



**METROPOLITAN
TRANSPORTATION
COMMISSION**

Bay Area Metro Center
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June 10, 2019

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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

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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

June 7, 2019

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Tony Tavares, *ex officio*
State Department of
Transportation (Caltrans)
Representative

Therese McMillan
Executive Director
Metropolitan Transportation Commission
Bay Area Metro Center
375 Beale Street, Suite 800
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

Thornton Tomasetti

Via email: 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.

Thornton Tomasetti

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

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,

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 Peer Review Panel:

John Fisher
Brian Kozy
Thomas Sabol
Robert Shaw