle velocity in each component.
F. A dated and signed copy of seismograph readings record.

At the Contractor's option, shot designs may be based upon scaled distance following the chart below. The scaled distance is the ratio of distance in feet from the blast site to the site to be protected to the square root of the maximum explosive weight used for each delay of 9 milliseconds or more.

Blast Design Table

Distance to site to be protected	*Scaled distance factor*
0 to 91 meters	*22.57 m/kg$^{1/2}$*
91 to 1,524 meters	*24.94 m/kg$^{1/2}$*
1,524 meters	*29.4 m/kg$^{1/2}$*

Environment Protection

Sound Pressure Level (SPL) due to blasting shall not be greater than 180 dB (decibels) in the water at a distance of 10 meters from any point on the shoreline at Yerba Buena Island. The Contractor shall design blasting plan to meet SPL performance limitations and shall perform trial blasts to select allowable charge weights per delay based on measured values of SPL. The Engineer will conduct acoustical monitoring and marine mammal monitoring during all blasting activities. The safe distance for marine mammals due to blasting effects is herein referred to as the Marine Mammal Safety Zone (MMSZ). The MMSZ will be established at a 50-meter radii from the shoreline adjacent to the blasting area, and may be increased or decreased in size based on results of acoustical monitoring. The purpose of the marine mammal monitoring is to prohibit blasting activity if marine mammals are present within the MMSZ. In addition, the Engineer will monitor for Pacific herring spawning event within a 200-meter distance from the shoreline adjacent to the blasting area. If spawning is observed, blasting activity will be prohibited. Work shall not resume until the Engineer notifies the Contractor, which is expected to be approximately 14 calendar days from the time of spawning.

The Contractor shall provide two working days advance notice to the Engineer before each day he is planning to blast. The marine mammal monitoring shall commence at least 15 minutes before blasting begins. The Engineer will have the sole discretion to direct Contractor with approval to proceed with blasting operation prior to each and every blast.

The Department will conduct surveys and monitoring of bird activity before and during blasting activities as part of an agreement with the resource agencies.

Air Blast and Noise Control

The Contractor shall install an air blast monitoring system between the main blasting area and the nearest structure subject to blast damage or annoyance. The equipment used to make the air blast measurements shall be the type specifically manufactured for that purpose. Noise levels shall be held below 125 dbA at the nearest structure or designated location. The Contractor shall use appropriate blast hole patterns, detonation systems, and stemming to prevent venting of blasts and to minimize air blast and noise levels produced by the blasting operations. The decibel level shall be lowered if it proves to be too high based on damage or complaints. The Contractor shall furnish a permanent, signed and dated record of the noise level measurement to the Engineer immediately after each shot.

Flyrock Control

Before the firing of any blast in areas where flying rock may result in personnel injury or unacceptable damage to property, parked vehicles or the work, the Contractor shall cover the rock to be blasted with approved blasting mats, soil, or other equally serviceable material, to prevent flyrock.

If flyrock leaves the construction site and lands on private property all blasting operations will cease until a qualified consultant, hired by the Contractor, reviews the site and determines the cause and solution to the flyrock problem. Before blasting proceeds, a written report shall be submitted by the Contractor to the Engineer for approval.

Video Recordings of Blasts

Videotape recordings will be taken of each blast. The tapes or sections of tapes will be indexed in a manner to properly identify each blast. At the option of the Engineer, copies of videotapes of blasts will be furnished on a weekly basis.

The Contractor shall keep accurate records of each blast. Blasting records shall be made available to the Engineer at all times and shall contain the following data as a minimum:

A. Blast Identification by numerical and chronological sequence.
B. Location (referenced to stationing), date and time of blast.
C. Type of material blasted.
D. Number of holes.
E. Diameter, depth and spacing of holes.
F. Height or length of stemming.
G. Types of explosives used.
H. Type of caps used and delay periods used.
I. Total amount of explosives used.
J. Maximum amount of explosives per delay period of 9 milliseconds or greater.
K. Powder factor (pounds of explosive per cubic yard of material blasted).
L. Method of firing type.
M. Weather conditions (including wind direction).
N. Direction and distance to nearest structure or structures of concern.
O. Type and method of instrumentation.
P. Location and placement of instruments.
Q. Instrumentation records and calculations for determination of ground motion particle velocity or for charge size based on scaled distance.
R. Measures taken to limit air noise and fly rock.
S. Any unusual circumstances or occurrences during blast.
T. Measures to limit over break
U. Name of contractor.
V. Name and signature of responsible blaster.

Blasting Guards

The Contractor shall provide sufficient blasting guards and station them around the blasting area during blasting to assure that people and structures are not endangered. Traffic during blasting shall be controlled by the Contractor.

Blasting operations may be suspended by the Engineer for any of the following:

A. Safety precautions, monitoring equipment and traffic control measures are inadequate.
B. Ground motion particle velocity or air noise exceeds the limits specified.
C. Blasting control plan have not been approved.
D. Required records are not being kept.
E. Excessive outbreak as determined by the Engineer

Suspension of blasting operations shall in no way relieve the Contractor of his responsibilities under the terms of this contract. Blasting operations shall not resume until modifications have been made to correct the conditions that resulted in the suspension.

Blasting complaints shall be accurately recorded by the Contractor as to complainant, address, date, time, nature of the complaint, name of person receiving the complaint, the complaint investigation conducted, and the disposition of the complaint. The Contractor shall make the complaint available to the Engineer as soon as practical, but no later than at the beginning of the following day's work shift.

PAYMENT

Full compensation for blasting including all the requirements as specified herein, shall be considered as included in the contract price paid per cubic meter for structure excavation (bridge) and no separate payment will be made therefor.

Blasting Photos

Photo 1. Pier W2. Before detonation. Blasting mats on top.

Photo 2. W2. Detonation

Photo 3. Detonation

Photo 4. Flyrock contained by blasting mats.

PROJ/RTE/PM: 04-SF-80-13.2 at Yerba Buena Island	
PROJECT NO. 04-0120C4 Senior Bridge Engineer	Video-photos from Leonard Fiji,

Figure D-3. Blasting Photos.

Pile Shaft (Type I) - Case Study

Contract No. 04-470804
04-SJ, Ala-205, 580-10.0/0.4 (near the City of Tracy)
580/205 Separation (Bridge No. 33-0693R)
Construction started in 2006.

Pile Shaft Project: Although this project has large diameter CIDH piles, this project is not considered a pier column. It **does not** have contract pay items for structure excavation (pier column) and structure concrete (pier column). Conventional methods were used to drill the CIDH pile.

However, the **pile shaft** design was chosen because limited space constraints next to the existing freeway and change of elevation differences between Abutment 1 to Abutment 8. If a pile cap foundation was chosen, then the pile caps would have had to have been excavated 10 to 20 feet beneath the existing freeway to account for the different column stiffness. This excavation would have been problematic due to space constraints in the middle of the existing freeway. Due to the limited space constraints, single column pile shaft foundations were considered easier to construct than a conventional pile cap with standard plan piles. Due to the different column lengths, isolation casing were required at certain locations to account for the different stiffness of short and long columns. Also, the claystone formation underlying the project site was conducive to drilled shaft construction since caving issues would be reduced after using temporary casings to stabilize softer/looser near surface soils (Comments by Tim Alderman, Caltrans Geologist).

The pile shaft design is designated as Type I, meaning that the pile and the column share the same bar reinforcement cage.

Description of Bridge Work: construct a 7-span cast-in-place prestressed concrete box girder bridge approximately 373 meters in length and 12.6 meters in width.
Pile shaft diameter: 1980-mm for Bents 2, 3, & 4; 2280-mm for Bents 5, 6, & 7.
Pile shaft length: 26.75 meters (Bent 4) to 39.8 meters (Bent 2)
Column heights: 8.9 meters (Bent 4); 19.2 meters (Bent 7)
Isolation casings: Bents 2, 3 & 4.

Construction Issues: Groundwater was anticipated and encountered. Two cranes were needed to lift the pile shaft column rebar into place. Windy conditions affected crane operations.

(Photos contributed by Gon Choi, Consultant Engineer.)

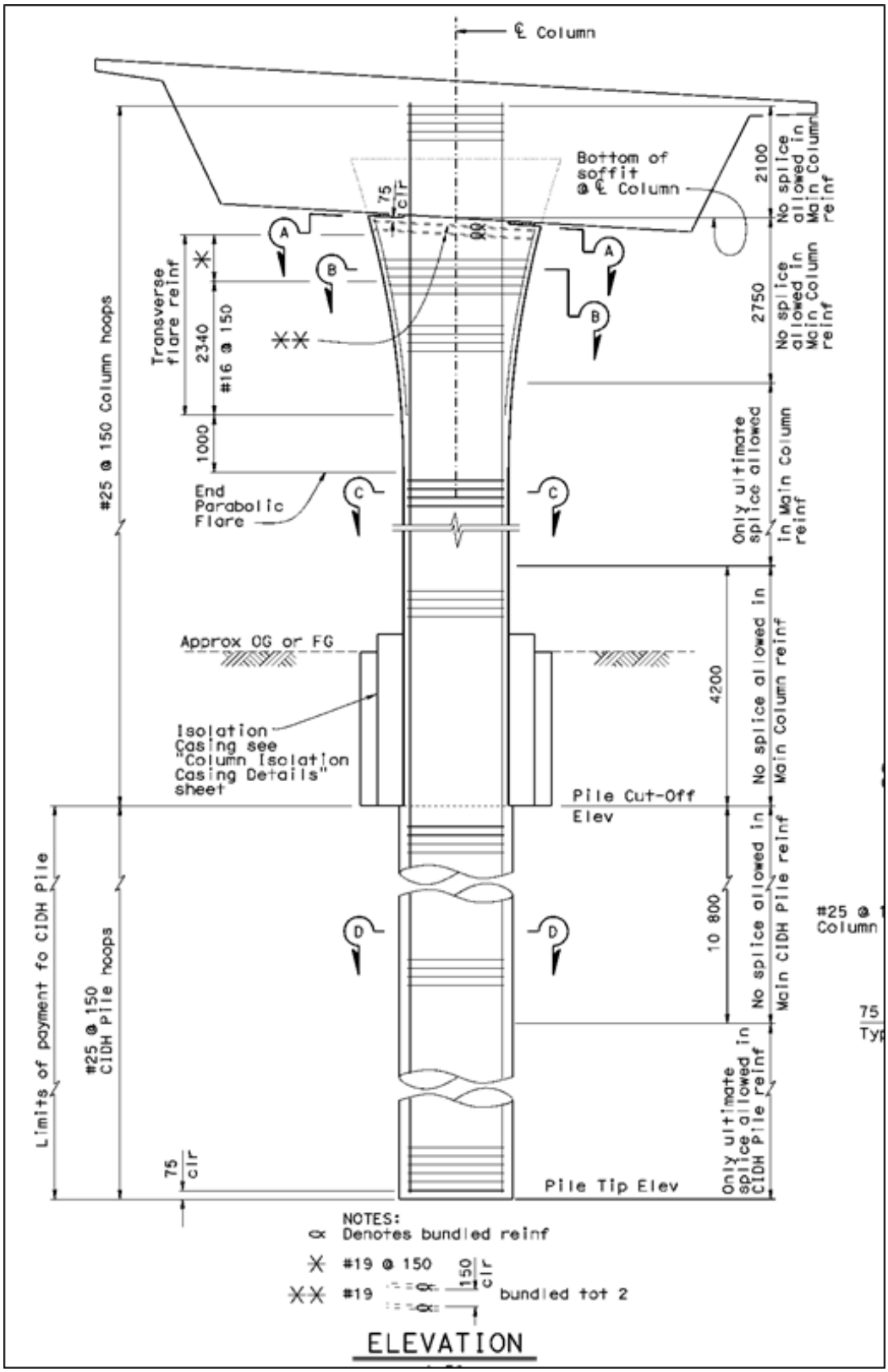


Figure D-4. Bents 2 & 3 Column Details – 580/205 Separation, Contract No. 04-470804.

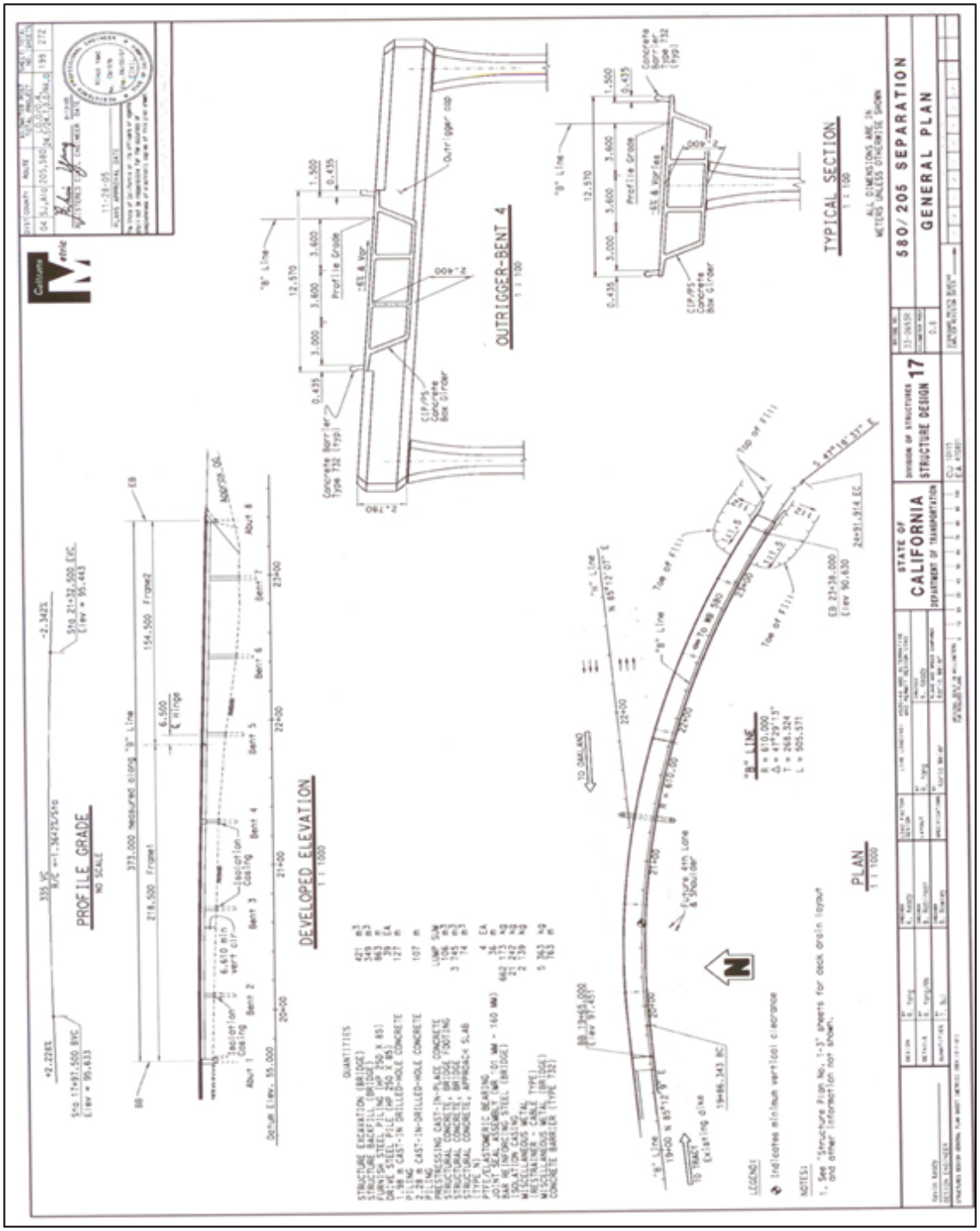


Figure D-5. 580/205 Separation General Plan.

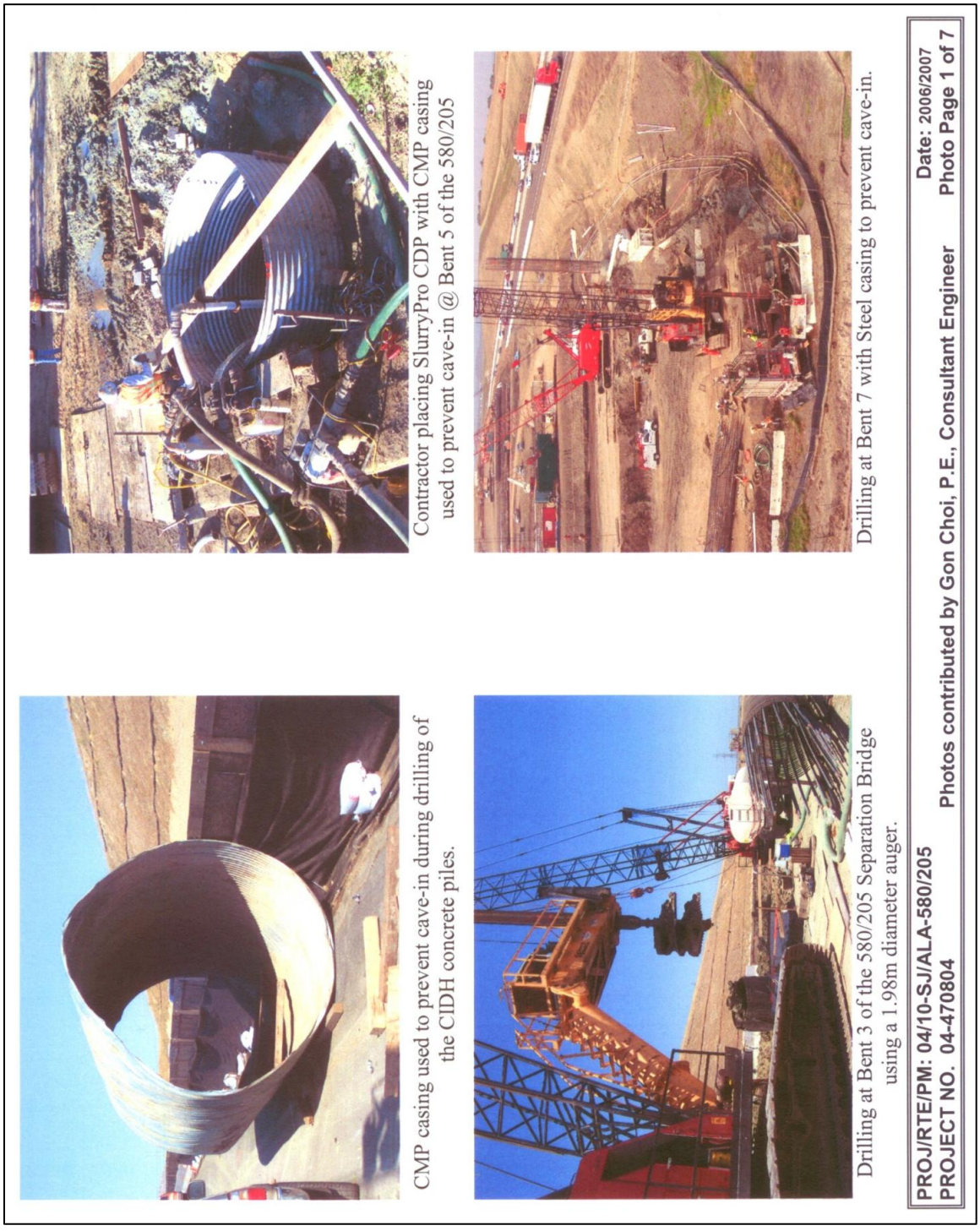
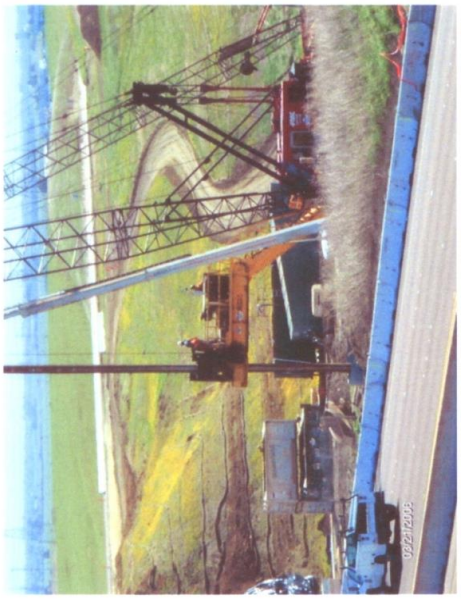


Figure D-6. 580/205 Separation CIDH Pile Construction 1.

2.13-m diameter Clean out bucket cleaning out Bent 7 of the 580/205 Separation Bridge.



Drilling at Bent 5.

Link Belt LS-518 Crane with Steven M Hain Co 450K, Series 1 drill.

Cave-in at Bent 3 of the 580/205 Separation Bridge.

PROJ/RTE/PM: 04/10-SJ/ALA-580/205
PROJECT NO. 04-470804

Date: 2006/2007
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Figure D-7. 580/205 Separation CIDH Pile Construction 2.

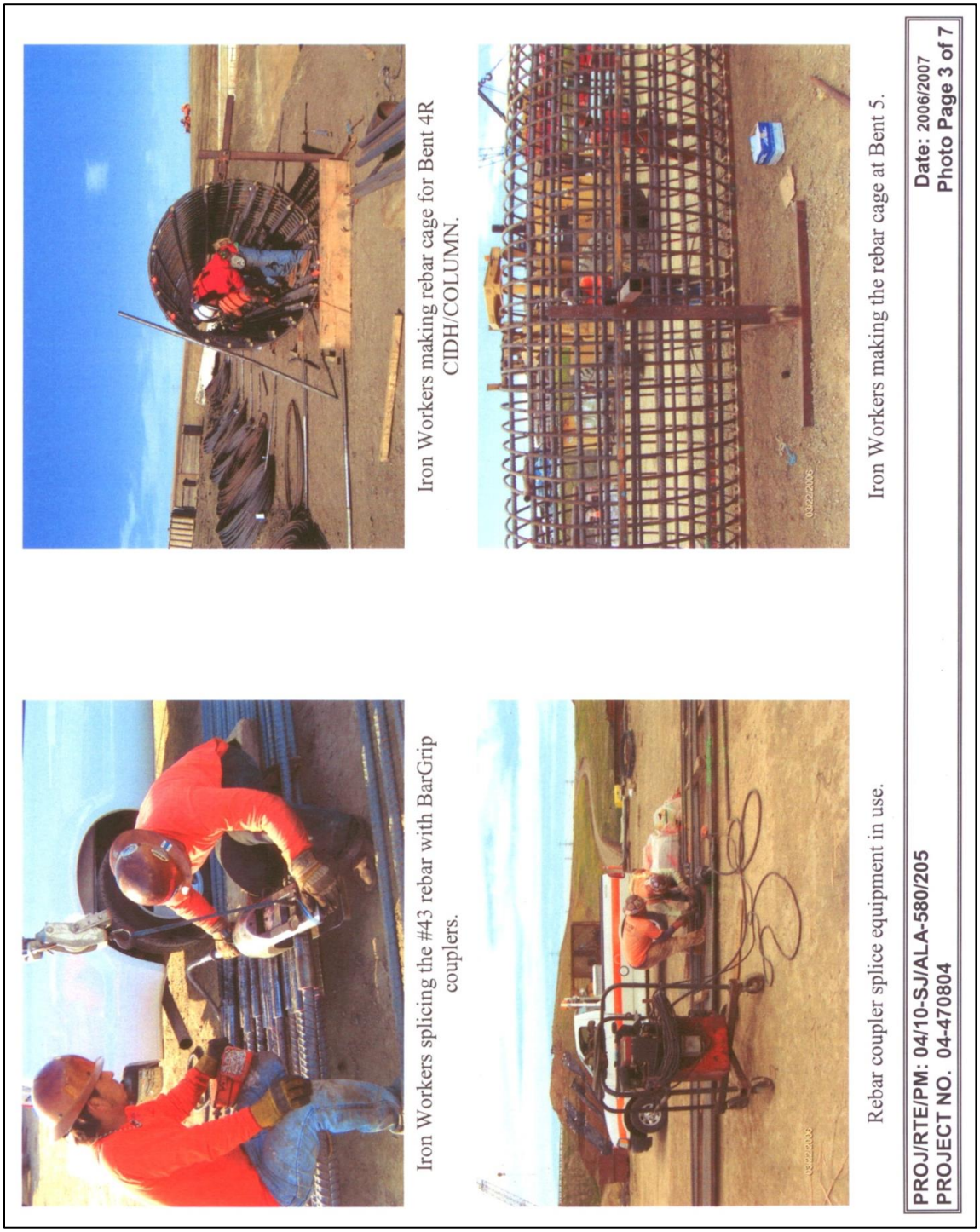

Figure D-8. 580/205 Separation CIDH Pile Rebar Cage Construction.

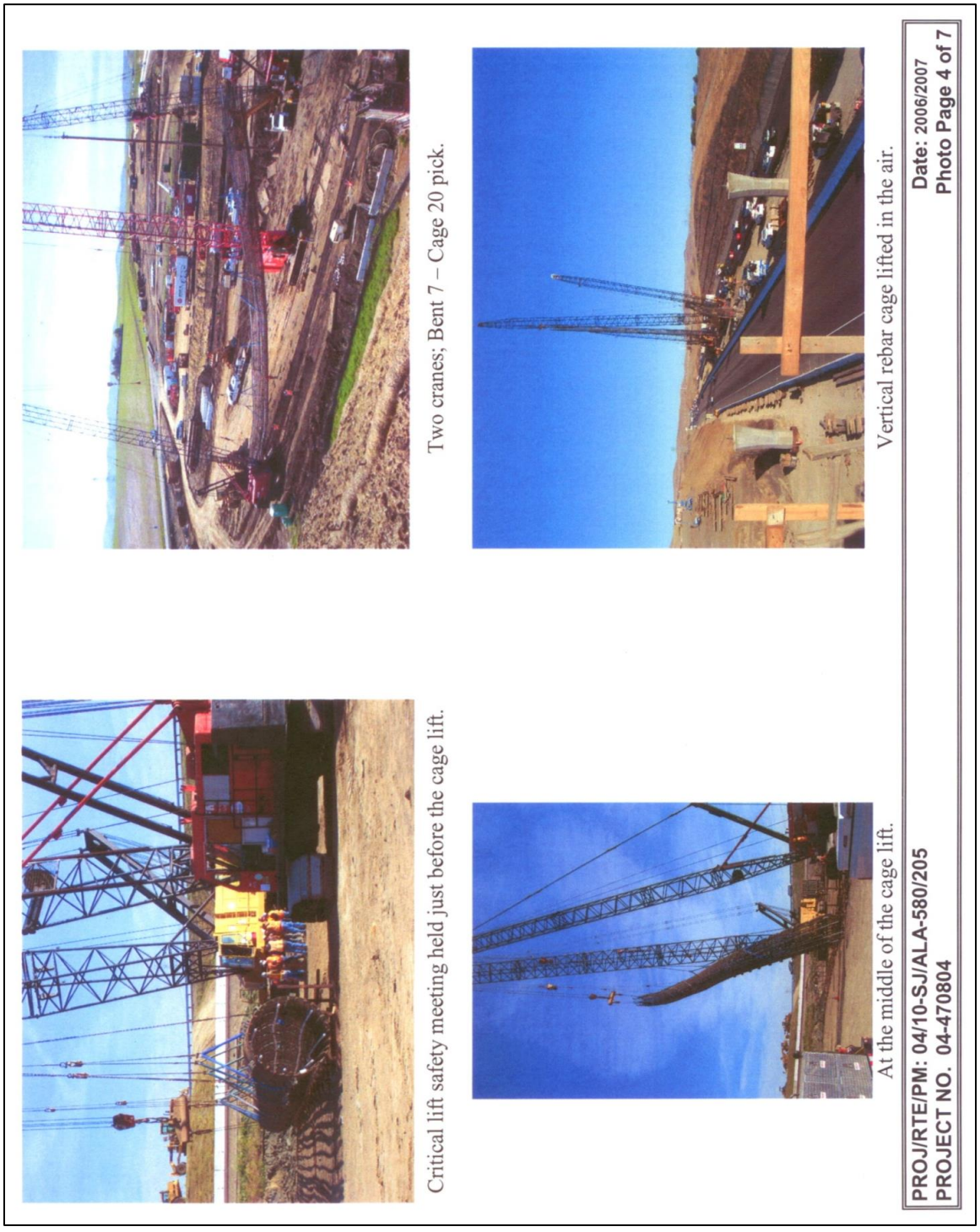

Figure D-9. 580/205 Separation CIDH Pile Rebar Cage Setting.

Figure D-10. 580/205 Separation CIDH Pile Concrete Placement.

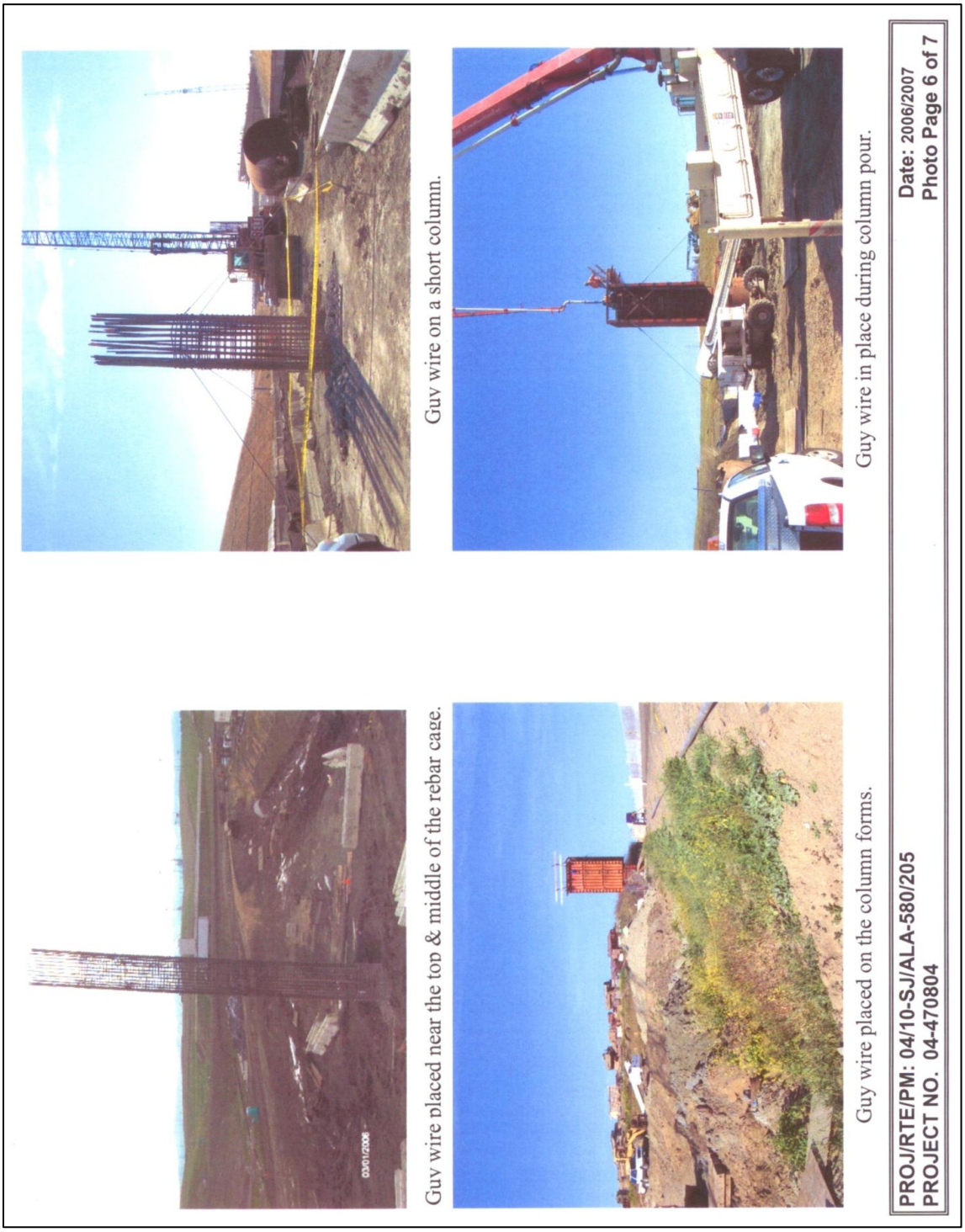

Figure D-11. 580/205 Separation Column Construction.

Figure D-12. 580/205 Separation CIDH Pile and Column Construction.