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Introduction to the Golden Gate Bridge Retrofit Project

Introduction au projet de consolidation du pont de Golden Gate

Einführung in das Ertüchtigungsprogramm für die Golden-Gate-Brücke

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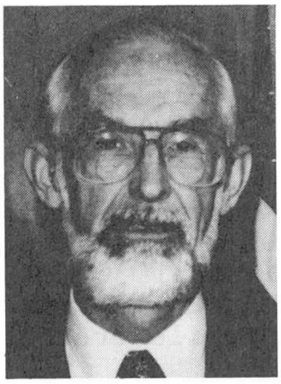

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SUMMARY

The Golden Gate Bridge and Highway District was formed in 1928 to design, construct and finance the bridge, which was opened to traffic in 1937. Today, tolls fund the operation and maintenance of the bridge and also subsidise a bus and ferry transportation system from the northern counties to San Francisco. Over 100'000 vehicles cross the bridge daily. After the Loma Prieta earthquake in 1989, the ongoing comprehensive maintenance program was completed with state-of-the-art seismic evaluation of the bridge. The retrofit project is well advanced and many measures are ready to be undertaken.

RÉSUMÉ

L'autorité du "Golden Gate Bridge and Highway District" a été créée en 1928 afin de concevoir, réaliser et financer la construction du pont, lequel a été ouvert au trafic en 1937. Actuellement, le péage permet de financer l'exploitation et l'entretien du pont, et subsidie également un système de transport par autocar et bateau entre les comtés du nord et San Francisco. Plus de 100'000 véhicules traversent le pont chaque jour. A la suite du tremblement de terre de Loma Prieta en 1989, le programme, global et continu, de maintenance a été complété par une évaluation parasismique détaillée du pont. Le projet de consolidation est en bonne voie et de nombreuses mesures vont être entreprises bientôt.

ZUSAMMENFASSUNG

Der "Golden Gate Bridge and Highway District" wurde 1928 für den Entwurf, den Bau und die Finanzierung der Brücke gegründet, die 1937 dem Verkehr übergeben wurde. Heutzutage finanzieren Brückenzölle den Betrieb und Unterhalt der Brücke und subventionieren einen Bus- und Fährebetrieb davon den Nordbezirken in die Stadt. Ueber 100.000 Fahrzeuge benutzen die Brücke täglich. Nach dem Loma Prieta Erdbeben 1989 wurde das laufende umfangreiche Unterhaltsprogramm mit einer Erdbebenbeurteilung nach dem heutigen Stand der Technik abgeschlossen. Das Ertüchtigungsprojekt ist weit fortgeschritten, und etliche Massnahmen sind vorbereitet.

On behalf of the Golden Gate Bridge, Highway and Transportation District, I am pleased and honored to introduce this session of the 1995 IABSE Symposium, "The Seismic Retrofit of the Golden Gate Bridge." The Bridge District has completed some extraordinary work in the field of seismic retrofit engineering: groundbreaking work that has laid the foundation for similar retrofit projects worldwide. This symposium is the first opportunity we have had to share our findings in detail with the international community. But first, I want to briefly outline the history of the Bridge and the District that runs it, and give some background on the seismic retrofit project to date.

On December 4, 1928, the Golden Gate Bridge and Highway District was formed to design, construct and finance the Bridge. The District consists of San Francisco County and five counties to the north. Voters within the District put up their homes, their farms and their business properties as collateral for a $35 million bond issue to finance the Bridge. After four years of construction, it was completed and opened to automobile traffic on May 28, 1937.

For 58 years, the District has successfully fulfilled its primary mission of maintaining and operating the Golden Gate Bridge. In 1971, the last of the construction bonds were retired. The bonds were financed entirely by tolls. Today, Bridge tolls completely fund the operation and maintenance of the Bridge.

But tolls support more than the Bridge itself. They also subsidize a bus and ferry transportation system from the northern counties to San Francisco.

Due to increasing traffic congestion, the California State Legislature, in 1969, authorized the District to develop a mass transportation system in the Golden Gate Corridor consisting of buses and ferries. The legislative mandate was clear: Reduce traffic congestion. However, the District was not given the authority to levy taxes to support transit. All intercounty service had to be subsidized by Bridge tolls.

Traffic growth in the Golden Gate Corridor has been held to a manageable level. Before Golden Gate Transit, approximately 30,000 people in 20,000 vehicles crossed the Bridge during each morning commute. Today, 38,000 people commute to San Francisco each morning while vehicle traffic had grown to only 22,000. In total, over 40 million vehicles crossed the span last year.

And with so many people depending upon the structure, its failure during a seismic event would deal a devastating blow to the region. As you know, in 1989, the Loma Prieta Earthquake caused severe damage to many structures in the Bay Area. The Richter magnitude 7.1 quake caused no significant damage to the Golden Gate Bridge, however, thanks to earlier seismic upgrade work in 1982 and an ongoing, comprehensive maintenance program.

For the Bridge District, however, the Loma Prieta was a call to action. Right after the quake, the District contracted for a state-of-the-art seismic evaluation of the Bridge by T.Y. Lin International of San Francisco. The firm reported that, although the Bridge had performed well in previous quakes, it is vulnerable to damage in a Richter magnitude 7 or greater with a nearby epicenter and could be closed for an extensive period of time after such an earthquake.

The Loma Prieta occurred over sixty miles south of the Golden Gate Bridge. Ground movement during that event brought the Bridge near its current earthquake design limits. If an earthquake the size of Loma Prieta occurred on the San Andreas or Hayward faults, 7 miles west and 10 miles east of the Bridge respectively, the results could be catastrophic.

As the District conducted its initial seismic evaluation, the California Governor's Board of Inquiry on the Loma Prieta Earthquake issued a 1990 report directing all important transportation structures in the state to be seismically retrofit to assure their function following a major earthquake. Accordingly the District, in concert with leading seismologists and seismic engineers, recommended a retrofit on the Golden Gate Bridge.

Since then, the Bridge District has completed geotechnical studies, preliminary environmental assessments and preliminary design concepts. The District spent over $2.3 million to ensure that all necessary, preliminary work was complete to provide the foundation for the final design.

In January 1993, the final design phase for the seismic retrofit began. Final design was placed on a fast track and conducted by two engineering firms simultaneously, Sverdrup Corporation, from Walnut Creek, California, and T.Y. Lin International/Imbsen & Associates, a Joint Venture from San Francisco. The final design phase is nearing completion and construction could begin as early as September 1995.

Just as Joseph Strauss found a challenge in funding the original Bridge construction, so it is with seismic strengthening. In 1991, understanding the regional and economic significance of a retrofit, the District developed a funding strategy to generate local match revenues for the project. The strategy called for a 50 percent increase in bridge tolls and adjustments to bus and ferry fares. These increases have already been implemented.

To date, bridge tolls have funded over $7.4 million of the seismic design effort. A federal grant financed an additional $5.9 million under the Intermodal Surface Transportation Efficiency Act of 1991, or ISTEA.

Further, between 1991 and 1996, Bridge tolls will generate a 20 percent local match for the estimated $165 to $175 million construction cost. The earthquake retrofit expense is significant, but represents only one-tenth of the replacement cost of the bridge, estimated to be over $1.4 billion.

As of this writing, the District is actively seeking federal funding. The District has generated the 20 percent local match for this project.

The Golden Gate Bridge itself is made up of seven distinct structures. The retrofit project includes both tuning the structures to reduce the violent actions caused by ground motion, and strengthening the structures to reduce the damage caused by these actions.

For example, starting from the San Francisco end, the approach foundations will be strengthened and the towers of the approach will be replaced altogether. Also, each of the separate spans of the approach will be connected so they move together during an earthquake rather than moving separately and potentially collapsing. Seismic motion isolators and dampers, or shock absorbers, are also being applied to this structure in innovative new ways. Vulnerability studies show the north and south approaches are most vulnerable to failure in an earthquake.

Other notable retrofit measures include the reinforcement of the Fort Point Arch. Advanced, computer-assisted modeling has shown that during a seismic event, the arch could actually jump off its support bearing at the base of the structure. Rather than securing the arch at the base, we've learned to let the arch move during an earthquake but control the movement so that when it does lift up, it will be guided back down into its proper place. Also, each of these pylons, equal in height to a 20-story building, will be strengthened.

Modeling has also shown that during a quake, the main span can act as a battering ram, slamming against each tower. As a result, connections between the towers and the roadway will be reinforced and dampers, or shock absorbers, will be installed. Also the tower legs, which have shown the potential to buckle, will be reinforced internally.

These are just a few of the many measures we are ready to undertake, and some of what will be covered in the following symposium. Even though most work will occur where motorists and visitors will not see, the District has gone to great lengths to preserve the existing, historical appearance of the structure. The retrofit is designed not to change the appearance of the Golden Gate Bridge.

As a result of our efforts, the Golden Gate Bridge, Highway and Transportation District has become what many consider an international leader in the seismic retrofit design field, applying state-of-the-art techniques to surpass any retrofit efforts to date. The District's design work and advanced seismic technology will assist similar seismic retrofit projects around the world.