

For Review

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Draft for Review

First Tunnel & Geotechnical Review of the
Linac Coherent Light Source Project

Stanford Linear Accelerator Center

August 31st through September 1st 2004

Report Date - TBD

Tunnel and Geotechnical Review

Dates	August 31 – September 1, 2004
Venue	Stanford Linear Accelerator Center – Redwood/Orange Rooms
Committee Members and Affiliation	Jon Kaneshiro, Parsons Engineering – Absent. Chris Laughton, Fermilab. Rick Nolting, Associate, Jacobs Associates.
Presentation and Interview Participants and Affiliation	Stanford Linear Accelerator Center: Jo Beth Folger, John Galyda, Mark Reichenadter, David Saenz, Andrei Seryi, Jim Welch. DOE Observer: Henley Lee. Rutherford and Chokene: Gyimah Kasali, Principal. Jacobs Engineering: Ron Drake, Mike Feroz, Steve Hill.

Agenda Outline
(times approximate)

Tuesday, August 31st

09:00-12:00 Project and Facilities overview and Committee Charge
12:00-13:00 Lunchtime discussion relative to invert performance in existing accelerator tunnels and potential construction impacts on adjacent accelerators
13:00-15:00 Site visit and inspection of some recent rock core
15:00-17:00 Interview with the Geotechnical Engineer responsible for site investigation, field, laboratory testing and data reporting

Wednesday, September 1st

08:30-10:00 Preparation for design discussion
10:00-11:00 Design discussion with the members of the design team responsible for the final design of the underground facilities
11:00-14:00 Preparation for close-out briefing
14:00-16:00 Project close-out.

Documents Reviewed

Title I Drawing Set
Geotechnical Data Report of August 2003
Tunneling Memorandum of August 2003
The cost estimate and schedule were not reviewed – they will be the subject of a separate review.

Committee
Background and an
Overview of the
Review Format

The Project has asked three professionally-registered geotechnical engineers (two attended – you might need to replace Jon if he resigns, especially as Rick and I probably agree too easily), with experience in the design of underground structures, to review the tunneling and geotechnical aspects of the LCLS conventional facilities design.

This is the first of three design reviews that have been scheduled to take place during the final design phase of the Project. The other two reviews have tentatively been scheduled for January and May of 2005.

The two-day review consists of a “kick-off” meeting at which the Project provides a brief update, poses a set of questions and presents relevant background material. The balance of the first day and morning of the second day is used for the collection of additional data, interviews and site visits. The Committee puts together draft responses/overheads to questions posed late in the morning of the second day and makes a power point presentation

at a close-out session in the afternoon.

The Committee will aim at providing a draft written report within a week of the end of the review. The report will provide answers to the specific questions posed and occasionally offer suggestions for the Project's consideration.

This review format appears effective but may be changed in the future to best suit the Project's needs at the time.

Executive Summary

This report summarizes the status of the site investigation, design work and other pertinent information gathered by the Committee and addresses the specific questions posed by the Project. The Committee answers the specific questions posed and makes suggestions relative to potential actions the Project may consider taking in the future.

Based on the documents reviewed and information provided, the Committee considers that the Project has adequately addressed the questions it posed to the Committee.

The Committee notes that several of the questions posed may warrant further investigation during the next stage of the design and provides some suggested approaches/strategies for the Project's consideration. These are not action items.

Status of Site Investigation and Rock Mass Characterization Work

At the time of the review, a second phase of geotechnical investigation had just been completed. Borehole core logs, geophysical logs and test data from this work phase had not yet been reported.

The scope of work specifically includes the collection and reporting of a comprehensive list of design parameters requested by the tunnel designer (Jacobs Engineering).

Some of the more recently retrieved core samples were inspected. The Project is arranging for the protection of the cores (cling film wrap or similar) and storage in a conditioned environment through completion of the contract.

Status of the Design Work

At the time of the Review, design requirements for the underground openings had been set and a preliminary design developed. The preliminary design was based on data obtained from the first phase of the site investigation campaign undertaken by Rutherford and Chokene and reported in the Geotechnical Data Report and Tunneling Memorandum (8/03).

The preliminary design will form a sound technical basis from which to plan-out and execute the final design and contract packaging.

Committee's Charge The Committee was asked by the Project to address the following questions:

- 1 – Does the tunnel design adequately consider the correct methods and means for the site-specific geological and seismic conditions?
- 2 – Are the current risk analyses sufficient?
- 3 – Is the Tunnel schedule reasonable?
- 4 – Is the highest degree of safety reasonably achievable incorporated into the design?
- 5 – Does the design adequately consider the potential for future growth?
- 6 – We are using cut and cover in the area where minimal ground cover is established. Is this a reasonable approach?
- 7 – Are adequate safety considerations being addressed? - Temporary and final liner support, fire, egress, ventilation, earthquake (SLAC has site-specific performance based goals that require the facility to sustain “very little” damage and shall remain “life safe”)

The Committee addresses these questions below.

1 – Does the tunnel design adequately consider the correct methods and means for the site-specific geological and seismic conditions?

The Tunneling Memorandum and Title I drawings identify a roadheader as the means of excavation and reinforced shotcrete, used in combination with lattice girder/bolting, for ground support. The Committee agrees that these methods and means are appropriate for the end-user needs and the site conditions. The rock mass is relatively soft and can be easily mined mechanically without recourse to explosives. Roadheaders are highly flexible and can be used to mine the various types of tunneled sections and intersections laid-out in the Title I drawing set. In recent years, roadheaders have been frequently used in California, and there is an experienced contractor pool within the State.

Suggestions: The Committee raises the following points for the Project's consideration:

- a) During the Review site visits were made to existing tunneled structures and brief discussions were held with Laboratory staff relative to the magnitudes and directions of time-dependent floor movement in these structures

(PEP and SLC Arcs tunnels). Some significant upward and downward displacements (millimeters rather than microns) have been observed in these tunnels (most notably PEP). The largest absolute movements appear to be associated with fill and cut and cover areas, but even the smaller displacements, recorded in the tunneled sections, could seriously impact the performance of the LCLS machine. There is a need to characterize the time-dependent properties of the different strata within the host rock materials, particularly those located under the Undulator Hall invert, where stability demands are greatest. Rutherford and Chokene indicated that samples retrieved from the most recent set of boreholes are being tested for their swelling properties and granulometry – results from these test were not available at the time of the review. This data will be key to support the development of cost-effective and practical foundation design(s).

- b) The designer and end-user may benefit from seeking-out design precedent from other research facilities, with strict floor stability requirements.
- c) Before moving ahead with detailed modeling or field-testing of any Undulator invert design(s) the new geotechnical data sets (a) and design precedents (b) should be studied and reviewed for constructability and cost.
- d) Detailed modeling (stress-displacement) and analyses of the larger excavations will also be necessary to ensure opening stability throughout the excavation and operations periods. The models developed should allow for the evaluation of structural stability under earthquake load conditions.
- e) During design, contract preparation and construction, special attention should be paid to the layout and specification of the ground monitoring programs (instrumentation). Instrumentation should be installed before and during excavation to track ground behaviour in the larger excavations and where excavations are opened adjacent to existing structures (e.g. PEP & SLC). Provisions should be made for continuing monitoring during installation and operation of the facilities to track any time dependent movement of critical structures.

2 – Are the current risk analyses sufficient?

An excellent framework for risk management has been established. This comprehensive plan and registry is already well documented and four specific conventional construction

risks identified: labor rate increases, tunneling under-performance, differing site conditions, and HVAC performance. Additional input will be needed from the engineering group during Title II design. The construction aspects of the risk management plan and inventory will need regular updating throughout the design and construction period.

Suggestions: The Committee suggests that the Project consider using some design and contract provisions to better manage construction risk, these include use of the following:

- a) Contractor Pre-qualification (includes all people contracted to work on any tunnel aspects of the project - CM, consultants builders, etc.)
- b) Reports on ground conditions and behaviour (Geotechnical Design Report, Geotechnical Baseline Report)
- c) Alternate Disputes Resolution methods
- d) Escrow Bid Documents
- e) Liquidated Damages
- f) Best Value consultant/contractor selection (avoid low-bid selection for any contracts pertaining to tunnel work – look for previous hands-on experience in similar ground, using similar equipment and materials; e.g. some questions procurement may ask prospective individuals and companies that offer any tunnel-related services to the Project:

- i) Have you worked in a position of responsibility on soft rock/soils tunnel construction?,
- ii) Have you worked with roadheader equipment and
- iii) Have you worked with lattice girder/shotcrete systems

There may be other key technical areas where technical pre-qualification is warranted – main thing is to ensure that the consultants or contractors you contract with are not learning at your expense!

3 – Is the Tunnel schedule reasonable?

Roadheader advance rates are currently based on input from “Bacchus Caves”, a California wine cave contractor. To evaluate the reasonableness of these advance rates for this site, the Project has arranged for a site-specific, “bottoms-up” review of cost to be performed. The Committee strongly endorses this action. The cost review will necessarily also allow for overall production rates (including learning curves), durations and logic ties between activities to be evaluated.

Tunnel work is known to be highly susceptible to cost and schedule overrun and a second opinion on the cost and duration

of this construction work is a wise move.

Suggestions: To further improve confidence in tunnel costs and durations and develop more familiarity with the tunnel construction process, the Committee suggests the following:

- a) Benchmarking of project production rates and costs (mining and lining) to similar jobs recently undertaken in the area (Case Histories)
- b) Organizing site visits to similar tunnel construction project so that the Project Team can see firsthand what the tunnel, portal and staging areas look like. (Jacobs Associates kindly offered to try and arrange such a visit to the Claremont Tunnel owned by EBMUD).
- c) Look for advice from other owners – they will provide you with another owner’s perspective and give their opinions for free (win-win situation!). Fellow tunnel owners, like EBMUD, could be a valuable resource as the Project Team seeks to develop the final design, put together the contract documents, pre-qualify contractors and develop an appropriate overall contracting strategy for the LCLS Project.

4 – Is the highest degree of safety reasonably achievable incorporated into the design?

See Response to Question 7

5 – Does the design adequately consider the potential for future growth?

The Committee believes that the Title I design has adequately identified the potential for the excavation of additional beamline housings adjacent to the baseline tunnel?

Suggestions: The Committee offers the following for the Project’s consideration:

- a) Continue to document the potential “additions” (text and drawings) within the context of the Title II design scope. In particular, it is suggested that Title II design work identify future tunnel volumes (avoid steel bolt impingement or use fiberglass in these “to be excavated later” volumes), establish “no-build” surface footprints and ensure future construction access corridors are kept unobstructed.
- b) Consider building tunnel stubs for these future beamlines

within the baseline scope in order to minimize any future disruption with beamline operation.

6 – We are using cut and cover in the area where minimal ground cover is established. Is this a reasonable approach?

Cut and cover appears to be a reasonable approach to adopt for this section of the Project given the relatively low amount of cover and the limited number of utility crossings in the area. The Committee notes that tunneling under low cover could also be feasible for extended distances or under utility banks but would probably require additional investigation, and potentially additional ground treatment/support.

Suggestions: Design and constructability reviews during final design may consider the following:

- a) A trade-off study could be conducted to evaluate the cost-effectiveness of tunneling under any utility banks etc.
- b) Given the weakness of the material it is suggested that the bulk excavation and sidewalls could be formed using large pieces of trenching equipment

7 – Are adequate safety considerations being addressed?

Safety issues were discussed during the Review. The unconventional nature of some of the construction work associated with these “conventional facilities” warrants particular attention throughout the design and construction period.

Suggestions: The Committee draws the attention of the design team to the following considerations:

- a) Quartz/Asbestos minerals are present in the host rock – the roadheader may create fine dusts that can enter the respiratory system - the Project and designer must make sure that all appropriate safety and health provisions are placed in the contract and enforced during construction
- b) Temporary and final tunnel support structures will need to be analyzed for stability under earthquake loading to ensure that they will perform to required SLAC standards.
- c) Comprehensive Environmental, Safety and Health reviews should be scheduled as integral parts of the Title II design process.
- d) Access to a safety person with firsthand experience in the construction of underground facilities, preferably familiar with working under Cal.OSHA, would be highly beneficial.