

**BAY AREA TOLL AUTHORITY**

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Executive Director

ANDREW B. FREMIER

Deputy Executive Director

BAY AREA TOLL AUTHORITY (BATA) MEETING

9:30 a.m. Wednesday, April 24, 2013

Joseph P. Bort MetroCenter

Lawrence D. Dahms Auditorium

101 8th Street, 1st Floor

Oakland, CA 94607

The Bay Area Toll Authority (BATA) considers matters related to the Toll Bridge Accounts, Toll Bridge Seismic Retrofit Program and the Regional Measure 1 (RM 1) Bridge Improvement Program.

This meeting is scheduled to be audiocast live on MTC's Web site: www.mtc.ca.gov

AGENDA

ACTION
RECOMMENDED**
Confirm Quorum

1. Roll Call

2. Pledge of Allegiance

3. Compensation Announcement (Committee Secretary)

Information

4. Chair's Report – Rein Worth

Information

5. Consent:

Authority Approval

a) Minutes – March 27, 2013 meeting.*

b) Draft Minutes – April 10, 2013 BATA Oversight meeting*

6. Bay Bridge Anchor Bolts Update (Peter Lee)

Information

Staff will update the Authority on the broken Bay Bridge anchor bolts at pier E2.

7. Public Comment / Other Business / Adjournment /
Next Meeting:

Information

Wednesday, May 22, 2013 at 9:30 a.m.

Joseph P. Bort MetroCenter

Lawrence D. Dahms Auditorium

101 8th Street, 1st Floor, Oakland, California.

BATA Agenda

Page 2

- * Attachment sent to Authority members, key staff and others as appropriate. Copies will be available at the meeting.
- ** All items on the agenda are subject to action and/or change by the Authority. Actions recommended by staff are subject to change by the Authority.
- + Non-voting Member.
- ++ Item will be distributed at the meeting.

Quorum: A quorum of this Authority shall be a majority of its regular voting members (10).

Public Comment: The public is encouraged to comment on agenda items at committee meetings by completing a request-to-speak card (available from staff) and passing it to the committee secretary. Public comment may be limited by any of the procedures set forth in Section 3.09 of MTC's Procedures Manual (Resolution No. 1058, Revised) if, in the chair's judgment, it is necessary to maintain the orderly flow of business.

Meeting Conduct: If this meeting is willfully interrupted or disrupted by one or more persons rendering orderly conduct of the meeting unfeasible, the Chair may order the removal of individuals who are willfully disrupting the meeting. Such individuals may be arrested. If order cannot be restored by such removal, the members of the committee may direct that the meeting room be cleared (except for representatives of the press or other news media not participating in the disturbance), and the session may continue.

Record of Meeting: BATA meetings are recorded. Copies of recordings are available at nominal charge, or recordings may be listened to at MTC offices by appointment. Audiocasts are maintained on MTC's Web site for public review for at least one year.

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Briefing on E2 Anchor Bolts – April 24, 2013



THE SAN FRANCISCO-OAKLAND
BAY BRIDGE
SEISMIC SAFETY PROJECT

CALTRANS BAY AREA TOLL AUTHORITY CALIFORNIA TRANSPORTATION COMMISSION

Toll Bridge Program Oversight Committee

- AB 144 established the ***Toll Bridge Program Oversight Committee***, composed of Director of the California Department of Transportation (Caltrans), and the Executive Directors of the California Transportation Commission (CTC) and the Bay Area Toll Authority (BATA), to be accountable for delivering the Seismic Retrofit Program.



MALCOLM DOUGHERTY
Director
California Department of
Transportation



STEVE HEMINGER
Executive Director
Bay Area Toll Authority



ANDRE BOUTROS
Executive Director
California Transportation
Commission



THE SAN FRANCISCO-OAKLAND
BAY BRIDGE
SEISMIC SAFETY PROJECT

Three Key Questions

- 1. What caused the E2 anchor bolts manufactured in 2008 to fail?**
- 2. What retrofit strategy should be used to replace the 2008 anchor bolts?**
- 3. Should the anchor bolts manufactured in 2010 be replaced?**



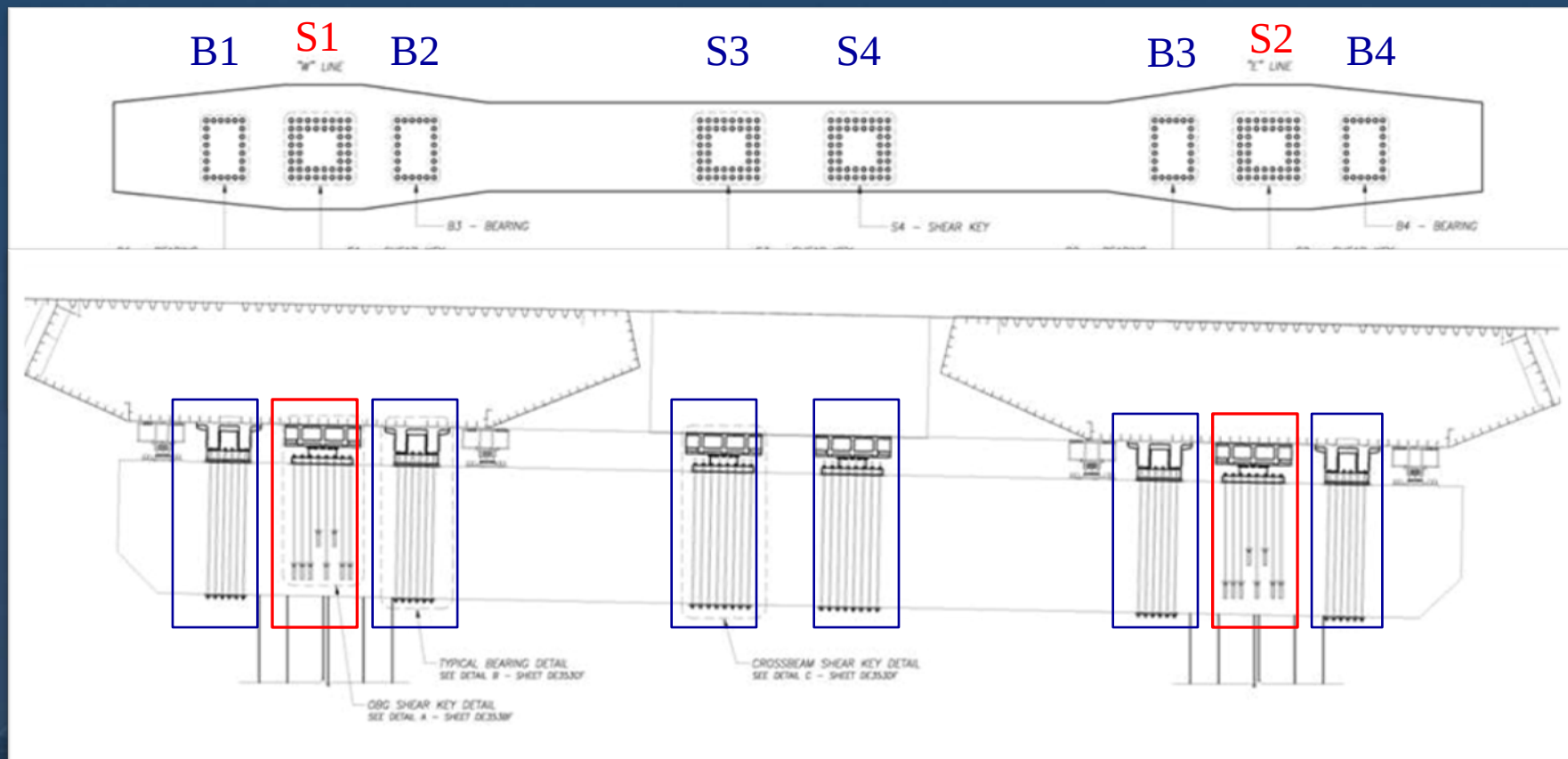


Pier E2



THE SAN FRANCISCO-OAKLAND
BAY BRIDGE
SEISMIC SAFETY PROJECT

CALTRANS BAY AREA TOLL AUTHORITY CALIFORNIA TRANSPORTATION COMMISSION



- Bearings and shear keys are secured to E2 by 3 inch diameter anchor bolts, ranging from 9 feet to 24 feet in length.
- 96 bolts manufactured in 2008 shown in red are embedded in the pier.
- 192 bolts manufactured in 2010 shown in blue are not embedded in pier.



1. What caused the E2 anchor bolts manufactured in 2008 to fail?

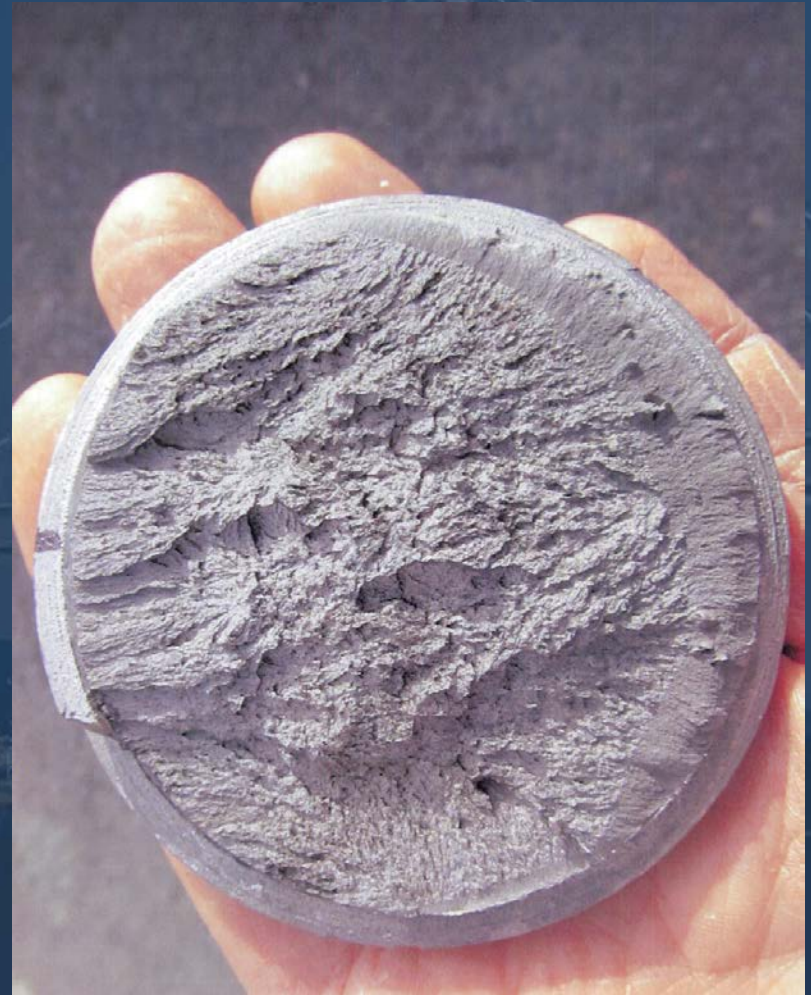


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SEISMIC SAFETY PROJECT

CALTRANS BAY AREA TOLL AUTHORITY CALIFORNIA TRANSPORTATION COMMISSION

Failure of 2008 Bolts Due to Hydrogen Embrittlement

- Under detailed investigation, 2008 bolt failures are due to hydrogen embrittlement.
- Excess hydrogen in the 2008 bolts caused the threaded areas of bolts to become brittle and fracture under high tension.

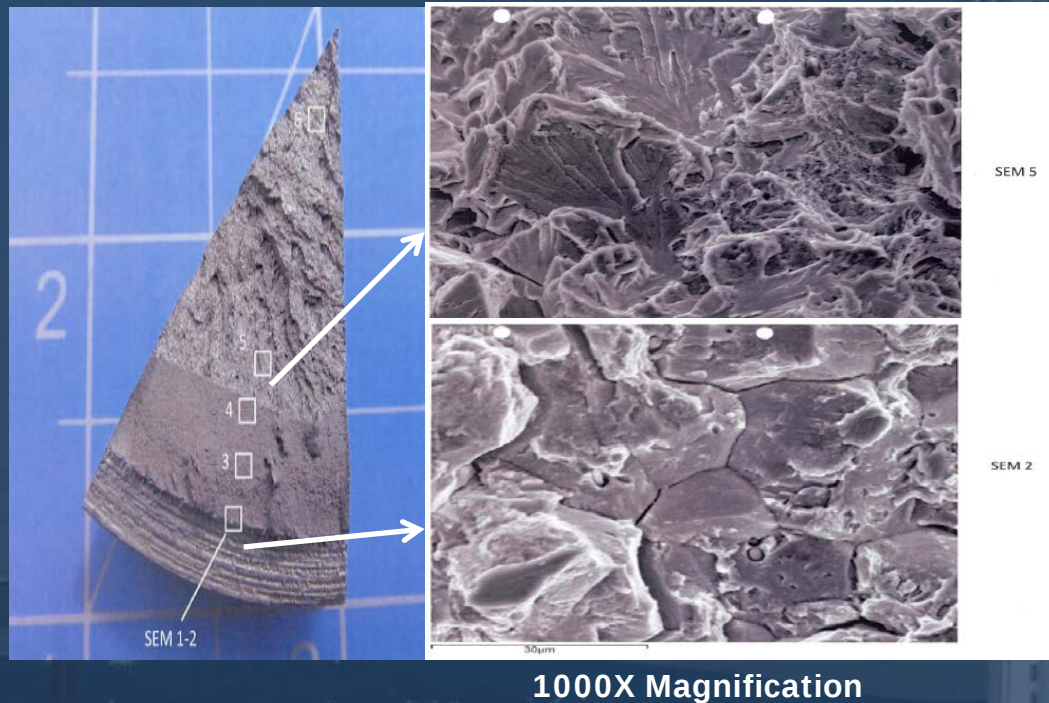


Hydrogen Embrittlement

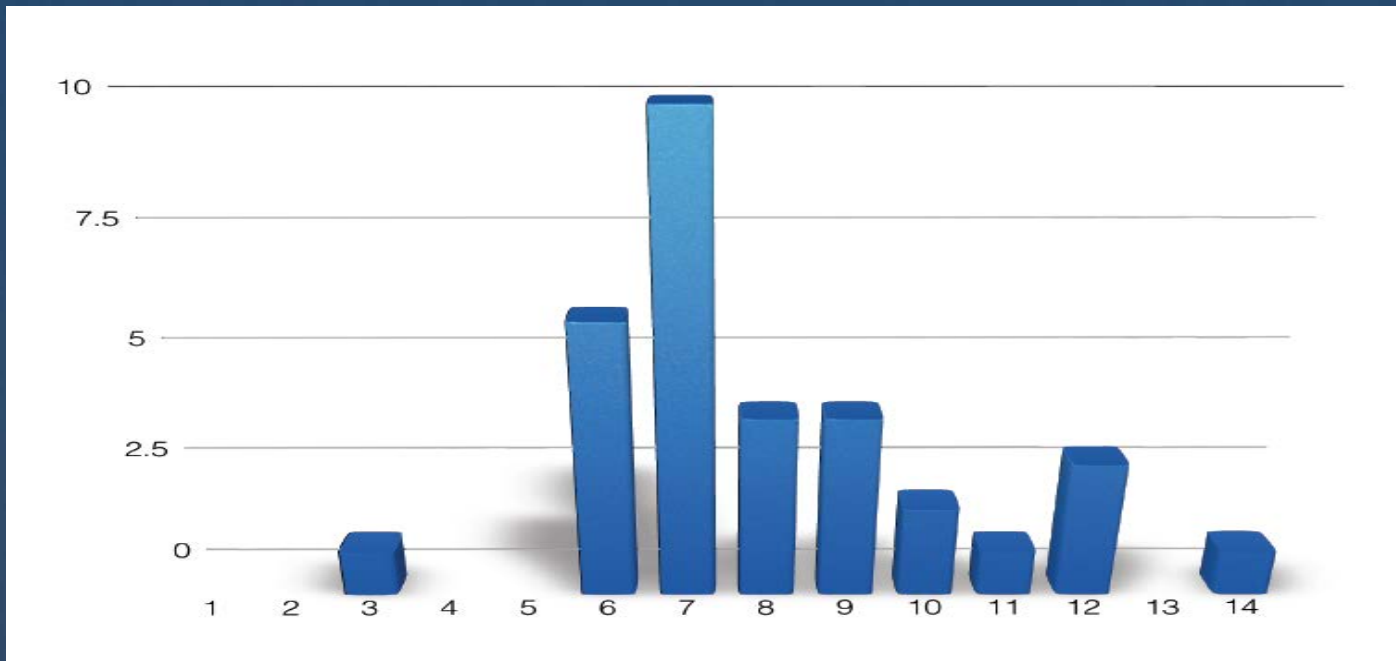
- **Requires 3 elements**
 - **Source of Hydrogen**
 - **Susceptible Material**
 - **Tension**
- **Sources of excess hydrogen may have been both internal (residual from production) and/or external.**



Hydrogen Embrittlement



- On-going metallurgical analysis indicates 2008 bolts were susceptible to hydrogen embrittlement due to “a lack of uniformity in the microstructure of the steel”
- Identified under electron microscope.



DAYS AFTER STRESSING (2008 BOLTS)

- Failure by hydrogen embrittlement is time dependent and should happen within weeks of tensioning.
- 2008 bolts failed days after tensioning. After 14 days, all 2008 bolts were de-tensioned.
- Industry standard testing protocols for A354 bolts are not time-dependent. Lesson learned: Additional material specifications and testing protocols could have reduced risk of hydrogen embrittlement.



Other Issues

Issue	Response
Documentation	All facilities involved in fabrication of the bolts received complete and unqualified “passes” from the Caltrans’ Quality Assurance (QA) audit of the facilities. Some facilities received initial “contingent passes”, which were followed by submission and review of additional information that adequately addressed contingencies. A final pass was given to all facilities.
Second Heat Treatment	It is not unusual for bolts to receive two heat treatments. The two heat treatments for the 2008 bolts did not result in additional susceptibility to hydrogen embrittlement.
Galvanization	Bolts are galvanized for long-term corrosion protection. Galvanization is allowed but cautioned in ASTM specifications; associated hydrogen embrittlement risks are addressed through elimination of pickling, as outlined by ASTM specifications.



Other Issues

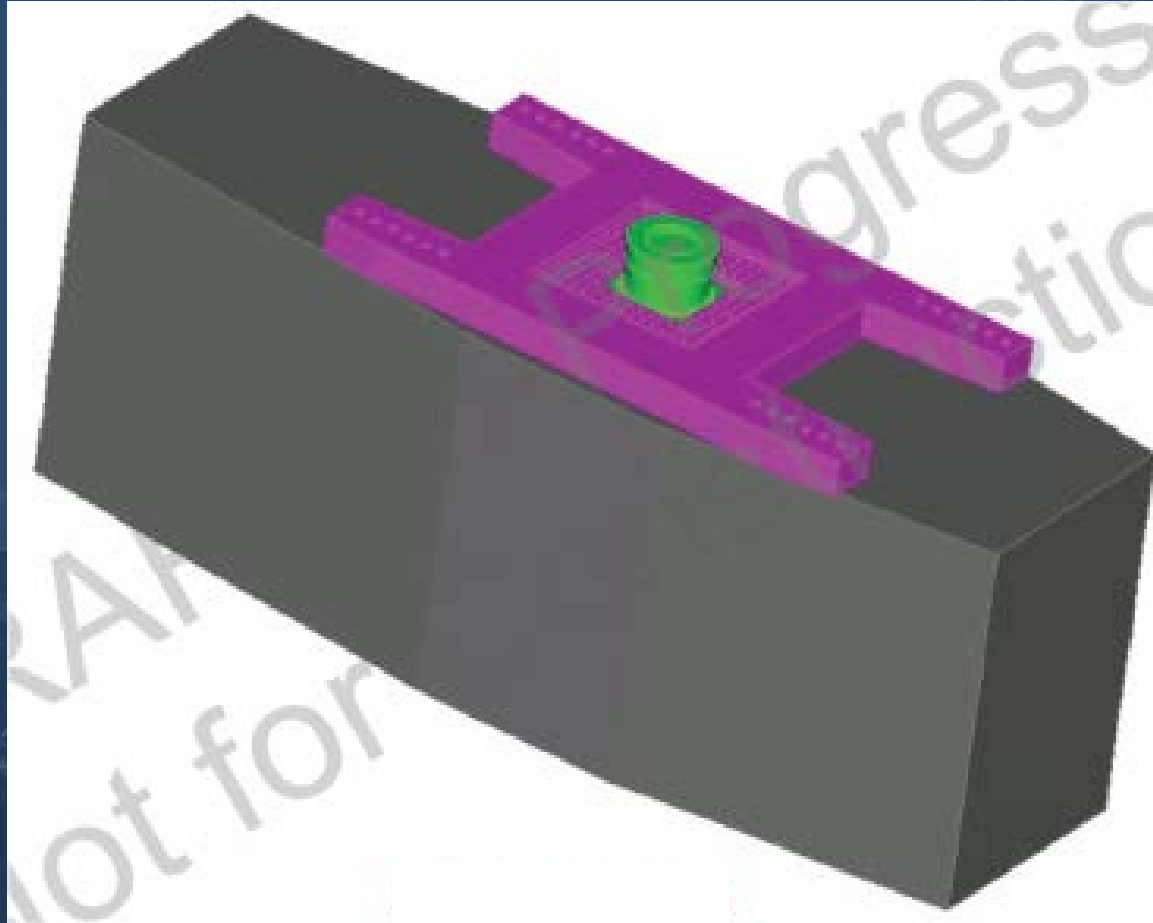
Issue	Response
Bolts Ordered Late	Although bolts were ordered on an accelerated basis, there was no reduction in quality control/quality assurance (QC/QA) measures taken.
Magnetic Particle Testing	The application (or lack) of magnetic particle testing (MT) is not relevant to hydrogen embrittlement. MT is not a mandatory ASTM requirement for these bolts. MT is related to identification of surface anomalies, and not associated with detection of hydrogen embrittlement.
Embedment of Bolts	Since bolt installation in 2008, staff noted that moisture was found in some of the bolt holes, which may have contributed to hydrogen contamination. Lesson Learned: Where feasible, tie-down elements this critical to seismic performances should be accessible to repair.



2. What retrofit strategy should be used to replace the 2008 anchor bolts?

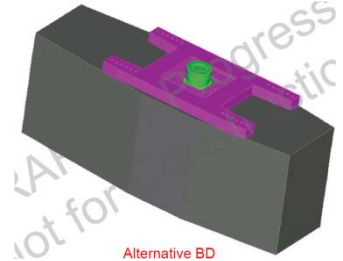
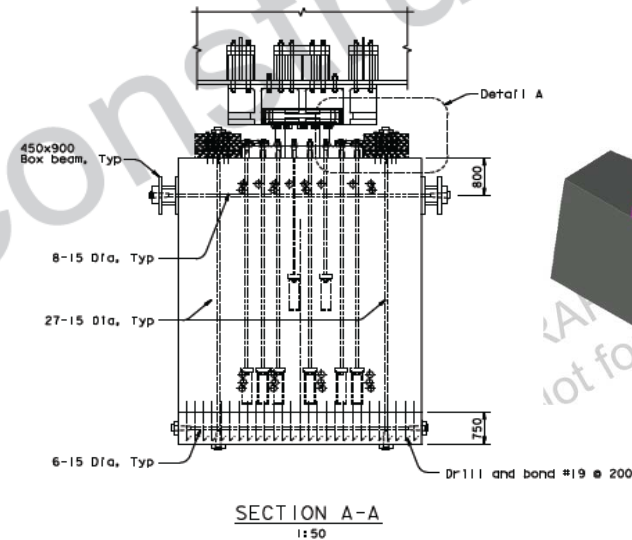
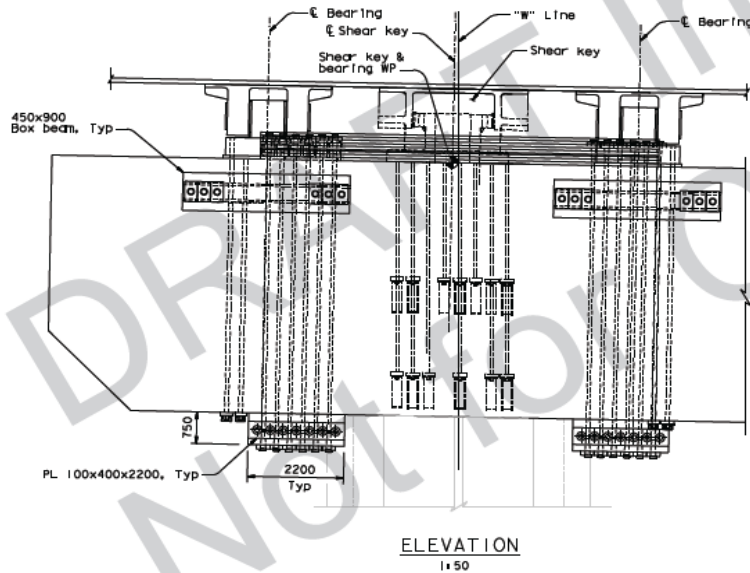
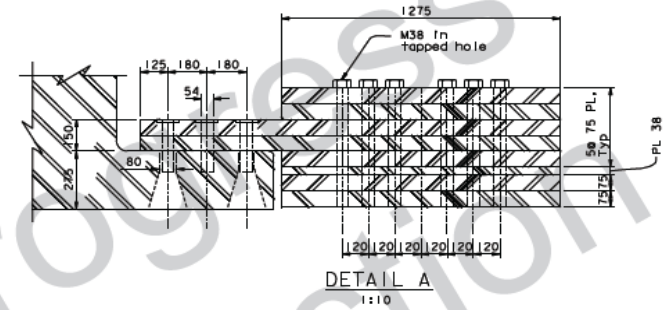
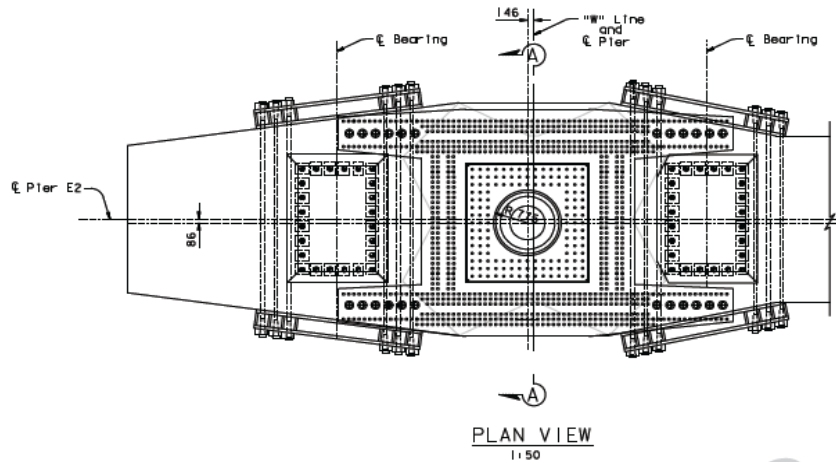


Option 1 – Steel Collar



Option 1 – Steel Collar

15 APR 2013



SFOBB SAS (SAS) Project #04-0120F4

Date: 2013-04-15
File Name: E2 SHEAR KEYS ANCHOR RODS RETROFIT - ALTERNATIVE BD2 (1 of 1)

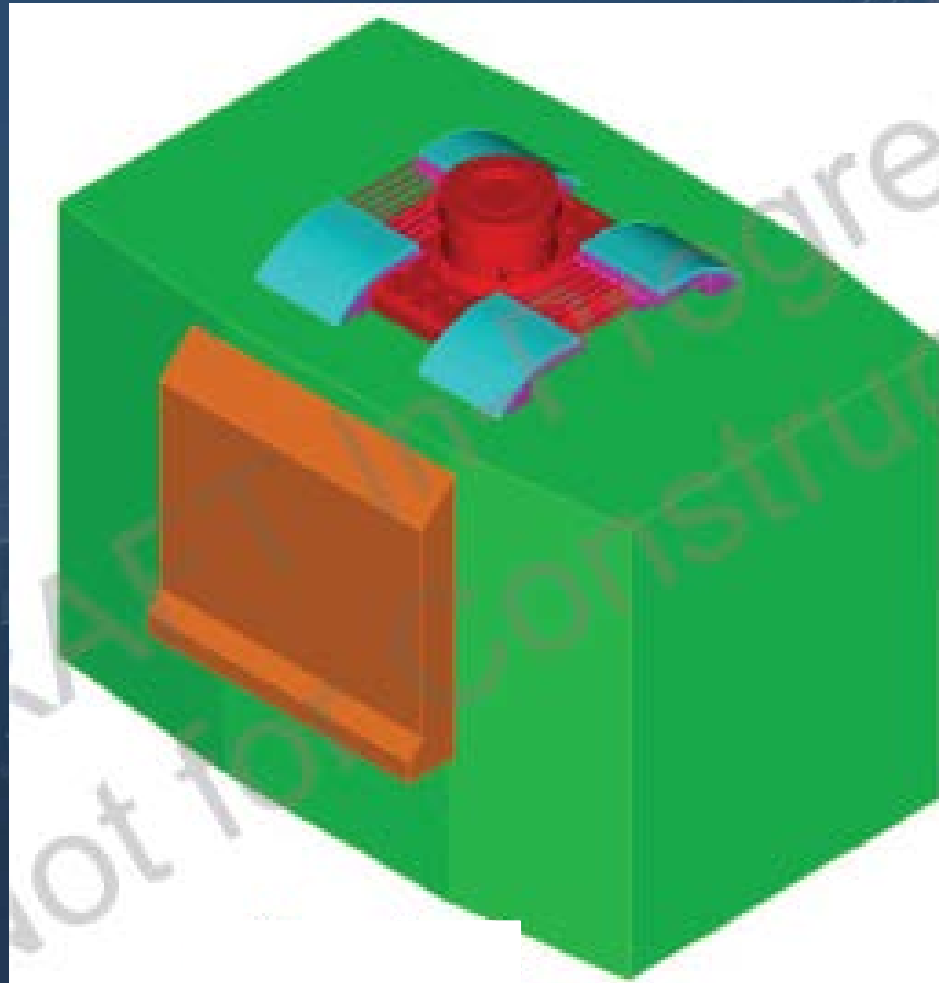


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SEISMIC SAFETY PROJECT

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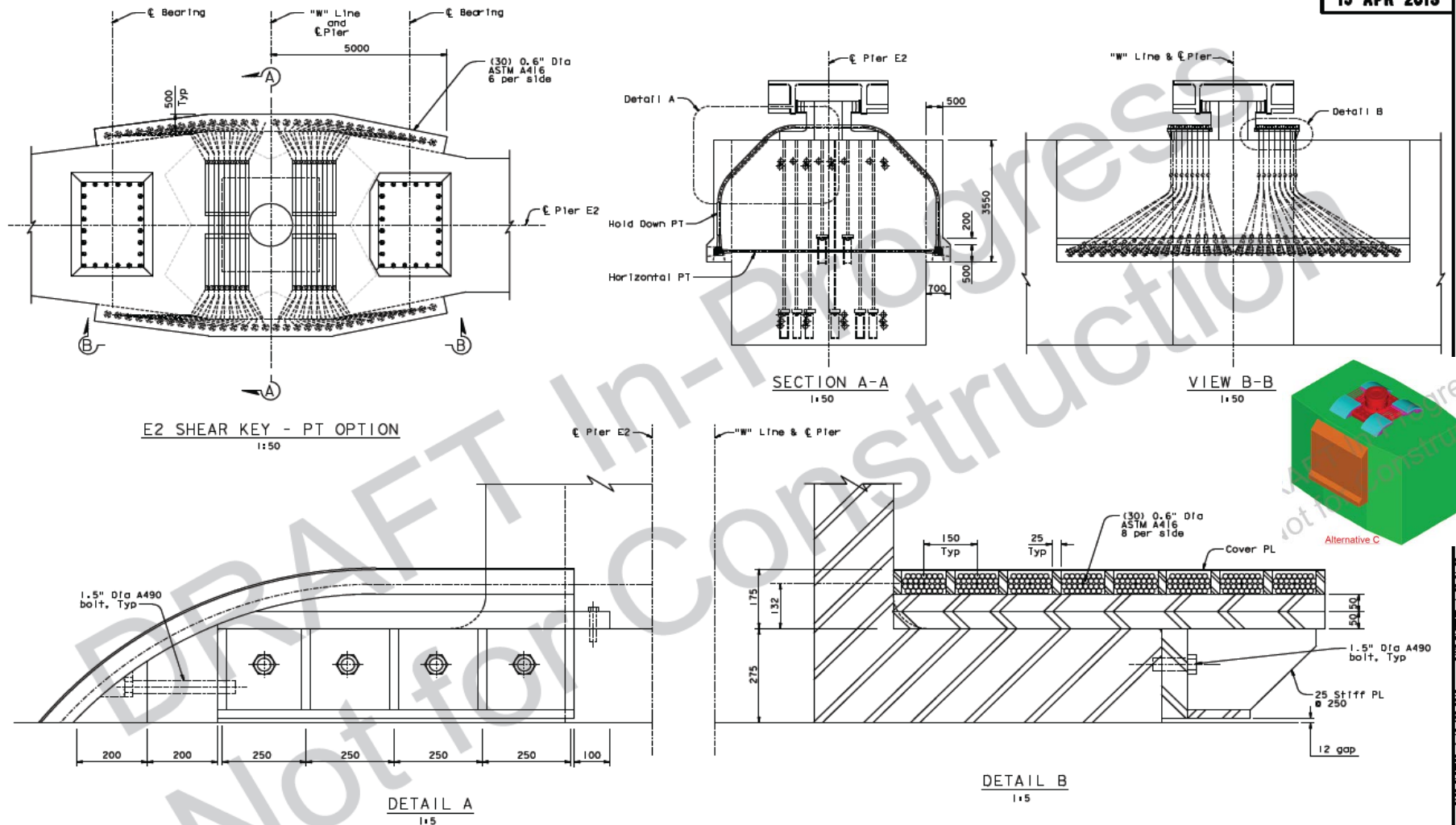
FILE: C:\Users\B12061\Working\staircase\p11\p11\Detail shear keys anchor rods retrofit\p11\p11\Detail shear keys anchor rods retrofit.dwg

Option 2 – Steel Saddle



Option 2 – Steel Saddle

15 APR 2013



SFOBS SAS (SAS) Project #04-0120F4

Date: 2013-04-15
File Name: E2 SHEAR KEYS ANCHOR RODS RETROFIT - ALTERNATIVE C (1 of 1)



THE SAN FRANCISCO-OAKLAND
BAY BRIDGE
SEISMIC SAFETY PROJECT

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General Comparison of Options

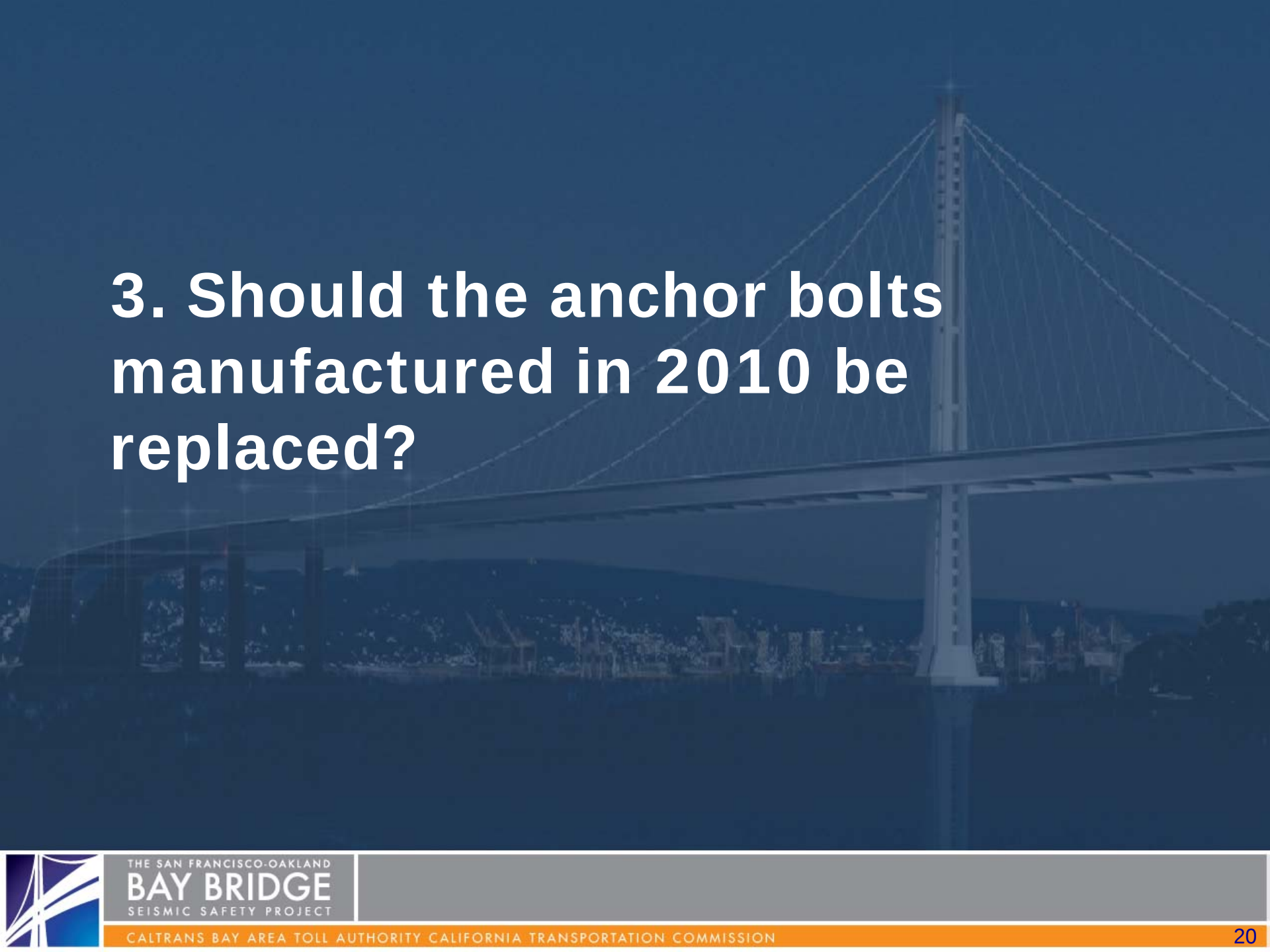
Option 1 – Steel Collar	Option 2 – Steel Saddle
Pros • No need to remove S1 and S2 shear keys • Potentially simpler to fabricate	Pros • No need to remove S1 and S2 shear keys • Less coring of E2 required
Cons • Need to find sufficient materials and resources • More coring of E2 required	Cons • Requires unique saddle system.



Additional Information

- Contractor already has placed steel order for both design options.
- Contractor already has selected local fabricator on Mare Island.





3. Should the anchor bolts manufactured in 2010 be replaced?



Differences

- After 15 to 25 days under tension, none of the 2010 bolts have failed.
- 2008 and 2010 bolts were manufactured 2 years apart using different batches of steel.
- There were fewer material batches used in the 2010 bolts and less variation on the mechanical properties.
- 2010 bolts are not embedded in E2 pier cap.
- Ongoing metallurgical analysis may reveal important additional differences.



Similarities

- Both 2008 and 2010 bolts originated from same principal supplier.
- Both sets of bolts were manufactured to the same specifications, including galvanizing.
- Both sets of bolts have been tightened to the same relatively high tension level.
- Both sets of bolts exhibit similar mechanical properties, but the 2010 bolts are marginally more ductile. (see next slide)



Post-Heat Treatment QC/QA Mechanical Tests

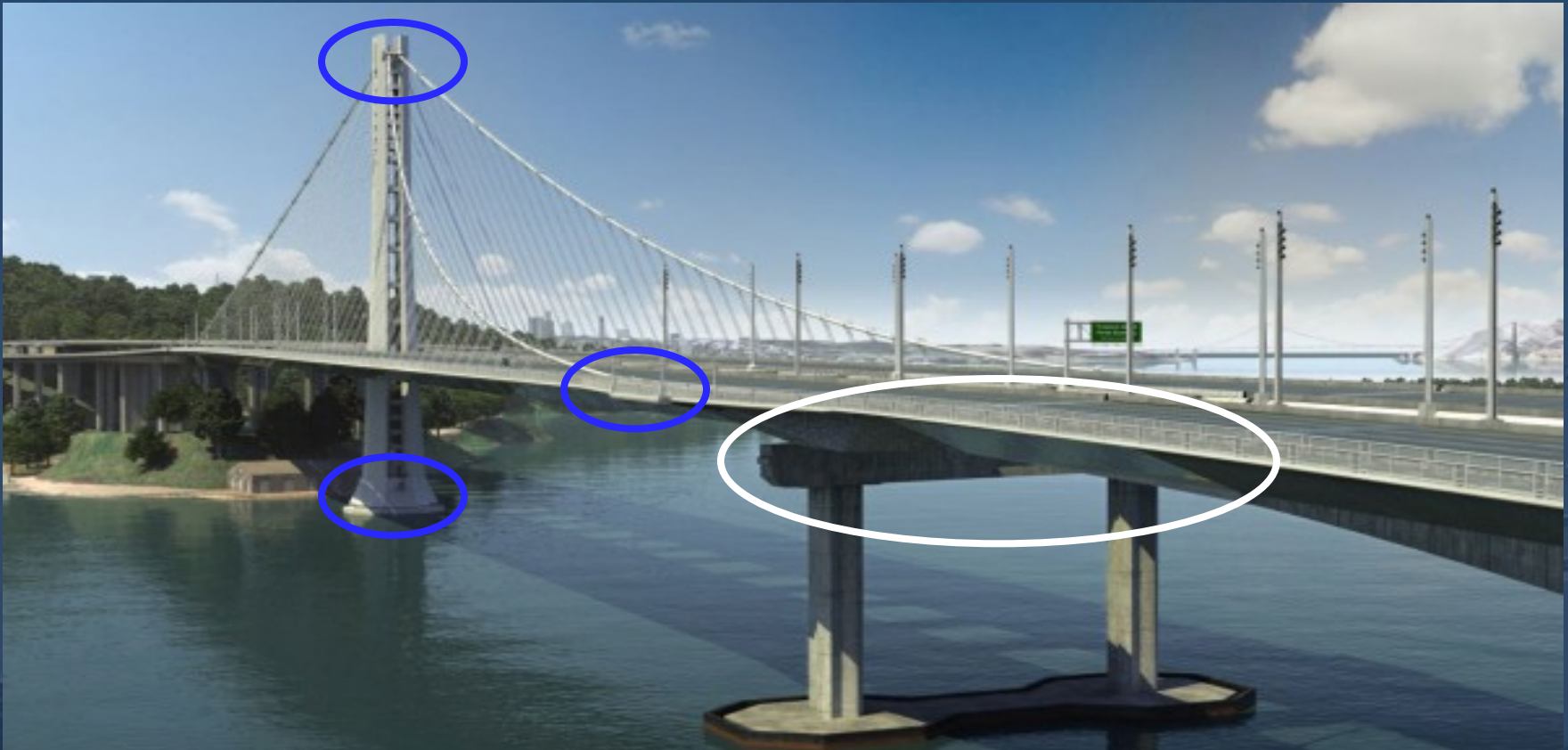
	Tensile (KSI)	Yield (KSI)	Elongation (%)	Reduction of Area (ROA)	Hardness (Rockwell C)
ASTM A354BD	140	115	14	40	31-39
2008 Average	164	142	14.3	48.4	36.8
2008 Min/Max	152/173	127/158	12.5/16.2	40/50	33/37
2010 Average	159	139	15.5	50.5	34.1
2010 Min/Max	153/165	132/147	13.2/17.1	40/55	32/37



Testing Protocol for 2010 Bolts

- **Current Contract Required Testing**
 - Tensile
 - Yield
 - Elongation
 - Reduction of Area
 - Hardness
- **New Additional Testing**
 - Tensioning bolts in-situ to required load for 30 days to allow time-dependent migration of hydrogen.
 - Tensile test of an extracted full-size bolt through to fracture.
 - Toughness and Chemical Analysis
 - Microscopic examination by electron microscope
 - Micro-Structural examination to determine presence of hydrogen.





- Visual inspections of similar anchor bolts revealed no abnormalities.
- Some E2 Bearing assembly bolts are not accessible to inspection.
- Most anchor bolts at other locations are under lower tension levels.
- Prioritized Desk Audit of QC/QA results underway.



Summary

- Failure of 2008 bolts was the result of hydrogen embrittlement.
- Two retrofit alternatives are still being evaluated.
- 2010 bolts are being tested with revised protocols.
- Prioritized desk audit of QA/QC results for similar bolts by same manufacturer underway. Findings will be made available as completed.



Items Expected at May 8th Briefing

- Selection of 2008 bolt retrofit solution, including cost and schedule impacts.
- Pending results from initial testing of 2010 bolts, decision on whether to replace 2010 bolts and, if so, when.
- Completion of desk review of additional QA/QC results for other high tension anchor bolt locations.



CHAIR AMY REIN WORTH: Our next Item 6, we have an update on the Bay Bridge bolts, and so I'd like to turn to our Executive Director, Steve Heminger, for that report.

STEVE HEMINGER: Thank you, Madam Chair, and good morning, Commissioners. We're here for, I think, the third briefing that we provided to you on the anchor bolts on the East Pier of our new bridge. And I'm pleased for this briefing to be joined by my two colleagues on the Toll Bridge Program Oversight Committee—to my right, the newly-confirmed Director of the Department of Transportation, Malcolm Dougherty, and to my left, Andre Boutros, the Executive Director of the California Transportation Commission.

Just to remind you and the audience, the Toll Bridge Program Oversight Committee was established under state law in 2005 to oversee all of the seismic retrofit projects and programs. We are now down to this project and the few months remaining in it before we can open it to traffic. And we have dealt with a wide range of issues over our tenure from welds to schedules to now bolts. And this partnership, I think, has been quite successful in dealing with challenges as they have arisen and I expect us to be successful here again.

Next one, Peter. We have been wrestling with—I think you have as well—and we've had quite an engaged citizenry wrestling with these problems, as well, with three key questions. The first is: What caused the anchor bolts of the East Pier that were manufactured in 2008 to fail? The second: What retrofit strategy should we pursue to replace those bolts? And third: Should the anchor bolts that were manufactured in 2010 that are also in position on that pier be replaced? And, again, just to remind you of where we are on the bridge, the East Pier, as you can see in this fairly recent picture of the bridge—not recent enough—the scaffolding I think those of you who've noticed driving on the bridge on the tower for the new bridge is about a third of the way down now, and it's looking great. So the East Pier is at the east end of the self-anchor suspension bridge. The West Pier is on the island, and the Tower Pier is underneath the towers, so those are the three

piers holding up that structure, and we are focused on anchor bolts on the East Pier at what's called E2.

To remind you, we have two different kinds of what I would call seismic stabilizing mechanisms that are on that pier to allow the roadbed to move a bit but not too much in a major earthquake. They are shear keys and bearings. They are shown on this slide with either S's or B's. You can see that there are four shear keys and four bearings. There are two shear keys—they are shown in red—that are right above the pier, the column that leads from the pier cap down to the water. And those are the location of the anchor bolts that were manufactured in 2008. And those are the anchor bolts that have failed. The remaining anchor bolts at the two other shear key locations, which are in the middle, as Peter is showing with the arrow, as well as the four bearings that are on either side of the shear keys where the bearings have failed, those bolts, all of them are shown in blue and they have not failed. They were manufactured in 2010.

Another principal distinction between these two sites and the two years of manufacture, the 2008 bolts, as I think we've reminded you in the past, do not pass all the way through the pier cap because the column for the pier is in the way. So they are embedded in the pier cap. The other two shear keys in the middle, as well as the four bearings—again, all of them manufactured with bolts in 2010—they are through bolts. In other words, they go all the way through the pier and are connected on the other side of the pier cap.

So with that as background, each of us are going to take turns giving you the best information we have on these three questions, and Malcolm is going to provide the information on Question 1.

MALCOLM DOUGHERTY: Thank you, Steve, Madam Chair, and Commissioners. Malcolm Dougherty, Caltrans Director. And, specifically, I'd like to talk a little bit about the anchor bolts that were located in the two shear keys that were problematic that came from a batch in 2008.

Since the discovery of the 2008 bolts and/or rods, the same reference, breaking, we've subjected them to an extensive evaluation, including

microscopic evaluation with a scanning electron microscope, chemical evaluation, and both basic and supplemental mechanical property testing. This evaluation has been conducted jointly by the Department, by the contractor, American Bridge Fluor, as well as our consultants. It was performed by three individuals who are actually preparing a report specific on the 2008 bolts and why they failed. Three individuals that will be authoring that report are Salim Brahimi, Rasmi Aguilar [?] and Conrad Christiansen. And Salim Brahimi actually has a very impressive resume. He is actually the chair of the ASTM Committee on fasteners that comes up with these specifications, so we are fortunate to have him in evaluating what caused the 2008 bolts to break. The other two individuals are at a Department employee, as well as a consultant, and they bring 60 years of combined experience with metallurgic properties. This group has shared its evaluation with the [...unintelligible...] at different times, and, again, they are producing a final report which should be available within days. We have also engaged our expert, external Pier Review Panel for consultation, as well.

This slide right here does talk about hydrogen embrittlement. What we do know is that the failed rods suffered from hydrogen embrittlement. Hydrogen embrittlement is caused by excess hydrogen in the rods, and the challenge is determining the source of that hydrogen. Two main sources of hydrogen are internal, as well as external or environmental sources. And another key factor is the susceptibility of the bolts to hydrogen, and, thus, hydrogen embrittlement. Three conditions have to exist for hydrogen embrittlement, three primary conditions—the presence of hydrogen in a certain quantity, the susceptibility of the material to hydrogen embrittlement, and then also the stress that we put on those rods specifically in this case the tension. And, again, the source of the hydrogen can either be internal or external, which I also refer to as environmental.

This slide shows specific pictures under the microscope of the failed rods that we have studied very carefully. It confirms that hydrogen embrittlement is the culprit of the rods that have broken. It also shows in this slide a lack of uniformity in the microstructure which adds to the susceptibility of these rods and the metal to hydrogen embrittlement. And

this specific slide actually shows a difference in the hardness between the perimeter in the center of the failed rods.

This shows the timeline of the failed bolts that fractured. All of these were from shear key-1, shear key-2 from the 2008 batch of bolts. After 14 days, which is the length of the time represented on this chart, the remaining rods were detentioned. This is the total of the 32 rods that did fail in that time period. And, again, hydrogen embrittlement is a time-dependent phenomenon and should happen within weeks of tensioning. Industry-standard testing protocols, which were utilized on these rods when they came to the project is not necessarily a time-dependent evaluation, and, therefore, current testing of the 2010 bolts, which we'll talk about a little bit later, were substantially expanding the amount of testing that were due into those 2010 bolts to evaluate their disposition. And, again, we'll talk about the 2010 bolts in a little bit.

Several subjects and other issues have been brought up either in question or in speculation, and I'd like to cover just a couple of those topics before we move on to solutions and the 2010 bolts. Regarding some of the documentation and/or non-compliance reports that were released in the documents that the Department previously made available, there was some reference to some contingent passes given to facilities that we did audits on. That was true, but those facilities were subsequently given clean passes once we had additional information and had additional evaluation on those.

The second item that has been brought up and questions have been raised about it is the second heat treatment that was... the 2008 bolts were subjected to. It's not necessarily uncommon for metal parts to get treated more than once or a second time. It's not necessarily a source of hydrogen. It does, in fact, increase the strength of those rods, which could bring into question the susceptibility of the rods. So it's not necessarily a source of hydrogen but it could be a contributing factor to susceptibility.

Another question and conversation and speculation has been about the galvanization process. And the bolts are galvanized for a long-term corrosion protection which would certainly be an endeavor in this

application. The galvanization is not necessarily a bad thing. The ASTM standard for galvanization does... or for these bolts, high-strength bolts, does have a cautionary statement about galvanizing such rods. We addressed that cautionary statement in the process and eliminated a pickling process. So, again, galvanization is to really address long-term corrosion, which would be appropriate for an application on a bridge like this. It's not necessarily a source of hydrogen. It does bring into question the susceptibility, because it could through that process trap any existing hydrogen in the bolts.

Some other questions was the ordering process, the bolts were ordered too late or were ordered on an accelerated basis. There was a non-compliance report in the documents that we've written on this subject. It is not a non-compliance in the testing process. It was a non-compliance in the release of the rods. The rods were shipped directly to the project site. They normally would be shipped to our lab, and then tested there and then released from there. All the testing that was required for those rods was conducted. It was just conducted after the rods were delivered to the site in a sampling batch. So that is a release non-compliance report. It was not an absence of any of the appropriate testing or called-for testing for those rods.

Another subject that was brought up was magnetic particle testing, and there was a letter in the documents we released asking for magnetic particle testing for multiple components that were on the bridge. That magnetic particle testing was conducted on all the components except these rods. These rods were already installed in the pier cap, the E2 pier cap. The magnetic particle testing, it's not a required ASTM testing for these bolts. It also is not related... it's related to surface anomalies. It is not related to hydrogen embrittlement. So this does not necessarily... it is not necessarily applicable to the discussion of where the hydrogen embrittlement came from, nor would it have headed off any concerns that we have about hydrogen embrittlement if we had conducted it on these bolts at that time.

And then the last discussion point is about the embedment of these bolts in this location. I think Steve described exactly what the scenario was with the first two shear keys and the location of those. It certainly presents a

challenge to us in replacing the bolts, now that an issue has arisen on those bolts. It also may have created a scenario where there's moisture down in the bottom of those holes that could have also contributed to the hydrogen in the bolts through an environmental contribution. So those are certainly challenges that we have to deal with now in retrospect. It's not that the design was a deficient design. The design, if this hydrogen embrittlement would not... did not occur, the design certainly would have been adequate for the performance of the bridge, but it certainly presents challenges to us today, now that we have to retrofit those 2008 bolts, and it also may have been a contributing factor by trapping water near the bottom of those bolts.

So, in summary, we are conducting a thorough investigation with several experts. We are going to produce a report that is pending within days. The failure of those rods was hydrogen embrittlement, and the 2008 rods, for multiple reasons, had a higher susceptibility than they should have. And I will defer the conversation about the 2010 bolts until they're covered later in the presentation.

So at this time, I'd like to hand it over to Andre Boutros to talk about the retrofits that we are proposing for the 2008 anchor bolts.

ANDRE BOUTROS: Good morning, Madam Chair, Commissioners, Andre Boutros, Executive Director of the California Transportation Commission. What we're here to show you today is really what the project team has narrowed down the options to two solutions that we will be looking at, further refinement hopefully over the next couple of weeks.

The first option that is shown here is what's termed as 'the steel collar.' It's essentially a steel plate or a combination of plates that is sitting on top of the pier that will be anchored into the pier cap or... to the pier cap to achieve the intended function of the shear keys that was designed at the time the bridge design as completed.

So if you look at the next slide, which is a little bit more detailed, there's a set of plates that will be either stacked or welded together. The option will be really refined as we move forward here, and that steel system will then be

anchored over the cap through post tensioning or other mechanical devices to achieve that clamping force that will then generate the resistance from the shear key to lateral loads from earthquakes or shaking of the bridge. So that's Option 1. That's the steel collar.

And we're also looking at another option which is called 'the steel saddle,' which is similar in concept except it will be solely relying on post-tensioning. The steel plates that you're seeing here will be kind of curved to allow for the post-tensioning system to essentially engage the pier cap, as well as the plates, again, to achieve the intended function of those shear keys for resistance of lateral movements.

So if you go to the next slide, Peter, this is a little bit more of a... kind of a delineation of how these plates will be anchored and where the post-tensioning will be going over the pier and really through the pier to a certain extent to make sure that we have the clamping force that will provide the resistance.

Both options are, again, well achieved, the design intent of this system. Both options are evaluated here in terms of pros and cons. Really, the pros are pretty similar in the sense that there is no removal of the shear keys themselves. There are some issues related to fabrications in terms of, you know, one being maybe a little bit potentially simpler to fabricate. The other one requires less coring through the cap.

As far as the cons are concerned, the first option would require maybe a little bit more fabrication in terms of the steel elements that would be placed on top of the cap, and it will, again, require more coring through the pier cap. The second option requires a unique saddle system that would have to be fabricated specifically for this application.

The last thing I would report is that the contractor has already been engaged in the process, and the contractor has already placed the steel orders for both options, and has already located a local fabricator to begin the process of looking into fabricating the steel that would be required for this application. We are hoping that we can get some of these refined a little bit further over

the next few weeks, like I mentioned, and we'll be happy to report to you maybe at the next meeting what we'll be doing.

And, at this point, I'd like to turn it back to Steve Heminger to talk about the 2010 bolt issues.

HEMINGER: Thank you, Andre. And, Commissioners, we're now to the third question: Should the anchor bolts manufactured in 2010 be replaced? And even though I'm the chairman of this committee, I've somehow been stuck with the hardest question, because this is a very challenging one to answer.

The next one, Peter. And the way we've approached this question is to try to understand the differences between the 2010 and 2008 bolts, as well as the similarities. And I have to say this is not an easy call. This is going to be a difficult call to make, starting with the obvious difference which is that after 15 to 25 days under tension, none of the 2010 bolts have failed. If they had failed early on in the process like the 2008 bolts, this would be an easy decision. You replace the 2010 bolts, too. But they have not failed and that, obviously, is a very important fact. Now, I think we need to know more than the fact that they have not failed. We need to know why they haven't failed, because we need a full understanding and a full level of confidence in all the products and materials on this bridge because we're talking about a bridge that needs to last not only through the big earthquake but for a hundred years or more.

So, moving beyond just that obvious difference, secondly, the two sets of bolts were manufactured two years apart using different batches of steel. And Malcolm showed you microscopic examinations of steel and there is... I suppose sort of a little bit like snowflakes... there's no single batch of steel that's like another batch of steel. And the fact that we manufactured these bolts two years apart conceivably in different atmospheric conditions... I mean there's all sorts of variables—who was working the shift that day?—all that sort of stuff. So the fact that they were manufactured two years apart, we believe, is a relevant factor.

Third, it's also the case that with the 2010 bolts, the bolts manufactured two years later, there were fewer material batches used in the run and less variation on their mechanical properties. So this sort of falls under the category of, you know, the more factors are at play, the more things that could go wrong. And the fact that there were fewer material batches introduces less uncertainty, perhaps, in the 2010 bolts than in the 2008s.

Fourthly, as we've noted already, and it looms large in this whole discussion, the 2010 bolts are not embedded in the Eastern pier cap, and that means that moisture to the extent it's there and, look, we're in a moist environment—these piers are sitting above the Bay, and we've got fog coming in all the time—the bolts for the 2010 series, since they go through the pier, the moisture can drain. It will not be captured at the bottom as the embedded bolts were, and that obviously is a major factor. Not only, as Malcolm indicated, in terms of the difficulty of repairing them, but also in terms of a source of hydrogen. And, finally, we have ongoing metallurgical analysis that may reveal other differences, and we will be coming back to you in a couple of weeks with that information as it becomes available as well.

So, to sum up, quite a few differences between the two sets of bolts. Peter?

Unfortunately, quite a few similarities, as well, and we have to weigh these in the balance with those differences. The first is that both sets of bolts originated from the same principal supplier. The second, they were both manufactured to the same specifications including galvanizing. Third, both sets of bolts have been tightened to the same relatively high level of tension. I think you're aware of the fact that there are other anchor bolts on the self-anchored suspension bridge. They're in differing locations. They're in differing lengths. One good thing about the rest is that most of them are at much lower tension levels, and the tension level does matter in terms of introducing stress into these elements. And that stress is what can feed off the hydrogen and either in the short-term cause this embrittlement problem that we've seen on the 2008s, or over the long-run cause something called, stress corrosion. So the fact that both sets of bolts are at that same high tension level is a very relevant fact.

And, finally, in terms of similarities, both sets of bolts exhibit similar mechanical properties, as I'll show in a second. One caveat, however, is that the 2010 bolts are marginally more ductile. And what ductile means to engineers, essentially, is a level of flexibility or give, if I can. And steel is such an excellent building material, because it is both strong and flexible. Now, obviously, you don't want it to be too flexible or it won't hold your building up or your bridge up. But at the same time, you also don't want it to be too tough or hard. And that, in fact, is the problem that we seem to have had with our steel, not that it gives too easy but that it's too strong, too brittle, and then had the problems that we experienced in 2008. So in that sense, even though the mechanical properties are similar, the 2010 bolts sort of have an edge over the 2008s, because they are not as tough or hard or brittle.

And if you can look to the next slide, it's a series of tests that have been performed on both sets of bolts, and I'll describe them briefly just so that you can get a drift of the numbers and what they mean. At the top row is the standard for the various measurements. And at the top—I'll just move from right to left—there's tensile strength, there's yield, there's an elongation, there's reduction of area—all of those are essentially outputs from a test where the steel is taken and stretched. And you're stretching it to understand its properties. Ultimately, you want to understand where it breaks in that process. And then, finally, there's also a hardness test where you bang the steel and see what kind of dent you leave. I know engineers in the room are probably, you know, grimacing at the way I described these things, but I'm trying to give it you in a way that layman understand and I'm one of them.

So that is the information you're seeing here. So you're seeing test results here for both the hardness question, the toughness, the strength question, as well as the flexibility question.

And if you now look below the standard, the next row is the average for the 2008 bolts, and below that is the minimum and the maximum value in the numerous tests that were run. There are multiple tests run for all of these

factors, and then you see the same kind of information for the 2010 bolts and the minimum, and the maximum. And just to make it easy, just focus on the white rows, which are the averages for 2008 and '10, and you can see that, on average, as I said earlier, the 2008 bolts are slightly stronger than the 2010—greater tensile strength. If you move over to the elongation question, the metric here is a percent, so the longer you can pull it before breaking, the more ductile it is. And in this case, you can see that the ductility advantage goes to the 2010 bolts. And then if you look farther over all the way to the right to the hardness question, which the more we study this issue, the more it seems to matter. You can see that on average, the 2008 bolts were a bit harder than the 2010 bolts, and the harder they get, the more they might be susceptible to the issues that we're raising—both hydrogen embrittlement and stress corrosion.

Now, you will see on that hardness scale at the top that the standard allows a great deal of variety, from a low of 31 to a high of 39 rockwells—that's the metric—and that is a feature that we are paying attention to and I'll loop back to in a second.

One thing we are doing now is subjecting the 2010 bolts to a fairly extensive regime of testing, and you can certainly raise the question of whether we should have done that before we installed them. I think that's probably one of the lessons that we've learned that these bolts were sort of bought out of the catalog instead of being tailored-made, and they are playing a very important role on this bridge in terms of holding down these critical, seismic safety elements. As Andy Framier [?], I think, said at your last briefing, the bolts are the dumb end of the operation, though. I mean, the seismic devices are the smart end, and you need something to hold the devices down. I mean, if it could have been super glue, that would have been fine if it worked. We use these bolts, but I think one of the lessons we've learned is that within the standard, there are variations, and there is room for movement and room for further specification, augmented specifications, and I'll get to it in a second, how we have applied that lesson that we have learned.

So the testing that is underway right now is not only that the 2010 bolts are under tension and, as I indicated earlier, are performing well under tension. There have been no breakages. And for some of them, they've been under tension for almost a month. But we are also going to be removing some of them, a limited number, and essentially subjecting them to destructive testing. So we're going to move them around until they break, and then we're going to examine the various properties of the breaks and test the rods under varying conditions so that we have a much better idea of how they'll perform, not only currently but over the long-run. Remember, we need these bolts not to last for a month. We need them to last for decades, probably not for the life of the bridge, but they need to last over the long-term. And so the trick is to find a test that will give you some insight into that and give you some confidence in that.

Now, I mentioned earlier that we've learned some lessons. I think Malcolm indicated a few. And one lesson I would indicate here that we are applying is that since we will be destroying a couple of these bolts in the course of testing them, we will need to have replacements. And we have now developed a specification for those replacements that is not off a catalogue shelf. It is tailored-made. And that new specification has a maximum level for hardness that is lower than the standard would permit, and also additional testing for embrittlement, additional testing for toughness. And to the extent we do go down the path of replacing the 2010 bolts, I can assure you that we will be putting out a standard... putting out a specification, rather, that will be augmented in several respects compared to the... what I would call, perhaps, the plain-vanilla specification that we used a few years ago.

Remember, as well, that the question here is not just the 2010 bolts that are on the East Pier, but there are also anchor bolts elsewhere on the bridge, and I think it's a natural, human impulse to say, 'Well, what about those, too? You know, do we need to worry about those?' And we are worried about them in the sense that we are making sure that we do due diligence on all of them. There are a number of reasons to worry quite a bit less about them. For starters, as I indicated earlier, most of them are under considerably lower tension levels. Some of them, in fact, are just like you can snug up a

bolt at your house. They're sort of snugged up, so they're under virtually no tension at all. Many of them are inside of elements or much more protected than these are at the East Pier. Many of them are much smaller. And I think one thing we've learned is that the extraordinary size of these bolts on the East Pier, they're 3-inches in diameter, you know, 20-feet long, could have contributed to the difficulty in testing them and making sure that the whole thing was good if you're only testing a sliver of it. So one thing we've done is visual inspection of all of them, all the ones that can be inspected, and that's most of them. And those inspections have revealed no abnormalities, and those inspections are continuing on a regular cycle.

Now, as I indicated, some of them are not accessible to inspection. It's relatively a small fraction. Some of them are on the bearings that are on the East Pier. They're internal to the bearing, so the only way you inspect them is you rip the bearing apart, and that's probably not sensible. What's more sensible is to inspect the quality control records and the manufacturing records for all of these other anchor bolts, and that's what we are doing. And so that work is underway. And, again, we have... hope to have those results available as we go.

But I think we are focused properly on the bolts on the East Pier that are holding down the shear keys and bearings. That's where the action is. That's where the greatest tension is. That's where we've had breakage and I think it's proper to focus there, but I think it's also appropriate to look around the rest of the bridge and make sure we don't have similar conditions that could lead to similar problems.

So, in summary, I think today we believe we have answered the first question, which is that the failure of the 2008 bolts was the result of hydrogen embrittlement, whether induced environmentally or induced in the manufacturing process, or both. On the second question: What do we do about those bolts? What kind of retrofit do we put in place? as Andre showed you, we've got two finalists. They're actually sort of evolving toward each other, as we've seen them develop, which is I think a very healthy thing. And we believe we'll be able to come back to you in two weeks and tell you which one we've picked, and start to build it. Thirdly, as

I've indicated, the 2010 bolts are being tested with a revised number of protocols, and to the extent we will replace at the very least the ones that we destroy in the testing, they will be replaced with bolts that are meeting an augmented standard, an augmented specification than the original bolts that were manufactured in 2010. And then we are ongoing with a review, a desk audit we call it here, of the quality assurance, quality control results for similar bolts by the same manufacturer and we'll be releasing that information as we go.

The last slide, Peter, indicates the items that we expect to bring you on May 8th, and that would be at the meeting of the BATA Oversight Committee in a couple of weeks. The first, as I indicated, is a selection of the 2008 retrofit solution, including its cost and schedule impacts. Second, pending the results from the testing that I've described, and that testing is going to take a long time, but we want to have a point where we have enough information that we think we can make a decision, and that may be in two weeks. It may not be, but we are hopeful that it can be, so that we can also report to you at that meeting our decision about whether or not to replace the 2010 bolts. That, obviously, has some related questions, if you answer that in the affirmative. One of them is, 'Well, replace them with what?' And, secondly, 'Replace them when?' And it's conceivable that we could recommend replacing them after we open the new bridge traffic, because the current bolts are performing their function today. I think the longer we see them perform that function without fraction or breakage, I think the more we transition from a concern about hydrogen embrittlement, which is time-dependent in near-term, to a concern about stress corrosion, which is much longer-term and which might allow you to replace them on a slower schedule than having to do it before we open the bridge. And, finally, as I indicated, we need to complete the desk review of all the additional results for the other anchor bolt locations.

Madam Chair, I'd like to conclude with just two points, if I could. And I would call them a promise and a reminder for Bay Area residents. The promise is this: We will open the new east span only when it is ready, and not a day sooner. The reminder, however, is this: That in the event of a major earthquake, the existing bridge is unsafe. We know that with

certainty. The only uncertain thing is when that earthquake will occur. That's why the sole objective of this project has always been to move traffic off the old bridge as soon as possible, and not a day later. Those twin challenges are what keep this team working so hard and focused on the finish line that has finally come into view. Safety is not job one on this project. It's the only job we've got.

So we appreciate the time and attention you've given us in prior briefings, as well as today, and we're happy to answer any and all questions.

CHAIR REIN WORTH: Thank you very much, gentlemen. I very much appreciate your presentation today. I know we all do. And I know that the Commission probably has some questions for you. But, again, I want to thank you for that outline, both that focused on what you're looking at, as well as the process that is undergoing in terms of really understanding exactly what the cause is and to gain confidence in what the ultimate solution will be.

So I'd like to first of all call on Commissioner Liccardo, and then if the Commissioners might indicate to me that they would like to speak, I'll just start a list. Okay. Thank you.

Thank you, Commissioner Liccardo.

COMMISSIONER SAM LICCARDO: Thank you, Madam Chair. Steve, and thank you all for the presentation and for the seriousness with which you are addressing this. I appreciate that we're heading quickly toward a solution, and that's important.

I guess my first question is really who pays?' I mean, clearly, we've identified... you've identified a manufacture defect that was foreseeable for the manufacturer and one that could have been potentially disastrous had we not found it. And the last thing I'd like to see is that this just gets swept into a contingency budget that ultimately leaves the taxpayer picking up the tab. So how is the manufacturer going to be held accountable and who pays?

DOUGHERTY: Well, primarily, as Steve, I think, very clearly articulated, our primary energy has been spent on determining what caused the failure and then also what the solution is. We have not crossed the path of addressing contractual requirements. We fully intend on having that conversation as far as contractual requirements. It is very likely that there are several contributing factors to the failure of the 2008 bolts, and we'll have to take that into consideration between design requirements, specifications, between contractor installation, and between the manufacturer of the bolts. So we still have to address the contractual terms of why the 2008 bolts broke, and we would be more than happy to brief you when that time comes.

COMMISSIONER LICCARDO: Thank you. I look forward to that conversation. I think it's an important one, but I appreciate that we have to solve it, fix it first.

Have we determined whether the 2008 bolts were manufactured in the same facility as the 2010 bolts?

DOUGHERTY: They were not manufactured under the exact same process with all the different players. They came from the same primary supplier, but some of the steps in the process were done differently in 2008 than in 2010.

COMMISSIONER LICCARDO: So the same primary supplier presumably had multiple manufacturers they were contracting with? Is that what you're telling me?

DOUGHERTY: Yeah, the steel, the source of the steel could have been different, the heating process could have been different, the galvanization process. There's different steps in the process, and between the 2008 and 2010 bolts, the process was not exactly the same.

COMMISSIONER LICCARDO: Did that process ultimately take place in the same plant? In other words, is there a single, physical location that we can point to where we say all the bolts came from?

DOUGHERTY: As one example, the heating process did not take place in the same location for 2008 and 2010 bolts. So that's one example. And I think these are the types of things we'll clearly articulate in detail with the report on the 2008 bolts as the differences.

HEMINGER: I think, Commissioner, that's one reason that I... when I mentioned one of the differences, you know, there was a longer supply chain, if you will, for the 2008 bolts. And I would say we had more cooks in the kitchen. And I think with more cooks, you know, that's more people who could get something wrong.

I would also say, earlier though, Commissioner, on the predicate of your question, you know, that we had a manufacturing failure or flaw, I don't think we have determined that yet. We had certain specifications for the 2008 and 2010 bolts. They were met in both cases. And so I think one of the questions, clearly, is: Were those specifications adequate as well? Should they have been augmented? And I think where I go, and Malcolm is right, we haven't sat down and tried to say, 'It's you, and you, and you.' But in terms of the failure that we did have here of the 2008 bolts, it's a very, very significant failure. It's a catastrophic failure. And, remember, we had 30 bolts failed and then the remainder were detentioned. They were loosened up. If we had left them tensioned, there could have been many more failures.

So the point is that with that kind of a loss, the likelihood in my mind is that it's a combination of factors, that it's not one thing, that it's several things working together. And, in this case, there could be part of that culpability belonging to the manufacturing process, there could be part due to the embedding of the bolts at that location, part could be due to the very high level of stress intentioned that they're subject to, so there are a number of things that we need to pars our way through before, I think, we get to the discussion about compensation and about claim.

COMMISSIONER LICCARDO: Thanks, Steve. I want to go back to a comment you made earlier on a slide which you indicated that some of the

2010 bolts would be tested more substantially. And I think in an earlier hearing, we heard that after 30 days, 10 of the bolts would be pulled off. And is that what you're referring to, is those 10 bolts...?

HEMINGER: That is, and as of today, we've extracted four. And I think we're probably going to take another two, at least. So the 10, I would probably call a maximum, and remember it's about 10 out of 190. So we need to take enough offline, so that we can test them adequately. And we're going to be subjecting them to different kinds of tests. Our experts have come up with a test that they think can be a good level of insight into this long-term stress corrosion issue. And you can't have a stress corrosion test that lasts 30 years. You know, you need something that you can make a decision on. And so they are putting together that kind of test, but we're also, as indicated on the slide, coming up with a whole series of other tests that are especially trying to get at this hardness question, because that is where the harder the material, the more susceptible it is to this issue when hydrogen, if it does show up, and then you put it under high levels of tension.

COMMISSIONER LICCARDO: Thank you.

CHAIR REIN WORTH: Okay, thank you, Commissioner Liccardo. Next Commissioner, Commissioner Cortese... Vice-Chair Cortese.

COMMISSIONER DAVE CORTESE: That's good enough, thank you. A question... my question has to do with something I'm only informed of through newspaper accounts as of yesterday, and that's the report that was done essentially unsolicited by an engineer who seemed to be inspired by listening to some of the commissioner questions, certainly not mine, but some of the other ones, perhaps our Chair or Commissioner Haggerty, and they were asking questions very specifically about I think what you were referring to as causation coming from the environment versus the manufacturing process. And I know you've touched upon that more than once in this presentation, but I don't think we've heard specifically about your feelings about the veracity of that report and what we'll do with it going forward. So I'd like to hear more about and I would just like to say,

as a commentary, it sounded like the response from all of our experts was, you know, very welcoming and cordial with regard to that report, although I'd like to hear if that's really the case today. It certainly is welcome information from my standpoint. Thank you.

DOUGHERTY: Sure, I would agree, the unsolicited report certainly came from an individual that is knowledgeable in metallurgy and has a history. And a lot of the issues that were brought up in his report are very consistent with the findings that we have found, as well. Actually, we've reached out to that individual and actually invited him down because he doesn't have as much information as some of our experts have, and we would like to share that information with him. So, we've been very receptive to that report and we're going to engage him in a conversation in more depth.

COMMISSIONER CORTESE: Thank you.

CHAIR REIN WORTH: Great. Thank you. Commissioner Pirzynski?

COMMISSIONER JOE PIRZYNSKI: Thank you, Madam Chair. Commissioner Pirzynski for the cities of Santa Clara County. I want to follow up to the Vice-Chair's question. Your response indicated that you're open to a dialogue. The report I saw seemed to indicate that there were additional concerns raised that went beyond the issue of the hydrogen intrusion. Could you speak more specifically to those issues that were raised? And I think there were two individuals who were reported as presenting unsolicited, professional analysis of what we have going on.

DOUGHERTY: I'm familiar with one offhand. I'm not sure which other one you would be referring to. Two issues that I'm familiar with that were brought up were surface hardness, and I think we're definitely addressing that, not only with the 2010 bolts but also going forward. The amount of testing that was done on the 2008, 2010 bolts that were installed was also brought up. I think we've clearly articulated the additional testing that we're going to subject them to. Going forward, we certainly will learn from the testing that we're subjecting the 2010 bolts to, to see whether or not those tests should be incorporated into our practices going forward under

certain circumstances. But I think the surface hardness was certainly brought up, and I think we're addressing that. As far as other issues, if there are other issues that you want me to specifically address, I'd be more than happy to.

COMMISSIONER PIRZYNSKI: I don't know the specific issues, but it was concerning to me to read what seemed to be a... perhaps additional or more comprehensive analysis that was done by these individuals that we had not as yet heard being addressed. I'm sorry I don't have the specifics, but I would like to see more information regarding that.

DOUGHERTY: In the next few days, we're going to be summarizing our findings from our metallurgists, as well as input from our experts on the 2008 bolts and what caused them to fail. At the same time, it's very important for us to look at the 2010 bolts, and I think Steve did a very good job talking in engineering language until he brought super glue into the conversation. But what we really need to do is differentiate between the 2008 bolts and the 2010 bolts, metallurgically. Until we can identify a difference between the 2008 bolts and the 2010 bolts, we haven't answered the question about why these were susceptible and why the 2010s won't be susceptible. And that's what we're really looking at determining is what is the difference between the two bolts and do we have the confidence in going forward with the 2010 bolts.

But I think on the 2008 bolts, I think when you know when we're looking at all the same issues that I think that some unsolicited folks have contributed, and I think we're going to summarize that in a very technical report and a brief consolidated report in the next few days, and we'll make that public, as well.

CHAIR REIN WORTH: Thank you. I know my colleagues have a number of other questions, but I just wanted to follow up on that line with our Executive Director. Steve, I know we've received a number of comments from the public regarding this problem we're addressing. And could you talk for the benefit of the Commission and the public what our process is

when we receive letters from the public and what you've been doing with those?

HEMINGER: Madam Chair, we welcome information that's provided to us from whatever source. And in the case of the report that Commissioner Pirzynski mentioned, it came from a very knowledgeable source, indeed. And I have to say I was reassured that he had sort of independently developed a line of thinking that was quite similar to the line of thinking that we've been pursuing. In answer to his question, as well, I do know that we were contacted by a professor at Cal, I believe, early on in the process of this story breaking in the newspapers, and I think we accorded him the same level of courtesy and interest that we did the second gentlemen. So that will always be the case here. The public has never been shy about talking about this bridge, believe you me.

CHAIR REIN WORTH: Thank you. So what you're saying is we forward all the information we get from the public on to Caltrans, so it becomes part of the information that is available?

HEMINGER: Certainly.

CHAIR REIN WORTH: Good. Good. Okay, then our next speaker is Commissioner Haggerty.

COMMISSIONER SCOTT HAGGERTY: Thank you, Madam Chair. Just a really quick question. Everything we do with this bridge certainly adds to the seismic strength of the bridge. And now we have done something that is... with the collar system is clearly deviating from what the engineers clearly had in mind as to the seismic vulnerability. What have we done now to this bridge? I mean, have we taken it from a 7.3 to a 7.1, an 8.2 to... what have we done here?

DOUGHERTY: We will not lose any performance with the solutions that we are proposing. If they did not meet the performance requirements as originally required, we would not consider them viable options.

COMMISSIONER HAGGERTY: Okay.

DOUGHERTY: They meet the same performance requirements that the original design with the bolts would have performed. If they did not meet the same performance requirements...

COMMISSIONER HAGGERTY: Oh, I actually heard you the first time. Okay, thanks.

CHAIR REIN WORHT: Thank you very much. Commissioner Campos.

COMMISSIONER DAVID CAMPOS: Thank you, Madam Chair. And thank you for the presentation, and I really appreciate all the work and especially the last two points, the two messages to the public, if you will.

One concern that I have is we understand that we're talking about hydrogen embrittlement here, but I haven't heard enough about what does that say about quality control in terms of the processes and systems that we had in place that allowed for the hydrogen embrittlement to get to this point? So do you have something to say about that at this point, or is that too early to say?

DOUGHERTY: I'll try to address it. I think Steve started to address it earlier on. I think we did a standard protocol testing for ASTM requirements for the bolts. I think in hindsight, realizing the problem that we already realized and going forward, we're using a much more rigorous testing. One of the challenges we have is we could have sampled the 2008 bolts to the exhaustive list of testing that we have now. And if the hydrogen embrittlement was contained down in the threaded area, it may or may not have been caught. The hydrogen may have been injected into or received into the bolts after they were installed and after we did the testing through environmental contributions, and, therefore, our testing process wouldn't have caught it then. Those are some of the challenges, but I think we have definitely looked at the fact that the susceptibility of these bolts was not identified in the testing protocols that we utilized before we installed them,

and we've developed a longer list of tests that we will subject future bolts to going forward.

COMMISSIONER CAMPOS: And are we convinced that these new protocols that we're using moving forward are sufficient to catch any embrittlement in the, for instance, 2010 bolts, as an example?

DOUGHERTY: I think we have consulted with some of the best metallurgists that we have available to us, and they came up with the testing protocols for the 2010 bolts that are out there, as well as any replacement bolts that we would utilize. So I think that we have relied on the best experts we have access to, to determine what the appropriate testing going forward is.

COMMISSIONER CAMPOS: Has there been a similar problem with other bridges in other parts of the country or the world? I mean, we have talked about hydrogen embrittlement being, you know, nothing necessarily unusual in a way, but have other jurisdictions, other projects dealt with something similar?

DOUGHERTY: Hydrogen embrittlement is not a new phenomenon. It's one that industry deals with on an ongoing basis. This is a unique bridge. These are unique components for a unique aspect of a unique bridge, so I don't know that this is something that is out of the ordinary and not been experienced in other places. And some of the testing actually is done when you tension the bolts up is the last telltale sign as to whether you have what you asked for or not. I don't know that this is out of the box. I think this is something that we certainly didn't anticipate, but it's not something that... you know, hydrogen embrittlement is something that metallurgists and bridge designers have been dealing with for a while.

COMMISSIONER COMPOS: I guess the question is more is there something that other projects, other jurisdictions have done in response to similar issues that we could learn from them as we're trying to figure out how to move forward?

DOUGHERTY: I think that will be part of the post dealing with the issue research to determine whether or not there are lessons learned. There will be lessons learned from this incident that are shared nationally.

COMMISSIONER CAMPOS: Just is the final question: I know that when Commissioner Liccardo talked about sort of going forward, perhaps liability, who's at fault: What is the total cost in terms of the monetary value of this delay?

HEMINGER: Commissioner, I don't know that we've got a cost on this delay, per se, because we continue to work on opening the bridge, and that work is proceeding. We will eventually, in fact, I hope in two weeks we will be able to report to you what the cost of the retrofit is, and that will probably be the subject of further discussions with the contractor and supplier about the question of, you know, who's going to chip in how much? So I would just ask you, if you could, to be patient for that information for probably a couple of weeks.

COMMISSIONER CAMPOS: Thank you.

CHAIR REIN WORTH: Okay, great. Thank you. Commissioner Quan.

COMMISSIONER JEAN QUAN: Thank you. Okay, so I come from a family of engineers, but I'm not an engineer. When we're looking at these two options, when you talk about one would replace your shear key and the other wouldn't, does that mean the component around the bolts?

BOUTROS: I'll take this. Neither one requires replacing the shear key, itself. This is really just anchoring the plates into the pier cap of the columns. The two options essentially... really essentially are similar. One is using stack steel plates, and the other one is using a system that will allow post tensioning strands to go through so you can achieve the same intent.

COMMISSIONER QUAN: Again, I'm trying to understand. We're replacing bolts, it sounds like.

BOUTROS: Right.

COMMISSIONER QUAN: And then we're building saddles or other stabilization mechanisms around them to increase the strength?

BOUTROS: It's really to keep the system in place. We want to keep the system anchored to the concrete cap on top of the columns. So that original design involved through-bolts, bolts essentially went through the concrete and clamped the system to the concrete. So what we're talking about right now is instead of those bolts that were in place, we're looking at some external application to hold that system down to the concrete.

COMMISSIONER QUAN: In addition to the bolts or in substitution?

BOUTROS: Yeah, the bolts essentially are no longer functioning. We're not really counting on them. They'll be taken out.

COMMISSIONER QUAN: So this substitutes for the bolts.

BOUTROS: Right, this is a substitute for the bolts, yes.

COMMISSIONER QUAN: That's a much simpler explanation, thank you.

HEMINGER: If I could try, and I'll try not to say 'super glue,' Malcolm. The upper left of this picture, I think you can see it probably better than on the color thing. You can see the shear key connection in the middle there and then the two bearings on either side. The current thinking among the engineers is that the 2008 bolts will not be replaced. They'll just be cut off and left in the pier cap. And what you see here are the strands fanning out there that are holding down the connection instead of the bolts, because the bolts aren't going to work. So in the case of this saddle, as well as in the case of the collar, what you have is a device that is holding the thing down in lieu of the bolts which have failed.

COMMISSIONER QUAN: And that will substitute. You know, I think it's very confusing... it's going to be very confusing, and if we could just say

that you're developing a system, because we're going to be debating these bolts... like we spent all this time debating the bolts, but if we're not relying on them anymore that doesn't matter. It's the new system that we should be focusing on. So just for communications, if we could communicate it that way.

HEMINGER: Yeah, I do want to... yeah, and if I could take the opportunity of your question just to confirm and clarify for everyone that even though 30 of the 90 2008 bolts have failed, we are writing them all off. We are not counting on any capacity from any of them. And so this device, as Malcolm answered to Commissioner Haggerty, is going to all by itself replace the capacity that we had there. I think the impact it might have, more than anything else, is on looks. And you probably won't see it from the deck, because it's underneath. You'll see it from a boat.

COMMISSIONER QUAN: So I think that's the main thing, because I thought that's what you were saying, but I thought we could say it more clearly.

Secondly, I'll go back to my question the last time. So if we approve these options next time, do you think we'll be done in time for the opening?

HEMINGER: Commissioner, I'm going to have to give you the same answer I gave Commissioner Campos, and that's just give us two weeks to develop an answer to that question.

COMMISSIONER QUAN: I don't think he actually asked for the timeline, but okay, all right.

HEMINGER: But we will have an answer for you on that question, I hope, in two weeks.

COMMISSIONER QUAN: Thank you very much.

CHAIR REIN WORTH: Thank you. Commissioner MacKenzie.

COMMISSIONER JAKE MACKENZIE: Thank you, Madam Chair. Jake MacKenzie representing Sonoma County and the nine Sonoma County cities. Back to the QCQA tests, looking at the matrix presented there seems to be in the post-heat treatment very little differential between the 2008 and the 2010 bolts. They're also, as I was listening, seems to be the supposition at least, if not the knowledge, that it was the environmental conditions under which the... to which the 2008 bolts were subjected and placed on the bridge that was possibly the cause of the hydrogen embrittlement. Has it been clearly established under what environmental conditions the 2010 bolts were subjected over their shorter lifetime on the bridge?

HEMINGER: Commissioner, very good question. And we've spent a lot of time talking about this embedded location, and it clearly has been a very difficult detail to manage now that we've got bolts that are busted. But the other factor there, obviously, is the fact that there was no ability to drain water out of those bolts. And so that as a potential source of hydrogen is certainly a leading culprit.

We have had, I think, quite a few experts, though, remind us that the bolts don't just need to be sitting in water. I mean, hydrogen is in the air and they're in a marine environment. And so it could also matter that the 2008 bolts have been out there two years longer than the 2010 bolts. And they are going to be susceptible to hydrogen their whole lives, because they're on a bridge over water in a foggy region. So I think we're trying to be cautious in not making too much of the embedded location, but it clearly has not only been a difficult detail to deal with in terms of the retrofit strategy but it also, if we had to do it all over again, we would have probably tried to find a way not to have an embedded location here and have the bolts go through as they are with the others.

COMMISSIONER MACKENZIE: Right. One other question, Madam Chair, if I may.

CHAIR REIN WORTH: Yes, please.

COMMISSIONER MACKENZIE: In terms of the desk audit of the actual data on QCQA, who is conducting that desk audit? Are these independent contractors that are doing the desk audit? How does that happen?

HEMINGER: Well... and Malcolm will correct me if I'm wrong, but the Department is gathering the information. Once they gather the information, it's subject to the oversight process we have, which means this Committee looks at it, our Peer Review Panel looks at it—a whole lot of outside experts. But the part of just gathering the information, that's... it's in their file, so they need to get it to us.

COMMISSIONER MACKENZIE: That I understand. It's more once you have the information, is there an independent... or one of these bodies, at least, are independent of all of us. We all have some vested interest in things.

HEMINGER: Yeah, I think the primary function that we rely on for that is our Peer Review Panel, and they have been very helpful to us throughout the life of the project on a lot of other issues and they are very engaged in this one.

COMMISSIONER MACKENZIE: Thank you very much. Thank you, Madam Chair.

CHAIR REIN WORTH: Thank you. Yeah, Mr. Dougherty?

DOUGHERTY: I was just going to add that, certainly, our consultants as well as our Peer Review and the metallurgist that was brought in by the contractor are all going to be reviewing the documents that are generated from that research.

CHAIR REIN WORTH: Okay. Thank you very much. I appreciate all the questions. I had a number of questions, but I appreciate my colleagues who have addressed a lot of those. I just have three questions that I'd like to address, again, with great appreciation for the opportunity today, not only for the Commission but for the public to hear and be part of this discussion

to understand both the extensive thought processes going into determining the cause of this problem, as well as building confidence in the solution.

I just wanted to focus, first of all, on the retrofit strategy. And I know that there have been a number of designs. You know, we saw one a couple... last meeting and then these other two options. Andre, I wonder if you could give us a little bit more background as to the factors that you are looking at when you go to develop this strategy, because I know one of the issues that has come up in the information we've seen is that we're taking essentially tension bolts that are here and we're providing that tension a little farther away from the column. And, as Steve mentioned, we're going to replace those... this will completely replace those bolts that are embedded into the concrete. Can you talk about those elements that you look at to make sure that this new retrofit has that same level of tensioning that... what was envisioned in the original design? Okay, thank you.

BOUTROS: Sure, I'll try this one. You know, one of the first things that the engineers will have to really consider when they're developing a solution is what are the loads that we're trying to resist here? So that's really the guiding principle. Then you're looking at the system that can transfer the loads to whatever the proposal is. So as we move further out, as you're referring to in terms of the steel elements, those steel elements get thicker. You know, that's why we have stacked plates or the saddle system is to allow that bridging, if you would, to transfer that load from where it needs to be to the points where those loads are transferred through the anchorage into the pier cap. All those... I mean, those are the intricacies that you have take into developing that solution.

The bottom line is the system that would be put on top of this column is going to be at least, if not better, than what was there to begin with, the design. And that's really what we're waiting for right now is the final details to decide which ones to move forward with is being developed and we're going to look at that and see which system really gives us not only the capacity that we're looking for, but then how do we build it, you know, how do we fabricate it and put it in place and what are the time-related issues related to that? And, Malcolm, maybe you can jump in, as well.

CHAIR REIN WORTH: Thank you.

DOUGHERTY: And if I can add to it. Thank you, Andre. Downward force is what we're looking for; minimal play, as far as the movement of the appurtenances; the shear keys and bearings has to be minimized to just a couple of millimeters; and then the performance over multiple seismic events.

CHAIR REIN WORTH: Okay, so that the intent of this is to enable the bridge to move slightly in the event of an earthquake, so it sort of moves and then it comes back and it doesn't break. It's kind of like a willow tree—you want it to be able to move but not... you know, retain its integrity.

DOUGHERTY: Right.

CHAIR REIN WORTH: Okay. Well, thank you. The next question is there's been a lot of discussion about the difference... you know, the 2008 bolts, the 2010 bolts, and still trying to look at what exactly is the cause of the embrittlement. One of the issues that had been raised and alluded to in the questions and you commented on is the fact that, you know, some of the embrittlement... some of the failures happen immediately at once those bolts were tensioned. But then the other comments revolve around the fact that from an environmental standpoint, hydrogen is in the air and is... you know, as it's been said it's the smallest atom, so it has... it's very tenacious. But I guess the question is are we looking at... in looking at the other bolts, the 2010 bolts, granted that they haven't failed yet... I know that one of the concerns that's been raised is they may last for a while. You know, are we looking at maybe different kinds of materials that might be more defensive against the possibility of hydrogen, the, you know, corrosion, that kind of thing? So recognizing that we do have ongoing maintenance of the bridge, but at the same time we want to be able to put the bolts, make sure that the bolts we're installing are the best and the strongest given what we know about metallurgy?

HEMINGER: Commissioner, as I tried to indicate earlier, the 2010 bolts seem to be making their way through the window of the hydrogen embrittlement problem. But that's not the only problem we need to worry about. An equally important one is this issue called stress corrosion.

CHAIR REIN WORTH: Exactly.

HEMINGER: And the fact is these bolts will be under very high tension for a very long time. They will be in an environment that is swimming in hydrogen, and they are susceptible to it because they are high-strength bolts, because that's what we specified and what we need to hold down these shear keys and bearings, because the seismic force that will be exerted on them is very, very considerable in the big earthquake. So all of that is in our mind, and it's why I said earlier, almost in jest, that it would have been easier if these things had broken in the first few days, because then the decision is clear. You replace them just like you replace the 2008s.

I do think it does lead to the question, though, even if we do decide to replace them, we could decide that we replaced them on a different schedule. One clear difference between the 2008 and 2010 bolts, we have written off the 2008 bolts. They need to be replaced before we open the bridge period. There's no other way to do it. The 2010 bolts, however, are currently performing the function they were designed to. And so, as I said earlier, it's conceivable and it may be desirable, in fact, to open the new bridge to traffic after the 2008 retrofit is complete but before the 2010 bolts are replaced. And they could be replaced sort of like the first order of the maintenance program is that we're going to replace these in the near-term, and your question gets to, 'What do we replace them with?' One of these retrofit strategies for 2008 uses post-tensioning strands, which are a completely different fastener from these bolts. So if we do get to the question and answer it affirmatively that we do need to replace the 2010 bolts, then we would be looking exhaustively at what our options are to replace them with.

CHAIR REIN WORTH: Okay, thank you. And just one final question: I know that there's been referenced to the fact that part of the... maybe part

of the challenge of these bolts is the galvanizing process, so we have a number of bolts that have been galvanized during the... across the bridge. Are you doing... can you talk a little bit more about the inspection and the analysis that you're undertaking to make sure, in particularly reviewing the galvanized parts through the whole structure to ensure their strength and stability?

DOUGHERTY: Well, a galvanization process... certainly, galvanization is something that in an environment like this, as Steve was talking about, is actually an important aspect of corrosion protection. We have identified all the high-stressed material bolts and gone back and done several visual inspections of each of those. And then we're also pulling up all the tests and the inspection reports that were done on those, and that's the desk audit that was referenced earlier that we're in the middle of doing to go back and look retroactively on everything that came in that is a similar specification to these bolts to ensure that they are okay.

Galvanization is not necessarily the evil in itself. It may have been a contributing factor to this... to the susceptibility of the 2008 bolts, but we galvanize things for a good reason, to protect against corrosion. And there's a cautionary note in the ASTM standard if you're going to galvanize these types of high-strength things. And that's why we're going back and looking at everything that was on the bridge that it fits into that category.

CHAIR REIN WORTH: Okay, great. I have one more question. Then I know Commissioner Aguirre has some questions. I just wanted to follow up. One of the other... you provided some good input on past tests that Caltrans has done and the tests that we're going to be... you're doing right now to look and to affirm where we are. You know, one of the comments that we have seen in the past is that... is during the manufacturing process, various tests that were recommended, and one of them was the magnetic particle testing. Can you, again, just reiterate what that does and give us a little more background on why it was done, or wasn't done, and what your thoughts going forward?

DOUGHERTY: Yeah, the magnetic particle test is really to look for surface imperfections, and it was not done on the 2008 bolts because they were already installed. It would have been difficult. It is not a test that identifies hydrogen embrittlement. It looks for, like I said, imperfections in the surface. So it was conducted on all the other components that were identified in the memo that we issued to the contractor. But the 2008 bolts, it was a little late to apply to those. Certainly, at that time, we did not know that we were dealing with a set of bolts that may be susceptible to a problem, but even if we had conducted magnetic particle testing on those, it would not have identified a hydrogen embrittlement issue or a concern.

CHAIR REIN WORTH: So it was the external, okay. Okay, well, great. Well, thank you very much. So, Commissioner Aguirre.

COMMISSIONER ALICIA AGUIRRE: Most of the information I think has been answered, but I am concerned the 2008 bolts are two years younger. And so what we found in them, you know, the... you also talked about the 2010 are more ductile. So in two years, will the 2010 look like the 2008 that we have now, even though we're manufacturing, and what are we doing proactively to not come back... I mean, obviously, we don't have 2013 bolts to say, 'We can test them.' So we only have these two bolts. So what are we looking at to say, 'Yes...' You mentioned all of the factors of why the 2010 are a little better. Some of them are very close in range, so they're not that different, but in two years, will the 2010 look like the 2008 that are here right now?

HEMINGER: Commissioner, I think Malcolm may have uttered the phrase, and I'll echo it, you know, that if we can't distinguish enough difference between the 2010 bolts and the 2008s, the 2010s are going to have to go, because we need to have a very high level of confidence in the performance of these fasteners. Now, to-date, again as I said earlier, we're not seeing the hydrogen embrittlement question present itself. It still might. You know, it's not that after 30 days you're out of the woods. But, given how quickly it manifested with the 2008 bolts, you would have expected to see something by now if it hasn't happened.

COMMISSIONER AGUIRRE: But they're also five years older... I mean, two years older.

HEMINGER: They are two years older, which is why I think the more important question in all likelihood for the 2010 bolts is this question of long-term stress corrosion. And the engineering experts that we've assembled have devised a test for that. And that's why we're removing some of the bolts from the line on the 2010 locations and subjecting them to that test. So we want to get a lot more information, destructive testing information on the 2010 bolts so we can compare it to the 2008 testing that's been done. And, again, the key result that we will be looking for is difference. And if we don't determine enough difference, then I think you are left with the very worry that you're expressing in your question: It's just two years apart. Are we just two years away from the same problem? And I think at that point we might well need to make the decision to replace the bolts, too.

DOUGHERTY: If I can add, it's a very good question. One thing to look at is the testing information that was provided. They were both... both tests... or all the tests and all the information for the 2008 bolts and the 2010 bolts were taken at about the same point in their life. So it is good information to us, as far as the susceptibility question for the 2008 and 2010 bolts. The tests were conducted at about similar times of their life—when they were delivered to California, both in 2008 and in 2010—but I think Steve also enumerated it very well, if we can't tell the difference between them, we're going to lump them into the same batch.

COMMISSIONER AGUIRRE: Thank you, great.

CHAIR REIN WORTH: Thank you very much. Oh, Steve, do you have a... I... yes... yes, Commissioner Cortese.

COMMISSIONER CORTESE: I just... I feel the need to just say this to the full Commission present. I know going back to Commissioner Liccardo's question, the answer is we're not there yet in terms of remedies that we might have to seek here as a Commission or to protect our interest or further

our interest in the overall scheme of things. But... and, really, this is I think primarily directed to our Executive Director. Hopefully, the Chair, Vice-Chair, the Commission could work with you in terms of the timing of that discussion because ordinarily a public entity, as we are, we would have that kind of a discussion in a privileged environment, in closed session. And I think it's going to be really important for us to time that such that when we... any decisions or anything that even resembles sign-off by our part... on our part, has been completely informed by that discussion, as well. So, anyway, look forward to having that conversation with you and not putting any carts before the horse.

HEMINGER: Certainly, Commissioner. Certainly.

CHAIR REIN WORTH: Okay. Commissioner Bates?

COMMISSIONER TOM BATES: Yeah, very quickly. First of all, I appreciate the presentation. I think it's actually encouraging that you're doing the kind of due diligence that we're doing, and I think the public can rest assure that with the best of our ability, we will... when we open that bridge, it's going to be safe.

So the question I have is actually when we finish the bridge and we're already and safe, what standard of... will it be able to absorb an earthquake, what level, I mean, are we talking about that this bridge will be engineered to withstand?

HEMINGER: Commissioner, I'm trying to remember the exact number of years, but it's something like a thousand-year earthquake. I mean, it's about as big as they come.

COMMISSIONER BATES: Like a 10? I mean, what's on the Richter Scale?

HEMINGER: No, I... they actually don't calculate it that way. I wish it were that easy but, you know, what you're looking at on both the Hayward

and the San Andreas, the design earthquake for this bridge is in the 8s. It's very large.

DOUGHERTY: The exact phrase, if I can recall it correctly, is that it is designed to withstand the greatest ground motions expected over a 1,500-year period. It doesn't necessarily translate to an 8 or a 9 because all those ground motions vary. But it is designed to withstand the greatest ground motions we expect over a 1,500-year period.

COMMISSIONER BATES: I think that's also reassuring. You know, once we get this done, this is going to be really a tremendous asset for the Bay Area.

CHAIR REIN WORTH: Okay. Thank you, Commissioner Bates. Again, I just wanted to come back and say also how much I appreciate the summary page which says items at this point, what we know you'll be bringing back to us at the BATA Oversight Committee on May 8th, and appreciate us knowing and recognizing. Just, again, I wanted to ask any of you based on the questions or the comments, if you have any additional summary comments that you would like to offer to the Commission?

HEMINGER: Well, other than, Madam Chair, just pointing to that last page—Peter, if you could get it up—which is what you should expect. And looking at Commissioner Dodd, he looks... he looks overjoyed to be expecting that in two weeks. But we will be bringing you, we hope, a retrofit solution and indicating to you its cost and schedule impacts. And we hope, also, if we have enough testing information to do so, to bring you a decision on the 2010 bolts, and then I think we'll be able to give you a much better clarity on where we are on any of the other bolt locations and whether we have any cause for concern there.

CHAIR REIN WORTH: Okay, great. Well, thank you. With that, I just wanted to, again, echo our appreciation for all of the hard work that's being done to ensure the safety of this bridge, both in terms of understanding the comprehensive nature of the causes and then, again, building confidence in the solution. I appreciate your explanations to us, many of us being history

majors as opposed to engineers. And so you've even... you know, we can relate to the super glue reference. But, again, I want to thank you very much.

I want to also thank the public for your involvement and the importance of our ability to convey to the public the seriousness with which this Commission, as well as our, you know, partners in the construction of this bridge and, as our Executive Director has said, safety is job on on this. So, thank you again for all the questions.

We'll just take a five-minute break after BATA, but I wanted to follow then with Item 7 to see if there's any public comment on this... on... for this Commission... for the Authority Meeting. Therefore, we will adjourn this meeting to Wednesday, May 22, 2013. Let's just take a five-minute break before we proceed to the Commission Meeting.