DEPARTMENT OF TRANSPORTATION
OFFICE OF THE DIRECTOR
P.O. BOX 942873, MS-49
SACRAMENTO, CA 94273-0001
PHONE (916) 654-5266
FAX (916) 654-6608
TTY 711
www.dot.ca.gov

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May 21, 2013

Hon. Sen. Mark DeSaulnier,
Chair, Senate Committee on Transportation and Housing
State Capitol, Room #5035
Sacramento, California 95814

Re: Summary of Decision to Follow National Standards for Bolts and Testing

Dear Sen. DeSaulnier:

Please accept this letter and attached documents as responsive to your request during the May 14, 2013, hearing of the Senate Transportation and Housing Committee for a history of the decision-making process that preceded the galvanization of high-strength rods on the San Francisco-Oakland Bay Bridge.

Those deliberations occurred a decade ago. Email communications show that designers, engineers and metallurgists were aware of the risks of hydrogen embrittlement—the phenomenon that led to the breakage of 32 such rods during construction in mid-March—and that they took steps in manufacturing and testing that they believed would prevent it.

As we discussed previously, the San Francisco-Oakland Bay Bridge was not the first structure on which this material was installed. In fact, decision-makers noted that it had already been in use on the Richmond-San Rafael Bridge when they concluded it could work on the Bay Bridge.

As you will see from the attached documents, the use of hot-dip galvanized steel fasteners on the San Francisco-Oakland Bay Bridge was approved in stages: first the type of steel itself, and then the method of protecting that steel from corrosion.

In response to the concern over hydrogen embrittlement, the department relied upon nationally-approved standard testing protocols—set by the American Society for Testing and Materials—to guard against this phenomenon. This approach proved inadequate. We now know that a more robust testing protocol and a more finely articulated set of specifications could have prevented the problem. We will, of course, use that knowledge as we replace fasteners that have to be removed as part of our investigative process.

Please also find attached a copy of the Design Criteria for the San Francisco-Oakland Bay Bridge, per your request.

As we continue gathering information and conduct testing during the investigation—and as we provide that information to the entities providing independent oversight of that investigation—please be assured I will keep you apprised of our progress. That information will include the quality assurance and quality control documents we discussed. Gathering those documents is labor-intensive and we are working diligently and methodically through that process.

The next key event in the investigation will be May 29, 2013 in which the Toll Bridge Program Oversight Committee (TBPOC)—the entity authorized by law to maintain oversight of all seismic improvements on the Bay Bridge—will present an update to the Bay Area Toll Authority on the status of the TBPOC investigation. Additional information about cost and schedule for the engineering solution to the broken bolts, as presented on May 8, 2013, will also be provided.

Regarding the 2010 bolts on the pier—and other similar bolts that remain sound after weeks and months of tensioning—preliminary test results and records continue to show multiple differences from the 2008 bolts that broke. These other bolts on the bridge continue to perform as expected. Although these other bolts on the bridge are sound, engineers will be testing these good bolts further to determine how many decades they will last before receiving routine maintenance, repair or replacement.

Safety is all that matters to Caltrans or anyone else. The Bridge will open only when it is safe.

Sincerely,

MALCOLM DOUGHERTY
Director

Enclosures:

Summary Timeline of Decision to Follow National Standards for Bolts Set by American Society for Testing and Materials
SAS Design Criteria
Caltrans Bridge Design Specifications
American Society for Testing and Materials (ASTM) Standard Specifications for Steel Bolts
ASTM Standard Specifications for Zinc Coating
ASTM Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
E2-T1 Special Provisions

California Legislature

SENATE COMMITTEE ON TRANSPORTATION AND HOUSING

MARK DeSAULNIER
CHAIRMAN

STATE CAPITOL, ROOM 2209
SACRAMENTO, CA 95814
TEL (916) 651-4121
FAX (916) 445-2209

May 21, 2013

Malcolm Dougherty, Director
California Department of Transportation
1120 N Street
Sacramento, California 95814

Dear Director Dougherty:

This letter is a follow up to the May 14th Senate Transportation and Housing Committee hearing. We don't feel satisfied with the answers that were provided. Below we outline a number of follow-up questions to which we'd appreciate timely responses. We understand you and your staff are busy attempting to resolve the steel bolt issues, but we firmly believe, as Mr. Heminger stated in the hearing, that the road to rebuilding the public's confidence in the bridge begins with frankly and honestly telling them what happened and what consequences may result.

Our specific questions include:

1. Our understanding is that Caltrans made the decision to use high-strength, galvanized steel fasteners during the design phase of the project in consultation with internal and external metal and corrosion experts. In the hearing, you pledged to make available details concerning the decision-making process by the May 29th Special Bay Area Toll Authority Meeting.
    a. Who was the Engineer of Record that ultimately agreed to the design deviation allowing the use of high-strength, galvanized steel fasteners on the Bay Bridge?
    b. Who was consulted, and what contribution did each person involved provide concerning this deviation?
    c. What reviews were conducted, who was involved in the review process, and at what point in the overall design phase was this decision made?
2. In the hearing, you referred to a "Design Engineering Team" that made design deviation decisions and specifically suggested that among the members of that team were corrosion experts.

a. Who are the members of the Design Engineering Team today, and who has historically been part of this team? Please provide names, titles, and qualifications for each as well as at what times they participated.
b. Please outline and describe every deviation from state, national, and international standards and specifications approved by the Design Engineering Team.
c. When and where did the Design Engineering Team meet? Were there regularly scheduled meetings, or was it on an "as needed" basis? If possible, please provide any agendas, minutes, notes, staff notes, electronic communications and correspondence related to these team meetings.
d. Who was the corrosion expert described in the hearing? Did he or she ever communicate any concerns regarding the design of the bridge or the use of high-strength, galvanized bolts? Please provide any documentation related to his or her concerns.

3. Caltrans specifications for the high-strength bolts and rods required them to be "blasted" instead of "pickled" when galvanized to address the potential for hydrogen embrittlement. Recent media reports suggest that the more than 424 anchor rods at the bottom of the tower were "pickled" when galvanized, despite Caltrans specifications. Experts suggest that this type of galvanization process increases the potential for hydrogen embrittlement, particularly given the tension of these rods. Our understanding is that these anchor rods are embedded in the base of the tower.
    a. Are you able to access these tower rods to test their hardness and determine their susceptibility to hydrogen embrittlement?
    b. Can you test the tension level of each rod to better estimate its susceptibility to hydrogen embrittlement?
    c. If you determine that they are susceptible to hydrogen embrittlement, what alternatives do you have to address the problem?
    d. Do you have some idea of how many of these anchor rods could suddenly fail without jeopardizing the safety of the bridge?

4. Your presentation stated that the 274 bolts that anchor each strand of the main cable are made of galvanized, high-strength steel and are tensioned to 40 percent. The critical stress curve in your presentation describes, and experts suggest, that hydrogen embrittlement is a concern at roughly 40 percent tension and grows when tensions are 50 percent or greater.
    a. Are you able to access the main cable anchor bolts to test their hardness and determine their susceptibility to hydrogen embrittlement?
    b. Can you test the tension level of each bolt to better estimate its susceptibility to hydrogen embrittlement?
    c. If you determine that these bolts are susceptible to hydrogen embrittlement, what alternatives do you have to address the problem?
    d. Do you have some idea of how many of these anchor bolts could suddenly fail without jeopardizing the safety of the bridge?

5. Experts suggest that, even if high-strength, galvanized bolts don't fail in the first week or two after tensioning, there is still a risk they could fail in the coming months or years.

a. Is the threat of hydrogen embrittlement susceptibility of the Bay Bridge's galvanized, high-strength bolts time-sensitive? In other words, is there a set period of time that, once reached, minimizes the likelihood of the bolts failing sometime in the future?
b. If you conclude that the hydrogen embrittlement susceptibility does not increase over time, upon what evidence do you base this conclusion?

In addition, the San Francisco Chronicle reported today that Mr. John Fisher and Mr. Robert Reis have both expressed concerns throughout the design process regarding the use of galvanized, high-strength steel bolts and rods. Please provide us with any reports, notes, correspondences or electronic communications that communicate their concerns.

We would appreciate written responses as soon as possible; by May 31st at the latest.
We hope to have answers to each question or an update on when you expect the answers to be available. Please let me know if you have any questions.

Sincerely,

MARK DeSAULNIER
Chair

TED GAINES
Vice Chair

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P.O. BOX 942873, MS-49
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May 31, 2013

The Honorable Mark DeSaulnier, Chair
California State Senate Committee
on Transportation and Housing
State Capitol, Room 2209
Sacramento, CA 95814

The Honorable Ted Gaines, Vice Chair
California State Senate Committee
on Transportation and Housing
State Capitol, Room 2209
Sacramento, CA 95814

Dear Senator DeSaulnier and Senator Gaines:

Please accept this letter as a response to your letter of May 21, 2013, regarding my testimony at the May 14, 2013, Senate Transportation and Housing Committee hearing regarding the Bay Bridge.

I had coincidentally sent Senator DeSaulnier a letter on May 21, 2013, *Re: Summary of Decision to Follow National Standards for Bolts and Testing*, along with eight attachments that addressed many of your questions. In particular, that letter answered your first and second questions about why the decision was made to use high-strength galvanized bolts and provided documents explaining how the decision was reached. I have attached my prior response for purposes of maintaining continuity.

As I endeavor to answer your remaining three queries in this letter, I will also note instances in which that information was included in those prior materials.

The engineer of record on the Self-Anchored Suspension (SAS) span of the San Francisco-Oakland Bay Bridge is T.Y. Lin International/Moffatt & Nichol, a joint venture, which began design work in November 1997. The design is based on standards and criteria from guidance documents, as well as from project-specific Design Criteria which was provided to you on May 21, 2013. Electronic correspondence regarding the decision first to use this particular kind of steel fastener, and the subsequent decision of how to provide it with corrosion protection was detailed in the attachments to that May 21, 2013, letter.

You also ask about the review process of the design. The work of the design consultant team was followed very closely by the Caltrans Design Oversight Team. Regular check points were established throughout the progress of the work as required by the design contract. The final design package also was reviewed by various Caltrans technical committees; one in particular was the Caltrans Structural Steel Committee. Correspondence from that committee also was included in the information package provided on May 21, 2013.

Members of the Design Joint Venture's Engineering Team include:
Rafael Manzanarez, Design Manager (no longer on the project)
Marwan Nader, Project Engineer
George Baker, Design Engineer
Doug Williams, Consultant for Welding/Steel Fabrication
Karl Frank, Consultant for Fasteners
Jim Rucker, Specifications Engineer

Regarding the frequency and location of design meetings, there were hundreds of such meetings, most of which were regularly scheduled, and others held on an as-needed basis. Most of the meetings were held at either the Project's "Pier 7" complex in Oakland or the design consultant's offices in San Francisco. The materials sent on May 21, 2013 contain electronic communications, correspondence and other records from those meetings that pertain to bolt selection.

You asked about the corrosion expert mentioned during the hearing. That individual is Robert Reis. He expressed initial concerns about embrittlement, but later accepted the corrosion solution because extra testing requirements were imposed according to national industry standards set by the American Society for Testing and Materials. In particular, an email from Allan Chow on March 27, 2003, represents that, in relation to the steel connectors, Mr. Reis initially "had concerns with strain age embrittlement and suggested to test the final product with ASTM A143 'Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement'." However, a subsequent email from T.Y. Lin on April 2, 2003, discussed the Richmond-San Rafael Bridge and how this issue was addressed by using a "4 hour window between blast cleaning and hot-dip galvanizing", and included an addendum for the project delineating this process. Mr. Reis responded "This looks good" on April 3, 2003. These emails were included in the May 21, 2013, documents provided.

You also requested information regarding the 424 tower anchor rods located at the base of the tower. We are able to access the 424 tower anchor rods and already know the tension levels of each rod. These rods are enclosed in a dehumidified zone to reduce the possibility of corrosion. These anchor rods are designed to resist twice the force that the tower base would expect to see, which would come from the seismic ground motions used in the design. We do not expect any rods to fail given these parameters, but we have twice as many as we need.

Regarding your questions about the 274 bolts that anchor each strand of the main cable, they are accessible and tension levels can be tested, although the tension level of each rod is already known based on monitoring during installation and construction. The tension level of these bolts is far below the 0.7 FU tension of the bolts that broke. As Dr. Maroney discussed during his testimony on May 14, 2013, hydrogen embrittlement requires three elements: 1) high levels of tension 2) susceptible material (e.g., too hard, low toughness), and 3) the presence of hydrogen through manufacturing or environment or both. Again, the anchor rod bolts are at relatively low tension levels. More importantly, however, these anchor rods have been performing as expected for more than eight months and will also be enclosed in a dehumidified chamber, which further reduces any risk of hydrogen exposure. Additionally, the design of the main cable has a safety factor of two, meaning that it has been designed to resist twice the load that it will ever see. As is true with the tower rods, we would not expect any rods to fail given the cable has twice the capacity of expected forces which include the greatest earthquake motions designed for.

You asked whether bolts on the bridge are at risk of hydrogen embrittlement over time. The only good thing about hydrogen embrittlement is that it is easy to spot early on because it leads to bolt failure shortly after tensioning. To date, the only bolts that broke are the 32 bolts on the pier and all others on the bridge are performing as required—many after months or years of tension. In other words, if there was an issue with hydrogen embrittlement elsewhere on the bridge, we would have already seen failures. This conclusion has been supported by leading experts, including Dr. Fisher and Mr. Salem Brahimi.

Although the short-term risk of embrittlement has likely passed, we are conducting additional testing known as the Stress Corrosion (Townsend) Test to determine if all bolts will meet the long-term performance requirements for the bridge over the design life. Regardless of these test results, all elements of the bridge will be regularly inspected as part of the routine maintenance program throughout its life. We will not make any final decisions about short-term or long-term risk until all testing is concluded, the investigation is finished, the Peer Review Panel has been consulted and the Federal Highway Administration has concluded its independent review.

And regarding your final question, Dr. Fisher's involvement with the Bay Bridge project began in 2006, well after the design phase was completed. Dr. Fisher is thoroughly involved with the evaluation of the bolts for the design purpose today. Mr. Reis was involved in early decision making and his comments have been summarized above, and provided in the May 21, 2013, documents.

I take the construction and management issues on the Bay Bridge very seriously. First and foremost, the San Francisco-Oakland Bay Bridge East Span will be seismically safe when it opens. My team continues to work through current challenges with external peer reviewers to ensure that we are delivering this project safely.

Thank you for your leadership on this issue. I believe that elected officials getting appropriate answers to legitimate questions is a critical element in giving Californians the confidence they deserve in their transportation infrastructure, the very backbone of our state's economic potential.

Sincerely,

MALCOLM DOUGHERTY
Director

Enclosures:

Letter addressed to Senator DeSaulnier dated May 21, 2013
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