ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT

Arkansas' R.M. Ruthven Bridge

EACH May the tiny town of Cotter, located at a U-shaped bend on the wild White River in northern Arkansas, hosts its annual Trout Festival, befitting a town that proclaims itself Trout Capital USA. The day-and-a-half event features live music, entertainment, arts and crafts vendors, and a whole lot of fish.

Fittingly, the festival takes place beneath the city's other claim to fame, a landmark rainbow arch bridge of reinforced concrete built in 1930. What is today known as the R.M. Ruthven Bridge was the largest to be designed by James Barney Marsh, who pioneered the use of majestic rainbow concrete arch bridges across the Midwest, building more than 20 structures in Iowa, Kansas, and Wisconsin.

The R.M. Ruthven Bridge, according to a 1988 Historic American Engineering Record (HAER) report authored by Lola Bennett and Corinne Smith, is 1,850 ft long and rises 78 ft at its highest point above the White River. Its main structure consists of five rainbow-shaped arches, each measuring 216 ft. In addition, the report notes, the bridge features "an arch viaduct of 132 feet, and 638 feet of deck girder approaches." The roadway is 24 ft wide.

Building the bridge helped open up the Ozarks as a major recreation destination. The work required not only innovative design and construction techniques but also some sleight of hand on the part of the man for whom the bridge is named.

In the 19th century, ore and timber were commonly transported along the White River in steamboats. The first railroad bridge crossed the river in 1905, and in the early decades of the 20th century people crossed the river by ferry. The ferries did a brisk business, but the White River was temperamental and flooded often. The HAER report indicates that the river could rise as much as 1 ft per hour for 50 hours straight, requiring travelers wishing to cross to trek all the way to Branson, Missouri, 100 mi away.

Efforts to build a bridge for cars date back to the second decade of the 20th century, but it wasn't until late in the following decade that state officials began pushing for better highway access through the Ozark region. To that point, road building had been a disorganized and uncoordinated affair overseen by individual counties.

In 1927 Arkansas established the State Highway Department, the precursor of the Arkansas State Highway and Transportation Department, after the passage of federal legislation turning highway planning over to the states. The State Highway Commission obtained approval from federal officials to construct nine toll bridges. R.M. Ruthven, a judge in Baxter County, the HAER report notes, "pushed for Cotter to be on the list of proposed sites." While U.S. Highway 62 was to pass through the city, the Cotter site wasn't ideal because traffic counts were low. A feasibility study, required for all bridge proposals, was conducted in June 1928.

According to a 1972 article in the *Arkansas Gazette* on the bridge written by Clifton Hull, the feasibility study approved all of the bridge sites except the one in Cotter. So Ruthven made a momentous decision. "Ruthven saw the survey report before the commission met," Hull writes, "and he realized what it meant to the people of his county. When he returned to his home that afternoon, the Cotter report went with him, where it remained for two decades."

The State Highway Commission, believing the disappearance of the report to be a simple oversight, approved the Cotter Bridge for construction. According to Hull, Ruthven finally returned the report to the state, and nothing untoward happened to him or his reputation. He later served in the state legislature and was mayor of Cotter.

Construction of the $391,000 Cotter Bridge began in November 1929. While Ruthven helped get the bridge off the ground, the real innovation came from its designer and method of construction. The crossing was the work of engineer James Barney Marsh, who formed the Marsh Bridge Company in 1896 and the Marsh Engineering Company in 1909.

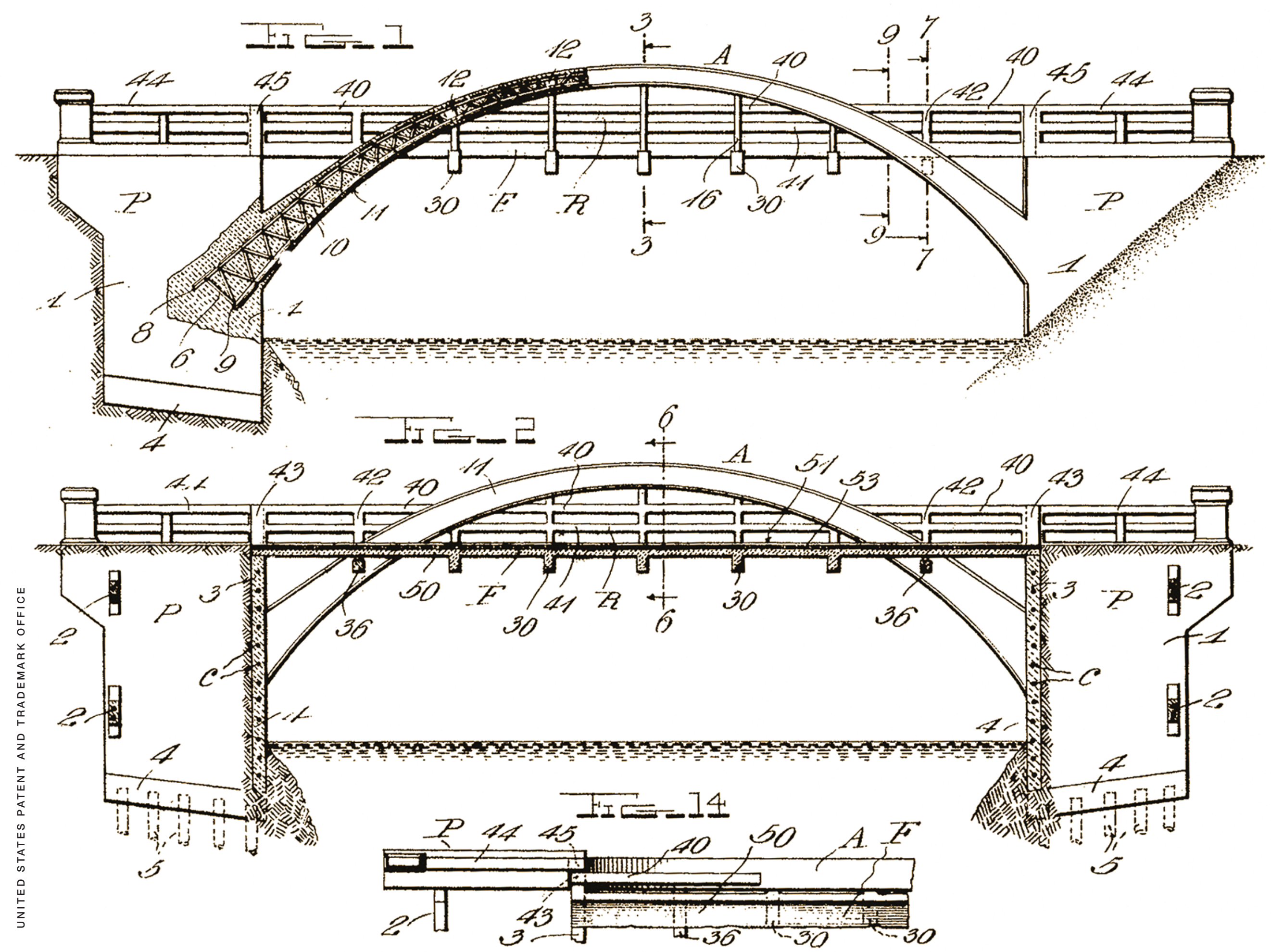
Marsh's innovative bridge ideas stretched back almost 20 years. His design for a reinforced arch bridge was patented in 1912, the first of two arch bridge patents he received.

The R.M. Ruthven Bridge, which rises over the White River in Cotter, Arkansas, was designed by James Barney Marsh, who pioneered the use of majestic rainbow concrete arch bridges across the Midwest, building more than 20 structures in Iowa, Kansas, and Wisconsin. His patent application for the reinforced arch bridge was filed on November 1, 1911, and the patent was awarded on August 6, 1912. Each steel arch weighed 22 tons.

"One of the great deficiencies and sources of failure in reinforced-concrete bridge construction as heretofore conducted is the improper and inadequate provision made for contraction and expansion due to temperature changes," Marsh wrote in his second bridge patent, from 1921. "This fault alone (aside from failures caused by faulty foundations) has wrecked more concrete bridges than any other one feature of faulty and incorrect design."

The goal, he noted in his first patent, was to construct a reinforced-concrete bridge that would limit expansion and contraction of the bridge arches and deck. "By designing the bridge so that the arches would spring from points in the abutments below [the] level of the deck, and hanging the deck from the arch with vertical members, Marsh accomplished his goal," write Bennett and Smith.

There were practical benefits to Marsh's design as well. Bennett and Smith note that there was growing demand for highway bridges in the 1920s and 1930s, and highway departments to an increasing extent were choosing arch bridges of reinforced concrete, which were "relatively inexpensive and quick to build, when compared with other types of



UNITED STATES PATENT AND TRADEMARK OFFICE bridge construction, and required less maintenance than traditional iron bridges."

Also noteworthy was the bridge's method of construction. The Cotter Bridge was built with the aid of a cableway rather than by building falsework in the river, which would have forced the workers to face the risk of unpredictable water levels. This approach, the report notes, conferred savings in time, money, and labor.

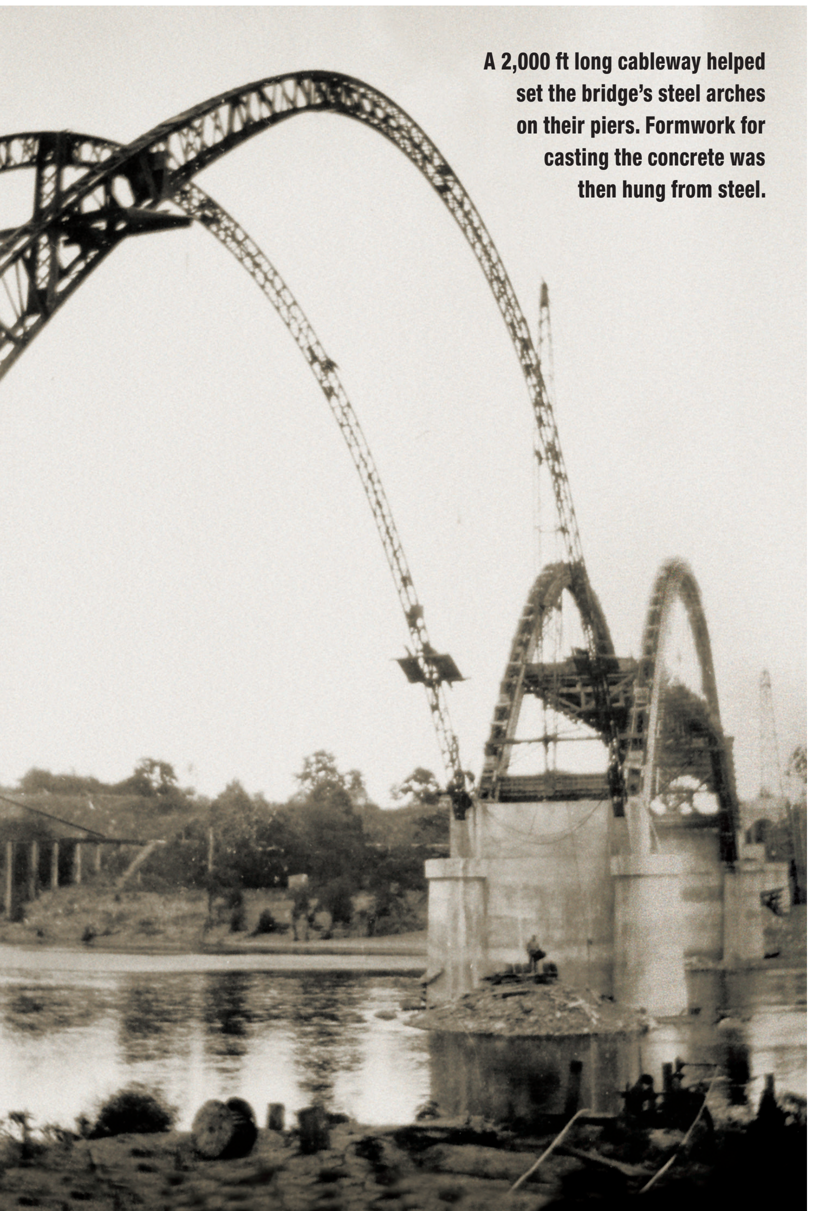
A 2,000 ft cable was strung between two towers on opposite banks of the river and then anchored into the ground. The bridge's steel arches, weighing about 22 tons, were assembled on the riverbank, according to the HAER report. Then "an auxiliary supporting 'mast' was carried out by cableway and set on the central pier as each steel arch was set in place. The top of this mast was attached to the main cable. The mast could be 'drifted' to either side to align the arches at about a 30-foot spread."

Each arch contains 17 verticals connecting it to the road deck: 11 hangers extending from the arch down to the deck and 6 spandrels reaching from the lower curve of the arch up to the deck close to where the arches meet the bridge piers. As the report notes, each pair of arches is braced laterally above and below the road deck: "Three lateral struts cross the road at the crown. The struts, four angles joined by double lacing, rise at a five degree angle from the two arch lines, to meet over the center of the road. Underneath the road, a beam connects the two arch lines near the springline, and angles with lacing cross just above the beam."

After the arches were placed on the bridge piers, the report continues, "formwork for casting the concrete was hung from the steel. As the concrete was cast on each part of the arch, the forms would be removed and positioned in the same place on the next arch. Forms for the floor were supported by a wooden truss with a steel tension rod placed under the floor beams." The concrete was produced on-site.

Bennett and Smith explain that concrete formwork was laid horizontally for much of the bridge deck, except for the curves along the arch. There, "concrete was poured in a sequence to induce the least amount of stress in the steel from the added dead load of the concrete." Furthermore, they point out that "the floor deck was poured before the hangers were covered so that the hangers were carrying the full dead load. Having the steel component of the hangers almost fully extended reduced the amount of cracking of the concrete cover when tension forces from live load were applied."

The bridge opened in November 1930, six months ahead of schedule, with a two-day gala that was attended by several thousand people and included a parade of roughly 1,000 cars.



A 2,000 ft long cableway helped set the bridge's steel arches on their piers. Formwork for casting the concrete was then hung from steel.

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Ironically, however, most people continued to use ferries to cross the river. This prompted a peevish letter from the state highway engineer: "If Baxter County people want new improvements on their highways they will have to patronize those already made.... The local people convinced the highway department that it was necessary that a bridge be constructed between Marion and Baxter Counties, and the bridge was built."

The solution to the problem was simple: pay off one of the last ferry operators to shut down, which the State Highway Commission did to the tune of $250. Shortly thereafter, business on the bridge picked up.

The Cotter Bridge was renamed in Ruthven's honor in 1976. The Arkansas State Highway and Transportation Department began an inventory of its bridges in the mid-1980s. When the inventory was completed, in 1987, the "Cotter Bridge was identified as one of the significant bridges in the state," says Nikki Senn, an architectural historian with the department. (The bridge had been accorded landmark status in ASCE's Historic Civil Engineering Landmark Program in 1986.) "It was recognized as very prominent and potentially eligible for the National Register. At that point it was discussed what to do with it." (The crossing was listed in the National Register of Historic Places in 1990.)

In the late 1980s, a new and more modern bridge opened a few miles north. But it wasn't until 2002 that the state finally began work on a $6.2-million restoration of Ruthven. Fixing the road deck was critical. Even when it first opened locals complained that it rode rough. The Arkansas State Highway and Transportation Department quickly overlaid the concrete road surface with asphalt, which solved the problem. But as the road on either side of the bridge was repaved over

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the years, the bridge itself kept receiving new layers of asphalt to keep the road surface level—9 to 10 in., all told. The asphalt soaked up salts and chlorides used in ice and snow removal "like a sponge," says John James, P.E., the department's resident engineer. As a result, the deck's concrete deteriorated. Worse, the asphalt was impeding the proper functioning of joints in the bridge, which needed to be able to expand and contract.

"The concrete looked like soil," says James. "It was just like you were digging in dirt." He adds that the concrete was still acting like concrete in that it still had some structural value, but it needed to be replaced.

Ultimately, while the arches themselves were in good shape, the portions of the bridge they supported were replaced, including the entire road deck and the decorative parapet walls on the side. James says there were concerns about what would happen when crews began working on the bridge: "There's not a whole lot of experience with these. There's not a lot of them around. So there was a concern as we tore out the deck that the concrete arches were going to be like springs and expand out. We didn't know exactly. We had some idea." So the highway department required the building contractor, Hardy Construction, to brace the arches as the deck was removed. "So he had to build bracing underneath and hold those arches," James recalls.

Hardy Construction also designed rolling platforms underneath to catch debris as bridge spans were demolished. It also monitored the bridge for movement while demolition was proceeding so that crews could spot any problems. Workers set up instruments away from the bridge, took elevation shots, took horizontal measurements, and then every so often compared the measurements to see if there was any movement. The arches held up well.

Hardy Construction also replaced the joints at the top of the piers and surrounding structures and pulled out the entire length of decorative railings along the sides of the bridge. The new parapet walls were remade of concrete, but fiberglass, rather than plywood, was used for the forms because it made it easier to obtain the walls' curved shapes. The concrete was then rubbed down to finish it to make it look just like the original railing. "It was a challenge for them to make them match," says James, "and they did a good job of that."

Lastly, the bridge's new concrete deck was built to its original grade, and the state redid the asphalt roadway approaches to match that grade. The bridge rehabilitation was completed in 2004.

The restored bridge remains a point of pride in this small community. "This was big to the city of Cotter," says James. "It was a small little town but it meant something to them. That's their landmark."

The HAER report quotes an approving appraisal of the bridge from 1930 published in the local newspaper. It's a sentiment that no doubt rings true today: "Probably no type [of] bridge adapts itself to the natural scenery as this one does. The graceful arches of the structure seem to fit in with the natural green contours of the surrounding mountains. Standing high on one of the nearby hills and looking down toward the bridge it looks as if it grew there, and was not put there by the hands of man." —T.R. WITCHER

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