

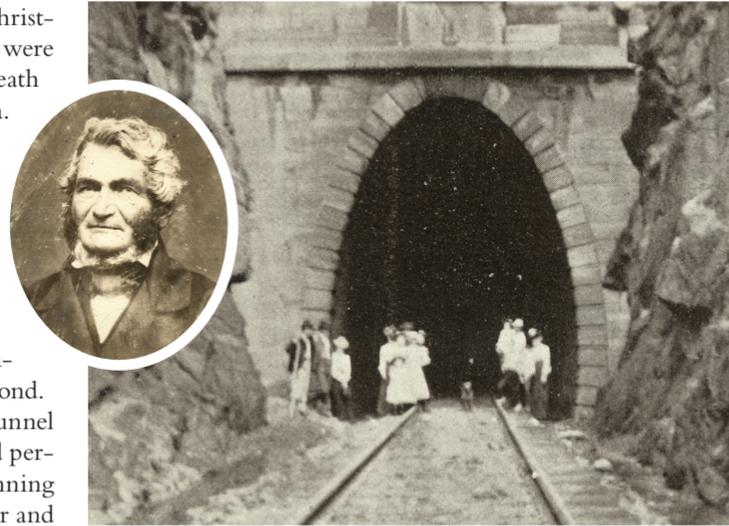
Uniting the Commonwealth: The Blue Ridge Tunnel

It must have been cold, damp, and dark on that Christmas Day in 1856 when two tunnel excavation crews were blasting and drilling their way toward each other beneath the Blue Ridge Mountains near Waynesboro, Virginia. The stagnant fumes from used black powder would have made breathing difficult for the men gathered near the point where the two tunnel headings would meet, one from the east, the other from the west. Among those on hand to witness the linkup was Claudius Crozet, a French-born engineer who designed, surveyed, and supervised the excavation of the tunnel as part of a rail line that would connect the eastern portion of the commonwealth of Virginia with its western portion and beyond. When the two crews linked up, the Blue Ridge Tunnel assumed the title of the longest tunnel in the country and perhaps in the world. The connection also signaled the beginning of the end of a project that had been fraught with danger and difficulty but is now regarded as a pioneering achievement in civil engineering.

Crozet was born in 1789, more than 60 years before the tunnel headings met. He was educated in France as a bridge engineer and later became an officer in Napoleon's artillery corps. Captured in Russia, he spent two years there as a prisoner of war. In 1816 he was married in Paris and shortly thereafter decided to emigrate to America. He became an assistant professor of engineering at the United States Military Academy at West Point, in New York.

In 1839, during his second term as the principal engineer of the Virginia Board of Public Works, Crozet proposed constructing a railroad that would pass through the Blue Ridge Mountains. (That same year he also helped found the Virginia Military Institute.) The proposal was dismissed by the board, and Crozet's job as principal engineer was dissolved in 1843. But six years later, in March 1849, the board recognized the need for a railroad that would connect the segments of the Louisa Railroad located east and west of the mountain range. It approved the formation of the Blue Ridge Railroad Company with the expectation that the tunnel would be sold to the privately owned Louisa Railroad after it was completed. Crozet was appointed the project's chief engineer.

The railroad was to pass through Rockfish Gap, a small opening in the Blue Ridge Mountains near Waynesboro. In an 1849 report, Crozet put the length of the railway at 62,082 ft (18,923 m). The tunnel, he estimated, would measure at least the 4,260 ft (1,298 m) specified in the call for proposals and possibly more. Preliminary surveys for the tunnel were difficult, he noted, because his compass varied by as much as 15 degrees, a discrepancy that might have been caused by the magnetic properties of



A prominent brick arch was constructed at the east entrance of the Blue Ridge Tunnel, above. The tunnel's engineer, Claudius Crozet, inset, decided that the tunnel, constructed near Waynesboro, Virginia, at Rockfish Gap, would assume an elliptical rather than a circular shape to provide more room for railcars and to better withstand gravity loads. During construction, Crozet and the tunnel's contractors encountered a significant number of challenges, including drainage and ventilation issues, financial crises, and an extremely volatile Irish labor force. Crozet was a French-born engineer who had served in Napoleon's army and been captured in Russia. After immigrating to the United States he taught engineering at West Point and served as the principal engineer of the Virginia Board of Public Works.

the rocks. "The needle is not at all to be relied on over this part of the Blue Ridge, and its irregularities have been a great source of annoyance, and a cause of considerable delay in the progress of my operations," he wrote.

Crozet's surveys indicated that three more tunnels would be needed along the railroad, but these would be much shorter than the Blue Ridge Tunnel. The surveys also determined that vertical shafts were impracticable. Crozet decided that the tunnel arch would assume an elliptical shape rather than a circular shape to better withstand gravity loads and provide sufficient room for the rail cars.

On February 14, 1850, the Virginia Board of Public Works signed a contract with Christian E. Detwald, John Kelly, and John Larguey to construct the Blue Ridge Tunnel—described as the "main tunnel"—and its approaches. Irish immigrants were employed as workers on the tunnel, but they proved to be a rather volatile group throughout the project. Most of them came from County Cork, in southern Ireland, and in 1850 they violently objected to the hiring of immigrants from the northern part of their native land who came seeking jobs on the

railway. Approximately 235 "Corkians" marched to the shantytown of the northerners, or "Fardowners," engaged them in a brutal fight, and burned their shanties to the ground.

This was not the end of Crozet's problems, however. Work was progressing slowly. The excavation of the east heading of the main tunnel began smoothly, but then it encountered rock that quickly dulled the hand drills of the workers. Furthermore, the workers were working uphill to excavate the rock; the east end of the tunnel was to be at the lower end of a 1.3 percent grade so that smoke from the locomotives would rise and exit at the west end while water would drain out of the east end. At the west heading the workers encountered other problems. The excavation crew found dangerously large fissures in the tunnel roof that required temporary timber supports until the roof and walls of the tunnel could be lined with brick. Complicating matters, water accumulating at the bottom of the west heading had to be pumped out.

Ventilation was an issue in both headings. Fumes from the black powder that was used to blast the solid rock remained in the tunnel. To remedy the problem, Crozet, who was constantly seeking ways to save the state money on the project, refused to bring in an expensive steam engine to act as a ventilator. Instead, he relied on a device nicknamed the Burgoyne ventilator, which was described in *A Rudimentary Treatise on Blasting and Quarrying*, by Sir John Fox Burgoyne. The apparatus comprised two tubs, one filled with water, the other, which was slightly smaller, suspended upside down above the first. An airtight tube was located in the center of the larger tub and extended into the tunnel. It featured a valve so that when the smaller tub dropped into the water and then was pulled out of it, the action would channel the stale air through the tube, thus providing ventilation in the tunnel. According to Burgoyne, the hand-operated apparatus was capable of pumping 4 cu yd/min (3 m³/min).

In 1853 the workers struck a large spring in the west heading, which rapidly filled the lower portion of the tunnel with water flowing at a rate too great to be pumped out. The resourceful Crozet brought in 1,800 ft (549 m) of 3 1/8 in. (76 mm) diameter pipe and successfully siphoned out two-thirds of the water before pumping out the remainder. At the time, Crozet's siphon was believed to be the longest one ever used.

Perhaps because of problems encountered in the tunnel, the Louisa Railroad, which by then had become the Virginia Central Railroad, hired Charles Ellet, Jr., a prominent bridge engineer, as its chief engineer. Ellet decided to construct temporary railroad tracks over the Blue Ridge Mountains. Crozet respected Ellet as an engineer and saw him as a potential friend, but Ellet apparently disappointed him. The relationship between the two was strained almost from the beginning, especially with regard to labor. Ellet expected Crozet to provide hands to complete the temporary track, but Crozet was reluctant to do so because Ellet's employer was also pressuring him to complete the unfinished portions of the permanent railroad. As a result, their relationship remained tense despite the fact that Crozet extended an olive branch to Ellet on several occasions.

That spring, another severe labor problem would hamper Crozet's efforts on the tunnel. He had hired a man named Paul

Stevens to help ventilate the tunnel, but it turned out that Stevens was more adept at fostering resentment among the laborers than he was at constructing ventilation systems, which he abandoned, forcing Crozet to hire another contractor. Crozet reported that Stevens spread rumors through the Irish workforce that they were not being sufficiently paid. When Stevens left the project, the Irish hands went on strike. Soon thereafter Stevens wrote to them from Cincinnati urging them to come and work on a tunnel there for more money, which many did. As a result Crozet was left with a greatly reduced workforce.

Faced with a labor shortage, Crozet decided to use slave labor. Robert P. Smith, a slave owner, agreed to a payment of \$1 per day for each slave. As Crozet finalized the number of slaves that were needed, one of Ellet's contractors moved in and offered \$1.25 per day for each slave. Ellet apparently later reprimanded the contractor for the disruption, but Crozet was still obligated to raise his wages to remain competitive. Exacerbating the labor situation, a cholera epidemic broke out among the workers in the spring of 1854. At an Irish shantytown on the east side of the tunnel, approximately 17 people died in one week.

In addition to illness, accidents took their toll on workers in 1853 and 1854. The coupling on a flat car being loaded by slaves snapped and careened down the slope, killing two and injuring a third. Also, according to the *Lexington Gazette*, the brakes on a passenger car carrying Ellet and others failed, and the car collided with an engine. The two mangled railcars continued for a considerable distance before they came to a stop. One person was killed, another was severely burned, and the rest sustained minor injuries.

The work was slowed again in the next few years by financial crises. The Board of Public Works did not have sufficient funds to pay the contractors in 1855. Nevertheless, the contractors continued to work, hoping to receive payment eventually. This decision greatly relieved Crozet, who noted that some of the excavation and construction could not have been put on hold for long because temporary structural elements would have begun to deteriorate.

Despite their many challenges, Crozet and his contractors successfully connected the two tunnel headings on that cold Christmas Day in 1856. The next year was spent removing the tunnel floor and preparing it for the track. The masonry arching also was being completed on those portions of the tunnel that needed to be reinforced. Despite these demands, Crozet did not neglect excavation work at the other three tunnels, some of which proved more unstable and dangerous than that on the main tunnel. By September 1857, however, Crozet left the finishing work to others so that he could participate in the design and construction of the Washington Aqueduct. The tunnel project underwent a final inspection in February 1858.

The Blue Ridge Tunnel was used extensively by General Stonewall Jackson's Confederate troops during the Civil War. Although it is no longer used because trains now have access to a larger tunnel built after World War II, it still stands as a monument to Crozet's fortitude and innovation. The Blue Ridge Tunnel has been formally recognized in ASCE's Historic Civil Engineering Landmark Program.

—Brett Hansen