How it Works: Engineering Bridges to Handle Stress

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Bridges are generally thought of as static structures. The truth is that they actually act more like dynamic, living beings. They constantly change, responding to different loads, weather patterns, and other types of stress in order to function. In some cases, much like a person undergoing a trauma, bridges must "react" to extremely stressful events like accidents, explosions, fires, earthquakes, and hurricanes in order to survive.

In this article, we'll look at how different types of bridges are engineered to handle stress. We'll also examine some of the most common forces that put stress on bridges. These stressors can have a big impact on how bridges age, fall into decline, and potentially fail.

Understanding them can help engineers develop durable structures and inspectors and maintenance personnel make existing structures last longer.

The gravity dilemma

The most profound force affecting bridges is gravity, which is constantly pulling at them, trying to drag them down to earth. Gravity isn't such a big deal when it comes to buildings, including large ones like skyscrapers, because the ground below them is always pushing back.

That's not the case when it comes to bridges. Their decking spans open space. "Space" provides no support against gravity. Bigger bridges that span longer spaces are more vulnerable to gravity than shorter ones. Similarly, heavier structures are more likely to fall victim to gravity than lighter ones.

Bridge failures are a relatively rare occurrence. So, what is it that keeps them from tumbling down due to the force of gravity?

The answer is pretty much the same no matter the type of structure:

- Compression (a force that pushes or squeezes inward) is carefully balanced with tension (a force that stretches and pulls outward).

- This balancing happens by channeling the load (the total weight of the bridge structure) onto the abutments (the supports at either end of the bridge) and piers (the supports that run under the bridge along its length).

These forces are distributed in a variety of ways on different types of bridges:

Beam Bridge

A beam bridge has its deck (beam) in tension and compression. (The beam can be squeezed and stretched depending on conditions.) The abutments are in compression, which means they are always being squeezed.

Arch Bridge

An arch bridge supports loads by distributing compression across and down the arch. The structure is always pushing in on itself.

Suspension Bridge

The towers (piers) of a suspension bridge are in compression and the deck hangs from cables that are in tension. The deck itself is in both tension <u>and</u> compression.

Cable-stayed bridge

A cable-stayed bridge is similar to a suspension bridge. However, the deck hangs directly from the piers on cables. The piers are in compression and the cables are in tension. The deck experiences both forces.

Truss bridge

A truss bridge is a variation of a beam structure with enhanced reinforcements. The deck is in tension. The trusses handle both tension and comprehension, with the diagonal ones in tension and the vertical ones in compression.

Cantilever bridge

A cantilever bridge is one of the simpler forms to understand. Basically, it addresses the forces of tension (pulling) above the bridge deck and those of compression (pushing) below.