

**STAFF REPORT FOR CALENDAR ITEM NO.: 6  
FOR THE MEETING OF: June 13, 2019**

**TRANSBAY JOINT POWERS AUTHORITY**

**BRIEF DESCRIPTION:**

This report is a summary of the events, analyses, findings, and signoff related to the fissures found on September 25, 2018, in two steel girders over Fremont street and their repair. In addition, it addresses the review and conclusions related to 1) the similarly designed girders located at First Street (which did not experience fissures), and 2) the comprehensive building-wide review effort undertaken of both structural steel and non-structural steel elements. Based on the completion of work and conclusions of the independent peer review panel, the transit center is being readied for re-activation by July 1, 2019.

**REPORT:**

**Key Entities**

The Fremont Street girders, and girders with the same structural design over First Street, were fabricated as part of Trade Group 7.1R Structural Steel Superstructure, which was awarded to Skanska USA Civil West California District Inc. (Skanska) in July 2013, with Webcor Obayashi Joint Venture (WOJV) as the Construction Manager/General Contractor (CM/GC). Skanska utilized four steel fabricators for the work under the trade group package: Herrick Steel, Oregon Ironworks, Thompson Metal Fabricators, and XKT as a second tier subcontractor to Herrick. The girders over Fremont and First streets were fabricated by Herrick Steel. Construction Management Oversight (CMO) for the project was performed by Turner Construction with special inspections provided by Inspection Services, Inc.

The engineer-of-record for the transit center is Thornton Tomasetti (TT), a subconsultant to the facility's lead architect Pelli Clarke Pelli Architects. TT is also the lead entity that engineered the shoring and repairs for the affected girders over Fremont Street with input from project team experts.

The Metropolitan Transportation Commission (MTC) was asked by San Francisco Mayor London Breed and Oakland Mayor Libby Schaaf to initiate an independent peer review of the cause and repair of the affected girders. MTC assembled a panel of nationally recognized experts in steel structures, fracture mechanics, and metallurgy. The panel is referred to as the Peer Review Panel (PRP).

The TJPA retained LPI, Inc., an independent lab in New York, to perform sampling, testing, and analyses to determine the cause of the fissures in the girders over Fremont street, and explain why the two girders of similar structural design over First Street were at a lower risk of brittle fracture. The project team (including WOJV, Skanska, and Herrick) and the PRP concurred with the selection of LPI.

The TJPA continued to utilize Inspection Services, Inc., as the testing lab for welding non-destructive testing at various stages of this review and repair, similar to their role during the construction phase of the Transit Center Project under Turner, the CMO.

### **Fissure Discovery, Assessment and Repair**

On September 25, 2018, two steel girders on the bus deck level of the transit center above Fremont street were found to have fissures. The discovery prompted the TJPA to immediately temporarily close the facility as a precaution. The facility has remainder closed pending completion of the independent review discussed below.

An initial temporary support system was installed within days after the closure for Fremont and First streets that involved the use of very large hydraulic jacks placed at street level (Bigge Crane & Rigging and Sheedy Drayage).

On October 4, 2018, Mayors Breed and Schaaf requested that MTC lead an effort to create an independent peer review of “the cause of the cracked beams and the plans to make repairs” (Attachment A). MTC responded that the PRP’s review would be expeditious but independent and thorough, “to insure [the Mayors] and the public may have confidence in the repair,” and so the transit center can return to normal operation (Attachment B). The PRP’s scope of work was initially defined as:

- Task 1: Review and comment on the Temporary Shoring System
- Task 2: Review and comment on the proposed sampling & testing plan
- Task 3: Review and comment on cause of the fissures at two girders
- Task 4: Review and comment on the Permanent Reinforcement Fix
- Task 5: Other reviews as needed and determined by Project Manager and in consultation with TJPA regarding priorities and available budget (Attachment C)

The PRP scope was refined into five stages:

- Stage 1: Load capacity of the temporary shoring system
- Stage 2: Sampling and testing plan for the material from the fractured steel girders
- Stage 3: Cause of failure, as informed by the material test results and design analysis
- Stage 4: Current condition of structural elements directly affected by the steel fractures
- Stage 5: Repair solution, as informed by the cause of failure and current condition (refer to Attachment B)

Subsequent to the initial temporary support system that was installed, a robust temporary shoring system was designed by TT for both Fremont and First streets with an oversight review by AECOM (Attachment D). Although no fissures were identified on the girders over First Street, out of an abundance of caution and based on the recommendation of the project team, a similar temporary shoring system was installed at First Street. The PRP reviewed and concurred with the designs of the temporary shoring systems at both Fremont and First streets (Attachment E).

In October 2018, LPI was retained by the TJPA, with the concurrence of the project team (including WOJV, Skanska, and Herrick) and the PRP, to perform a root cause assessment of the girder fractures. LPI was chosen by the TJPA to be independent of any design or construction entity and to develop the procedures necessary to retrieve samples from the girders with the fissures, develop a proposed list of tests to be performed, perform the analysis on the test data, and provide the “causation of failure” report based on the analysis. The PRP concurred with this procedure (Attachment F and Attachment B). The effort commenced with the removal and testing of samples by the end of November 2018.

In December 2018, LPI released its preliminary findings regarding the cause of the fissures in the two girders over Fremont Street, and an explanation as to why two similar girders over First Street were at lower risk of brittle fracture (refer to Attachment B and LPI’s Board presentation at [https://tjpa.org/uploads/2018/12/Item9\\_MTC-Peer-Review-Panel-LPI-TT-presentation.pdf](https://tjpa.org/uploads/2018/12/Item9_MTC-Peer-Review-Panel-LPI-TT-presentation.pdf)). At that time, the PRP generally concurred with the preliminary findings that the fractures were caused by the combination of specific material properties, existence of an initiating crack, and stress in the girders, and noted that review was on-going to validate the initial hypothesis and provide further detail on the relative influence of the contributing. The PRP subsequently confirmed its concurrence, with MTC noting the “broad consensus among the [PRP] and TJPA consultants on [the] conditions that caused the fractures” (refer to Attachment B). LPI is still finalizing its final report on causation, which will include input from the PRP and various project team experts. This report will be provided when complete.

In parallel, while utilizing the data from LPI’s preliminary investigative effort, TT developed a proposed design of the final repair to be installed at the Fremont Street location and a reinforcement design for the First Street location (refer to TT’s Board presentation at [https://tjpa.org/uploads/2018/12/Item9\\_MTC-Peer-Review-Panel-LPI-TT-presentation.pdf](https://tjpa.org/uploads/2018/12/Item9_MTC-Peer-Review-Panel-LPI-TT-presentation.pdf)). This repair design strategy was the outcome of a charette that included many contractor experts and TT, who created a matrix of options. The final repair design, which was determined to be the most effective and appropriate design, uses two plates sandwiched on either side of the fractured surface of each girder’s bottom flange utilizing a bolted connection (Attachment G). TT (and the project team) submitted their recommended designs to the PRP and received their concurrence (Attachment H and Attachment B). Among other things, the PRP concurred that enough similarities exist between the condition of the girders over Fremont and First streets to support application of the reinforcement to the First Street location although there were no fissures at that location (refer to Attachments B and H). San Francisco’s Department of Building Inspection was also engaged to review the design plans to ensure compliance to code (Attachment I). Shortly thereafter, procurement of the materials for the approved repairs and reinforcement commenced.

In March 2019, the repair and reinforcement efforts began onsite as the procured steel plates for the repair arrived. As each location was installed, TT, as the engineer-of-record of the repair design, reviewed and provided a letter of compliance (Attachments J and K). DBI found the structural construction documents for the girder repair at Fremont Street and girder retrofit at First Street to be in general conformance with the applicable building code (refer to Attachment I). During the last weeks of April 2019, as each location was signed off, the temporary shoring systems were removed and the traffic striping was restored to its original alignment. The final repair was completed at Fremont Street on April 19, and First Street was completed on April 27.

### **Efforts to Re-Confirm Integrity of the Facility**

The PRP recommended a search through construction documents for other locations at the facility that might have the same combination of factors that contributed to the girder fractures (refer to Attachment B). The PRP had a choice to hire an independent designer to lead the building-wide review for areas susceptible to brittle fracture, but the PRP determined that the most efficient entity to lead this review was the engineer-of-record, TT, with oversight from the PRP and their supplemental staff of experts hired as consultants to assist the panel. Therefore, the TJPA project team initiated the search starting in January 2019, with TT as the lead. TT developed a list of locations susceptible to fracture, which focused the review on examining existing project records and performing visual inspections. An evaluation process was developed that included (1) evaluation criteria, (2) design and fabrication details, (3) construction submittals, (4) quality assurance and quality control documentation, (5) onsite visual examinations and testing, and (6) correction action plans (if necessary) (Attachment L). The PRP agreed with the process and provided input to the criteria (refer to Attachment B). An exhaustive review of over 15,000 shop drawings and specific fabricator piece drawings was performed in conjunction with various field inspections to affirm the site conditions. TT provided milestone updates to the PRP with the effort culminating in May 2019 and the resolution noted at the end of this discussion.

In a parallel but separate effort from the PRP, the TJPA revisited the original design by engaging and re-activating two members of the original Structural and Seismic Review Committee (SSRC) who peer-reviewed the design during the original design development phase. The SSRC originally formed in November 2008 to provide guidance on the transit center structural engineer's design assumptions (Attachment M). Over a six-year period, the SSRC reviewed the structural basis of design and various drawings and calculations, culminating with its recommendation to DBI that a building permit be issued for the below-grade portion of the structure (October 2012) and the above-grade structural portion of the project (April 2014), which DBI issued (Attachment N and Attachment O). Two of the SSRC members reviewed the recent information related to the Fremont Street girders, then presented their findings at the January 2019 TJPA Board meeting ([https://tjpa.org/uploads/2019/01/Item10\\_SSRC-Presentation-1-10-19.pdf](https://tjpa.org/uploads/2019/01/Item10_SSRC-Presentation-1-10-19.pdf)). Their presentation concluded that the SSRC's review was thorough, the design concept is sound as originally determined, the design is conservative, construction permits were issued based on the SSRC's recommendation, and the design meets or exceeds applicable codes and standards.

Also in a parallel but separate effort from the PRP, the TJPA engaged in a facility-wide validation effort of the non-structural steel elements. This validation effort included (1) reviewing test and inspection records to confirm that the structural concrete, piles, bolts, and other elements placed in the transit center meet or exceed the design specifications, (2) commissioning the building management systems, and (3) revalidating full fire and life safety systems. The CMO, Turner, presented their findings at the March 2019 TJPA Board meeting and May 2019 AC Transit Board meeting (Attachment P and Turner's Board presentation at [https://tjpa.org/uploads/2019/03/Item6\\_Construction-temp-closure-Update-3-14-19.pdf](https://tjpa.org/uploads/2019/03/Item6_Construction-temp-closure-Update-3-14-19.pdf)). Turner summarized that between 2011 and 2018 there had been approximately three million individual quality assurance inspections and observations for the Transbay Program, both on- and offsite, of all components of the project, including soils, concrete, reinforcing steel, structural steel,

fireproofing, and building systems. On re-review, Turner confirmed throughout this exercise that there were no issues identified related to non-structural steel elements of the transit center.

During the month of May 2019, the building-wide review culminated with a comprehensive 12+ hour presentation over multiple days to the PRP on all the findings and supporting evidence. During this presentation, there was enough supporting documentation and onsite evidence with verification submitted to close the majority of the issues. With some additional investigation on a few items, the remaining issues were closed in early June. The PRP subsequently provided their concurrence with TT's determination that the building-wide concerns had been satisfied.

### **Conclusion**

In conclusion to the efforts over the last 8+ months, TT has issued a letter regarding the structural integrity of the building (Attachment Q). With receipt of that letter, the PRP issued its concurrence letter to the MTC (Attachment R). Both letters were compiled and sent to the Mayors via the MTC on June 10, 2019 (Attachment S). MTC and the PRP concur with the determination to reopen the transit center. In conjunction with the significant effort to validate the structural steel integrity, the non-structural steel elements have also been verified facility-wide (refer to Attachment P).

Based on all of the above, the transit center is scheduled to re-open on July 1, 2019. Transit center staff are working diligently to re-activate the center with the proper staffing required.

### **RECOMMENDATION:**

For information only.

### **RELATED ATTACHMENTS:**

- a. Mayors London Breed and Libby Schaaf October 4, 2018 letter to the MTC
- b. Various MTC letters to the Mayors (October 2018 to April 2019)
- c. Cooperative Agreement between the MTC and TJPA
- d. AECOM correspondence regarding shoring at First and Fremont streets, TT letter regarding shoring installation at Fremont street, TT letter regarding shoring installation at First Street
- e. PRP concurrence letter regarding the shoring at Fremont Street at First Street
- f. PRP concurrence letter for LPI's sampling and testing plan
- g. Two plate design strategy
- h. PRP acceptance of the repair design at Fremont Street and the remediation design at First Street
- i. SFDBI review and code compliance letter for design of First Street and Fremont Street repair/remediation
- j. TT letter regarding the conformance of the repair at Fremont Street allowing shoring removal
- k. TT letter regarding the conformance of the remediation at First Street allowing shoring removal
- l. Graphic showing facility-wide validation process

- m. TIPA memo outlining the SSRC scope of work
- n. SSRC (Degenkolb) design review letter
- o. SFDBI approval letter regarding transit center design
- p. Board staff report regarding QA/QC program
- q. TT letter regarding sound structural framing and re-activation of the transit center
- r. PRP concurrence letter to the MTC regarding sound structural framing and re-activation of the transit center
- s. MTC letter to the Mayors stating support for reopening the transit center based on the project team's structural findings and the PRP's concurrence

## Attachment A



October 4<sup>th</sup>, 2018

Mr. Steve Heminger  
Executive Director  
Metropolitan Transportation Commission  
Bay Area Metro Center  
375 Beale Street  
San Francisco, CA 94105

Dear Executive Director Heminger,

We write you today to express our continued concern over the situation at the Transbay Transit Center and to call on your agency to assist in evaluating the cause of the cracked beams and the plans to make repairs.

The Transbay Transit Center provides a crucial transportation link between our two cities. Once high-speed rail and Caltrain are brought to the terminal, it will be the transportation hub for our entire region. The Transit Center is too important to the future and the people of the Bay Area for there to be any uncertainty around its structural soundness.

There are many questions about what might have caused the beams to crack, who might be responsible, and how the beams will be repaired so that the Transit Center can reopen to the public. These questions must be answered quickly and the public needs to trust the answers.

We understand that the Transbay Joint Powers Authority (TJPA) is conducting its own analysis on the failures in order to develop a plan to make necessary repairs and we encourage that process to continue expeditiously. But we also believe that it is critical to the constituents of our cities and our region that there be confidence in the findings of that analysis. We believe that the only way to ensure this public confidence is by engaging an outside firm to review and verify any findings, and for this peer review to be managed by and produced for the Metropolitan Transportation Commission.

We respectfully urge the MTC to engage an outside firm as quickly as possible so that we can get down to the bottom of what happened with these beams, feel confident that the problem is isolated, and make the necessary repairs so that the Transbay Transit Center can serve the people of the Bay Area once again.

Sincerely,

A handwritten signature in black ink that reads "London N. Breed".

London N. Breed  
Mayor, City and County of San Francisco

A handwritten signature in black ink that reads "Libby Schaaf".

Libby Schaaf  
Mayor, City of Oakland



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October 10, 2018

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The Honorable London N. Breed  
Mayor, City and County of San Francisco  
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The Honorable Libby Schaaf  
Mayor, City of Oakland  
City Hall  
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Oakland, CA 94612

RE: Transbay Transit Center Peer Review

Dear Mayor Breed and Mayor Schaaf:

Thank you for your letter of October 4<sup>th</sup> about the current closure of the new Transbay Transit Center. At your request, we have initiated an independent peer review of "the cause of the cracked beams and the plans to make repairs." Our review will be expeditious, but it will be thorough. The owner/operator of the facility – the Transbay Joint Powers Authority (TJPA) – has assured us of its full cooperation with the inquiry.

We have assembled a nationally-recognized panel with expertise in steel structures, fracture mechanics, and metallurgy. We have confirmed participation from the six individuals listed below:

- Michael D. Engelhardt Ph.D., P.E. Professor, Department of Civil, Architectural and Environmental Engineering at the University of Texas at Austin and Director of the Ferguson Structural Engineering Laboratory (Chair)
- Ewa Z. Bauer-Furbush, P.E. District Engineer at Golden Gate Bridge, Highway and Transportation District
- John W. Fisher, PhD. Professor Emeritus of Civil Engineering at Lehigh University and director emeritus of the ATLSS Engineering Research Center
- Brian Kozy, PhD., P.E., Principal Engineer at the Federal Highway Administration
- Thomas A. Sabol, Ph.D., S.E. Principal at Englekirk Structural Engineers and an Adjunct Professor of the Civil and Environmental Engineering Department at UCLA

Mayor Breed and Mayor Schaaf  
Page 2 of 2  
October 10, 2018

- Robert E. Shaw, Jr., P.E., President of the Steel Structures Technology Center and member of the D1 Structural Welding Committee at the American Welding Society

Over the course of the panel's work, we will ensure that you receive regular updates. The panel will produce a final report for presentation to the Metropolitan Transportation Commission and TJPA. Please do not hesitate to contact me with any questions or concerns in the weeks ahead.

Sincerely,  
  
Steve Heminger  
Executive Director

cc:  
Jake MacKenzie, Chair, Metropolitan Transportation Commission  
Mohammad Nuru, Chair, Transbay Joint Powers Authority

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# Attachment B - 2



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November 7, 2018

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*Bridget Paul*  
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The Honorable Libby Schaff  
Mayor, City of Oakland  
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Oakland, CA 94612

RE: Transbay Transit Center Peer Review

Dear Mayor Breed and Mayor Schaff:

We write to you to provide the second update on the scope and progress of the work of the peer review by the expert panel assembled by MTC. On October 4<sup>th</sup>, we wrote that our panel would review "the cause of the cracked beams and the plans to make repairs."

Working with the full cooperation of the Transbay Joint Powers Authority (TJPA), we have divided the review into the following five stages:

1. Load capacity of the temporary shoring system.
2. Sampling and testing plan for the material from the fractured steel girders.
3. Cause of failure, as informed by the material test results and design analysis.
4. Current condition of structural elements directly affected by the steel fractures.
5. Repair solution, as informed by the cause of failure and current condition.

TJPA's consultants, contractors, and subject matter experts will develop the material for each of the above stages, which TJPA will provide to MTC's five-person peer review panel<sup>1</sup>. MTC's panel will provide an expeditious but thorough independent review to insure you and the public may have confidence in the repair, and so the Transbay Transit Center can return to normal operation.

MTC's panel is currently reviewing material from the first two stages. It has reviewed the shoring at Fremont Street to insure its stability during the sampling of material from the fractured girders. The panel has also reviewed and takes no exception with the TJPA's current sampling and testing plan. Material samples have been removed and shipped to a materials testing laboratory in New York City where the samples are in the process of being machined for testing.

<sup>1</sup> The five panelists include: Michael D. Engelhardt, Ph.D., P.E.; John W. Fisher, Ph.D.; Brian Kozy, Ph.D., P.E.; Thomas A. Sabol, Ph.D., S.E.; and Robert E. Shaw, P.E. On October 26, Ewa Z. Bauer-Furbush, P.E. stepped down from her role on the panel due to the time demands from her commitments as District Engineer for the Golden Gate Bridge.

Mayor Breed and Mayor Schaaf  
Page 2 of 2  
November 7, 2018

We will continue to keep you updated on the progress of this work. Please do not hesitate to contact me with any questions or concerns in the meantime.

Sincerely,



Steve Heminger  
Executive Director

cc:

Jake MacKenzie, Chair, Metropolitan Transportation Commission  
Mohammad Nuru, Chair, Transbay Joint Powers Authority  
Mark Zabaneh, Executive Director Transbay Joint Powers Authority  
Michael Engelhardt, Ph.D., Chair, Peer Review Panel

## Attachment B - 3



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December 13, 2018

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The Honorable Libby Schaaf  
Mayor, City of Oakland  
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RE: Transbay Transit Center Peer Review

Dear Mayor Breed and Mayor Schaaf:

We write you to provide the third update on the scope and progress of the work of the Peer Review Panel (PRP) assembled by MTC to review the cause and repair of fractured girders at the Transbay Transit Center.

In our November 7<sup>th</sup> letter to you, we defined the phases of the review as follows:

1. Load capacity of the temporary shoring system.
2. Sampling and testing plan for the material from the fractured steel girders.
3. Cause of failure, as informed by the material test results and design analysis.
4. Current condition of structural elements directly impacted by the steel fractures.
5. Repair solution, as informed by the cause of failure and current condition.

The PRP has been engaged with the TJPA and its consultants as the latter have developed analyses on the cause of failure and the repair. The TJPA will present these findings at its board meeting on December 13.

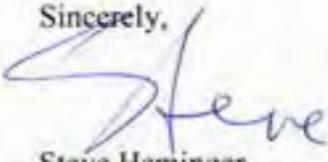
TJPA's consultant, LPI, Inc, is leading the analysis of the cause of failure of the two girders over Fremont Street. LPI has developed a fracture hypothesis based on studies completed to-date and supported by available evidence. LPI's findings also provide an explanation as to why the two similar girders over First Street were at a lower risk of brittle fracture.

TJPA's engineer of record, Thornton Tomasetti, has considered several ways to repair the fractured girders over Fremont, and is converging on a preferred design. The design team is still considering how to address the girders on First Street.

Mayor Breed and Mayor Schaaf  
Page 2 of 2  
December 13, 2018

The PRP met with TJPA and its consultants several times over the last two months as these analyses progressed, and provided feedback along the way. Review is ongoing, but the PRP is satisfied with the general level of progress being made in understanding the root causes of the fractured beams over Fremont Street. The PRP will also evaluate whether it recommends TJPA perform additional analyses to those already identified.

As progress is made, we will continue to keep you updated. Please do not hesitate to contact me with any questions or concerns in the meantime.

Sincerely,  
  
Steve Heminger  
Executive Director

Cc:  
Jake MacKenzie, Chair, Metropolitan Transportation Commission  
Mohammad Nuru, Chair, Transbay Joint Powers Authority  
Mark Zabaneh, Executive Director Transbay Joint Powers Authority  
Ramakrishna Pochiraju, P.E. Executive Director of Planning & Engineering, AC Transit

# Attachment B - 4



MEMORANDUM  
TRANSPORTATION  
COUNCIL

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February 8, 2019

*John McWhorter, Esq.*  
Yuma County and Cities

*Scott Haggerty, Vice Chair*  
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Deputy Executive Director, Operations

*Brend Pined*  
Deputy Executive Director,  
Local Communities Agency

The Honorable London N. Breed  
Mayor, City of San Francisco  
City Hall  
1 Dr. Carlton B. Goodlett Place  
San Francisco, CA 94102

The Honorable Libby Schaaf  
Mayor, City of Oakland  
City Hall  
1 Frank H. Ogawa Plaza  
Oakland, CA 94612

RE: Transbay Transit Center Peer Review

Dear Mayor Breed and Mayor Schaaf:

I write you to provide the fourth update on the scope and progress of the work of the Peer Review Panel (PRP) assembled by MTC to review the cause and repair of fractured girders at the Transbay Transit Center.

The scope and status of the following reviews is summarized below:

1. Shoring capacity: Complete
2. Sampling and testing plan: Complete
3. Cause of failure: In progress
4. Other areas impacted by the steel fractures: In progress
5. Repair solution: In progress

The PRP concurs with the initial hypothesis on the cause of failure as based on the analysis of material test results: that the fractures were caused by the combination of specific material properties, existence of an initiating crack, and stress in the girder. LPI, Inc., a consultant of the Transbay Joint Powers Authority (TJPA), is currently performing finite element and fracture mechanics analyses to validate the initial hypothesis and provide further detail on the relative influence of the contributing factors.

TJPA's engineer of record, Thornton Tomasetti, has developed a repair that bolts new plates across the fractured surfaces of the two girders over Fremont Street. In addition, enough similarities exist between the condition of those girders and two girders over First Street that the TJPA plans to retrofit the First Street girders in a similar manner. The PRP concurs with this plan and with LPI and Thornton Tomasetti's assessment that the cause of failure is understood with enough certainty to proceed with the repairs. TJPA has ordered the materials and expects to receive them on site by March.

The PRP recommended and the TJPA project team has initiated a search through construction documents for other locations at the facility that might have the same combination of factors that contributed to the girder fractures. Thornton Tomasetti will

Mayor Breed and Mayor Schaaf

Page 2 of 2

February 8, 2018

develop a list of such locations susceptible to fracture, if they exist, and will then review existing project records and conduct visual inspections, if necessary, to determine if any additional repairs are needed. The PRP will review updates on this progress and provide recommendations. After the review of documents is complete and a list of susceptible locations identified, we expect TJPA will be better able to project when the Transit Center will reopen for public use.

As progress is made, we will continue to keep you updated. Please do not hesitate to contact me with any questions or concerns in the meantime.

Sincerely,



Steve Heminger  
Executive Director

Cc:

Jake MacKenzie, Chair, Metropolitan Transportation Commission

Mohammad Nuru, Chair, Transbay Joint Powers Authority

Mark Zabaneh, Executive Director Transbay Joint Powers Authority

Ramakrishna Pochiraju, P.E. Executive Director of Planning & Engineering, AC Transit



METROPOLITAN  
TRANSPORTATION  
COMMISSION

Bay Area Metro Comm  
115 Beale Street, Suite 800  
San Francisco, CA 94111  
415.778.6700  
www.mtc.ca.gov

April 3, 2019

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San Francisco

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*Brad Paul*  
Alameda County, Director, Operations

The Honorable London N. Breed  
Mayor, City of San Francisco  
City Hall  
1 Dr. Carlton B. Goodlett Place  
San Francisco, CA 94102

The Honorable Libby Schauf  
Mayor, City of Oakland  
City Hall  
1 Frank H. Ogawa Plaza  
Oakland, CA 94612

RE: Transbay Transit Center Peer Review

Dear Mayor Breed and Mayor Schauf:

I write you to provide an update on the progress of the expert panel assembled by MTC to review the cause and repair of fractured girders at the Transbay Transit Center. I also want to clarify the scope of this panel's findings to date and expectations for future findings and recommendations.

In response to your October 4, 2018 letter, MTC selected a panel of experts, the Peer Review Panel, to provide an independent review of the cause of failure analysis and repair design so that you and the public may have a high level of confidence that the girders are structurally safe once the Transit Center reopens to the public. The Peer Review Panel is comprised of experts in the fields of structural steel design, fracture mechanics, and steel construction for this purpose. Dr. Michael Engelhardt, a professor of civil engineering at the University of Texas at Austin, chairs this panel.

The Peer Review Panel has reviewed analyses performed by consultants under contract with the Transbay Joint Powers Authority (TJPA) that: identify the conditions present in the steel girders that contributed to the fractures; and inform the repair design. The progress of the peer review is outlined in the attachment. There is broad consensus among the Peer Review Panel and TJPA consultants on these conditions that caused the fractures. There is also agreement on the design of the girder repair at Fremont Street and retrofit at First Street.

The TJPA staff recently announced it believes the steel subcontractor is the party responsible for the fracture based on a series of decisions and actions associated with fabrication of the holes cut in the flanges of the girders. This statement reflects TJPA's interpretation of code and contractual terms and responsibilities. Note that the Peer Review Panel was not asked to and does not intend to address this line of inquiry concerning which parties were responsible for the fractures, and whether the work was in compliance with code or contract provisions.

The Peer Review Panel will continue with its directive to understand the failure mechanism and ensure the repairs are appropriate. At the present time, the repair and retrofit are being installed. Concurrently, TJPA staff is searching through records and performing new inspections as necessary to determine if there are other locations susceptible to brittle

Mayor Breed and Mayor Schaaf  
Page 2 of 2  
April 3, 2019

fracture, and whether any additional retrofits are required. The Peer Review Panel has concurred with the criteria being used for this search and will review the results.

In addition, MTC has asked the Peer Review Panel, as it completes its work, to comment on lessons learned from this incident. These will likely take the form of rather broad recommendations on issues this panel believes should be considered by the industry to help avoid this type of failure in the future.

Thank you for your continued support and concern for the safety of our transit riding public. We will continue to keep you updated as progress is made. Please do not hesitate to contact me with any questions or concerns in the meantime.

Sincerely,



Therese W. McMillan  
Executive Director

cc:

Scott Haggerty, Chair, Metropolitan Transportation Commission  
Michael Engelhardt, Chair, Peer Review Panel  
Mohammad Nuru, Chair, Transbay Joint Powers Authority  
Mark Zabaneh, Executive Director, Transbay Joint Powers Authority  
Ramakrishna Pochiraju, Executive Director of Planning & Engineering, AC Transit

TM:SW

F:\SECTION\EXEC\EXE\Therese McMillan\Correspondence-2019\Breed\_Schaaf\_McMillan\_Transbay Transit Center Peer Review\_20190403.docx

Attachments

## Schedule

### Milestones to Date:

- August 12, 2018: Transit Center opens for bus operations.
- September 25, 2018: Workers installing ceiling panels discover a fracture in the bottom flange of a girder over Fremont (see Images 1-3 on page 3). TJPA closes the Transit Center. In the following days, TJPA discovers a fracture in a second similarly designed girder over Fremont Street. Two other girders over First Street share the design of the fractured girders but remain intact. TJPA installs shoring at Fremont and First Street.
- October 4, 2018: The mayors of Oakland and San Francisco write a letter to MTC requesting MTC provide an independent evaluation of the cause of failure and repair. Subsequently, MTC assembles a Peer Review Panel (PRP) consisting of experts in steel design and construction, structural analysis, and fracture mechanics.
- December 13, 2018: TJPA presents to its board the failure hypothesis based on materials analysis and the preliminary design for the repair. PRP concurs.
- January 2019: TJPA begins search for other areas susceptible to brittle fracture.
- February 14, 2019: TJPA reports to its board that it will retrofit First Street similar to the Fremont Street repair. PRP concurs.

### Next Steps:

- April 2019: Final computational analysis results for cause of failure are expected to be received for peer review.
- June 2019: TJPA projects the Fremont Street repair and First Street retrofit will be complete.
- Reopening of the Transit Center for bus operations: Dependent on completion of the repair and retrofit and resolution of the search for other areas susceptible to brittle fracture.

## Participants

### TJPA's project team:

1. Thornton Tomasetti: Structural Engineer of Record
2. LPI: Failure investigation and fitness for service consultant
3. Webcor: General contractor
4. Skanska: Steel subcontractor
5. Herrick: steel fabricator of fractured girders and repair

### PRP:

1. Michael Engelhardt, Chair, Univ. of Texas
2. John Fisher, Lehigh University
3. Tom Sabol, Englekirk Companies
4. Bob Shaw, Steel Structures Tech. Center
5. Brian Kozy, FHWA

### Support to PRP:

1. Bill Mohr, Edison Welding Institute
2. David Ruby, Ruby + Associates

## Scope and Status of Peer Review

MTC divided the scope of the peer review into six parts, as follows:

**1. Shoring capacity: Reviewed and concurred.**

Shores were added below the Fremont Street and First Street girders to provide an alternative load path. The PRP reviewed the design to ensure the shores had sufficient capacity and stability.

**2. Sampling and testing plan: Reviewed and concurred.**

TJPA's project team developed a plan to remove steel surrounding the fracture and test it to provide data to support the failure analysis.

**3. Cause of failure: General concurrence with findings; pending final report.**

In December 2018, the results of the material testing pointed to a preliminary hypothesis that the cause of failure was a result of: material properties (low fracture toughness at the mid-thickness of four-inch-thick steel plates); the presence of initiating defects (micro-cracks introduced by the flame cutting of slots); and stress across the fracture plane (residual stress due to adjacent welding, and applied stress from loads on the girders after erection).

**4. Impact of fractures on adjacent elements: Review nearing completion.**

When the girders fractured, the existing static load would have redistributed to adjacent elements and a dynamic pulse load would have also traveled through them. Based on preliminary calculations and non-destructive testing, LPI concluded no adjacent members were compromised. Some additional analysis and testing will be conducted by LPI for peer review.

**5. Repair of Fremont Street girders: Reviewed and concurred.**

The preliminary hypothesis from material testing provided enough knowledge of the cause of failure to allow Thornton Tomasetti to design a repair. The repair is a sandwich of steel plates bolted across the fractures (See Image 4 on page 3). The design of the girders at Fremont Street is replicated at First Street. Differences in fabrication reduced the risk of fracture at First Street, but TJPA will implement a retrofit to the First Street girders similar to the repair of the Fremont Street girders as a precautionary measure.

**6. Search for other areas susceptible to brittle fracture: Concurrence with criteria; review of TJPA project team's work on-going.**

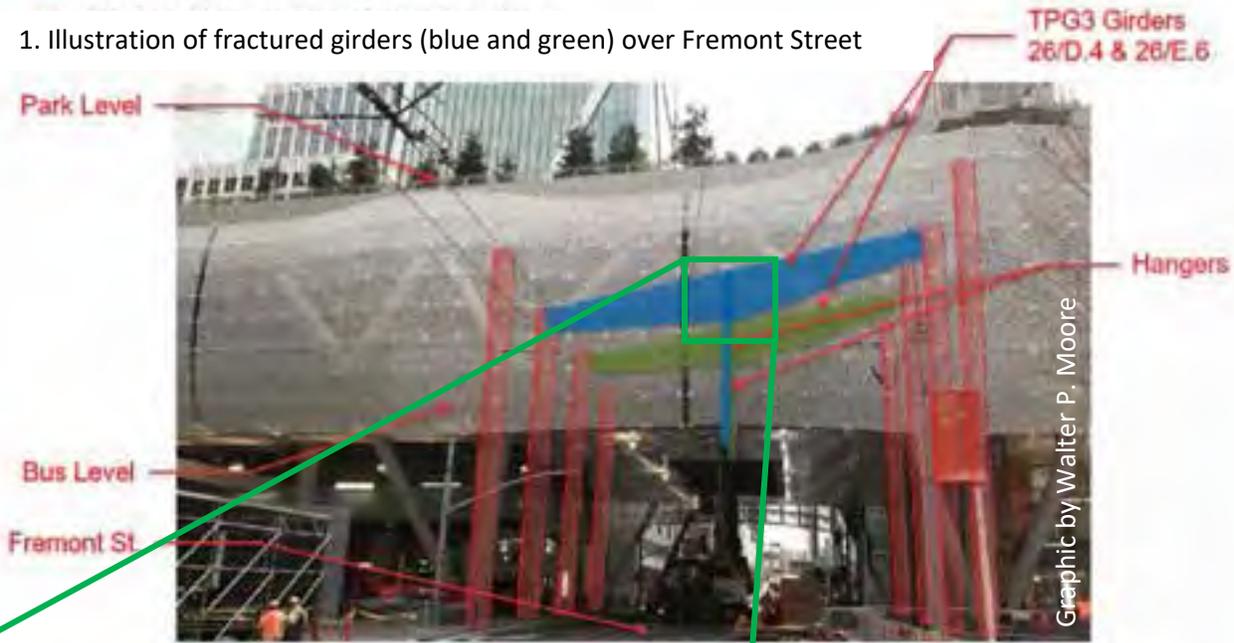
Although no other locations share the exact same design as the girders at Fremont and First Streets, the factors that led to brittle fracture (material properties, initiating defects, and stress) may be present elsewhere. TJPA's project team has developed criteria to filter the components of the steel structure down to the locations, if any, that need to be retrofitted, and is currently conducting this search.

The Peer Review Panel will review work completed by the TJPA project team; it is not performing a separate analysis. The Peer Review Panel will not determine responsibility, nor will it evaluate whether work complied with code or contract documents, but it will make recommendations for changes to code and industry standards to help avoid this type of failure in the future.

The Peer Review Panel's letters of concurrence to MTC for Parts 1, 2, and 5 are attached.

Images

1. Illustration of fractured girders (blue and green) over Fremont Street



2. Hanger-to-girder connection at site of fracture (before fracture)



3. Fracture through bottom flange



4. Bolted sandwich plate repair

March 15, 2019

Stephen Wolf, P.E.  
Principal  
Metropolitan Transportation Commission  
Bay Area Metro Center  
375 Beale Street, Suite 800  
San Francisco, CA 94105

RE: Transbay Transit Center  
Review of Temporary Shoring Systems at Fremont Street and First Street

Dear Stephen:

This Peer Review Panel (PRP) was assembled by MTC at the request of the mayors of San Francisco and Oakland to review the activities undertaken in response to the fractured girders at the Transbay Transit Center (TTC). Our review was initially divided into the following five phases:

1. Capacity of the temporary shoring systems.
2. Sampling and testing plan for material from the fractured steel girders.
3. Cause of failure.
4. Impact of fractures on adjacent elements.
5. Repair of Fremont Street girders.

The results of the initial review may lead the panel to recommend other related investigations and analyses, which the panel may also subsequently review.

The purpose of this memo is to document the completion of our review of Phase 1, capacity of the temporary shoring systems. Our review included the temporary shoring systems both at Fremont Street and at First Street, installed to provide an alternative load path from the four TPG3 girders. In both cases, we did not review the initial shoring systems installed on an emergency basis that involved the use of very large hydraulic jacks placed at street level provided by Bigge Crane and Rigging. Our review covered the subsequent more permanent, albeit still temporary, shoring systems that employed the use of hydraulic rams at street level provided by Sheedy Drayage Company.

Our review of the Fremont and First Street shoring systems was to ensure TJPA's project team performed proper due diligence in developing the design. We looked at the basis of design, structural concept and layout, overall stability, selected critical details, and selected calculations. Our scope did not include an in-depth review of all design details

and calculations nor a check for code compliance as this was done by other parties engaged by TIPA.

The process and results of our review are summarized separately below for the Fremont Street shoring and the First Street shoring.

#### Fremont Street Shoring

The review process included numerous online meetings between Thornton Tomasetti and the PRP. The major documents reviewed by the PRP throughout this process are as follows:

- Reports dated October 8 and October 10, 2018 by Thornton Tomasetti, titled: *Salesforce Transit Center – Fremont Street Shoring – Structural Calculations.*
- Memo dated October 13, 2018 from Steven Brokken of AECOM to Mark O'Dell of TIPA, with the subject: *Peer Review of Thornton Tomasetti Fremont Street Shoring at the Salesforce Transit Center.*
- Memo dated October 22, 2018 from Bruce Gibbons of Thornton Tomasetti to Mark O'Dell of TIPA, with the subject: *Shoring Design Peer Review Comments*
- Drawings of the shoring system by Thornton Tomasetti, in the files: "20181022 TempShoringSet\_TT.pdf," and "20181022 TempShoringSet\_rl.pdf"
- Drawings and calculations by Thornton Tomasetti, in the file: "20181025 Stress Check in TPG3 @ GLE.6 with Composite Section Modulus.pdf"
- Memo dated October 30, 2019 from John Abruzzo to Dennis Turchou titled: *TPG-3 Grid Line 26 Bus Deck Shoring - Brace Calculation.*
- Drawings and calculations by Thornton Tomasetti, in the file: "20181205 Bending and Shear Demands in Fremont Shoring Due to Seismic Rocking.pdf"
- Drawings and calculations by Thornton Tomasetti, in the file: "TPG3 Demands with reduced Jacking Forces 10-24-18.pdf"
- Drawings of the shoring system by Thornton Tomasetti, in the file: "TempShoringAtFremontStSet\_TT20190108\_wStamp.pdf"
  - Sheets: S1-8105; S1-8120 to 8123; S1-8130 to 8138.

Thornton Tomasetti addressed questions and comments from the PRP throughout this process. The PRP concurs with the design of the shoring system at Fremont Street. The basis of our concurrence is the final set of design drawings, which is the last item in the list above ("TempShoringAtFremontStSet\_TT20190108\_wStamp.pdf"), combined with the installation of additional lateral bracing for the W36x529 spreader beams at the bus deck level. This additional lateral bracing is not shown on the final set of design drawings, but has been installed.

### First Street Shoring

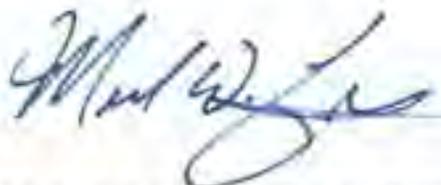
The review process included numerous online meetings between Thornton Tomasetti and the PRP. The major documents reviewed by the PRP throughout this process are as follows:

- Report dated November 9, 2018 by Thornton Tomasetti, titled: *Salesforce Transit Center – First Street Shoring – Structural Calculations*
- Memo dated December 3, 2018 from Steven Brokken of AECOM to Mark O'Dell of TJPA, with the subject: *Review of Salesforce Transit Center First Street Shoring*.
- Calculations dated December 20, 2018 by Thornton Tomasetti, titled: *Hanger Compression Check*.
- Drawings of the shoring system by Thornton Tomasetti, in the file: "TempShoringAtFirstStreetSet\_TT20181112\_wStamp.pdf"
- Drawings of the shoring system by Thornton Tomasetti, in the file: "TempShoringAtFirstStreetSet\_TT20181113\_wStamp.pdf"
- Drawings of the shoring system by Thornton Tomasetti, in the file: "TempShoringAtFirstStreetSet\_TT20190108\_wStamp.pdf"
  - Sheets: S1-8205; S1-8220 to 8222; S1-8230 to 8231; S1-8234.

Thornton Tomasetti addressed questions and comments from the PRP throughout this process. The PRP concurs with the design of the shoring system at First Street. The basis of our concurrence is the final set of design drawings, which is the last item in the list above ("TempShoringAtFirstStreetSet\_TT20190108\_wStamp.pdf").

While the PRP has reviewed and concurs with the design of the shoring systems at Fremont Street and at First Street, the responsibility for the design remains with the engineer of record, and the in-depth engineering design check and regulatory review were done by others.

Sincerely,



Michael D. Engelhardt, P.E., Ph.D,  
Chair, Peer Review Panel

c. Members of PRP:

John Fisher  
Brian Kozy  
Thomas Sabol  
Robert Shaw

March 9, 2019

Stephen Wolf, P.E.  
Principal  
Metropolitan Transportation Commission  
Bay Area Metro Center  
375 Beale Street, Suite 800  
San Francisco, CA 94105

RE: Transbay Transit Center  
Review of TJPA Sampling and Testing Plan for Material from Fremont  
Street Girders

Dear Stephen:

This Peer Review Panel was assembled by MTC at the request of the mayors of San Francisco and Oakland to review the activities undertaken in response to the fractured girders at the Transbay Transit Center (TTC). Our review was initially divided into the following five phases:

1. Capacity of the temporary shoring system.
2. Sampling and testing plan for material from the fractured steel girders.
3. Cause of failure.
4. Impact of fractures on adjacent elements.
5. Repair of Fremont Street girders.

The results of the initial review may lead the panel to recommend other related investigations and analyses, which the panel may also subsequently review.

The purpose of this memo is to document the completion of our review of Phase 2, the TJPA plan for sampling and testing material from the fractured Fremont Street girders. The material sampling and testing was done to support analysis of the cause of the fractures and development of a repair plan. During the development of the plan, members of the PRP had a number of meetings with the TJPA project team, which includes the testing laboratory, engineer of record, contractor, and associated subcontractors, to review and discuss the plan. These meetings took place by conference call, as well as through in-person meetings at the TTC in San Francisco and at LPI, Inc. in New York. Our review started on October 15, 2018 with a meeting with the TJPA in San Francisco and site visit at the Transit Center, and was essentially completed with a visit of panel members to LPI, Inc. in New York on November 8, 2018.

Questions, concerns and recommendations from the PRP throughout this process were addressed by TJPA and reflected in the final material sampling and testing plan. That document, which forms the basis of our concurrence, is titled: "Transbay Transit Center Project – Girder Fracture Specimen Removal & Testing Protocol," dated 11.02.2018 Rev 4.

Our concurrence with the TJPA plan for sampling and testing material from the Fremont Street girders does not preclude future recommendations from the PRP for possible additional material sampling and testing, should we see the need for this as the investigation proceeds.

While the PRP has reviewed and concurs with the material sampling and testing plan, the responsibility for all aspects of the investigation of the fractured girders and resulting actions remains with the engineer of record.

Sincerely,

A handwritten signature in blue ink, appearing to read "Michael D. Engelhardt".

Michael D. Engelhardt, P.E., Ph.D.  
Chair, Peer Review Panel

c. Members of PRP:

John Fisher  
Brian Kozy  
Thomas Sabol  
Robert Shaw

March 15, 2019

Stephen Wolf, P.E.  
Principal  
Metropolitan Transportation Commission  
Bay Area Metro Center  
375 Beale Street, Suite 800  
San Francisco, CA 94105

RE: Transbay Transit Center  
Review of Designs for Repair of Fremont Street Girders and Retrofit of  
First Street Girders

Dear Stephen:

This Peer Review Panel (PRP) was assembled by MTC at the request of the mayors of San Francisco and Oakland to review the activities undertaken in response to the fractured girders at the Transbay Transit Center (TTC). Our review was initially divided into the following five phases:

1. Capacity of the temporary shoring systems.
2. Sampling and testing plan for material from the fractured steel girders.
3. Cause of failure.
4. Impact of fractures on adjacent elements.
5. Repair of Fremont Street girders.

The results of the initial review may lead the panel to recommend other related investigations and analyses, which the panel may also subsequently review.

The purpose of this memo is to document the completion of our review of Phase 5, repair of Fremont Street girders. The repair is meant to restore the structural capacity of the bottom flanges of the fractured tapered plate girders over Fremont Street (designated in the design drawings as TPG3), and consists of dressing requirements for the existing material and a new steel sandwich plate design bolted across the fractures.

This memo also documents the completion of our review for a related item, the design of the retrofit of First Street girders. Although the two TPG3 girders over First Street did not fracture and were subject to a different sequence of fabrication that substantially minimized that risk, the PRP concurs with TJPA's decision to further mitigate the risk and consequences of fracture by retrofitting the girders. The retrofit provides redundant capacity to the bottom flanges of the TPG3 girders over First Street. The design is similar to that at Fremont Street, with modifications accounting for the intact flange.

The review process included numerous online meetings as well as in-person meetings between Thornton Tomasetti and the PRP. The review extended over several months, starting with initial discussions of the design concepts and then continuing through evaluation of the detailed design.

Thornton Tomasetti addressed questions and comments from the PRP throughout this process. The PRP concurs with the design of the repair of the Fremont Street girders and the design of the retrofit of the First Street girders.

The basis of our concurrence for Fremont Street is:

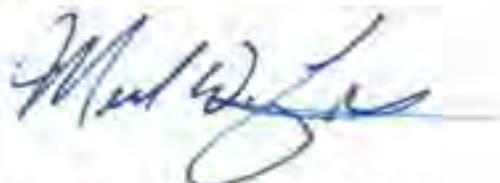
- The final set of design drawings prepared by Thornton Tomasetti, dated January 28, 2019. The drawings are titled: "Fremont Street TPG3 Girders Repair Sections and Details," and are marked "Issued for Construction."
  - Sheets: S1-8401 to 8403.

The basis of our concurrence for First Street is the following documents:

- The final set of design drawings prepared by Thornton Tomasetti, dated February 22, 2019. The drawings are titled: "First Street TPG3 Girders Repairs and Details," and are marked "Issued for Construction."
  - Sheets: S1-8404 to 8406.
- Document: LA181690-PR-003 TTC TPG3 Hanger Blend Grinding Procedure - Rev 2A.
- Document: LA181690-PR-004 TTC TPG3 Hanger Needle Peening Procedure - Rev 1A.

While the PRP has reviewed and concurs with the design of the repair of the Fremont Street girders and the retrofit of the First Street girders, the responsibility for the design remains with the engineer of record.

Sincerely,



Michael D. Engelhardt, P.E., Ph.D  
Chair, Peer Review Panel

c. Members of PRP:

John Fisher  
Brian Kozy  
Thomas Sabol  
Robert Shaw  
Bill Mohr (consultant to PRP)



October 4<sup>th</sup>, 2018

Mr. Steve Heminger  
Executive Director  
Metropolitan Transportation Commission  
Bay Area Metro Center  
375 Beale Street  
San Francisco, CA 94105

Dear Executive Director Heminger,

We write you today to express our continued concern over the situation at the Transbay Transit Center and to call on your agency to assist in evaluating the cause of the cracked beams and the plans to make repairs.

The Transbay Transit Center provides a crucial transportation link between our two cities. Once high-speed rail and Caltrain are brought to the terminal, it will be the transportation hub for our entire region. The Transit Center is too important to the future and the people of the Bay Area for there to be any uncertainty around its structural soundness.

There are many questions about what might have caused the beams to crack, who might be responsible, and how the beams will be repaired so that the Transit Center can reopen to the public. These questions must be answered quickly and the public needs to trust the answers.

We understand that the Transbay Joint Powers Authority (TJPA) is conducting its own analysis on the failures in order to develop a plan to make necessary repairs and we encourage that process to continue expeditiously. But we also believe that it is critical to the constituents of our cities and our region that there be confidence in the findings of that analysis. We believe that the only way to ensure this public confidence is by engaging an outside firm to review and verify any findings, and for this peer review to be managed by and produced for the Metropolitan Transportation Commission.

We respectfully urge the MTC to engage an outside firm as quickly as possible so that we can get down to the bottom of what happened with these beams, feel confident that the problem is isolated, and make the necessary repairs so that the Transbay Transit Center can serve the people of the Bay Area once again.

Sincerely,

A handwritten signature in black ink that reads "London N. Breed".

London N. Breed  
Mayor, City and County of San Francisco

A handwritten signature in black ink that reads "Libby Schaaf".

Libby Schaaf  
Mayor, City of Oakland

**COOPERATIVE AGREEMENT**  
**Between METROPOLITAN TRANSPORTATION COMMISSION**  
**And TRANSBAY JOINT POWERS AUTHORITY**  
**For TRANSBAY TRANSIT CENTER PEER REVIEW PROJECT**

THIS COOPERATIVE AGREEMENT (“Agreement”), entered into effective on October 12, 2018, is between the TRANSBAY JOINT POWERS AUTHORITY, referred to herein as “TJPA,” and the METROPOLITAN TRANSPORTATION COMMISSION, referred to herein as “MTC.”

RECITALS

WHEREAS, TJPA is a joint exercise of powers authority created by the City and County of San Francisco, the Alameda-Contra Costa Transit District, the Peninsula Corridor Joint Powers Board, the California High Speed Rail Authority, and Caltrans, and TJPA has primary jurisdiction with respect to all matters concerning the financing, design, development, construction, and operation of the new transit center in downtown San Francisco; and

WHEREAS, On September 25, 2018, workers discovered a fissure in the bottom flange of a steel girder in the ceiling of the bus deck level of the transit center near Fremont Street. Further inspections revealed a second fissure through half of the lower flange on a separate girder parallel to the first near the same location at Fremont Street; and

WHEREAS, As a result of the fissures, project contractors have implemented a shoring system at Fremont Street as well as at First Street (which has a similar design as Fremont Street) (“Temporary Shoring System”); and structural engineers are designing a proposed permanent reinforcement fix for Fremont Street and First Street (“Permanent Reinforcement Fix”); and

WHEREAS, TJPA and MTC have agreed MTC will facilitate a panel of technical experts to participate in an independent review of the Temporary Shoring System and the Permanent Reinforcement Fix, TJPA’s findings with respect to the cause of the fissures, and such other related matters as appropriate; and

WHEREAS, MTC has started to facilitate the independent peer review panel, and the panel’s work is on-going.

NOW, THEREFORE, the parties hereby agree as follows:

**I. MTC AGREES**

A. MTC has engaged a panel of technical experts (Consultants) to participate in an independent review of the Temporary Shoring System and the Permanent Reinforcement Fix, TJPA’s findings with respect to the cause of the fissures, and such other related matters as appropriate (collectively, “PROJECT”), as described in Attachment A, Scope of Work. MTC will

provide all reasonably necessary staffing and support resources to complete the PROJECT as described in Attachment A.

B. The budget for the PROJECT is described in Attachment B, Budget. The maximum amount payable to MTC for PROJECT, including (as applicable) labor, supervision, applicable surcharges such as taxes, insurance, and fringe benefits, indirect costs, overhead, profit, subcontractors costs (including mark-up), travel, equipment, materials and supplies, and expenses, and excluding any indemnification and defense obligations of TJPA under Section II.C., below, shall not exceed five hundred ten thousand dollars (\$510,000) ("Maximum Payment").

C. MTC shall maintain full and adequate PROJECT books, records, and accounts in accordance with generally accepted accounting practices. All such books, records, accounts, and any and all work products, materials, and other data relevant to PROJECT performance under this Agreement shall be retained by MTC for a minimum of four (4) years following the fiscal year of the last expenditure under this Agreement.

D. MTC shall permit TJPA and its authorized representatives to have, during normal business hours, access to the MTC's books, records, accounts, and any and all work products, materials, and other data relevant to this Agreement for the purpose of making an audit, examination, excerpt and transcription during the term of this Agreement and for the period specified in Section I.C. above. MTC shall not dispose of, destroy, alter, or mutilate said books, records, accounts, work products, materials and data for that period of time. Such permission shall extend to books, records, accounts, and any and all work products, materials, and other data relevant to this Agreement of MTC's contractors and subcontractors. Such permission shall include any access necessary for TJPA's reimbursement of costs under this Agreement as may be made by TJPA's contractors or insurers.

E. MTC shall comply with any and all laws, statutes, ordinances, rules, regulations, and procedural requirements of any national, state, or local government, and of any agency of such government including but not limited to TJPA that relate to or in any manner affect the performance of the Agreement.

## **II. TJPA AGREES**

A. TJPA agrees to provide an amount not to exceed Maximum Payment defined in Section I.B above in non-federal funds to MTC to fund PROJECT.

B. Subject to the terms of the previous paragraphs, TJPA agrees to make payments to MTC within forty-five (45) days after receipt by TJPA of each acceptable invoice, subject to the review and approval of TJPA's Project Manager.

MTC shall deliver or mail invoices to TJPA, as follows:

Attention: Mark Zabaneh, Executive Director  
Transbay Joint Powers Authority  
201 Mission Street, Suite 2100  
San Francisco, CA 94105

C. TJPA shall indemnify and hold harmless MTC, its Commissioners, representatives, agents, and employees (collectively, "MTC Indemnified Parties") from and against all claims, injury, suits, demands, liability, losses, damages, and expenses, whether direct or indirect (including any and all costs and expenses in connection therewith) (collectively "Claims"), incurred as a result of MTC's performance of the PROJECT, except to the extent that such indemnity is void or otherwise unenforceable under applicable law, and except to the extent such Claims are caused by the gross negligence or willful misconduct of an MTC Indemnified Party, in which case TJPA shall indemnify MTC Indemnified Parties for the full proportion of the Claims that is not as a result of the gross negligence or willful misconduct of the MTC Indemnified Party. TJPA agrees at its own cost, expense, and risk to defend any and all Claims, actions, or other legal proceedings brought or instituted against MTC Indemnified Parties, or any of them, arising out of MTC's performance of the PROJECT, and to pay and satisfy any resulting judgments, except such portion resulting from the gross negligence or willful misconduct of an MTC Indemnified Party.

D. Should MTC or Consultants request records or information in the TJPA's files in performance of PROJECT, TJPA shall reasonably cooperate in providing the requested materials (it being expressly recognized that because of MTC's services under this Agreement, MTC's access to confidential and privileged records and information of the TJPA does not waive the TJPA's right to claim any applicable privileges as to such materials, and, further that such materials may contain Sensitive Security Information (SSI) protected under federal law and MTC's access to any such protected materials is intended to be in conformance with and subject to federal law). Should MTC or Consultants request access to the construction site and related field operations in performance of PROJECT, MTC shall provide reasonable notice to the TJPA, and the TJPA shall provide access as it deems reasonable; TJPA makes no representation or warranty as to the safety or accessibility of the site.

### **III. IT IS MUTUALLY AGREED**

A. Any substantive material changes in the activities to be performed under this Agreement, or in the terms thereof, shall be incorporated in written amendments, which shall specify the changes in work performed and any adjustments in compensation and schedule. All amendments shall be executed by the MTC Executive Director, or a designated representative, and the TJPA's Executive Director, or a designated representative. No request for additional compensation or an extension of time shall be recognized unless contained in a duly executed amendment.

B. The term of the Agreement shall begin on the Effective Date and conclude on April 1, 2019, unless either party terminates this agreement earlier as provided below except for obligations of the parties that by their nature would extend beyond such term.

C. Either party may terminate this Agreement without cause upon fourteen (14) days prior written notice; however MTC will be entitled to payment for PROJECT costs appropriately incurred during the term, up to the Maximum Payment under this Agreement.

D. Except for invoices submitted by MTC to the TJPA pursuant to Section II.B above, all notices or other communications to either party by the other shall be deemed given when made in writing and delivered or mailed to such party at their respective addresses as follows:

To MTC:                    Attention: Stephen Wolf, Project Manager  
Metropolitan Transportation Commission  
375 Beale St, Suite 800  
San Francisco, CA 94105  
Email: [swolf@bayareametro.gov](mailto:swolf@bayareametro.gov)

To TJPA:                    Attention: Mark Zabaneh, Executive Director  
Transbay Joint Powers Authority  
201 Mission Street, Suite 2100  
San Francisco, CA 94105  
Email: [MZabaneh@tjpa.org](mailto:MZabaneh@tjpa.org)

Either party may change the address to which notice is to be sent by giving written notice thereof to the other party.

E.     The formation, interpretation, and performance of this Agreement shall be governed by the laws of the State of California. Venue for all litigation relative to this Agreement shall be in San Francisco.

F.     This Agreement sets forth the entire agreement between the parties relative to PROJECT, and supersedes all other oral or written provisions relative to PROJECT.

G.     This Agreement may be executed in counterparts, each of which shall be deemed an original, but all of which taken together shall constitute one and the same instrument.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement effective on the date first mentioned above.

TRANSBAY JOINT POWERS AUTHORITY

METROPOLITAN    TRANSPORTATION  
COMMISSION

By:   
Mark Zabaneh, Executive Director

By: \_\_\_\_\_  
Steve Heminger, Executive Director

Approved as to form:



\_\_\_\_\_  
Attorney  
TJPA

To MTC:                   Attention: Stephen Wolf, Project Manager  
Metropolitan Transportation Commission  
375 Beale St, Suite 800  
San Francisco, CA 94105  
Email: [swolf@bavareametro.gov](mailto:swolf@bavareametro.gov)

To TJPA:                   Attention: Mark Zabaneh, Executive Director  
Transbay Joint Powers Authority  
201 Mission Street, Suite 2100  
San Francisco, CA 94105  
Email: [MZabaneh@tjpa.org](mailto:MZabaneh@tjpa.org)

Either party may change the address to which notice is to be sent by giving written notice thereof to the other party.

E.     The formation, interpretation, and performance of this Agreement shall be governed by the laws of the State of California. Venue for all litigation relative to this Agreement shall be in San Francisco.

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TRANSBAY JOINT POWERS AUTHORITY

METROPOLITAN TRANSPORTATION  
COMMISSION

By: \_\_\_\_\_  
Mark Zabaneh, Executive Director

DocuSigned by:  
**Steve Heminger**  
By: \_\_\_\_\_  
Steve Heminger, Executive Director

Approved as to form:

\_\_\_\_\_  
Attorney  
TJPA

ATTACHMENT A

**SCOPE OF WORK**

The services to be performed by MTC's independent expert panel shall consist of services requested by the MTC Project Manager or a designated representative as described below. In all Tasks, the panel is reviewing and commenting on products produced by the TJPA team.

**Task 1: Review and comment on the Temporary Shoring System.**

**Task 2: Review and comment on the proposed sampling & testing plan.**

**Task 3: Review and comment on cause of the fissures at two girders.**

**Task 4: Review and comment on the Permanent Reinforcement Fix.**

**Task 5: Other reviews as needed and determined by Project Manager and in consultation with TJPA regarding priorities and available budget.**

ATTACHMENT B

**BUDGET**

Actual expenses for individual tasks and line items may vary from the totals shown below as long as the cumulative total for all tasks and line items remains at or below the Estimated Total shown below.

	Quantity <sup>1</sup>	Unit	Weeks	Avg Hours per Week	Rate	Total
<b>Labor</b>						
<b>Task 1: Review and comment on Temporary Shoring System</b>						
Review by panelists	4*	Panelists	1	52	\$225 - \$425**	\$16,800
<b>Task 2: Review and comment on proposed sample &amp; testing plan</b>						
Review by panelists	4*	Panelists	3	52	\$225 - \$425**	\$50,400
<b>Task 3: Review and comment on the cause of the fissures at two</b>						
Review by panelists	4*	Panelists	3	52	\$225 - \$425**	\$50,400
<b>Task 4: Review and comment on the Permanent Reinforcement Fix</b>						
Review by panelists	4*	Panelists	4	52	\$225 - \$425**	\$67,200
<b>Task 5: Other reviews as needed and determined</b>						
Review by panelists	4*	Panelists	1	52	\$225 - \$425**	\$16,800
<b>Tasks 1-5: Consultant assistance, as needed</b>						
Consultant assistance to provide additional technical expertise or	3	Consultants	10	12	\$350	\$126,000
<b>Direct Costs***</b>						
Travel out-of-state (4 people, 6 trips ea: flights, hotels, and per diem)	30	person trips	total over 11 weeks		\$2,200	\$66,000
Travel in-state (1 person, 6 trips ea: travel and per diem)	6	person trips	total over 11 weeks		\$500	\$3,000
Reprographics	1	lum sum			\$15,000	\$15,000
Meals (hosted events external to MTC and panel)	150	lunch/breakfast			\$25	\$3,750
MTC Travel (2 people, 2 trips ea, flights, hotels, and per diem)	4	person trips			\$2,200	\$8,800
<b>Subtotal</b>						<b>\$424,150</b>
<b>Contingency</b>					<b>20%</b>	<b>\$84,830</b>
<b>Estimated Total - All Tasks and Line Items</b>						<b>\$508,980</b>

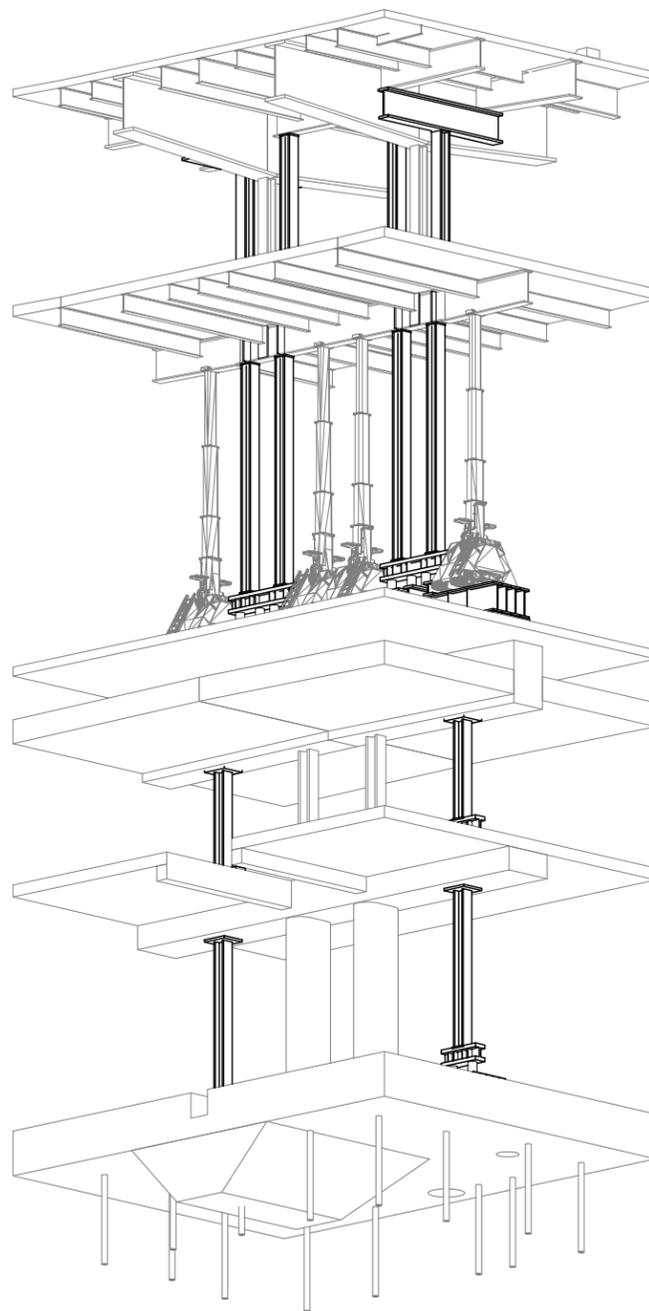
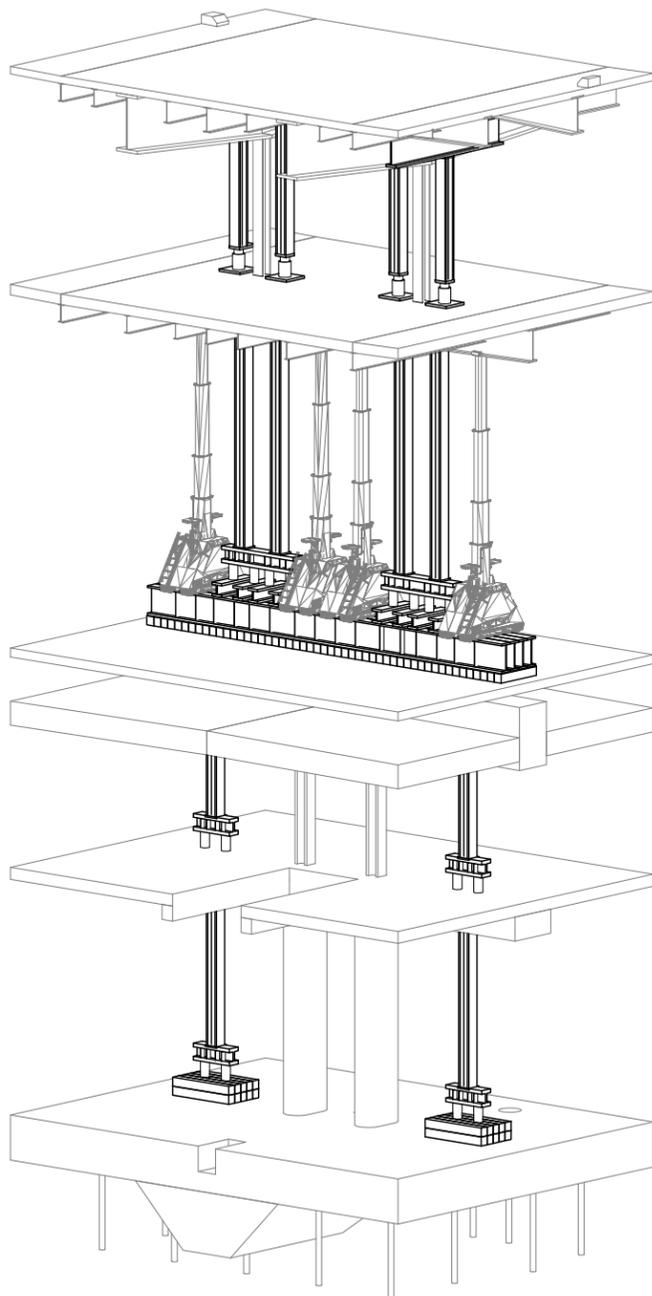
\* There are a total of 5 panelist, however, there is no charge for the panelist from FHWA

\*\* Individual panelists rates are as follows:

Michael Engelhardt, Chair	\$	300
Tom Sabol	\$	350
John Fisher	\$	425
Robert Shaw	\$	225 (\$200 in-office \$250 on-site)
Brian Kozy, FHWA		no charge

\*\*\* Travel-related expenses (e.g., airfare, automobile rental, taxicab fares, parking, meals) must adhere to the "TJPA Travel Policy for Consultants and Subconsultants."

**Attachment D**



SEISMIC LOADING CRITERIA (PER ASCE 7-10)	
PARAMETER	VALUE
OCCUPANCY CATEGORY	III
SITE CLASS	E
SEISMIC DESIGN CATEGORY	D
$S_s$	1.5g
$S_1$	0.6g
$S_{05}$	0.9g
$S_{01}$	0.96g
IMPORTANCE FACTOR, $I_e$	1.25
RESPONSE MODIFICATION COEFFICIENT, $R^*$	
EXISTING BUILDING NORTH-SOUTH DIRECTION	8.0 (SPECIAL STEEL MOMENT-RESISTING FRAME SYSTEM)
EXISTING BUILDING EAST-WEST DIRECTION	7.0 (ECCENTRICALLY BRACED STEEL FRAME SYSTEM)
*EXISTING BUILDING WAS DESIGNED USING PERFORMANCE BASED DESIGN (PBD) APPROACH HOWEVER, SYSTEM R FACTORS WERE ALSO USED TO SATISFY BUILDING CODE BASED CHECKS.	

**1 OVERALL 3D**  
NOT TO SCALE

**2 OVERALL 3D FROM BELOW**  
NOT TO SCALE



**Thornton Tomasetti**

707 Wilshire Blvd, Suite 4450  
Los Angeles, CA 90017-3618  
T 213 330 7000 F 213 330 7001

**OVERALL 3D VIEW**

**TRANSBAY TRANSIT CENTER**

PROJECT NUMBER: SS8510.00

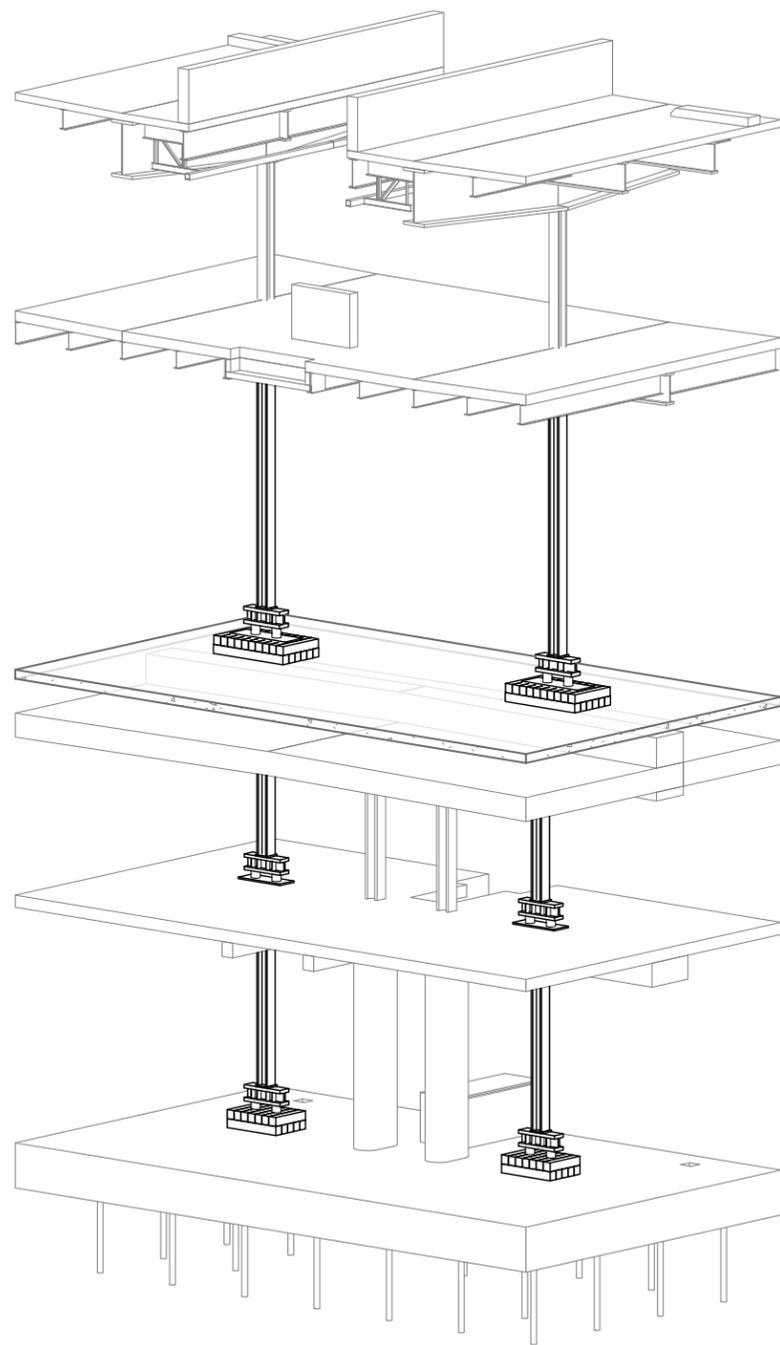
DATE:

SCALE: 1" = 1'-0"

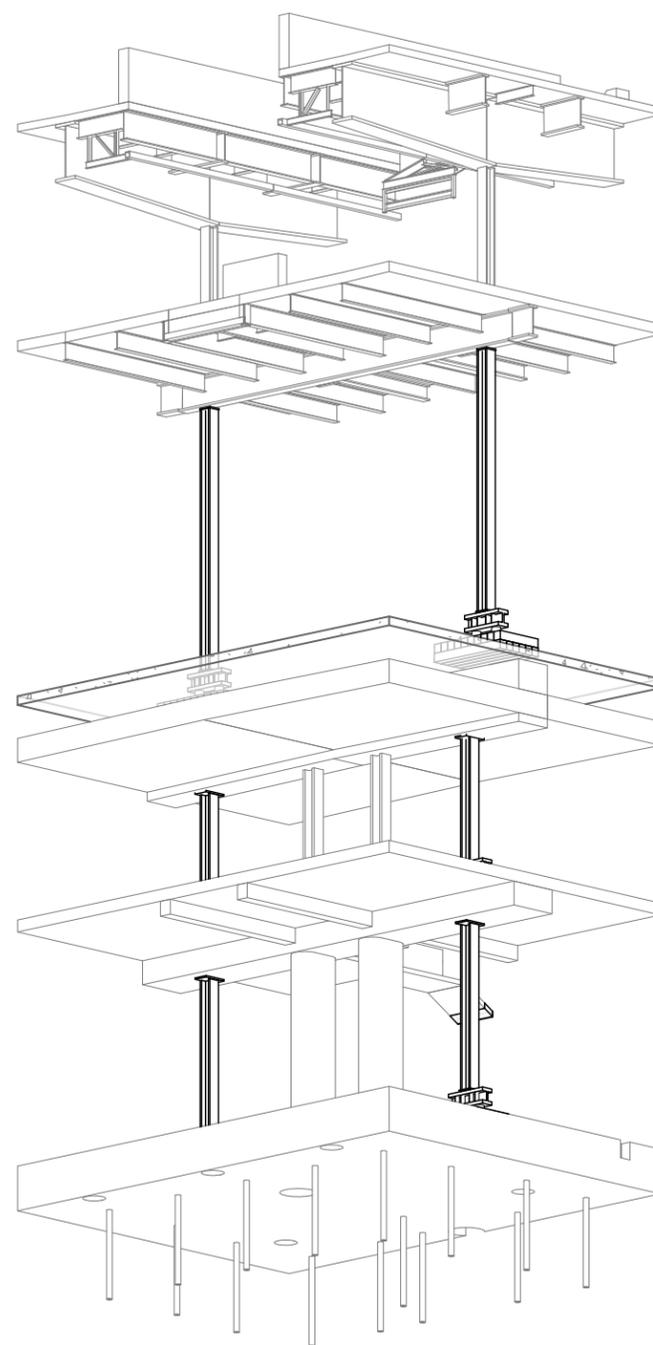
DRAWING NUMBER

**S1-8105**

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**1 ISOMETRIC AT FIRST STREET**  
NOT TO SCALE



**2 ISOMETRIC FROM BELOW**  
NOT TO SCALE

SEISMIC LOADING CRITERIA (PER ASCE 7-10)	
PARAMETER	VALUE
OCCUPANCY CATEGORY	III
SITE CLASS	D
SEISMIC DESIGN CATEGORY	D
$S_s$	1.5g
$S_1$	0.6g
SDS	1.0g
SD1	0.612g
IMPORTANCE FACTOR, $I_e$	1.25
RESPONSE MODIFICATION COEFFICIENT, $R^*$	
EXISTING BUILDING NORTH-SOUTH DIRECTION	8.0 (SPECIAL STEEL MOMENT-RESISTING FRAME SYSTEM)
EXISTING BUILDING EAST-WEST DIRECTION	7.0 (ECCENTRICALLY BRACED STEEL FRAME SYSTEM)
*EXISTING BUILDING WAS DESIGNED USING PERFORMANCE BASED DESIGN (PBD) APPROACH HOWEVER, SYSTEM R FACTORS WERE ALSO USED TO SATISFY BUILDING CODE BASED CHECKS.	



**Thornton Tomasetti**  
707 Wilshire Blvd, Suite 4450  
Los Angeles, CA 90017-3618  
T 213 330 7000 F 213 330 7001

**ISOMETRIC VIEW AT FIRST STREET (GL 18)**

**TRANSBAY TRANSIT CENTER**

PROJECT NUMBER: SS8510.00 DATE:

SCALE: 1" = 1'-0"


DRAWING NUMBER  
**S1-8205**

© COPYRIGHT THORNTON TOMASETTI 2007

**Project name:** Salesforce Transit Center

**Project ref:** Fremont Street Shoring

**From:** Steven Brokken

**Date:** October 13, 2018

**To:** Mark O'Dell

**CC:** Martin Czarnecki

# Memo

**Subject:** Peer Review of Thornton Tomasetti Fremont Street Shoring at the Salesforce Transit Center

Mr. O'Dell:

AECOM has been provided with the following documents from Thornton Tomasetti for the purpose of providing Peer Review Services for temporary shoring for stabilization of two girders at the roof parking level of zone 6 of the Salesforce (formerly Transbay) Transit Center:

- Salesforce Transit Center, Fremont Street Shoring, Structural Calculations, October 08, 2018  
This is a 98-page set of calculations prepared by Thornton Tomasetti provided in PDF format
- TempShoringCombinedSet (This is the precise title of the document delivered, not a typographic error)  
This a 15-page set of drawings in PDF format. Drawings 1-9 present the shoring system, and drawings 10-15 are reference drawings of the Transit Center building system which is being supported by shoring.
- Salesforce Transit Center, Fremont Street Shoring, Horizontal Restraint Connections at Top And Bottom of Fremont Street Shoring Columns, Supplementary Structural Calculations, October 08, 2018  
This is a set of calculations addressing stability of the shoring system when the building system is potentially subject to earthquake ground motion.
- Salesforce Transit Center, Fremont Street Shoring, Structural Calculations, October 10, 2018  
This is a 123-page set of calculations prepared by Thornton Tomasetti provided in PDF format. This is an update to the October 08, 2018 previously provided and incorporates shoring connection calculations between the mat and the bus deck for stability under building drift due to earthquake ground motion, and shoring connections to the existing structure above the bus deck level.
- TempShoringCombinedSet\_r1 (This is the precise title of the document delivered, not a typographic error)  
This a 19-page set of drawings in PDF format. Drawings 1-13 present the shoring system, and drawings 14-19 are reference drawings of the Transit Center building system which is being supported by shoring.

This shoring system will be referred to as the Thornton Tomasetti shoring system or TT shoring system.

Two specific girders are being provided with stabilization by installation of temporary shoring. These two girders and their specific locations in the building are as follows:

- The first girder is located on building grid line E.6 between grid lines 24.9 and 27.1.
- The second girder is located on building grid line D.4 between grid lines 24.9 and 27.1.

The TT shoring is provided along one building line, line 26, with the use of jacks with locking collars. This will replace the original shoring that was put in place prior to this peer review of the TT shoring. The original shoring was provided by use of jacks and put in place without peer review due to the immediate need following identification of the cracked welds. The TT shoring system reviewed herein is intended by the TT designers to fully replace this original shoring. According to our understanding of the TT design intent, the load transfer from the original shoring to the TT shoring will be accomplished by jacking to pick up and transfer load into the TT shoring. Again, per our understanding of the design intent, the system proposed by TT is intended to be monitored by hydraulic pressure driving the jacks, thus allowing fully controlled transfer between the shoring systems. Locking collars on the TT shoring system jacks provide for final shoring loads to be maintained without reliance on the hydraulic systems.

All of the above is inferred by AECOM from reviewing TT's documents described above. One of our recommendations is that TT provide in these documents a clear Basis of Design (BOD) so there is no uncertainty about the design intent.

The TT shoring is provided with a series of reaction beams and 1x12 timber cribbing provided as continuous pads where necessary intended to distribute loading and prevent local damage or overload due large local reactions. Load sharing/distribution between shoring elements and structural elements available to participate in carrying loading has been accounted for and determined by relative stiffness determined by appropriate structural modeling. Modeling has addressed superposition of loading, loading currently present, and addressed additional loading as applied to this already present loading, including step by step modeling of when loading is applied to correspond with sequencing of operations in the field.

As peer reviewers, we find the product provided by Thornton Tomasetti to be substantially acceptable, but do have a few recommendations. Along with these recommendations we would like to specifically comment that these recommendations are largely related to stability of the shoring system due to drift of the building system under earthquake ground motion. It was specifically agreed going into peer review that approvals by peer review could be a two-step process, one for gravity stabilization, and a second for approval which specifically includes stability of the shoring system due to drift of the building system under earthquake ground motion.

Recommendations:

1. Add a clear statement of Basis of Design along with an unambiguous statement of design intent.
2. For clarity of documentation, we recommend the probability of the earthquake ground motion generating drift that has been addressed for stability of the TT shoring system be clearly stated on the drawings and calculations. This is simply to clearly indicate the TT shoring system for the building in its final state (including all approved EQ stabilization for the shoring) meets current code requirements for earthquake loading. We consider this comment as minor, as compliance should be as simple as addition of a couple of comments on drawings and calculations.
3. There is no check for lateral stability of the TT shoring regions below the jacks, for example at the ground level between the 4-W36x441 and the timber cribbing mat, or between the timber mat and the surface below. While there should be sufficient friction to prevent motion, an actual calculation to demonstrate the friction remaining under minimum preload (reduced at maximum EQ uplift) does not drop below that required to maintain the required horizontal reaction, is required. Alternatively, positive mechanical anchorage is required. This comment is typical at all similar conditions at all levels. We consider this comment as minor, as compliance should be simple.

4. Spring steel washers have been provided at the top column shoring connections of heavy plate to plate connections to prevent prying action from developing large unintended bolt tension in the A490 bolts. For the geometry present at the EQ drift, the actual displacement requirement due to prying action for the spring washer needs to be computed. The displacement capacity of the installed device needs to be verified as capable of meeting this calculated value. A specific inspection of these as installed is recommended to verify proper installation. We consider this comment as minor, and this cannot have been done in advance of verifying the actual spring steel product to be installed.
5. Spring steel washers need to be utilized at the bottom connection of column shoring connections of heavy plate to plate connections to prevent prying action from developing large unintended bolt tension in the A490 bolts. All recommendations for spring steel washers to be installed at top of column shoring connections apply, (see recommendation above).

Conclusions:

For installation of shoring for temporary support of girders while final repairs to the two girders are designed and undertaken, with shoring per the final version of documents as provided by Thornton Tomasetti for review by AECOM for the support of the roof girders located on building grid line E.6 between grid lines 24.9 and 27.1 and the roof girder located on building grid line D.4 between grid lines 24.9 and 27.1:

- No exception is taken for use of the TT shoring documents for support of gravity loading;
- Revise as noted; distribute record copy for use of the TT shoring documents for support of gravity loading plus stability of the shoring system due to drift of the building system under earthquake ground motion. The meaning of revise as noted is to incorporate recommendations into the TT shoring system as provided in this AECOM peer review memorandum.

**Project name: Transbay Center****Project ref: Shoring****From: Steven Brokken****Date: Dec 3, 2018****To: Mark O'Dell****CC:**

# Memo

**Subject:** Review of Salesforce Transit Center First Street Shoring

Mark:

As a follow-on activity from review shoring at Fremont Street at the Salesforce Transit Center, AECOM has been requested to review shoring proposed the Transit Center at First Street. AECOM has been provided with Drawings and Calculations for this purpose.

Documents were received November 13, 2018 for review, and are as follows:

- Thornton Tomasetti, Salesforce Transit Center, First Street Shoring, Structural Calculations, November 9, 2018, 76 pages, signed by Bruce Gibbons, SE# 4160.
- Drawings S1-8205, S1-8220, S1-8221, S1-8222, S1-8230, S1-8231, S1-8234, S1-8130; and reference drawings S1-2104, S1-2304, S1-2404, S1-2504, S1-2604. Drawings are signed by Bruce Gibbons, SE# 4160, reference drawings contain the signature and seal of Bruce Gibbons dating from the time of original issuance of those drawings in 2015.

We find the First Street shoring documents to be prepared in conformance with criteria and recommendations incorporating prior review comments provided by this office for the shoring installed at Fremont Street. The structure in the region of interest is close to being a duplication of that occurring at Fremont Street, and the shoring provided at all levels with minor exceptions utilizes the same detailing as utilized at Fremont Street. Calculations include forces and evaluation of positive stabilization including installation of specific bracing elements where necessary for stability of the shoring system under drift for code level earthquake ground motion.

Our review has generated minimal comments, comments are as follows:

At the lower concourse level, bracing angles are provided with connections by fillet welding. Without care in end preparation of the members, the geometry of this weld could be non-compliant with AWS. We have requested TT provide instruction to the inspector or special inspector to verify the weld throat provided meets or exceeds that which would occur for the specified weld symbol.

Drawing S1-8130, Detail 1 and Section A: The stitch 5/16 fillet weld (3-12) connecting the 2" plate to concrete with Kwik bolts and welded to the shoring 1" column top plate. AECOM expressed concern regarding the risk associated with weld cracking due to weld prying when the building is subject to earthquake drift. Upon discussion, it was opined that in the direction of the web, full restraint is provided even if weld cracking occurs due to the bolted plated functioning as keepers, and in the perpendicular direction, the welding has a factor of safety equal 4, thus the probability of all welds cracking is small, and if all welds crack, the resulting surfaces will not be smooth and not promote sliding. For these reasons this was suggested as sufficient. Installation of a pair of heavy flatbar keepers completely mitigate any potential associated with weld cracking. AECOM recommends installation recommends installation of some alternative load path unless weld cracking due to prying is addressed.

TRANSBAY TRANSIT CENTER – PEER REVIEW PANEL

March 15, 2019

Stephen Wolf, P.E.  
Principal  
Metropolitan Transportation Commission  
Bay Area Metro Center  
375 Beale Street, Suite 800  
San Francisco, CA 94105

RE: Transbay Transit Center  
Review of Temporary Shoring Systems at Fremont Street and First Street

Dear Stephen:

This Peer Review Panel (PRP) was assembled by MTC at the request of the mayors of San Francisco and Oakland to review the activities undertaken in response to the fractured girders at the Transbay Transit Center (TTC). Our review was initially divided into the following five phases:

1. Capacity of the temporary shoring systems.
2. Sampling and testing plan for material from the fractured steel girders.
3. Cause of failure.
4. Impact of fractures on adjacent elements.
5. Repair of Fremont Street girders.

The results of the initial review may lead the panel to recommend other related investigations and analyses, which the panel may also subsequently review.

The purpose of this memo is to document the completion of our review of Phase 1, capacity of the temporary shoring systems. Our review included the temporary shoring systems both at Fremont Street and at First Street, installed to provide an alternative load path from the four TPG3 girders. In both cases, we did not review the initial shoring systems installed on an emergency basis that involved the use of very large hydraulic jacks placed at street level provided by Bigge Crane and Rigging. Our review covered the subsequent more permanent, albeit still temporary, shoring systems that employed the use of hydraulic rams at street level provided by Sheedy Drayage Company.

Our review of the Fremont and First Street shoring systems was to ensure TIPA's project team performed proper due diligence in developing the design. We looked at the basis of design, structural concept and layout, overall stability, selected critical details, and selected calculations. Our scope did not include an in-depth review of all design details

and calculations nor a check for code compliance as this was done by other parties engaged by TJPA.

The process and results of our review are summarized separately below for the Fremont Street shoring and the First Street shoring.

#### Fremont Street Shoring

The review process included numerous online meetings between Thornton Tomasetti and the PRP. The major documents reviewed by the PRP throughout this process are as follows:

- Reports dated October 8 and October 10, 2018 by Thornton Tomasetti, titled: *Salesforce Transit Center – Fremont Street Shoring – Structural Calculations*.
- Memo dated October 13, 2018 from Steven Brokken of AECOM to Mark O'Dell of TJPA, with the subject: *Peer Review of Thornton Tomasetti Fremont Street Shoring at the Salesforce Transit Center*.
- Memo dated October 22, 2018 from Bruce Gibbons of Thornton Tomasetti to Mark O'Dell of TJPA, with the subject: *Shoring Design Peer Review Comments*.
- Drawings of the shoring system by Thornton Tomasetti, in the files: "20181022 TempShoringSet\_TT.pdf," and "20181022 TempShoringSet\_r1.pdf"
- Drawings and calculations by Thornton Tomasetti, in the file: "20181025 Stress Check in TPG3 @ GLE.6 with Composite Section Modulus.pdf"
- Memo dated October 30, 2019 from John Abruzzo to Dennis Turchon titled: *TPG-3 Grid Line 26 Bus Deck Shoring - Brace Calculation*.
- Drawings and calculations by Thornton Tomasetti, in the file: "20181205 Bending and Shear Demands in Fremont Shoring Due to Seismic Rocking.pdf"
- Drawings and calculations by Thornton Tomasetti, in the file: "TPG3 Demands with reduced Jacking Forces 10-24-18.pdf"
- Drawings of the shoring system by Thornton Tomasetti, in the file: "TempShoringAtFremontStSet\_TT20190108\_wStamp.pdf"
  - Sheets: S1-8105; S1-8120 to 8123; S1-8130 to 8138.

Thornton Tomasetti addressed questions and comments from the PRP throughout this process. The PRP concurs with the design of the shoring system at Fremont Street. The basis of our concurrence is the final set of design drawings, which is the last item in the list above ("TempShoringAtFremontStSet\_TT20190108\_wStamp.pdf"), combined with the installation of additional lateral bracing for the W36x529 spreader beams at the bus deck level. This additional lateral bracing is not shown on the final set of design drawings, but has been installed.

### First Street Shoring

The review process included numerous online meetings between Thornton Tomasetti and the PRP. The major documents reviewed by the PRP throughout this process are as follows:

- Report dated November 9, 2018 by Thornton Tomasetti, titled: *Salesforce Transit Center - First Street Shoring - Structural Calculations*
- Memo dated December 3, 2018 from Steven Brokken of AECOM to Mark O'Dell of TIPA, with the subject: *Review of Salesforce Transit Center First Street Shoring*
- Calculations dated December 20, 2018 by Thornton Tomasetti, titled: *Hanger Compression Check*
- Drawings of the shoring system by Thornton Tomasetti, in the file: "TempShoringAtFirstStreetSet\_TT20181112\_wStamp.pdf"
- Drawings of the shoring system by Thornton Tomasetti, in the file: "TempShoringAtFirstStreetSet\_TT20181113\_wStamp.pdf"
- Drawings of the shoring system by Thornton Tomasetti, in the file: "TempShoringAtFirstStreetSet\_TT20190108\_wStamp.pdf"
  - Sheets: S1-8205; S1-8220 to 8222; S1-8230 to 8231; S1-8234.

Thornton Tomasetti addressed questions and comments from the PRP throughout this process. The PRP concurs with the design of the shoring system at First Street. The basis of our concurrence is the final set of design drawings, which is the last item in the list above ("TempShoringAtFirstStreetSet\_TT20190108\_wStamp.pdf").

While the PRP has reviewed and concurs with the design of the shoring systems at Fremont Street and at First Street, the responsibility for the design remains with the engineer of record, and the in-depth engineering design check and regulatory review were done by others.

Sincerely,



Michael D. Engelhardt, P.E., Ph.D.  
Chair, Peer Review Panel

c. Members of PRP:

John Fisher  
Brian Kozy  
Thomas Sabol  
Robert Shaw

March 9, 2019

Stephen Wolf, P.E.  
Principal  
Metropolitan Transportation Commission  
Bay Area Metro Center  
375 Beale Street, Suite 800  
San Francisco, CA 94105

RE: Transbay Transit Center  
Review of TJPA Sampling and Testing Plan for Material from Fremont  
Street Girders

Dear Stephen:

This Peer Review Panel was assembled by MTC at the request of the mayors of San Francisco and Oakland to review the activities undertaken in response to the fractured girders at the Transbay Transit Center (TTC). Our review was initially divided into the following five phases:

1. Capacity of the temporary shoring system.
2. Sampling and testing plan for material from the fractured steel girders.
3. Cause of failure.
4. Impact of fractures on adjacent elements.
5. Repair of Fremont Street girders.

The results of the initial review may lead the panel to recommend other related investigations and analyses, which the panel may also subsequently review.

The purpose of this memo is to document the completion of our review of Phase 2, the TJPA plan for sampling and testing material from the fractured Fremont Street girders. The material sampling and testing was done to support analysis of the cause of the fractures and development of a repair plan. During the development of the plan, members of the PRP had a number of meetings with the TJPA project team, which includes the testing laboratory, engineer of record, contractor, and associated subcontractors, to review and discuss the plan. These meetings took place by conference call, as well as through in-person meetings at the TTC in San Francisco and at LPI, Inc. in New York. Our review started on October 15, 2018 with a meeting with the TJPA in San Francisco and site visit at the Transit Center, and was essentially completed with a visit of panel members to LPI, Inc. in New York on November 8, 2018.

Questions, concerns and recommendations from the PRP throughout this process were addressed by TIPA and reflected in the final material sampling and testing plan. That document, which forms the basis of our concurrence, is titled: "Transbay Transit Center Project – Girder Fracture Specimen Removal & Testing Protocol," dated 11.02.2018 Rev 4.

Our concurrence with the TIPA plan for sampling and testing material from the Fremont Street girders does not preclude future recommendations from the PRP for possible additional material sampling and testing, should we see the need for this as the investigation proceeds.

While the PRP has reviewed and concurs with the material sampling and testing plan, the responsibility for all aspects of the investigation of the fractured girders and resulting actions remains with the engineer of record.

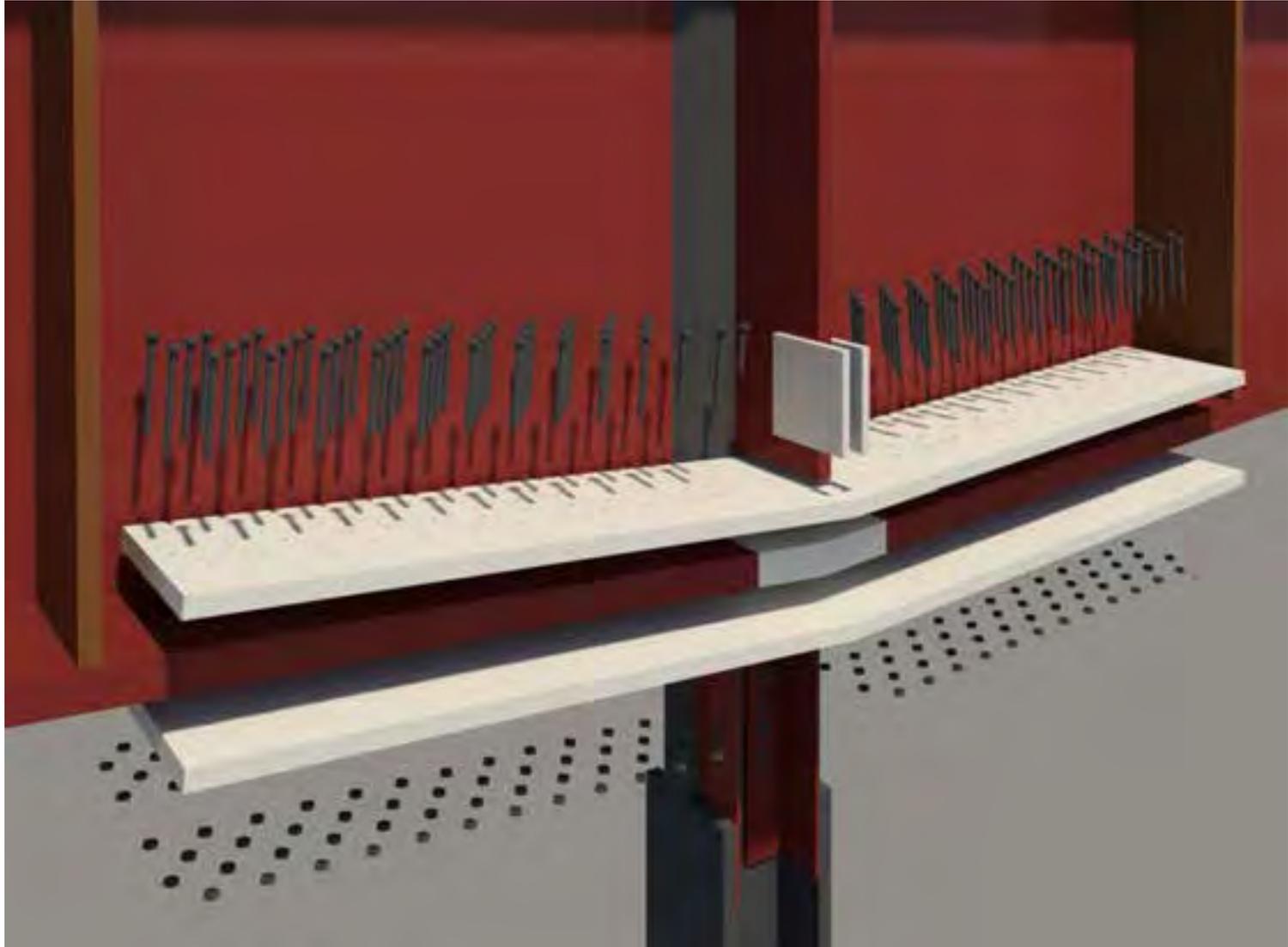
Sincerely,



Michael D. Engelhardt, P.E., Ph.D.  
Chair, Peer Review Panel

c. Members of PRP:  
John Fisher  
Brian Kozy  
Thomas Sabol  
Robert Shaw

# Girder Remediation Detail



This graphic has details specific to Fremont street girders

# Recent Actions



March 15, 2019

Stephen Wolf, P.E.  
Principal  
Metropolitan Transportation Commission  
Bay Area Metro Center  
375 Beale Street, Suite 800  
San Francisco, CA 94105

RE: Transbay Transit Center  
Review of Designs for Repair of Fremont Street Girders and Retrofit of  
First Street Girders

Dear Stephen:

This Peer Review Panel (PRP) was assembled by MTC at the request of the mayors of San Francisco and Oakland to review the activities undertaken in response to the fractured girders at the Transbay Transit Center (TTC). Our review was initially divided into the following five phases:

1. Capacity of the temporary shoring systems.
2. Sampling and testing plan for material from the fractured steel girders.
3. Cause of failure.
4. Impact of fractures on adjacent elements.
5. Repair of Fremont Street girders.

The results of the initial review may lead the panel to recommend other related investigations and analyses, which the panel may also subsequently review.

The purpose of this memo is to document the completion of our review of Phase 5, repair of Fremont Street girders. The repair is meant to restore the structural capacity of the bottom flanges of the fractured tapered plate girders over Fremont Street (designated in the design drawings as TPG3), and consists of dressing requirements for the existing material and a new steel sandwich plate design bolted across the fractures.

This memo also documents the completion of our review for a related item, the design of the retrofit of First Street girders. Although the two TPG3 girders over First Street did not fracture and were subject to a different sequence of fabrication that substantially minimized that risk, the PRP concurs with TJPA's decision to further mitigate the risk and consequences of fracture by retrofitting the girders. The retrofit provides redundant capacity to the bottom flanges of the TPG3 girders over First Street. The design is similar to that at Fremont Street, with modifications accounting for the intact flange.

The review process included numerous online meetings as well as in-person meetings between Thornton Tomasetti and the PRP. The review extended over several months, starting with initial discussions of the design concepts and then continuing through evaluation of the detailed design.

Thornton Tomasetti addressed questions and comments from the PRP throughout this process. The PRP concurs with the design of the repair of the Fremont Street girders and the design of the retrofit of the First Street girders.

The basis of our concurrence for Fremont Street is:

- The final set of design drawings prepared by Thornton Tomasetti, dated January 28, 2019. The drawings are titled: "Fremont Street TPG3 Girders Repair Sections and Details," and are marked "Issued for Construction."
  - Sheets: S1-8401 to 8403.

The basis of our concurrence for First Street is the following documents:

- The final set of design drawings prepared by Thornton Tomasetti, dated February 22, 2019. The drawings are titled: "First Street TPG3 Girders Repairs and Details," and are marked "Issued for Construction."
  - Sheets: S1-8404 to 8406.
- Document: LA181690-PR-003 TTC TPG3 Hanger Blend Grinding Procedure - Rev 2A.
- Document: LA181690-PR-004 TTC TPG3 Hanger Needle Peening Procedure - Rev 1A.

While the PRP has reviewed and concurs with the design of the repair of the Fremont Street girders and the retrofit of the First Street girders, the responsibility for the design remains with the engineer of record.

Sincerely,



Michael D. Engelhardt, P.E., Ph.D.  
Chair, Peer Review Panel

- c. Members of PRP:
- John Fisher
  - Brian Kozy
  - Thomas Sabol
  - Robert Shaw
  - Bill Mohr (consultant to PRP)

# Attachment I

City and County of San Francisco  
Department of Building Inspection



London N. Breed, Mayor  
Tom C. Hui, S.E., C.B.O., Director

April 17, 2019

Mr. Mark Zabaneh, P.E.  
Executive Director  
Transbay Joint Powers Authority  
201 Mission Street, Suite 2100  
San Francisco, CA 94105

Subject: Intergovernmental Agreement (10/16/2018)  
Professional Services on Transit Center Building Repairs  
(DBI #2018-1017-3473)

Dear Mr. Zabaneh:

The Department of Building Inspection (DBI) has concluded its plan review of the construction documents for the Repair of Fremont Street Girders and Retrofit of First Street Girders, prepared by Thornton Tomasetti, engineer of record for Transbay Transit Center. We reviewed several submittals of structural drawings and calculations, and participated in several review meetings between the Peer Review Panel assembled by Metropolitan Transportation Commission (MTC) and Thornton Tomasetti. We are pleased to inform you that we have found the structural construction documents for the repair and retrofit to be in general conformance with the 2016 San Francisco Building Code, based on our review of the following items:

- Construction drawing package, dated 3/13/19
- Structural calculations, dated 3/13/19
- Peer Review Panel letter to MTC, dated 3/15/19

If you have any questions or comments, please do not hesitate to contact the undersigned.

Sincerely,

A handwritten signature in blue ink, appearing to read "Howard Zee".

Howard Zee  
Structural Engineer  
Plan Review Services Division

cc: Tom C. Hui, S.E., C.B.O, Director  
Daniel Lowrey, Deputy Director for Permit Services  
Edward Sweeney, Deputy Director for Inspection Services  
Taras Madison, Deputy Director for Administrative Services  
Gary Ho, S.E., Manager, Plan Review Services  
James Zhan, P.E., Senior Engineer, Plan Review Services  
Dennis Turchon, Senior Construction Manager, TJPA

**Thornton Tomasetti**

Via email: dturchon@tjpa.org

April 19, 2019

Mr. Dennis Turchon  
Senior Construction Manager  
TJPA  
201 Mission Street, Suite 2100  
San Francisco, CA 94105

RE: Completion of Structural Repair of TPG-3 Girders at Fremont Street  
Thornton Tomasetti Project No. U18099

Dear Dennis,

I have reviewed the completed work, observed the installation periodically, and reviewed the inspection reports for the work associated with the repair of the TPG-3 Girders at Fremont Street. I believe the repairs constructed meet the intent of the repair drawings and are in general conformance to the repair drawings S-18401, S1-8402, S1-8403 which embody the repairs at this location.

Very Truly Yours,

**THORNTON TOMASETTI, INC.**



John Abruzzo, SE 6363 CA  
Managing Principal  
Thornton Tomasetti, Inc



Cc:  
Bruce Gibbons  
Gary Panariello

# Thornton Tomasetti

Via email: dturchon@tjpa.org

April 27, 2019

Mr. Dennis Turchon  
Senior Construction Manager  
TJPA  
201 Mission Street, Suite 2100  
San Francisco, CA 94105

RE: Completion of Structural Repair of TPG-3 Girders at First Street  
Thornton Tomasetti Project No. U18099

Dear Dennis,

I have reviewed the completed work and observed the installation periodically for the work associated with the repair of the TPG-3 Girders at First Street. I believe the repairs constructed meet the intent of the repair drawings and has been performed in accordance with positive inspections and are in general conformance to the repair drawings S-18404, S1-8405, S1-8406 which embody the repairs at this location.

Very Truly Yours,

**THORNTON TOMASETTI, INC.**



John Abruzzo, SE 6363 CA  
Managing Principal  
Thornton Tomasetti, Inc



Cc:  
Bruce Gibbons  
Gary Panariello

# Facility-Wide Validation

## Full Building Structural Steel Health Check

Progression through the successive sieves of the funnel has been completed and confirmed to be acceptable.





**Memorandum**

---

To: Bob Beck  
Brian Dykes  
File Code: 1.40-6.90

Cc: Gerry MacClelland, Stephen Perreault,  
Alfred Lau, Ed Sum, Document Control  
Reply Required: No

From: Mark O'Dell  
Date Required: N/A

Date: May 10, 2010  
Via:  Mail  Hand deliver  
 Email  Other (specify)

Subject: Report on the Structural and Seismic Review Committee

---

As of today May 10, 2010, the Structural and Seismic Review Committee (SSRC) is working on the following four review assignments: Ground Motion Hazard Evaluation, Structural Basis of Design, the Buttress and Shoring Wall Design, and the Bus Ramp Design Criteria.

The SSRC was formed in November of 2008 to provide guidance to the TJPA by validating the Transit Center Structural Engineers' proposed performance-based design assumptions. The first two assignments listed above, the Ground Motion Hazard Evaluation and the Structural Basis of Design, are the two documents that correspond to that initial purpose.

In November of 2009, the San Francisco Department of Building Inspection (DBI) requested that TJPA employ members of the SSRC to assist DBI staff in the structural plan review of the Transit Center.

Based on requirements in DBI's Administrative Bulletin 82, the SSRC was organized to address the following Structural Design Review Elements:

1. Ground Motion Hazard Analysis
2. Structural Basis of Design
3. Soil Structure Interactive Analysis & 2D Finite Element Analysis
4. 3D Finite Element Analysis
5. Buttress and Shoring Design
6. Substructure (Train Box) Construction Documents
7. Superstructure (Primary Steel Frame) Construction Documents
8. Bus Ramp

To expedite review of these eight Structural Design Review Elements, the PMPC has assigned specific members of the SSRC to each, based on expertise and availability. The accompanying chart illustrates this organization.

The following is a synopsis of the SSRC reviews currently in progress:

## **Ground Motion Hazard Analysis**

### **Background**

On December 2, 2009, the Ground Motion Hazard Analysis was issued to the SSRC for review and comment. Between December 11, 2009, and February 9, 2010, the SSRC and the design team exchanged multiple comment and response documents in an attempt to resolve outstanding issues. A meeting was held on February 11, 2010, to review the issues in detail, and to decide on a path toward resolution.

### **Outstanding Issues**

At the end of the meeting there were two issues to resolve:

- Whether the selected ground motions included velocity pulses appropriate for the building and the site
- Whether the ground motion studies accounted for sufficient variability in the soil profile

### **Resolution Efforts**

Over the ensuing month multiple e-mail exchanges took place regarding both issues.

Ultimately, at a SSRC buttress meeting on March 11, 2010, the design team agreed to review other records for their velocity pulse content, choose three, and then conduct site response analyses for these. A series of conference calls and meetings between the SSRC and the design team to determine which records to use took place over the next few weeks.

Regarding the variability of the soils, the design team feels very strongly that this effect is more than adequately addressed by calculating the effect of the permanent unloading of the soil, due to the excavation, on the dynamic soil properties that are about to be used in detailed soil-structure interaction analysis. This effect is substantially larger than the natural variability of the ground. While such calculations go beyond normal requirements, they are appropriate for this unique situation. In this way the effects of soil variability on the structural behavior of the train box during earthquake loading can be examined. The design team is thus addressing the SSRC's concern and hope it concurs.

### **Current Action**

The design team is completing its analysis and report.

A meeting or conference call will occur the week of May 10 to review the next steps with the SSRC.

## **Structural Basis of Design**

### **Background**

Thornton Tomasetti formally proposed seismic design criteria for the Transit Center on March 30, 2009. Over the following year, that criteria along with the structural design was discussed, debated and refined. The building has transverse structural steel special moment-resisting frames (SMRF) and longitudinal eccentric braced frames (EBF).

### **Outstanding Issues**

The SSRC has two concerns:

- The proposed EBF system and link beams lack redundancy.
- The SMRF and the EBF are unique and have not been previously tested.

### **Resolution Effort**

To address the SSRC's concerns, Thornton Tomasetti drafted requests for proposals in order to select labs to perform the required testing to ensure the connections as currently designed will meet the seismic criteria. These RFPs have been sent to the SSRC for review and comment.

### **Current Actions**

The SSRC has written a letter to DBI recommending that the structural design proceed based on the further acceptance criteria established in the SSRC's recommendation letter for the EBF links, and the testing program developed for the frames.

A meeting or conference call will occur the week of May 10 to review the next steps with the SSRC.

## **Buttress and Shoring Design**

### **Background**

In May of 2009, Arup hosted a two-day presentation/workshop to review the preliminary design of the buttress. Arup has hired its own Geotechnical Board of Consultants (BOC) to provide guidance. After the May 2009 presentation, the BOC issued its first report regarding the design of the buttress and shoring, and the geotechnical investigations. Since then, numerous meetings have been held with Arup, the BOC, the SSRC, and the TJPA to refine the design of both the buttress and the shoring.

Site trials of the buttress construction methods were successfully carried out between September 2009 and the end of the year. Results of the trials and associated analyses were presented to the SSRC on January 6, 2010.

### **Outstanding Issues**

Based on the SSRC review meeting of January 6, Arup prepared additional 2D and 3D analysis requested by the SSRC and presented those at the March 11 meeting. The results have been incorporated in the calculation packages for building permit submission. The SSRC reviewed the calculations and issued comments, which are currently being responded to by Arup.

### **Resolution Effort**

After the SSRC receives and agrees with Arup's comment responses, the SSRC will write its recommendation letter to DBI.

### **Current Actions**

We are currently scheduled to issue the Buttress/Shoring/Excavation Bid Package for both bid and final DBI review and concurrence in June 2010.

A meeting or conference call will occur the week of May 10 to review the next steps with the SSRC.

## **Bus Ramps**

### **Background**

In February of 2010, the design team issued its Preliminary Engineering Report and draft Geotechnical Data Report to the SSRC for review. Subsequently, on February 19, a meeting was held with the design team and the SSRC to discuss the structural design criteria for the Bus Ramps.

### **Outstanding Issues**

Finalization and acceptance of design criteria.

### **Resolution Effort**

ARUP will develop a detailed basis of design and rationale for proposed basis for follow-up presentation to the SSRC.

### **Current Actions**

Arup is currently developing a detailed basis of design.



San Francisco  
Los Angeles  
Portland  
Oakland  
San Diego  
Seattle

April 15, 2014

Mr. Hanson Tom  
San Francisco Department of Building Inspection  
1660 Mission Street, 2<sup>nd</sup> Floor  
San Francisco, California 94103

Reference: **Above Grade Structural Construction Package  
Transbay Transit Center  
San Francisco, California  
[Degenkolb Job Number A5138052.02]**

Dear Hanson:

The Structural and Seismic Review Committee (SSRC) for the Transbay Transit Center held its initial meeting in December 2008 and has been reviewing the Structural Basis of Design and various drawings and calculation submittals over the past 6 years. We sent you a letter dated October 30, 2012, in which we recommended that a Building Permit be issued for the Below Grade portion of the structure.

The SSRC has now completed its review of the above ground structural package and has resolved all outstanding comments and issues. The SSRC finds that the current drawings for the Above Grade Structural Package are in general conformance with the San Francisco Building Code and the Basis of Design Report for the project. The SSRC recommends that a Building Permit be issued for the Above Grade structural portion of the project with the following caveats or exceptions:

1. There is a proposed Roof Park Restaurant that is currently in design and therefore has not been reviewed by the SSRC. We will review that design when it is completed including any modifications needed to the basic structure.
2. We understand that future bridges from adjacent buildings and a proposed Transbay Tower Gondola are in planning that will undoubtedly affect the design of the terminal. The SSRC has not seen these designs and should review these designs before they are permitted.
3. The SSRC continues to review drawings, calculations and revisions to the Glazing and facade packages for the Terminal that will be part of the overall Phase 1 Main Package. While glazing is normally a non-structural item, many of these systems are structural in nature and are potential life safety concerns. The SSRC will report to you separately on these systems and they should not be included in the current permit you will be issuing.

www.degenkolb.com

Degenkolb Engineers

235 Montgomery Street  
San Francisco, California 94104

500  
SUITE

415

392.6952 phone  
981.3157 fax



April 15, 2014

Page 2

4. The SSRC continues to review the design and details of the Bus Ramps that will connect the Bus Level of the Transbay Terminal with the Bay Bridge. While the permitting of this bridge type structure will probably be issued by the San Francisco Department of Public Works (possibly with Caltrans), we will include DBI in our correspondence when the SSRC completes its review of this bridge structure.

We believe the proper set of drawings to approve for construction is the "Structural Steel and Concrete Superstructure Package" dated April 4, 2014.

Please call if you have any questions. This recommended acceptance for the Above Grade Structural Construction Package has been reached by SSRC members Mason Walters and Loring Wyllie. Jack Moehle was involved in some of the early reviews of this package. Mason Walters has reviewed and agreed to the text of this letter.

Very truly yours,

DEGENKOLB ENGINEERS

A handwritten signature in black ink, appearing to read "Loring A. Wyllie, Jr.", written in a cursive style.

Loring A. Wyllie, Jr.  
Chair, SSRC

cc: Mason Walters  
Jack Moehle  
Howard Zee  
Mark O'Dell  
Brian Dykes  
Daniel Alvarado

# Attachment O

City and County of San Francisco  
Department of Building Inspection



Edwin M. Lee, Mayor  
Tom C. Hui, S.E., C.B.O., Director

April 16, 2014

Mr. Mark Zabaneh, P.E.  
Senior Program Manager  
Transbay Joint Powers Authority  
201 Mission Street, Suite 2100  
San Francisco, CA 94105

Subject: TG07 Superstructure Structural Steel and Concrete  
Above Grade Structural Construction Package  
(DBI #2011-0912-4364)

Dear Mr. Zabaneh:

The Department of Building Inspection (DBI) has concluded its plan review of the construction documents for the Above Grade Structural Construction Package TG07 of the Transbay Transit Center. We reviewed numerous submittals of structural drawings and calculations over the past several years. We have concluded our review, noting that possible roof park restaurant and cafe, and future bridges and gondola system from adjacent buildings are excluded from the scope of our review and this letter. We are pleased to inform you that we have found the structural construction documents to be in general conformance with the 2007 San Francisco Building Code, based on our review of the following items:

- Construction drawing package for TG07, various dates, submitted 4/11/2014
- Structural calculations by Thornton Tomasetti, dated 4/3/2014 (3 volumes)
- SSRC review letter dated 4/15/2014

For DBI inspection services, please contact Mr. Donal Duffy, Building Inspection Division, at (415) 558 6120. Mr. Duffy will also coordinate plumbing and electrical inspections, as necessary. Please provide us a minimum of three working days advanced notice prior to the date inspections will be required.

If you have any questions or comments, please do not hesitate to contact the undersigned.

Sincerely,

Handwritten signature of Howard Zee in black ink.

Howard Zee  
Structural Engineer  
Plan Review Services Division

Handwritten signature of Hanson Tom in black ink.

Hanson Tom, S.E.  
Principal Engineer  
Plan Review Services Division

cc: Tom C. Hui, S.E., C.B.O., Director  
Edward Sweeney, Deputy Director for Permit Services  
Daniel Lowrey, Deputy Director for Inspection Services  
Mark O'Dell, TJPA  
Ed Sum, P.E., TJPA

**Plan Review Services**  
1660 Mission Street – San Francisco CA 94103  
Office (415) 558-6133 – FAX (415) 558-6041 – [www.sfdbi.org](http://www.sfdbi.org)

# Attachment P

## STAFF REPORT FOR CALENDAR ITEM NO.: 6 FOR THE MEETING OF: March 14, 2019

### TRANSBAY JOINT POWERS AUTHORITY

#### BRIEF DESCRIPTION:

Summary of the Quality Control/Quality Assurance Program for the Salesforce Transit Center.

#### REPORT:

The Transbay Program's Quality Management System (QMS) is a systematic approach to implementing and ensuring that all services and products for the Program are delivered and produced at the highest quality available to the industry. The QMS requirements for quality control/quality assurance (QC/QA) during construction follow the Federal Transit Administration's 2012 Quality Management System Guidelines and the U.S. Army Corps of Engineers (USACE) Guideline Specification 01451, Contractor Quality Control.

#### Quality Team

The Quality Program for the Salesforce Transit Center requires a collaborative "Quality Team" approach where each team member's responsibilities are clear, each is accountable for quality, and each follows a well-documented quality process with multiple levels of checks and balances throughout.

The Program Quality Team consists of:

- TJPA Program Quality Assurance—Program QA establishes the Program's quality policy and quality objectives for the management of planning, design, construction, and commissioning of the projects within the Program. Program QA communicates the importance of meeting quality requirements and conducts management quality reviews and audits.
- Architect and Engineer-of-Record (Pelli Clarke Pelli Architects/Thornton Tomasetti—the architect and engineer set quality standards and requirements during design and specification development, thus setting the requirements through contract documents. They verify standards through the submittal process and through field observations during construction.
- Construction Management Oversight (CMO-Turner Construction Company)—the CMO functions as the TJPA's eyes and ears during construction. The CMO's role is quality assurance, which includes performing specialty inspections and establishing QA plans and procedures to provide for effective oversight of the projects, including Contractor Quality Control (CQC).

From a QA standpoint, the CMO's duties are to:

- Develop the QA Plan in accordance with the Program QMS, FTA requirements and USACE best practices and update the QA Plan as construction progresses.
- Perform quality surveillances of the CM/GC and vital offsite surveillances at manufacturing facilities around the country.

- Inspect steel, soils, concrete, fireproofing, and building systems over the course of the project, following protocols established by the engineer-of-record, the architect, or the authority responsible for compliance with governing code.
- Track inspection requests and results. Construction Manager/General Contractor (CM/GC-Webcor Obayashi Joint Venture)—the CM/GC manages and directs the work. The CM/GC’s role is quality control; they direct their trade subcontractors to execute their respective CQC plans and maintain compliance with all project requirements as described in the contract documents.

From a QC standpoint, the CM/GC and trade subcontractor’s duties are to:

- Develop and execute a CQC Plan specific to their scope of work, in accordance with the Program QMS.
- Review submittals and requests for information for completeness, clarity and coordination with other trades prior to submitting them to the TJPA.

### **Special & Code Compliance Inspections**

The CMO conducted approximately 3 million individual QA inspections and observations for the project, both on and offsite between 2011 and 2018. The major inspections, observations, and tests performed are summarized in the following sections:

#### ***Structural Concrete***

Approximately 200,000 cubic yards of concrete were poured for the transit center and bus ramp projects. This includes installation of a 5-foot-thick mat foundation, foundation walls, columns, structural walls, and all structural slabs on the metal decks from the ground to the rooftop park levels. Concrete inspections and testing involved the following protocols:

- Concrete Verification:
  - Verify and confirm concrete batch plant tickets meet design specifications.
  - Perform “slump cone” test per American Society for Testing and Materials (ASTM) C143, Standard Test Method for Slump of Hydraulic Cement Concrete
  - Record supplier, air temperature, concrete mix temperature, air content & weight
- Concrete Sampling
  - Report location of concrete placement, sample size, time/duration of placement, No. of samples taken & confirm approved concrete mix design.
  - Secure samples sets per ASTM C172, Standard Practice for Sampling Freshly Mixed Concrete
- Concrete Placement Observation
  - Inspect reinforcing steel placed prior to concrete pours—approximately 3700 such inspections were done for the project
  - Verify placement times & procedure
- Concrete Testing
  - One sample is taken for every 100 cubic yards poured

- Shrinkage test per ASTM C157, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
- Test cylinders per ASTM C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field, and ASTM C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Concrete testing verified that the specified design strength was achieved on all concrete poured for the project.

### ***Micropiles***

As part of the excavation contract, 1896 micropiles were installed at a depth of 75–85 feet to anchor the building against hydrostatic uplift pressure. Testing and inspections involved:

- Material Certifications: Confirm bar diameter/grade/type/length per ASTM A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- Installation Verification
  - Verify identification number and location
  - Verify grout mix—consistency and specific gravity measured using the Mud Balance method (per American Petroleum Institute recommended practice for field testing water-based drilling fluids (API RP-13B-1) or the Flow Cone Method (per California Test Method 541, Method of Test for Flow of Grout Mixtures)
  - Verify 3-day strength of 2000 psi and 28-day strength of 4000 psi
- Proof Testing
  - Verify equipment calibration—gauge and ram
  - Perform a “pull” test on every micropile to 1.54 times the design strength or 308 kips
  - Verify displacement—less than 0.0825 inch in 10 minutes at 308 kips
  - Verify creep movement—less than 0.04 inch in 10 minutes; less than 0.08 inch in 6 to 60 minutes at 308 kips

Each micropile was tested, and testing verified that all micropiles met the specified design criteria.

### ***High Strength Bolts***

10,000’s high-strength bolts were installed throughout the structural system of the building. Testing and sampling involved, of the testing performed only 4 ea. Nonconformance Reports were written and subsequently were closed by re-torquing or replacement and retesting:

- Material Certification & Sampling/Testing
  - Verify material and mill certification
  - Collect samples to be taken per specification/engineer-of-record
- Equipment Calibration
  - Verify equipment calibration reports

- Proof Testing
  - Perform failure testing to 840 kips (specific to light column bolts)
  - Perform testing (pulling, bending, breaking) per the following ASTM standards:
    - A722/722M, Standard Specification for High-Strength Steel Bars for Prestressed Concrete
    - A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products
    - E30, Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron
    - A700, Standard Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment

Each bolt was tested, and testing verified that all high strength bolts met the specified design strength.

### **Mechanical, Electrical, Plumbing Third Party Inspections**

The MEP systems include all mechanical, electrical, plumbing, ventilation, air conditioning, and fire suppression/protection systems for the transit center. Each system was tested and verified for compliance with governing code. Over 4,000 inspections were performed by:

- City of San Francisco
  - Fire Department—inspections of fire suppression systems and fuel oil piping, and code required testing
  - Department of Building Inspection—electrical, plumbing, mechanical/building systems
  - Public Works—civil work in the streets and sidewalks
- Public Utilities Commission—underground utility duct banks and sewer connections
- Cal/OSHA—elevators and escalators
- PG&E—inspection of underground conduits and gas piping

Additionally, project elements on state right-of-way were subject to oversight by the Department of Transportation, which reviewed quality assurance documentation, inspections and records, per contract requirements.

### **MEP Commissioning**

Commissioning is a quality assurance process for achieving, verifying, and documenting that building systems are installed and perform functionally as intended according to the owner's project requirements, the A/E's basis of design, and the requirements of the contract documents. A third-party Commissioning Agent (Cx) oversaw the following commissioning process:

1. Installation Verification—Conducted by the Contractor
  - To field verify and document proper installation of the system equipment, assemblies, and components prior to conducting startup

2. Equipment Startup & Pre-functional Checkout—Conducted by the Contractor
  - To ensure that equipment will operate as intended and manufacturer warranties are not voided
3. Systems Readiness Checklist—Completed by the Contractor (reviewed by the Cx)
  - To ensure equipment and systems have been properly installed, connected, started, and are operational, and that the equipment is ready for the start of functional testing
4. Functional Performance Test are conducted by the Cx (System commissioning to be verified as a percentage of systems)
  - To dynamically test the equipment and system performance under full operation as they would operate upon project completion

**RECOMMENDATION:**

For information only.



Via email [dturchon@tjpa.org](mailto:dturchon@tjpa.org)

June 7, 2019

Mr. Dennis Turchon  
Senior Construction Manager  
TJPA  
201 Mission Street, Suite 2100  
San Francisco, CA 94105

RE: Re-occupancy of Salesforce Transit Center  
Thornton Tomasetti Project No. U18099

Dear Dennis,

This letter is to memorialize the adequacy and acceptance of the investigation and repair work performed to allow resumption of operation of the center after closure due to the discovery of cracks in the TPG-3 steel girders located in the roof structure that crosses over Fremont Street

As a result of this discovery, the similar condition which occurs where the building crosses over First Street was immediately exposed and inspected for damage. While no damage was found, the similar repair produced for the Fremont Street location was also installed as a remediation to the TPG-3 girders over First Street. We believe this to be the prudent course of action.

The portions of the cracked elements which embodied the cracks were removed from the structure and studied by LPI to determine the conditions which caused fracture. While this study is not yet complete, it is clear that the steel plates, which comprise the lower flange of the girders, fractured in a brittle manner under normal service stresses in the girders. Study of the cause of the cracks informed our repair and remediation and explained why the girders over First Street did not fracture as the fabrication sequence was different.

In light of this, we also reviewed many other structural details and fabrications with the assistance of the construction team of Webcor, Skanska and their fabricator subconsultants and agents for TJPA such as Turner, LPI, ISI and others. The scope of the review was to determine if other conditions existed where brittle fracture was possible through the combination of fabrication, material and stress.

RE: Re-occupancy of Salesforce Transit Center

Page 2 of 2

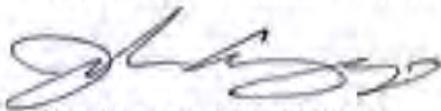
We have reviewed the completed work, observed the installation, and reviewed the inspection reports for the work associated with the repair of the TPG-3 Girders at Fremont Street and First Street. We believe the repairs constructed are in general conformance with the repair and remediation drawings.

We also have concluded our study of other areas which may be susceptible to brittle fracture and based on the exhaustive investigation have found no areas of concern.

Therefore, Thornton Tomasetti, Inc. believes the structural framing to be sound and competent and can be placed in service.

Very Truly Yours,

THORNTON TOMASETTI, INC.



John Abruzzo, SE 6363 CA  
Managing Principal  
Thornton Tomasetti, Inc



Bruce Gibbons, SE 4160 CA  
Managing Principal  
Thornton Tomasetti, Inc.

Cc:  
Gary Panariello

TRANSBAY TRANSIT CENTER - PEER REVIEW PANEL

June 10, 2019

Stephen Wolf, P.E.  
Principal  
Metropolitan Transportation Commission  
Bay Area Metro Center  
375 Beale Street, Suite 800  
San Francisco, CA 94105

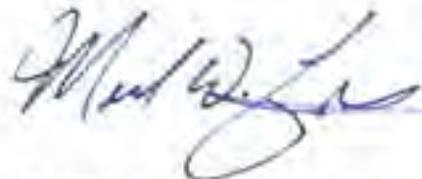
RE: Transbay Transit Center  
Re-Occupancy of Transit Center

Dear Stephen:

This Peer Review Panel was assembled by the Metropolitan Transportation Commission at the request of the mayors of San Francisco and Oakland to review the activities undertaken in response to the fractured girders at the Transbay Transit Center (TTC). The purpose of this letter is to document that the Peer Review Panel believes the project team and consultants of the Transbay Joint Powers Authority (TJPA) performed the proper due diligence in their evaluation of the root physical cause of fracture, design of the repair, and search for other areas susceptible to brittle fracture. The Peer Review Panel takes no exception with the recommendation by Thornton Tomasetti to allow resumption of operation of the center, as documented in their letter to TJPA dated June 7, 2019.

While some aspects of our review of work undertaken by TJPA in response to the fractured girders are still ongoing, these ongoing items do not impact re-occupancy of the TTC.

Sincerely,



Michael D. Engelhardt, P.E., Ph.D.  
Chair, Peer Review Panel

c. Members of Peer Review Panel:  
John Fisher  
Brian Kozy  
Thomas Sabol  
Robert Shaw

# Attachment S



**METROPOLITAN  
TRANSPORTATION  
COMMISSION**

Bay Area Metro Center  
175 Bush Street, Suite 800  
San Francisco, CA 94105  
415.776.6700  
[www.mtc.ca.gov](http://www.mtc.ca.gov)

June 10, 2019

*Gene Haggerty, Chair*  
Maricopa County

*Alyssa Padron, Vice Chair*  
Santa Clara and Cities

*Yvonne Bralton*  
Cities of Santa Clara County

*Doreen Connolly*  
Santa Clara County and Cities

*Davey Corbin*  
Santa Clara County

*Carol D'Amico-Harwood*  
City of Maricopa County

*Doreen H. Gungah*  
U.S. Department of Transportation

*Patricia D. Glavin*  
Santa Clara County

*James W. Hallock*  
San Francisco Bay Conservation  
and Development Commission

*James Jackson*  
U.S. Department of Housing  
and Urban Development

*Nick Bergbreit*  
San Francisco, Newark, Agencies

*Sam J. Lacerda*  
San Jose Mayor's Agency

*John Madenauer*  
Santa Clara County and Cities

*Clara Pagan*  
Cities of San Mateo County

*David Rubin*  
Member of Bay Area Commission

*Allyson Bunn*  
District County of San Francisco

*Libby Schaaf*  
Oakland Mayor's Agency

*Warren Skyles*  
San Mateo County

*James P. Sperry*  
Santa Clara County and Cities

*Joey Zavers*  
California State  
Transportation Agency

*Greg B. Havel*  
Cities of Contra Costa County

*Thomas W. McMillin*  
Executive Director

*Ally Madenauer*  
Deputy Executive Director, Policy

*Andrew B. Frenson*  
District Executive Director, Operations

*David Paul*  
Finance Executive Director,  
Food & Environmental Services

The Honorable London N. Breed  
Mayor, City of San Francisco  
City Hall  
1 Dr. Carlton B. Goodlett Place  
San Francisco, CA 94102

The Honorable Libby Schaaf  
Mayor, City of Oakland  
City Hall  
1 Frank H. Ogawa Plaza  
Oakland, CA 94612

RE: Update on Transbay Transit Center Peer Review

Dear Mayor Breed and Mayor Schaaf:

In response to your letter last October 5 to Steve Heminger, my predecessor as the Commission's executive director, MTC convened an independent panel of experts to review the investigations into the cause of the fracture of two girders at the Transbay Transit Center, and to review the repairs made to the girders. This independent review effort has progressed for the past eight months, and in MTC's sixth update to you I am pleased to report the Peer Review Panel's concurrence with the recent determination by the Transbay Joint Powers Authority (TJPA) that the steel structure is sound for continued service.

As you will recall, the scope of the review conducted by MTC's Peer Review Panel was divided into the following six phases, with status noted alongside. The last of these six phases was added once the cause of failure was understood. Additional detail is provided in the attachment.

1. Shoring capacity: Reviewed and concurred
2. Sampling and testing plan: Reviewed and concurred
3. Cause of failure: Reviewed; concurrence with fracture hypothesis
4. Other areas impacted by the steel fractures: Reviewed and concurred
5. Repair solution: Reviewed and concurred
6. Search for other areas susceptible to brittle fracture: Reviewed and concurred

I have attached the June 7, 2019 letters from TJPA and its Engineer of Record, Thornton Tomasetti, which document their determinations that the repairs to the fractured girders are complete and the steel structure is sound. I have also attached the Peer Review Panel's June 10, 2019 letter to MTC, which concurs with these findings.

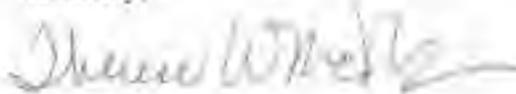
MTC supports the reopening of the Transbay Transit Center based on TJPA's project team's structural findings and the Peer Review Panel's concurrence. We agree the steel structure is ready for service. The reopening date is subject to other work by TJPA that is beyond our purview, including review of testing and inspection reports, commissioning of building management systems, revalidation of fire/life safety systems, and ramp-up of operations.

Mayor Breed and Mayor Schaaf  
Page 2 of 2  
June 10, 2019

While the Peer Review Panel's examination of structural issues related to reopening the Transbay Transit Center is complete, there are additional items to close out over time. These include resolving the Peer Review Panel's comments on the failure analysis report with TJPA's project team, and review of TJPA's fatigue assessment plan. Lastly, the panel expects to issue a letter that will include comments on lessons learned and will recommend changes to code and industry standards to help avoid this type of failure in the future.

We can represent to you and the public alike confidence that the Transbay Transit Center's girder problem was isolated and that the appropriate repairs have been performed. Please do not hesitate to contact me with any questions.

Sincerely,



Therese W. McMillan  
Executive Director

cc:

Scott Haggerty, Chair, Metropolitan Transportation Commission  
Michael Engelhardt, Chair, Peer Review Panel  
Mohammad Nuru, Chair, Transbay Joint Powers Authority  
Mark Zabaneh, Executive Director, Transbay Joint Powers Authority  
Ramakrishna Pochiraju, Executive Director of Planning & Engineering, AC Transit

TM: SW

J:\SECTION\EXEC\EO\Therese McMillan\Correspondence\2019\0610\_Schaaf\McMillan\_Transbay Transit Center Peer Review\_20190610.docx

Attachments

## Schedule

### Milestones to Date:

- August 12, 2018: Transit Center opens for bus operations.
- September 25, 2018: Workers installing ceiling panels discover a fracture in the bottom flange of a girder over Fremont Street. Transbay Joint Powers Authority (TJPA) closes the Transit Center. In the following days, TJPA discovers a fracture in a second similarly designed girder over Fremont Street. Two other girders over First Street share the design of the fractured girders but remain intact. TJPA installs shoring at Fremont and First Streets.
- October 4, 2018: The mayors of Oakland and San Francisco write a letter to MTC requesting MTC provide an independent evaluation of the cause of failure and repair. Subsequently, MTC assembles a Peer Review Panel (PRP) consisting of experts in steel design and construction, structural analysis, and fracture mechanics.
- December 13, 2018: TJPA presents to its board the fracture hypothesis based on materials analysis and the preliminary design for the repair. PRP concurs.
- January 2019: TJPA begins search for other areas susceptible to brittle fracture.
- February 14, 2019: TJPA reports to its board that it will retrofit First Street similar to the Fremont Street repair. PRP concurs.
- May 2019: Fremont Street repair and First Street retrofit are complete. PRP provides comments on the results of the computational analysis of the cause of failure, prepared by LPI. The report supports the fracture hypothesis reported in December 2018.
- June 2019: TJPA completes search for other areas susceptible to brittle fracture and finds there are no conditions of further concern. Thornton Tomasetti certifies and TJPA agrees the structure is sound and ready to reopen. PRP concurs.
- After Reopening of the Transit Center: Resolution of the Peer Review Panel's comments on the failure analysis report with TJPA's project team. Review of TJPA's fatigue assessment plan. Completion of PRP's final report, including recommendations for changes to code and industry standards.

## Participants

### TJPA's project team:

1. Thornton Tomasetti: Structural Engineer of Record
2. LPI: Failure investigation and fitness for service consultant
3. Webcor: General contractor
4. Skanska: Steel subcontractor
5. Herrick: steel fabricator of fractured girders and repair

### PRP:

1. Michael Engelhardt, Chair, Univ. of Texas
2. John Fisher, Lehigh University
3. Tom Sabol, Englekirk Companies
4. Bob Shaw, Steel Structures Tech. Center
5. Brian Kozy, FHWA

### Support to PRP:

1. Bill Mohr, Edison Welding Institute
2. David Ruby, Ruby + Associates

## Scope and Status of Peer Review

MTC divided the scope of the peer review into six parts, as follows:

**1. Shoring capacity: Reviewed and concurred.**

Shores were added below the Fremont Street and First Street girders to provide an alternative load path. The PRP reviewed the design to ensure the shores had sufficient capacity and stability.

**2. Sampling and testing plan: Reviewed and concurred.**

TJPA's project team developed a plan to remove steel surrounding the fracture and test it to provide data to support the failure analysis.

**3. Cause of failure: General concurrence with findings; pending final report.**

In December 2018, the results of the material testing pointed to a fracture hypothesis that the cause of failure was a result of: material properties (low fracture toughness at the mid-thickness of four-inch-thick steel plates); the presence of initiating defects (micro-cracks introduced by the flame cutting of slots); and stress across the fracture plane (residual stress due to adjacent welding, and applied stress from loads on the girders after erection). The failure analysis report on the advanced computational methods used to model the mechanics behind the fracture is still being edited, but the results support the fracture hypothesis.

**4. Impact of fractures on adjacent elements: Reviewed and concurred.**

When the girders fractured, some of the existing static load would have redistributed to adjacent elements and a dynamic pulse load would have also traveled through them. Based on analysis and non-destructive testing, LPI concluded these effects were minor and no adjacent members were compromised.

**5. Repair of Fremont Street girders: Reviewed and concurred.**

The fracture hypothesis provided enough input on the cause of failure to allow Thornton Tomasetti to design a repair. The repair is a sandwich of steel plates bolted across the fractures. The design of the girders at Fremont Street is replicated at First Street. Differences in fabrication reduced the risk of fracture at First Street, but TJPA implemented a retrofit to the First Street girders similar to the repair of the Fremont Street girders as a precautionary measure.

**6. Search for other areas susceptible to brittle fracture: Reviewed and concurred**

Together, the PRP and Thornton Tomasetti identified nearly 50 details that might be susceptible to brittle fracture if under a similar combination of conditions that were present at the Fremont Street girders. Where existing test reports and photographs were not sufficient to make a determination, some combination of visual observation, non-destructive testing, and computational analysis was performed until Thornton Tomasetti could conclusively determine the as-built condition was sound. In the process, three weld irregularities were found; these were further tested and analyzed and determined to be of no consequence to the design criteria, but were removed in any case.

The Peer Review Panel reviewed work completed by the TJPA project team; it did not perform separate analyses. The Peer Review Panel did not determine responsibility, nor did it evaluate whether work complied with code or contract documents, but it will make recommendations for changes to code and industry standards to help avoid this type of failure in the future.



TRANSBAY JOINT POWERS AUTHORITY

Mark Zabaneh • Executive Director

**TJPA Board of Directors**

Muhammad Huru, Chair  
San Francisco Mayor  
Representative

Jeff Dawson, Vice Chair  
San Francisco County Board  
Representative

Matt Haney  
SF Board of Supervisors  
Representative

Michael Hursh

Boris Lipkin  
San Francisco Board of Supervisors  
Representative

Richard W. Rahn  
San Francisco Board of Supervisors  
Representative

Michelle Brown  
San Francisco Board of Supervisors  
Representative

George Tsamis  
San Francisco Board of Supervisors  
Representative

June 7, 2019

Terese McMillan  
Executive Director  
Metropolitan Transportation Commission  
Bay Area Metro Center  
375 Beale Street, Suite 600  
San Francisco, CA 94105

Re: Reopening the Salesforce Transit Center

Dear Director McMillan:

I would like to thank the Metropolitan Transportation Commission for empaneling a Peer Review of highly respected and nationally-recognized experts to review the Transbay Joint Powers Authority's work as it relates to structural steel at Salesforce Transit Center which included a review of our root cause analysis of the fissures discovered in two steel girders at the Fremont Street location, affirming our repair and reinforcement strategy of the steel girders in question, and overseeing our comprehensive facility-wide review to determine if any other area at the Salesforce Transit Center was susceptible to brittle fracture.

When we began our own comprehensive and robust review, we committed to reopening the transit center only after determining the root cause of the fissures, repairing the affected area, performing a comprehensive facility-wide review, and fully cooperating with your independent peer review panel.

As you know, the safety of the public is our highest priority. Our goal is to reopen the transit center with a high level of public confidence and to rebuild trust with our constituents. Cooperating with the independent peer review panel, your staff, and all relevant agencies to recommission the building is important to achieving these goals.

I am pleased to submit the attached communication from Thornton Tomasetti, our engineer of record, reporting that all necessary steps to safely reopen the transit center are now complete. I concur with their findings.

Sincerely,

Mark Zabaneh, PE  
Executive Director

Attachment: EOR's (Thornton Tomasetti) Re-occupancy of the Transit Center letter

Via email [dturchon@tjpa.org](mailto:dturchon@tjpa.org)

June 7, 2019

Mr. Dennis Turchon  
Senior Construction Manager  
TJPA  
201 Mission Street, Suite 2100  
San Francisco, CA 94105

RE: Re-occupancy of Salesforce Transit Center  
Thornton Tomasetti Project No. U18099

Dear Dennis,

This letter is to memorialize the adequacy and acceptance of the investigation and repair work performed to allow resumption of operation of the center after closure due to the discovery of cracks in the TPG-3 steel girders located in the roof structure that crosses over Fremont Street

As a result of this discovery, the similar condition which occurs where the building crosses over First Street was immediately exposed and inspected for damage. While no damage was found, the similar repair produced for the Fremont Street location was also installed as a remediation to the TPG-3 girders over First Street. We believe this to be the prudent course of action.

The portions of the cracked elements which embodied the cracks were removed from the structure and studied by LPI to determine the conditions which caused fracture. While this study is not yet complete, it is clear that the steel plates, which comprise the lower flange of the girders, fractured in a brittle manner under normal service stresses in the girders. Study of the cause of the cracks informed our repair and remediation and explained why the girders over First Street did not fracture as the fabrication sequence was different.

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RE: Re-occupancy of Salesforce Transit Center

Page 2 of 2

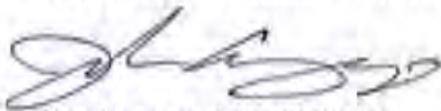
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We also have concluded our study of other areas which may be susceptible to brittle fracture and based on the exhaustive investigation have found no areas of concern.

Therefore, Thornton Tomasetti, Inc. believes the structural framing to be sound and competent and can be placed in service.

Very Truly Yours,

THORNTON TOMASETTI, INC.



John Abruzzo, SE 6363 CA  
Managing Principal  
Thornton Tomasetti, Inc



Bruce Gibbons, SE 4160 CA  
Managing Principal  
Thornton Tomasetti, Inc.

Cc:  
Gary Panariello

June 10, 2019

Stephen Wolf, P.E.  
Principal  
Metropolitan Transportation Commission  
Bay Area Metro Center  
375 Beale Street, Suite 800  
San Francisco, CA 94105

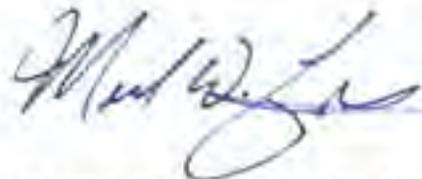
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Re-Occupancy of Transit Center

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While some aspects of our review of work undertaken by TJPA in response to the fractured girders are still ongoing, these ongoing items do not impact re-occupancy of the TTC.

Sincerely,



Michael D. Engelhardt, P.E., Ph.D.  
Chair, Peer Review Panel

c. Members of Peer Review Panel:

John Fisher  
Brian Kozy  
Thomas Sabol  
Robert Shaw