

BAY BRIDGE ANCHOR RODS

That Fasten Shear Keys S1 & S2 to Pier E2



THE MESS:

- Grade BD steel is installed & cannot be economically replaced

THE ROAD TO THE MESS:

- Wrong metallurgical DECISIONS: Grade BD instead of BC
- Wrong metallurgical ANALYSIS: Hydrogen from corrosion, not manufacture

THE DRIVER TO THE MESS:

- No metallurgical engineering expertise on SAS project

Report on the A354 Grade BD High-Strength Steel Rods on the New East Span of the San Francisco-Oakland Bay Bridge With Findings and Decisions

July 8, 2013



“METALLURGICAL” ENGINEERING JUDGEMENTS

ASTM A354

Grade BC and BD Alloy Steel Threaded Fasteners

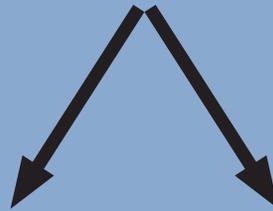
- Caltrans chose high-strength Grade BD steel rather than the more suitable Grade BC
- A354 explicitly warns of the risk of HE to hot-dip galvanized Grade BD bolts.¹
- A354 generically assigns Grade BD a hardness range of 31 to 39 HRC
- Knowing the risk of HE with high hardness, Caltrans engineers failed to restrict hardness to a safer number even though A354 gives room for it

THE KEY QUESTION:

“WHY DID ALL RODS BREAK IN BOTTOM THREADS”?

WAS NOT EXPLAINED BY FAILURE ANALYSIS TEAM

HYDROGEN EMBRITTLEMENT



MANUFACTURING:

PICKLING & HOT DIP GALVANIZING



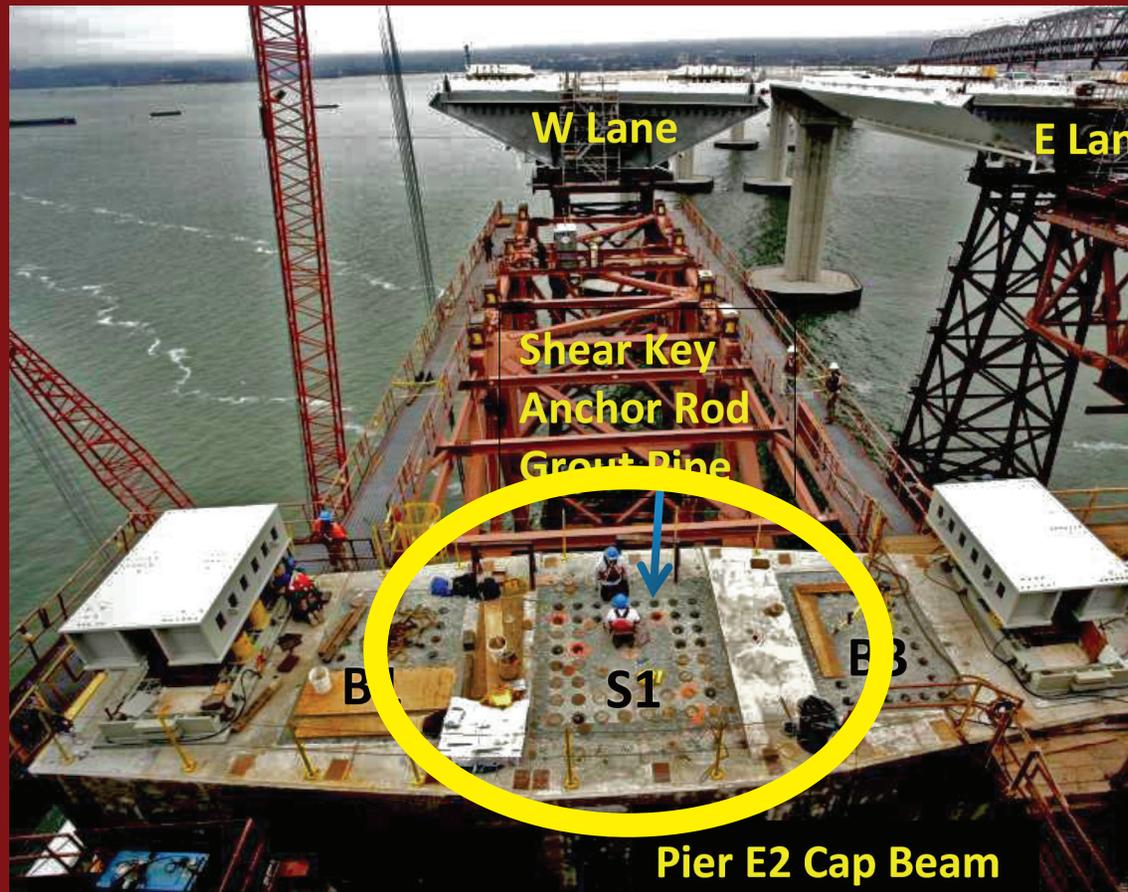
TBPOC CONCLUSION

CORROSION IN SERVICE:

5 YEAR STINT IN MARINE WATER



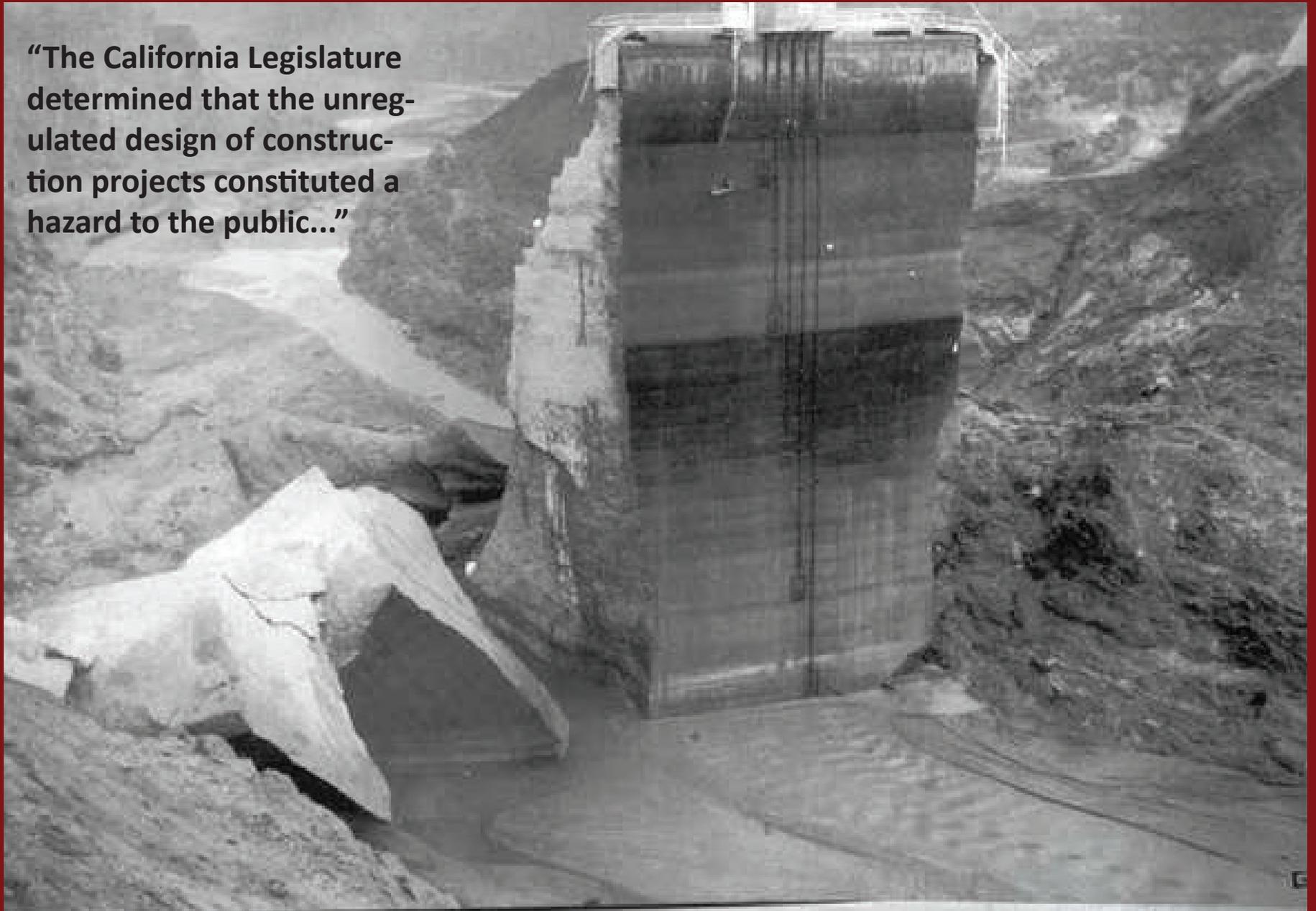
ACTUAL CAUSE



- ANCHOR RODS CORRODED BY INTRUSION OF WATER INTO OPEN GROUT PIPES
- HYDROGEN ATOMS FROM CORROSION OF ZINC LAYER DIFFUSED INTO THE STEEL

BOARD FOR PROFESSIONAL ENGINEERS, LAND SURVEYORS, AND GEOLOGISTS

“The California Legislature determined that the unregulated design of construction projects constituted a hazard to the public...”



St. Francis dam