ASR Workshop – 6th Street Viaduct, August 27, 2008

ATTENDEES: See Attendee List

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FROM: Yoga Chandran

DATE: September 8, 2008

The workshop to discuss Alkaline Silica Reaction (ASR) impact to 6th Street Viaduct structure was held on August 27th at 100 South Main Street. Gary opened the meeting and described the expectation of the workshop as to discuss the ASR impact to the 6th Street bridge. Gary introduced the moderator Glen Dake. Glen went through the introduction of the following panel members:

Gary Lee Moore (GM) / City Engineer
Phi Richardson (PR) / Program Manager, Bridge Program
John Koo (JK) / Group Manager, Bridge Program
Jim Wu (JW) / Project Manager, Bridge Program
Glen Dake (GS) / Moderator, Landscape Architect, Former Green Deputy for City of LA
Ken Bernstien (KB), Head, Office of Historic Resources
Leo Ferroni (LF) / Retired Caltrans Materials Expert
Don McDonald (DM) / Bridge Architect
Eric Delony (ED) / Former Head, Historic American Engineering Record
Stephen Mikesell (SM) / Deputy State Historic Preservation Officer
Steve Thoman (ST) / Design Project Manager, Structural Lead, DEA
Mike Buhler (MB) / LA Conservancy
Kent Sasaki (KS) / Structural Engineer, Materials Testing, WJE
Dan Weddell (DW) / Design Structures Lead, Seismic Retrofit Strategy, PBS&J

Following the introductions, Glen introduced the agenda for the workshop. The following presentations were made to provide background information on the ASR impact and the potential retrofit schemes investigated by the City.

Presentation No. 1: Sixth Street Bridge Material Testing Program Findings by Kent Sasaki. The following topics were discussed by Kent

- Investigation of cracking done in 2001
- Surface mapping and sampling program
- Cores taken at various components for observation and testing
- Photographs of representative samples
- Effectiveness of epoxy limited to few inches
- Results of Petrography testing

- Evidence of new cracks observed on epoxy coated areas
- ASR still active and could continue forever until they become aggregate

Presentation No. 2: ASR Case Studies by Eric Delony. The following were discussed

- Characterized the Merrill- Butler bridges 8 years ago with documents and photos
- Eric described the outreach he did across the world to seek out opinion on the ASR mitigation. Contacted approximately 100 bridge experts, scientists, academia, and preservationist.
- Received about 30 percent response
- In general the methods used for mitigating ASR include controlling moisture, replacing impacted components or replacing the structure, if the impact is severe.
- Based on his observation, Eric stated that the prognosis for the 6th Street Bridge is not good. The bridge is severely impacted by ASR and based on his outreach to the world community has not found a "silver bullet" to mitigate the impact.
- Lithium can be used to stop the chemical reaction, but it has not been proven on large civil engineering structures and does not repair the damage that has already taken place.

Presentation No. 3: "Retrofit Strategies" by Steve Thoman. The following retrofit strategies were considered for the retrofit of the structure:

- A total of 6 retrofit schemes were considered. Only two were found to have some merit. These are heavy steel casing and substructure replacement.
- Heavy Steel Casing
    - Architectural Impacts
    - Provides confinement of the columns by adding post-tension bars across the column section and installing steel casing around the column. A concrete facing is provided around the steel casings to improve the aesthetics of this retrofit scheme.
- Substructure Replacement
    - Replace all columns, foundations, bent caps, and railings
    - Provide seismic safety for the replaced components
    - Potential damage – local buckling of steel arches
    - Joint shear failure

The cost estimates for these two schemes is $226 and $382 million respectively having a remaining design life of 30 years. Replacement cost range from $315 to $402 million depended upon the alignment and bridge type selected. The replacement alternative would have a 75 year design life. Life cycle costs are lowest for the replacement alternative, as the retrofit scheme will require replacement within the next 30 years.

Question and Answer:
After the presentations were complete, Glen opened the floor for discussions. The following topics were discussed during the meeting:

Ken Bernstein: FHWA recommends Lithium treatment to mitigate ASR. Why not use this for this bridge? Ken understands that FHWA has said that this method has been successfully implemented.
Leo Ferroni: Caltrans has attempted lithium saturation, however the penetration of the lithium treatment is at best is few inches. In addition considering the presence of feldspar within the aggregate, the lithium will not be able to control the expansion. The bridge has active materials and would be difficult to control using Lithium to the depth needed. The application of Lithium has been proven effective only on small laboratory samples and not been applied to bridges such as the 6th Street bridge.
Kent Sasaki: The effectiveness of lithium is limited to certain types of members. We have very large elements, columns are 8′ x 9′ and foundations are larger. Need penetration of lithium deep enough into element to stop future damage, doesn't repair the damage, and just stops further cracking. It's mitigation, but not a permanent fix,
Steve Thoman: You have to keep injecting lithium because new cracks will continue develop because of the active ingredients still present within the structural members. If you keep injecting, new cracks will form and continue the need for injections. In 2007, FHWA published a report on the use of lithium. It can stop the potential reaction if initially used in the concrete mixture, but has been found to have limited used for existing structures having requiring deep penetration within existing concrete.

Mike Buhler: what is the role of the arches in the structure in the center span?
Steve Thoman: The bridge deck loads are transferred into transverse floor beams and then through the vertical members to the arches, the arches carry the loads to the piers and then down to foundation where the loads are transferred to the earth.

Mike Buhler: Has the ASR affected the integrity in the arches?
Steve Thoman: No, ASR only effect concrete materials and the arches are steel. It's fatigue life is unknown and approaching expected design life. If just one of the steel arches were to fracture (or be removed), the whole bridge could come down as the arch system is consider "facture critical". The steel is very ductile (flexible), but because it is imbedded in the concrete it is more rigid and could contribute to local buckling of the arch during a design earthquake event.
Mike Buhler: Is the weakening of the steel related to the ASR?
Steve Thoman: No, the ASR is a cancer solely of the concrete, not steel.

Eric Delony: Can the arches be used for the new bridge?
Steve Thoman: Not structurally, but architecturally/aesthetically yes.

Ken Bernstein: Any less visually intrusive method of retrofit? What about carbon fiber wraps for reinforcement?
Steve Thoman: Yes, we looked at carbon fiber, but the issue was that it would not have a long life. The heavy steel casing retrofit actively confines the column with the use of the steel post-tensioning bars, where as the carbon fiber can not provide an active confining force. It is applied like a wall paper, is much stronger than steel, but doesn't apply the needed active pressure. The concrete will expand with ASR and carbon fiber doesn't restrict movement. Need to prevent expansion.

Dan Weddell: Need confinement, carbon fiber is used for round columns and increases column size. It can be used for rectangular columns for shear strength, but is not effective in providing confinement that is need for the issues relating to the 6th Street Viaduct.

Ken Bernstein: Have there been collapses caused by ASR?
Steve Thoman: He didn't know of any. However, ASR is a gradual reaction where the distress signs can be observe prior to a sudden collapse. Therefore, the action can be taken to repair or replace before a collapse.

Mike Buhler: Appears bridge deck over the river has been constructed differently than the viaduct.
Dan Weddell: Yes, on main section over the river the concrete deck is supported by steel floor beams. Bridge area deck differs from viaduct portions the main span is an arch structural system, whereas the approach viaducts are concrete deck/girder structural systems.

Mike Buhler: Were cores taken from heavy steel girder area?
Kent Sasaki: No.

Glen Dake: Visual analysis more conservative than the cores?
Kent Sasaki: The bridge is more cracked on the interior. The visual inspection show less damage than the actual damage based on cores taken within the concrete members.

Glen Dake: Visual analysis correlates to the test findings?
Dan Weddell: Close enough

Glen Dake: Can electro chemical process halt the continuation of ASR?
Leo Ferroni: In theory yes, in practice very hard to implement. Fixes future issue, but what do you do with damage already done? To be successful would require full removal of the aggregate (impossible). Need to remove moisture (hypothetical).
Eric Delony: 10 major concrete and steel bridges along the Oregon Coast were impacted by chlorides (salts). ODOT replaced the Alsea Bridge which was similar to the 6th Street Bridge. Salt within the waterway (bay) reactions with the reinforcing steel causing rusting of the reinforcing steel and cracking of the surrounding concrete. A number of the bridges along the Oregon cost were retrofitted with electro-chemical processes to drive off chloride ions (salt) to save the concrete. However, this is not the cause of distress within the 6th Street Viaduct.
Wally Stokes: Merrill Butler's grandson has original drawings that imply the Alsea Bay Bridge was the model for the 6th Street Bridge.

Glen Dake: How do you prevent ASR in future new bridges?
Leo Ferroni: The concrete mix design requires certain ingredients to control the ASR impact on future bridges.

Steve Mikesell: Has ASR impacted other LA River bridges?
Leo Ferroni: In my experience there are approximately 350 bridges affected by ASR in CA. The Glen Annie Bridge in Santa Barbara was removed. Most bridges in Santa Barbara have some degree of ASR. No other bridges in the city appear to have the severe ASR damage.

Eric Delony: Why is 6th Street the worst?
John Koo: Because the aggregate came from the quarry in Lake Piru area (no longer being used) and the aggregate for the other bridges likely have come from other quarries.

Mark Spilo: Regarding coring, how did you choose locations for coring and how were you able to avoid the rebar?
Dan Weddell: The as-builts were referenced and coring was planned accordingly.
Kent Sasaki: We also had rebar monitoring and to help the team avoid rebar when coring. Rebar was hit occasionally, but avoided as much as possible.

Edgar Garcia: Was the main culprit of the ASR reaction the moisture from the LA River? Did the climate contribute to the moisture in the reaction?
Kent Sasaki: Many sources contributed, the river is a small portion of that, and the majority is at grade (i.e. Surface moisture, such as rain water). The asphalt overlay added trapped moisture in the deck combined with the humidity in the box was enough to cause reaction.

Eric Delony: Does everyone agree that it's the aggregate that has ASR? Testing shows this?
Kent Sasaki: Oh yes.

Mark Spilo Does the retrofit deal with ASR or only structural safety being addressed?
Steve Thoman: If only addressing improvements mandatory for life safety then the retrofit is a feasible option for a period of time (30 years estimated), if addressed totally, full replacement is necessary. Other concrete members such as the deck, deck girders and a number of columns and foundations are not retrofitted with the steel casing and would be more venerable to ASR and damage in an earthquake event.

Flora Chou: No attempt to slow and stop?
Steel Thoman: Steel casing for confinement (compression) and reinforced steel stitched through would still have ASR, but it can't kill the reaction.

Flora Chou: You're not going to try lithium?
Steve Thoman: Penetration is only for 1" according to FHWA. Our columns are too thick for the lithium to reach the ASR areas deep within the concrete members. A constant supply of lithium is needed, but that can't happen unless the lithium was to be applied on a regular basis which is not feasible.

Ken Bernstein: What are the safety hazards? What factors are there in determining a 30 year life? Does the steel need to be replaced? ASR eventually addressed? Or threat of collapse?
Dan Weddell: Reason for 30 year life, purely looking at collapse prevention, not addressing girder and deck. Non-critical to seismic if concrete keeps deteriorating, either start repairing deck and girders piece by piece. Still deteriorating superstructure.
Steve Thoman: With implementation of the seismic retrofit schemes, it is likely that the viaduct would have significant damage following a design earthquake and could be so severe that replacement would be required. It is also questionable that doweling of new reinforcing steel within existing concrete would be reliable to transfer earthquake loads.

Edgar Garcia: Are there experimental treatments being developed besides those discussed?
Kent Sasaki: Treatments being looked at are fibers to help restrain reactive aggregates in new concrete structures, lithium and penetration also, but no others to fix existing, just to mitigate for future damage.
Eric Delony: I've got literature on the mitigation measures, but there seems to be no "silver bullets" to address these problems in any part of the world.
Kent Sasaki: On small pieces can benefit from lithium. Limited moisture sealing spray and putting water proof in cracks is being used, but that doesn't fix the damage already done and even traps existing moisture.

Edgar Garcia: Has the ASR been present in the bridge since the bridge was built or recent?
Kent Sasaki: In 1950 cracks were documented (bridge built in 1932). Typically ASR takes 5-10 -15 years to develop. Not necessarily immediate.
Steve Thoman: The city had no way of knowing because the reaction was in the interior. The city could have never recognized it.
Eric Delony: A pylon was removed in 50's from severe cracking, may have been due to ASR.

Glen Dake: How is the federal government supporting (funding) this project? Good or bad?
Phil Richardson: Federal level funding 88%, seismic eligible, so state putting in additional share. We have financing.
John Koo: From the 1989 list of seismic retrofit for bridges, 10 bridges remain to be repaired and one that is labeled "potential to collapse under a major earthquake event." Prop 1B provides extra 12% funding.

Mike Buhler: All alternatives supported by funding?
John Koo: Yes at this time.

Mark Spilo: Can you reuse the aggregate for other uses.
Leo Ferroni: As long as for driveways or for non-structural purpose. Can use on shoulders and under concrete. Will only last 50 years, so ASR doesn't come up. Is water underneath pavement free of sodium? Don't know.
Eric Delony: (To audience) Does everyone have a basic understanding of ASR now? What is your impression of the impact of ASR on 6th Street?

Teresa Marquez: I've stopped driving over the bridge. I'm convinced of too much damage. Don't know if it will continue. So far damage is so great that we shouldn't take the chance. I went to the bridge and saw the damage. I'm learning and no matter what if it doesn't seem like we can save it, we might be able to save the architecture and redo it? We need to move on and replace it. Find funding. I wonder what the damage was from the last earthquake. One building in Boyle Heights was evacuated and labeled unsafe. I'm fully convinced of the ASR cancer. I see we can try to save it, but it will be unsuccessful. The damage is scary. Let's go forward. The numbers will tell us and the visuals tell us also. Don't see how we can hold on to the bridge.
Kent Sasaki: Out on the table there are concrete core samples for everyone to look at.
Jim Wu: The sample 1 on the end is good, so you can compare it to the ones from 6th Street.

ASR Workshop
Sign-in Sheet

City of Los Angeles Bureau of Engineering

The 6th St. Viaduct Improvement Project

Workshop on Alkali-Silica Reaction (ASR)

Caltrans Building August 27, 2008 1:30 pm-3:30pm

Name	Address	City & Zip	Phone	Email	Organization
Kelly Ewing Toledo	100 S. main	Los Angeles 90012	213-897-4095	kelly.ewing-toledo@dot.ca.gov	Caltrans
Claudia Harbert	100 S. Main	LA 90012	213.897.0115	claudia.harbert@dot.ca.gov	Caltrans
Carrie Chasteen	100 W. Walnut	Pasadena 91124	6264402461	carrie.chasteen@parsons.com	Parsons
Mike Buhler	523 W. SIXTH St. Suite 824	LA 90014		mbuhler@laconservancy.org	LA Conservancy
Flora Chou	"	"		fchou@laconservancy.org	LA Conservancy
Clark Robins	1149 So. Broadway LA 90014		213 485 4915	Clark.Robins@LACity.Org	LA Public Works Bur of Engineering

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Name	Address	City & Zip	Phone	Email	Organization
Kelly Ewing Toledo	100 S. Main	Los Angeles 90012	213-897-4095	kelly.ewing-toledo@dot.ca.gov	Caltrans
Claudia Harbert	100 S. Main	LA 90012	213.897.0115	claudia.harbert@dot.ca.gov	Caltrans
Carrie Chasteen	100 W. Walnut	Pasadena 91124	6264402461	carrie.chasteen@parsons.com	Parsons
Mike Buhler	523 W. Sixth St. Suite 826	LA 90014		mbuhler@laconservancy.org	LA Conservancy
Flora Chou	"	"		fchou@laconservancy.org	LA Conservancy
Clark Robins	1149 So. Broadway LA 90014		213 485 4915	Clark.Robins@LACity.Org	LA Public Works Bur of Engineering

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Name	Address	City & Zip	Phone	Email	Organization
Jim Bickley	585 S. Santa Fe	Los Angeles 90013	213-657-8[illegible]	Jim@Spine.com	Spini
Marc Spino	"	"	"		"
BEARJ SARKIS	100 S. main St. LA 90012	L.A. CA 90012	213 9289669	bearj.sarkis@lacity.org	LADOT
Edgar Garcia	200 N. Spring st Rm. 620	LA CA 90012	213-978-1189	edgar.garcia@lacity.org	Office of Historic Resources
Andrew Goodrich	200 N Spring St Rm 620	Los Angeles, 90012		agoodric@ucsd.edu	Office of Historic Resources
Domingo Leon E	3605 Long Beach ave 235	LB 90807	562 9894500	dleon.engineers@verizon.net	Engineers.
QATHRYN BREHM	725 S. Crocker St	LA 90021	213-228-8484 x203	qbrehm@centralcityeast.org	CCEA

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Name	Address	City & Zip	Phone	Email	Organization
Kent Sasaki	2200 Powell St., Ste 925	Emeryville CA 94608	(510) 428 2907	ksasaki@wje.com	WJE
Phil Richardson	221 N Fig Ste 350	LA 90012	213 202 5579	Phil.Richardson@lacity.org	City of LA
Gary Lee Moore	1149 S. Broadway Ste 700	LA 90015	213 485-4935		City of LA
Steve Thomson	1544 Eureka Roseville, CA	Roseville 95661	916 760 5118	sjt@deainc.com	DEA
JOHN KOO	221 N Figueroa St #350	LA 90012	(213) 202.5591	JOHN.KOO@LACITY.ORG	PUBLIC WORKS BUREAU OF ENGR
Dan Weddell	600 the City Drive South #210 Orange, CA 92868	Orange 92868	714 750 7275	dweddell@pbsj.com	PBS&J
Mike Buhler	523 W. 6th St., #826 LA, CA 90014		213/430-4203	mbuhler@laconservancy.org	LA Conservancy

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Name	Address	City & Zip	Phone	Email	Organization
ERIC DELONY	21 CAGUA ROAD	SANTA FE, NM 87508	(505) 466-1448	PONTIST@COMCAST.NET	CH2M-HILL
Stephen Mikesell	1416 9th St.	Sacramento CA 95814	916 653-7113	SMikesell@parks.ca.gov	OHP
Jim Wu	221 N. Figueroa St. Suite 350 LA CA 90012	L.A. 90012	213 202 5595	jim.wu@lacity.org	City of L.A Bureau of Engineering
DONALD MACDONALD	1516 FOLSOM SAN FRANCISCO 94103	←	415 626-9100	dmd@dmdarch.com	MACDONALD ARCHITECTS
LEO Ferroni	POB 76 Sprague RV. OR 97639		541-533-2466	LRFERRY@WMConnect.Com	Consultant CH2M Hill
Ken Bernstein	200 N. Spring St #620	Los Angeles, CA 90012	213 978-0195	ken.bernstein@lacity.org	Office of Hist. Resources

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Name	Address	City & Zip	Phone	Email	Organization
Danielle Elkins	1000 Wilshire Blvd. 21st Floor	LA, CA 90017	213.228.8262	danielle.elkins@ch2m.com	CH2M Hill
Javad Rahimzadeh	100 S. Main Suite 100 LA, CA 90012	LA 90012	213 897-6846	javad_rahimzadeh@dot.ca.gov	CT
David Lewis	100 S Main	LA 90012	213-897-2860	david.lewis@dot.ca.gov	Caltrans
Teresa Marquez	3122 E. 3RD ST L.A. CA 90063	LA 90063	(323) 267-1687	TMARQ3711@AOL.com	BHR Home owners ASSN.
Wally Stokes			213) 202-5580	wally.stokes@lacity.org	LA BoE

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Name	Address	City & Zip	Phone	Email	Organization
NOAH M. STEWART	100 S MAIN ST	LA 90012	213) 897-2601	noah.stewart@dot.ca.gov	CALTRANS
BRETT JONES	18004 SKY PARK CIR., #200	IRINE, CA	714.402.0511	bej@deainc.com	DEA
Yoga Chandran	3 HUTTON CENTRE DR. #200	SANTA ANA	714-435-6111	cyoga.ch@ch2m.com	CH2M HILL
JING JAW	221 N. Figueroa #350	LA 90012	213-202-5588	JING.JAW@LACITY.ORG	CLA BOE
WALT QUESADA	3780 KILROY AIRPORT WAY LONG BEACH	LB 90830	562 426-9551	WQUESADA@MOFFATTNICHOL.COM	MOFFATT & NICHOL
DOMINGO LEON	3605 Long Beach Blvd - 235	LB 90807	562 989 4500	dleon.engineering@verizon.net	D'Leon Consulting Engs
Anne Kochaon	100 W. Walnut St, Pasadena, CA	CA 91076	626-440 6055	anne.kochaon@parsons.com	Parsons.