

# California High-Speed Train Project



## TECHNICAL MEMORANDUM

### Development of Design Earthquake Ground Motions for 30% Design TAP Recommendations TM 200.01

Prepared by: Signed document on file 07 October 10  
Vince Jacob, PE Date

Checked by: Signed document on file 12 February 11  
John Chirco, PE, Infrastructure Manager Date

Approved by: Signed document on file 15 February 11  
Ken Jong, PE, Engineering Manager Date

Released by: Signed document on file 17 February 11  
Hans Van Winkle, Program Director Date

Reviewed by: Signed document on file 02 March 11  
Kent Riffey, Chief Engineer Date

Reviewed by: Signed document on file 07 March 11  
Roelof Van Ark, Chief Executive Officer Date

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Prepared by The logo consists of the letters 'PB' in a bold, italicized font. Below 'PB' is the word 'YEARS' in a smaller, all-caps font, with horizontal lines extending from the sides of 'PB' to meet the ends of 'YEARS'.

for the California High-Speed Rail Authority

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## ABSTRACT

This technical memorandum presents the benefits of having a single entity develop the design earthquake ground motions for use in the design of high-speed train structures.

The Regional Consultant teams were originally scoped to develop the ground motions for their respective segments for use in the structure designs. This method for developing ground motions was consistent with the Program's overall approach to delegate as much of the preliminary engineering effort as practical to the regional teams in order to distribute the program workload as required to balance schedule priorities with the available budget. Since the development of ground motions require region-specific information and considering the magnitude of the program, it was determined that a distributed effort could succeed with oversight by the Program Management Team (PMT). The PMT issued guidelines for the Regional Consultants to develop the ground motions for their respective region in a consistent manner.

The project's Technical Advisory Panel (TAP) subsequently recommended the use of a single entity to develop statewide ground motions that would be reviewed by the TAP to ensure consistency and quality. Development by a single entity reduces the program design risk because ground motions are developed by a single source, working with a single quality control methodology, and working directly with the TAP. Following TAP review, 30% ground motions would be available for use by the Regional Consultant teams for preliminary engineering.



## 1.0 INTRODUCTION

### 1.1 PURPOSE OF TECHNICAL MEMORANDUM

This memorandum presents the approach to the development of the design earthquake ground motions for use in the 30% design of high-speed train infrastructure. This approach was developed to be consistent with the recommendation of the Technical Advisory Panel (TAP) that the earthquake ground motions be developed by a single entity.

## 2.0 DEFINITION OF TECHNICAL TOPIC

The Regional Consultant teams (RC) were originally scoped to develop the ground motions for their respective segments for use in the structure designs. This method for developing ground motions was consistent with the Program's overall approach to delegate as much of the preliminary engineering effort as practical to the regional teams in order to distribute the program workload as required to balance schedule priorities with the available budget. Since the development of ground motions require region-specific information and considering the magnitude of the program, it was determined that a distributed effort could succeed with oversight by the Program Management Team (PMT). The PMT issued guidelines for the Regional Consultants to develop the ground motions for their respective region in a consistent manner.

The project's Technical Advisory Panel subsequently recommended the use of a single entity to develop statewide ground motions that would be reviewed by the TAP to ensure consistency and quality. Development by a single entity reduces the program design risk because ground motions are developed by a single source, working with a single quality control methodology, and working directly with the TAP. Following TAP review, 30% ground motions would be available for use by the Regional Consultant teams for preliminary engineering.

## 3.0 ASSESSMENT / ANALYSIS

### 3.1 ALTERNATE APPROACHES CONSIDERED

Several organizational structures were considered for a development of design earthquake ground motions, including:

**ORG 1:** **Program Management Team.** PMT staff would use in-house technical expertise and resources to prepare the statewide ground motions. Budget would need to be transferred to the PMT from the regional teams to accommodate the increase in the PMT work scope for ground motion development.

**ORG 2:** **PMT Led Consultant Team.** Convene a team led by the PMT which includes selected RC staff to generate ground motions using a consistent methodology. Program Management and Regional Consultant teams currently employ individuals with the expertise and credentials to complete this work and all are under contract



with the Authority. The Regional Consultant would commit selected individual(s) for several months to support the effort to develop statewide ground motions. Regional Consultants are already under contract, scoped and budgeted to complete this work.

- ORG 3:** **Independent (third party) Team.** Contract with an established entity, such as United States Geologic Survey (USGS), Pacific Earthquake Engineering (PEER) Center, California Geologic Survey (CGS). These entities have or can convene qualified professionals capable of independently developing the ground motions, although may not have a proven track record for large efforts such as a statewide ground motions and delivering these under constrained project schedules and budgets.

### **3.2 RISK/LIABILITY CONSIDERATIONS**

The professional liability associated with the work varies depending on the organizational structure as noted below.

- ORG 1:** PB will assume liability since the PMT subconsultants are under contract to PB. Consideration could be given to convene a ground motion peer review team for oversight and review of the work effort.

- ORG 2:** The PMT will assume the liability since the PMT will act as the lead and is directing all work performed by the Regional Consultants. Additionally, the Authority is not expected to extend the current Regional Consultant contracts beyond the 30% design phase.

While not a liability related issue, where Regional Consultant Teams are providing structural design support to successful bidders, there may be unanimity on the seismic design approach which can benefit the program. This benefit is not easily quantifiable but is deemed likely given the limited qualified staff to perform this specialized work.

- ORG 3:** The Authority or their consultant will take on the liability, dependent upon how the third party entity is procured.

### **3.3 SINGLE ENTITY APPROACH**

A single entity approach to producing ground motions for the entire program is commonly used for projects that encompass large geographical areas. The benefit is especially realized where the interface between different segments would have produced inconsistencies.

This approach is consistent with the recommendation of the TAP that the earthquake ground motions be developed by a single entity. Although it is possible that the program would benefit from cost and schedule efficiencies associated with development by a single entity, these efficiencies have not been quantified. However, most concur that quality is expected to benefit. This



increased quality could also provide a cost and schedule savings but is difficult to estimate.

The TAP has recommended their involvement in review of the ground motions. As the TAP is not currently scoped to perform this review, a redistribution of budget between PMT and Regional Consultants may be appropriate to fund the additional TAP involvement.

### **3.4 PROPOSED PHASING OF GROUND MOTION DEVELOPMENT**

A single entity approach would employ a two-stage, iterative process; first developing the interim ground motions required to support 30% design, followed by the refinement of the ground motions required for final design based on new soil data.

Furthermore, the ground motions for the 30% Design will be phased to facilitate the advancement of the prioritized geographical sections and to work within the FY10-11 budget. The 30% Design phases are described below.

**Phase 1.** Develop ground motions for three prioritized geographic sections since this information is required to perform the seismic design of structures in the latter part of this FY. The segments for Phase 1 include:

- Merced-Fresno
- Fresno-Bakersfield
- San Jose-Merced

**Phase 2.** Develop ground motions for the remaining four (4) regional sections. The design ground motions to be used for the final design will be developed after FY10-11.

The intent of this approach is that the PMT will be solely responsible and lead this effort resulting in uniform and consistent ground motions. The scope of work includes development of design response spectra for each geographic segment for two levels of earthquakes and an associated seven sets (each set containing two horizontal and one vertical) of ground motion time histories for each response spectra.

For ORG 2, the design response spectra will be developed by the PMT. Ground motion time-histories will be developed by RDT personnel under the supervision of the PMT. Results will be presented in a Preliminary Ground Motions Report. These results will be reviewed by the Technical Advisory Panel and will be finalized to incorporate their input, as appropriate. The results will be presented to the RDTs through a Preliminary Ground Motions Workshop.

Preparation of the Phase 1 seismic design spectra for preliminary design for three prioritized sections will take 17 weeks. The time histories for preliminary design for three prioritized sections are estimated to require 26 weeks for preparation and TAP review.



## 4.0 SUMMARY AND RECOMMENDATIONS

### 4.1 RECOMMENDATION

It is recommended that a PMT-led consultant team (ORG 2) be implemented consistent with the TAP recommendation that a “single entity” prepare the ground motions. With the PMT providing direct management of the effort and establishing a core team to progress the seismic design criteria into final design, this approach will meet the intent of the TAP recommendation and address the consistency and quality concerns.

This approach utilizes expertise and budget within the Regional Consultant teams allocated for this effort in FY 09/10. The total cost for the first phase to support 30% Design is estimated at roughly \$400,000 to \$500,000. It is expected that the budget would be split equally between the PMT and RC staff. Originally, the PMT was anticipated to provide oversight which is estimated at 10% or \$50,000. The increase in effort by PMT staff of approximately \$200,000 can be offset by deferral of scope to FY 10/11, so as to be budget neutral. The deferred scope would need to be that which does not adversely affect the overall program schedule and priorities, and would be as agreed with the Authority.

## 5.0 SOURCE INFORMATION AND REFERENCES

None Applicable



## 6.0 DESIGN MANUAL CRITERIA

None Applicable

