**Tacoma Narrows Bridge**

**1940 - Tacoma, Washington - 1950**

The Washington Toll Bridge Authority built the 5,000-foot, 314 million Tacoma Narrows Bridge in 1950 to replace a previous structure, designed by the respected engineer Leon S. Moisseiff, that collapsed in 1940 from aerodynamic instability. Like its predecessor, it was the world's third longest suspension bridge, behind only the Golden Gate and the George Washington bridge for length of suspended span. But unlike its predecessor, the second Tacoma Narrows Bridge was built with several features that made it unaffected by wind forces. It marked a new beginning for the structural engineering field in the type of construction.

Bethlehem Pacific Coast Steel Corporation was the general contractor. John A. Roebling's Sons Co. supplied the cable work.

University of Washington structural engineers directed by F. B. Fairclough attempted to understand the first structure's flaws through wind tunnel testing of dynamic scale models. They pioneered the field of bridge aerodynamics with the fruits of their research resulting in the design of the second Tacoma Narrows Bridge and other bridges that followed.

Charles E. Andrew and Dexter R. Smith, principal design engineers, incorporated many elements in the new bridge directed at preventing the dangerous twisting and galloping motions that destroyed its predecessor. These included deep open deck trusses, rather than shallow plate girders, that insured greater structural rigidity and, when combined with deck grating between traffic lanes, less wind resistance. A larger roadway width-to-span length increased twisting resistance, and reliable damping mechanisms prevented the indefinite progressive increase in aerodynamic oscillation magnitude seen in the earlier bridge.

**Location Map**

*Scale: 1" = 3000', 1/36,000*

**Detail**

**Hold Down Ropes at Tower No. 3 - 1940 Bridge**

Scale: 3/8" = 1'-0", 1:32

**Hold Down Cables at Tower No. 3 - 1950 Bridge**

Scale: 3/8" = 1'-0", 1:32
The Tacoma Narrows Bridge collapsed on 7 November 1940 during a gale between 35 to 42 miles per hour, with a wind pressure of only five pounds per square foot. The steady wind's effects on the structure produced a fluctuating resultant force that synchronized in timing and direction with the bridge's natural harmonic motions (figs. 1A, 2, 3, 4), progressively amplifying them to destructive levels. Both vertical and torsional oscillations contributed to the failure of the bridge. The bridge's inherent weakness and susceptibility to these winds lay in its shallow stiffening girders and its narrow roadway.

Theodore von Karman, who had pioneered wind tunnel analysis at the California Institute of Technology, argued that the bridge deck's aerodynamic shape was a more important factor in its failure than its lightness and flexibility. Von Karman suspected that the bridge had experienced vortex shedding, a condition where objects like airplane wings or bridge decks displace air flowing around them and form eddies or vortices, which may induce vibration in the object (figs 5A, 6). He believed that wind flowing over the bridge's solid girder side plates created shedding that when combined with the flutter and resonance already present in the deck produced the violent oscillations that caused the catastrophic failure (figs. 5A, 6).

Designing the replacement bridge's deck stiffening system involved subjecting dynamic scale models to wind tunnel testing to better understand wind effects on them.

Designers for the 1950 bridge were not satisfied with their ability to eliminate torsional and vertical movements in their proposed structure. They hoped to enhance their design's natural damping ability with mechanical devices. One of these was a double-lateral bracing system in the stiffening truss. It increased torsional frequency motion and torsional stiffness.

The towers of the 1940 bridge accommodated a two-lane road deck. Tower legs for the 1950 bridge were designed for a four-lane road deck. Wider piers were erected for the new tower legs. They were also lengthened 16 feet to raise the tower steel above the Narrows' corrosive salt water.