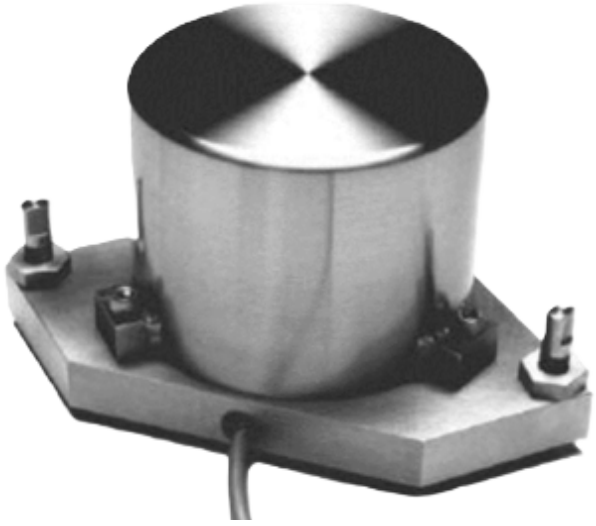
Jewell Instruments

Monitoring Ground Movement And Deflection For The Golden Gate Bridge

- **Objectives:** Measure ground movement and deflection
- **Solution:** Jewell Instruments **Model 702**
- **Benefits:** Extreme precision and durability
- **Results:** Reliable measurements of structural health

Overview

Even with incredible design to address many of the risks and difficulties the bridge faces daily, the Golden Gate Bridge utilizes a total of 122 structural and seismic sensors - including accelerometers, relative displacement meters, and high-precision tiltmeters - managed alongside wireless sensor networks to monitor real-time vibrations, seismic activity, and pier movements.



Jewell Instruments Model 702

Background

The Golden Gate Bridge is a suspension bridge spanning the Golden Gate, the one-mile-wide (1.6 km) strait connecting San Francisco Bay and the Pacific Ocean in California, United States. The structure links San Francisco - the northern tip of the San Francisco Peninsula - to Marin County, carrying both U.S. Route 101 and California State Route 1 across the strait. The Golden Gate Bridge also has lanes to carry both pedestrian and bicycle traffic and is designated as part of U.S. Bicycle Route 95. This marvelous structure is recognized by the American Society of Civil Engineers as one of the Wonders of the Modern World, and the bridge has become one of the most internationally recognized symbols of San Francisco and California.

The idea of a fixed link between San Francisco and Marin had gained increasing popularity during the late 19th century, but it was not until the early 20th century that such a link became feasible. Joseph Strauss served as chief engineer for the project, with Leon Moisseiff, Irving Morrow and Charles Ellis making significant contributions to its design. The bridge opened to the public on May 27, 1937 and has undergone various retrofits and other improvement projects in the decades since.

Phone : +1 (603) 669-6400

Email : info@jewellinstruments.com

Web : jewellinstruments.com

The Golden Gate Bridge is described in Frommer's travel guide as "possibly the most beautiful, certainly the most photographed, bridge in the world". At the time of its opening in 1937, it was both the longest and the tallest suspension bridge in the world, titles it held until it was overtaken by the 1964 Verrazzano–Narrows Bridge and the 1998 Akashi Kaikyo Bridge, respectively. Its main span is 4,200 feet (1,280 m) and its total height is 746 feet (227 m). Each year the Golden Gate Bridge attracts more than 10 million visitors to take in its tremendous 746-foot tall towers, sweeping main cables, signature International Orange color and Art Deco styling. It is a sensory experience featuring color, light and sound.

The bridge faces severe natural and structural hurdles, including violent ocean tides, hurricane-force winds, a location just seven miles from the San Andreas Fault, and continuous exposure to corrosive salt air. The bridge spans over a mile-wide strait with cold, 400-foot-deep waters and fierce, dangerous ocean currents. In addition, unpredictable gales and heavy windstorms cause the massive suspension span to flex, twist, and ripple. Its position is directly in a seismic zone near major fault lines with changing soil settlement, threatening the rigidity of the towers and foundation, Lastly, frequent heavy fog and salt air accelerate rust and structural decay, requiring constant maintenance.

Project

The Golden Gate Bridge was built with a basic structural design; however, the engineers that designed the bridge introduced "deflection theory" by which a thin, flexible roadway would flex in the wind, greatly reducing stress by transmitting forces via suspension cables to the bridge towers.

The Golden Gate Bridge gets its remarkable strength from a balance of massive steel suspension cables, rigid deck trusses, and deep-set concrete anchorages that work together as a dynamic equilibrium. There are two primary cables that run across the top of the towers. Each cable contains 27,572 individual galvanized steel wires tightly bundled together to resist immense downward and outward pulling forces. The legs of the bridge are Honeycomb Tower Legs which provide high load-bearing capacity while remaining flexible enough to handle strong winds and earthquakes. The roadway is supported by deck trusses that use interlocking triangles—an inherently stiff and strong geometric shape—to distribute the weight of cars and traffic. The main suspension cables are locked into massive concrete anchorages on both shores, securely fastening the entire tensile network to the ground. Finally, the Golden Gate Bridge was designed using early deflection theory, the structure can flex safely during heavy winds or extreme traffic loads without transferring destructive stress to the rigid core.

Amongst other sensors of various types, The Golden Gate Bridge utilizes three of Jewell Instruments model 702 submersible stainless steel high precision tiltmeters. The model 702 is a Platform mount tiltmeter designed for extremely high precision tilt measurements. The model 702 delivers ultra-high sensitivity to <25 nrads (<-.00000143 degrees) with nearly zero long-term drift. Output is a stable ±8 DC voltage (±16 VDC differential). Rugged, reliable, and extremely accurate, the model 702 is the preferred choice high-precision geotechnical engineering, measuring extremely small changes in ground movement and bridge deflection - ideal for this application.

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