Building Bridges

When bridges need to stand up to high winds, heavy loads and salty air, castings span the gap.

Shannon Kruse, *Senior Editor*

Image by Patty Godslave, Dreamstime.com

THE NIGHT'S ALRIGHT ***Construction on the new Tacoma Narrows Bridge in Tacoma, Wash., continues into the night.***

Before the opening credits to the Academy Award-winning movie Crash appear, the logo for Vancouver-based Lionsgate Films flashes on the screen. Most moviegoers don't give it another glance, but for Tom Sherlock, technical sales, Highland Foundry, Surrey, B.C., Canada, the name triggers thoughts of a bridge. The landmark Lions Gate Bridge, namesake for the film company, is an icon for the Vancouver region, an image that for many identifies the town like the Gateway Arch identifies St. Louis.

Huge bridges like Lions Gate and the Golden Gate in San Francisco, have a majestic, skyline-changing quality that makes for great pictures and easy identification. Participating in projects involving structures, whether on a grand, lion-sized bridge or a humble puddle-jumper, gives metalcasters the unique opportunity to change the landscape.

"We do not do many bridge castings," Sherlock said, "But Lion's Gate Bridge is the signature bridge of Vancouver."

Sherlock and Highland Foundry participated in upgrading the bridge by casting huge steel parts critical in supplying strength in an earthquake zone. It was one of several bridge projects that metalcasting facilities participate in throughout North America.

Tacoma Narrows

Atlas Castings & Technology, Tacoma, Wash., doesn't normally produce castings for bridges, but a few years ago the steel caster found itself in the midst of an $849 million project for one of the most notorious bridge locations–a strip of the Puget Sound in Tacoma called the Tacoma Narrows. Well-known in engineering

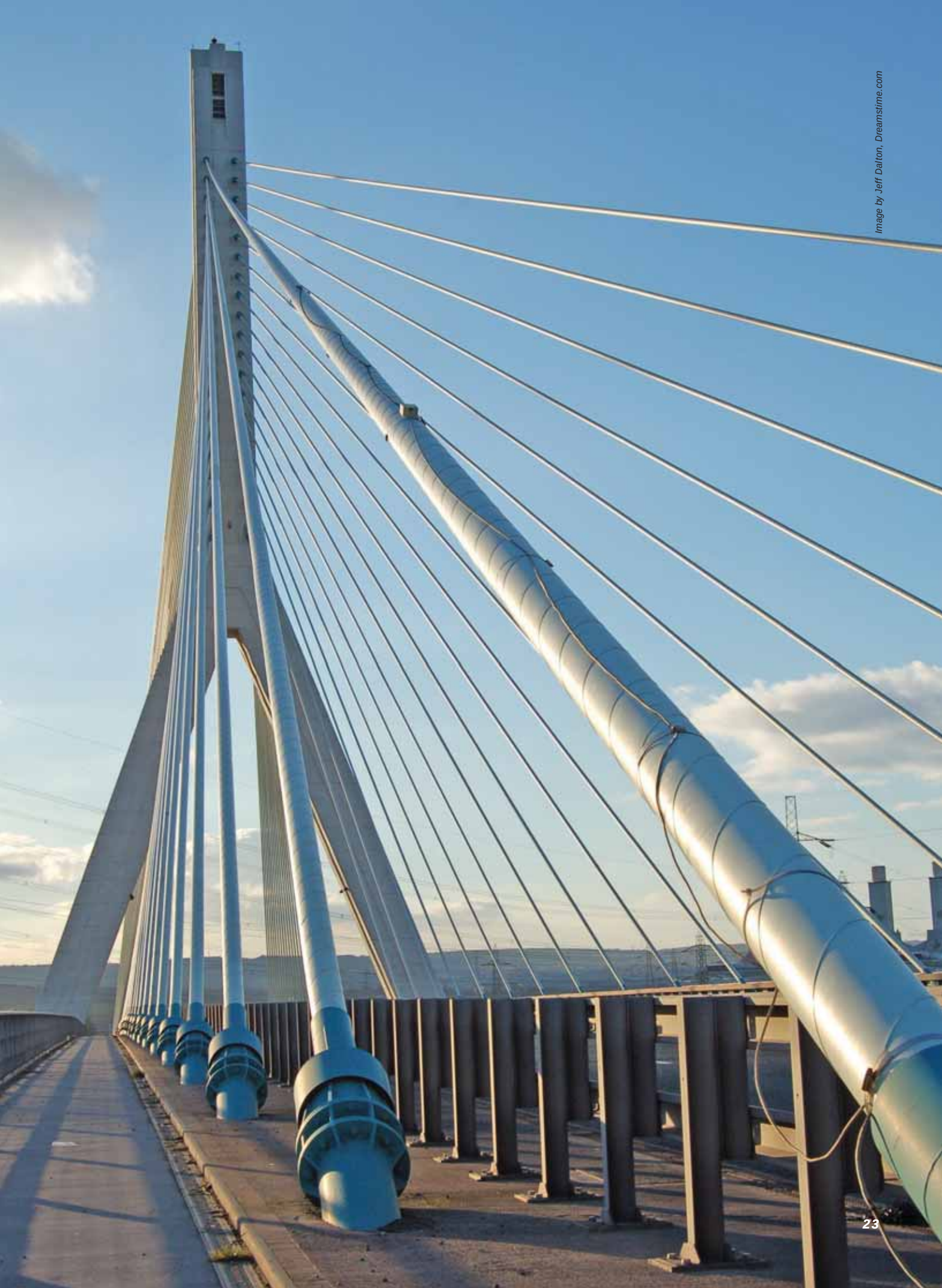


Image by Jeff Dalton, Dreamstime.com

Condition of U.S. Highway Bridges in 2004

Total Bridges
593,813

Urban Bridges
137,598

Rural Bridges
456,215

Total Deficient Bridges
158,319

Deficient Urban Bridges
42,473

Deficient Rural Bridges
115,846

circles for its first bridge, Galloping Gertie, the Tacoma Narrows needed a new bridge following the collapse of the first one. The redesigned bridge, sometimes referred to as Sturdy Gertie, has been in use since the 1950s without a scare, but Tacoma Narrows wasn't finished with its bridge challenges.

When Sturdy Gertie was built in 1950, it was designed to handle 60,000 vehicles a day. By 2005, 90,000 vehicles traveled the bridge daily, and an estimated 120,000 cars would be making the trip by 2020. More lanes were needed to help with the increasing traffic. Washington State Dept. of Transportation decided to build another bridge parallel to the existing one.

The 5,400-ft. suspension bridge relied on steel cables to carry the weight of the bridge deck. Each cable had 19 steel bundles, and each bundle consisted of 464 wires. Castings were required at the top of the suspension towers to transfer the bridge's weight down through the towers and at the location of the anchors at the end of the bridge to spread and wrap the cables at the back of each anchor.

"In the process of building the suspension bridge, when they are stringing cables back and forth, they are actually putting a lot of tension in them so that the towers are bending toward the banks," said David Caldwell, vice president of sales. "So, as the heavy bridge sections are added, the towers straighten back up."

Although Atlas generally builds pressure-vessel castings for the oil and power generation industries, it knew it had the qualifications to cast the parts. Plus, the bridge was just down the road. The casting company put in a bid for

SADDLE UP ***The 20-ton splay saddle, used on the new Tacoma Narrows bridge, was produced using a nickel-chromium-molybdenum steel alloy.***

Image provided by Dreamstime.com

TEST FOR STRENGTH ***Castings for bridges must exhibit high strength and corrosion resistance. Customers often require a high level of testing and inspection be performed at the casting site.***

the unique opportunity.

"We were selected partly for location and partly for the size castings we are capable of producing," said David Caldwell, vice president of sales. "Bridge castings can be quite large. Some we've cast were in the 40,000-lb. category."

Bridge castings require high strength and specifications, so Atlas' experience with pressure-vessel castings gave it an edge in meeting the customer's needs. Atlas Casting and Technology is a high specification jobbing metalcasting facility employing more than 650 people at two site, a machine shop and a casting import business.

"One of our advantages was that we had the ability to handle the value-added aspects of the project that were required," Caldwell said. "We provided machining, assembly and testing."

Besides the high strength required from the 90-60 grade steel, the customer wanted Atlas to provide the finished product to the job site. So Alas was responsible for delivering the assembled and painted components to the job site for direct installation on the bridge.

"Our customer required a witness to be present for a fit up test of the completed assembly at the facility prior to us shipping it to the jobsite," Caldwell said. "We also had to provide as-built drawings, which included callouts and changes made to the part, and prove the castability of the component before starting the project. All this had to be approved by the engineers."

Additionally, Atlas performed magnetic particle inspection, ultrasonic inspection, detailed dimensional inspection, and Charpy impact tests on the components. With a tower height of 510 ft. and a structural steel weight of 49.7 million lbs. (excluding the towers), the tight specifications for the castings are no surprise.

Hood Canal

Although casting bridge components is not the norm for Atlas, it participated in another bridge project, also in Washington. The Hood Canal Bridge connects the Olympic Peninsula and the Kitsap Peninsula across the Hood Canal. At 7,869 ft, it's the longest floating bridge in the world over a saltwater tidal basin and the third longest floating bridge overall.

Built in 1961, the bridge has been standing for more than four decades with the help of repairs and new construction. In a recent repair project, Atlas Casting and Technology provided the replacement roller assembly components for retrofitting the retractable section of the floating bridge.

There are four castings in each roller

SAFE-TEA for the Bridge Industry

Replacement and new construction work similar to the Hood Canal, Lion's Gate and Tacoma Narrows bridges may see a rise in the coming years in the U.S. The newly-passed Safe, Accountable, Flexible, Efficient Transportation Equity Act-A Legacy for Users (SAFETEA-LU) bill pledged $25.6 billion over six years to the federal highway bridge program.

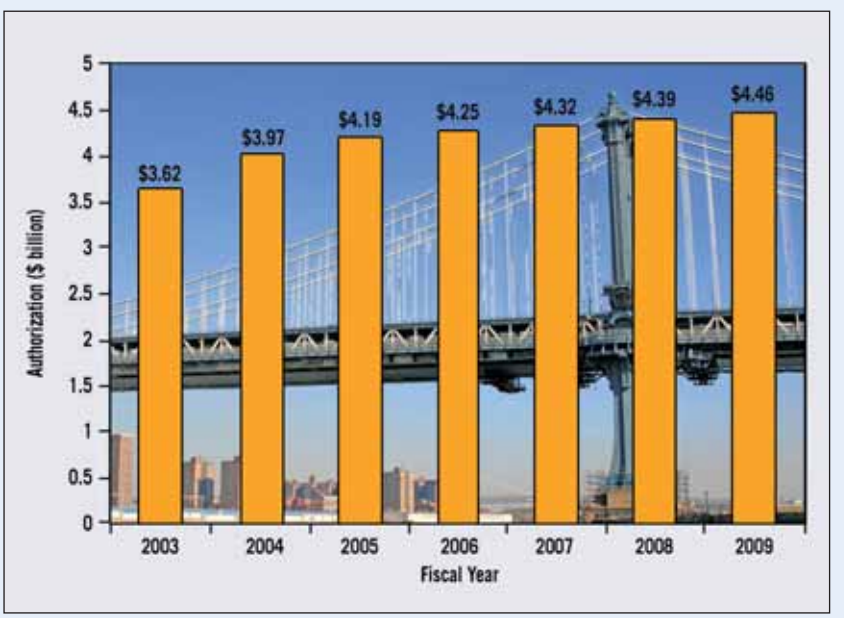
The legislation came after the Transportation Equity Act for the 21st Century (TEA-21), signed by President Clinton in 1998, which provided $217 billion through 2003. It was the largest public works legislation in U.S. history. SAFETEA-LU will provide nearly $300 billion in funding through 2009 and offers a 25.5% increase over the $20.4 billion the TEA-21 first authorized for the Highway Bridge Program.

Of the more than 600,000 bridges in the U.S., 45% are under the financial jurisdiction of state governments, and 38% are controlled by county authorities. The bill could be a reprieve for local governments that are in need of new or repaired bridges but have been handcuffed by tight budgets. The sluggish economies of the early 2000s put many state and local governments on their back feet, and new and upgraded bridge projects stalled in this time period.

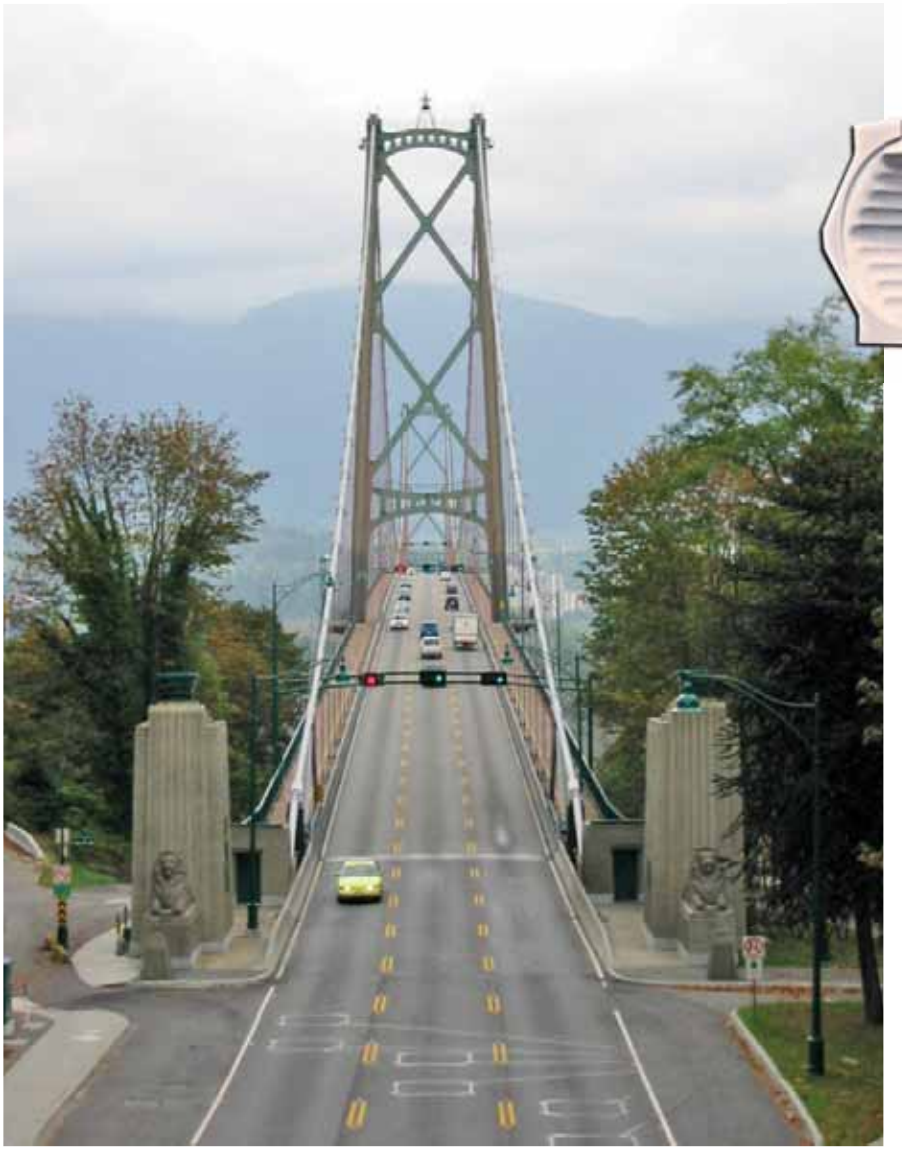
According to a U.S. Dept. of Transportation report on the status of the nation's highways, bridges and transit systems, 158,319 bridges, both rural and urban, out of a total 593,813 in the U.S. in 2004 were in need of repair or replacement. With more than a quarter of the nation's bridges in need of some work, the door is open for potential casting projects. According to a report by the American Road and Transportation Builders Association on job contracts for October 2006 compared to 2005, the number of bridge and tunnel contracts grew by 27.8%, while the value of the contracts rose 93.8%.

While the SAFETEA-LU bill authorized $26.2 billion to enable states to improve the conditions of their bridges, it also designates $100 million be set aside for specific bridge projects each year. This allotment will break down as follows:

1. Golden Gate Bridge—$12.5 million
2. Bridge joining the Island of Gravina to the community of Ketchikan, Alaska—$18.75 million
3. Replacement of the bridge over the Hoover Dam in the Lake Mead National Recreation Area—$12.5 million
4. Bridge connecting St. Louis, Mo., to the State of Illinois—$12.5 million
5. Replacement and reconstruction of Oklahoma bridges—$12.5 million
6. Missisquuoi Bay Bridge, Vt.—$4.5 million
7. Replacement and reconstruction of Vermont bridges—$8 million
8. Design, planning and right-of-way acquisition for Interstate Route 74 bridge from Bettendorf, Iowa, to Moline, Ill.—$8.75 million
9. Replacement and reconstruction of Oregon bridges—$10 million



SAFETEA-LU, which earmarks $25.6 billion for the Highway Bridge Program over six years, is a 25.5% increase over the $20.4 billion pledged by the TEA-21.



IN LIKE A LION ***Rather than be torn down and replaced with a new bridge, the Lions Gate Bridge, Vancouver, went through a series of repairs and upgrades, including newly-cast roller castings (r) to meet current and future demands on the bridge.***

assembly and 56 assemblies in the project. The two 5,200-lb. roller castings were joined together by a 7,400-lb. equalizer casting and attached to the bridge through a 5,900-lb. pivot casting. The bridge is exposed to tide swings of 16.5 ft., so a high strength material was needed.

The metal choice lay between a duplex stainless or martensitic stainless material. Although less corrosion resistant, the martensitic stainless steel grade CA6NM was chosen because it was less expensive and easier to cast in heavy sections. The contractor applied a special coating to the finished components to add further corrosion resistance.

"The original roller assemblies were carbon steel fabrications with cast wheels that had rusted together from years of exposure to sea water," Caldwell said. "The new design was all cast and better suited to meet the strength and corrosion requirements for extended life."

Lion's Gate

Highland Foundry ran into some of the same requirements for its casting produced for the Lion's Gate Bridge in nearby Vancouver. Because of the components' exposure to the elements, the surface of the casting had to be sandblasted, primed and finished with a zinc-rich paint.

The Lion's Gate bridge is located at the entrance of Vancouver's harbor and connects the city with West Vancouver. "While most places tend to scrap bridges and put up a new one, this bridge was refurbished instead," Sherlock said.

Because the bridge was in an earthquake zone, the deck could sway excessively. To solve the problem, a new clamp and traction rod assembly was designed to join the main car deck to the bridge cables. The cast clamp was made out of ASTM A148 grade 115-95 steel. Each casting was half a clamp, measured 92 in. long and weighed 1,700 lbs.

"The casting challenge involved matching the interior cast flutes of the clamp to the 13.8-in. diameter main wire rope of the bridge over the 92 in.," Sherlock said. "Most clamps of this nature are less than 48-in. long."

The castings were partially machined, and it was important, but difficult, to have high dimensional accuracy over the length of the casting so the as-cast part of the component matched the machined part.

Before starting the project, Highland Foundry drew up a quality plan, which had to be reviewed and approved by the customer's design engineer before proceeding with casting the clamps. Like Atlas Casting, the bridge industry is not a typical market for Highland Foundry, but its experience in the pressure-vessel industry made participating in the project a compatible and attractive venture.

Because of its experience with high specification jobs, the firm had in place the necessary testing and finishing procedures, such as magnetic particle inspection, radiographic inspection, tensile tests, chemical tests, hardness report and Charpy impact test.

In addition to the testing and machining, Highland Foundry drilled 18 holes on each side of the clamp. In order to aid the construction workers at the site in properly aligning and accurately assembling the castings, the metalcasting firm left dowel pins in four corner holes.

The $70 million reconstruction of the Lion's Gate Bridge was completed in 2002. With an overall length of 4,977 ft. and a mainspan of 1,550 ft., the structure continues to be a recognizable symbol for the Canadian city. *ECS*

For More Information

"Building New York," *S. Kruse, MODERN CASTING Nov/Dec 2006, p. 20.*