TEXAS SUSPENSION BRIDGES
Texas Historic Bridges Recording Project II
Austin
TRAVIS ~~Austin~~ County
Texas

HAER No. TX-98

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

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HISTORIC AMERICAN ENGINEERING RECORD
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HISTORIC AMERICAN ENGINEERING RECORD

TEXAS SUSPENSION BRIDGES HAER No. TX-98

Location: Texas Department of Transportation, Austin, Travis County, Texas

Dates of Construction: 1885-1940

Significance: Prior to 1940, several short-span (100' to 140') suspension bridges were built in the north central region of Texas. This concentration represents a regional adaptation to environmental conditions as well as a tradition of inventive design by vernacular builders. This study builds on the 1996 documentation of nine extant bridges of this type.

Historian: Mark M. Brown, Ph.D., August 2000.

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INTRODUCTION

Histories of American suspension bridges have traditionally focused on the heroic and monumental achievements of the greatest names of American bridge engineering: Finley, Ellet, John and Washington Roebling, Lindenthal, Ammann, and Steinman. In recent years, however, it has become clear that there was a large body of suspension bridges built alongside this monumental tradition, including many by those who were not academically trained. Richard S. Allen has conducted research on Andrew Smith Halladie's California suspension bridges.[1] David A. Simmons has documented a cluster of suspension bridges built in the years after John Roebling's Covington and Cincinnati Suspension Bridge of 1867.[2] Spivey, Boothby, *et al.* conducted a structural analysis of a 300' span in Pennsylvania that first appears to be a suspension bridge but actually behaves as a "two-hinged inverted trussed arch."[3] The present study is an outgrowth of these recent intellectual developments and of HAER's documentation of a number of 100' to 140' suspension bridges in Texas during the summers of 1996 and 2000. The 1996 research made it clear that the nine extant suspension bridges built in Texas before 1940 were part of a once much larger building tradition, that they were largely concentrated in north central Texas, and that some of these bridges were unexpectedly inventive (see Appendix Table 1). A series of provocative questions emerged from these findings. Why were such short-span suspension bridges built in Texas? What accounts for their geographical distribution? How might we explain their limited period of popularity? What can we learn about the inventors and

[1] Richard Sanders Allen, "California's Old Wooden Truss and Suspension Bridges," Paper presented at the annual meeting of the Society for Industrial Archeology, Sacramento, California, 1 June 1996.

[2] David A. Simmons, "'Light, Aerial Structures of Modern Engineering': Early Suspension Bridges in the Ohio Valley," in *Proceedings of an International Conference on Historic Bridges to Celebrate the 150th Anniversary of the Wheeling Suspension Bridge*, ed., Emory L. Kemp (Morgantown, W. Va.: West Virginia University Press, 1999), 73-86.

[3] Historic American Engineering Record (HAER) National Park Service, U.S. Department of the Interior. "Lower Bridge at English Center," HAER No. PA-461; From time to time HAER has had occasion to document both non-academic, or vernacular, suspension bridges as well as short-span bridges by professionally trained engineers: "New Portland Suspension Bridge," HAER, No. ME-3; "Nisqually River Suspension Bridge," HAER, No. WA-44; "Chow Chow Suspension Bridge," HAER, No. WA-5; "Kellams Bridge," HAER, No. PA-470.

builders of these bridges and their understandings of what they did? How do we understand the behavior of these structures today?

Donald Sayenga has pointed out the difficulties of expanding the study of suspension bridges beyond the heavily documented monumental spans. This is especially true of smaller span suspension bridges that were pre-designed, not unlike "catalog" truss bridges, to be replicated as needed.[4] The Texas vernacular suspension bridges represented an opportunity to develop documentation in response to Sayenga's challenge. In planning the summer 2000 research, HAER and its cosponsors, the Texas Department of Transportation and the Texas Historical Commission, developed a research plan intended to address these and other questions. Three additional suspension bridges were designated for full documentation. Field research was conducted in several north central Texas counties that had evidence of suspension bridge traditions or otherwise associated with known builders and designers. A structural analysis of selected types was commissioned to compliment the historical documentation and this overview.[5]

SUSPENSION BRIDGES FOR TEXAS

Suspension bridges in general have certain economic advantages, namely
- -flexibility of span length reduces the number of piers,
- -erection does not require falsework,
- -prefabrication is less expensive compared to metal trusses,
- -typically smaller parts ease transport to remote locations, and
- -wire manufacturers often provided the ancillary materials such as anchor-block castings and hangers.[6]

While generally thought of as most suitable for long-span bridges, the suspension bridge clearly

[4] "Contextual Essay on Wire Bridges," No. NJ-132.

[5] "Barton Creek Bridge," HAER No. TX-87; "Rock Church Bridge," HAER No. TX- 81; "Choctaw Creek Bridge," HAER No. TX-85. "Structural Study of Texas Cable-Supported Bridges," HAER No. TX-104.

[6] F. H. Frankland, *Suspension Bridges of Short Span* (New York: American Institute of Steel Construction, 1934), 11-15; Robert M. Vogel, *Roebling's Delaware & Hudson Canal Aqueducts*, Smithsonian Studies in History and Technology, No. 10 (Washington, D.C.: Smithsonian Institution Press, 1971; reprint, Philadelphia: Eastern National Park and Monument Association, 1994), 9; "Beveridge Bridge," No. TX-46.

proved to be an economic alternative for a range of needs in Texas, although they did not find favor in the far west, the Panhandle, or central Texas. Both the TransPecos and the Panhandle are historically very dry and as such do not require many bridges. Extensive areas of the eastern two-thirds of the state, however, experience dramatic floods, particularly in the Brazos, Colorado, and Trinity river basins. Rocky conditions in central Texas spare bridge builders the difficulty of finding solid footings in alluvial flood plains and coastal marshlands. Local tradition reports, for example, that the Rock Church Bridge is located where it is because only there do the banks of the Paluxy, a tributary of the Brazos, not collapse.[7] Indeed, the designer of the Bluff Dale and Barton Creek suspension bridges pointed out that

> it is greatly desirable to make a single span from shore to shore, or at most to have butone pier embedded in the river, because of the difficulty in sinking coffer-dams and finding strata of sufficient density to form stable anchors for the piers.[8]

Just as the Covington and Cincinnati Suspension Bridge demonstrated the potential of suspension bridges to promoters throughout the Ohio Valley, so too did the Waco Suspension Bridge made a strong impression on the people of the Brazos basin.[9] The 475' main span opened in 1870 – just three years after Covington-Cincinnati, though it was substantially shorter than the latter's 1,057' span.[10] Waco's bridge was a monumental undertaking that required importing cable and fittings from eastern foundries, 2.7 million bricks for the crenellated towers, and the

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[7] Barbara Stocklin, "Historic Bridges of Texas, 1866-1945," National Register of Historic Places Nomination, 1966 (copy on deposit with Environmental Division, Texas Department of Transportation, Austin, Tex.), Section E, 5; "Rock Church Bridge." No. TX-81.

[8] Edwin Elijah Runyon, "Suspension-Bridge," U.S. Patent No. 394,940 (18 Dec. 1888), lines 52-7.

[9] Mark M. Brown, "Nineteenth-Century Cable-Stayed Texas Bridges," in *Proceedings – Fifth Historic Bridge Conference*, ed., David A. Simmons (Columbus, Ohio: Fifth Historic Bridge Conference Organizing Committee, 1997), 40. "Contextual Essay on Wire Bridges," HAER No. NJ-132. Roger N. Conger, "The Waco Suspension Bridge," *Texana* I, No. 3 (summer 1963): 175-84; T. Lindsay Baker, *Building the Lone Star: An Illustrated Guide to Historic Sites* (College Station, Tex.: Texas A&M University Press, 1986), 260-62.

[10] The following 1959 commemorative inscription is on the Waco bridge: "Opened January 7, 1870 as a private toll bridge and at that time the longest (475') single span suspension bridge in the world." Even though the "longest bridge" claim is not correct, the inscription proclaims a higher truth about the importance of the bridge to Waco.

expertise of academically trained civil engineer Thomas M. Griffith.[11] The final $141,000 cost was such a massive sum that it could only have been raised through a stock offering and tolls, and accomplished by an ambitious community seeking to make a bold statement. Besides validating the value and potential of suspension bridges, Waco set several precedents.[12] It was a parabolic, or catenary, suspension bridge with inclined stays and a stiffening truss. While these features would become standard or, as in the case of inclined stays, fairly common on subsequent Texas suspension bridges, Waco used pre-manufactured wire ropes. Most Texas suspension bridge builders would fabricate their in situ cables.[13] When Texans needed to build long-span highway bridges before World War II, they followed the precedent of Waco and turned to privately financed suspension bridges. This would happen only across the Rio Grande and the Red River, where the added complexities of negotiations between sovereign states must have

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[11] Griffith was assistant for a ca. 1850 suspension bridge across the Niagara Gorge at Lewiston, and engineer for both the 1855 and the 1875 Mississippi River suspension bridges at Minneapolis. In 1883, he patented a suspension bridge "composed entirely [of] pieces of moderate length and weight, which can easily be carried hy man or pack-mules, and which when once delivered to the site of the proposed structure can easily and cheaply put together" Thomas M. Griffith, "Suspension-Bridge," U.S. Patent No. 285,257 (18 Sept. 1883), lines 9-14. While there is no evidence that Texans were familiar with Griffith's patent, it did feature towersconstructed of pipe, a parabolic cable with diagonal stays, and a truss stiffened deck. Special thanks to Charles E. Walker, Senior Bridge Design Engineer, Bridge Division, Texas Department of Transportation for calling my attention to this information in Arne A. Jakkula, "A History of Suspension Bridges in Bibliographical Form," *Bulletin of the Agricultural and Mechanical College of Texas*, 4th ser., 12, no. 7 (1 July 1941):146-48, 155-56, 187-88, 193-94, 454-55.

[12] Jim Steely, Texas Historical Commission, has observed that most Texans would have been unaware of the Waco Suspension Bridge because not the vast majority of settlers did not migrate along the river basins, but rather from east to west across the rivers, and they stayed put once they settled. While this is undoubtedly true, hridge huilders were almost certainly aware of the Waco Bridge. Also, the 1892 addition of the *Texas State Gazetteer and Business Directory* puhlished two advertisements for different bridge companies, each illustrated with an engraving of the Waco Bridge. Waco meant "bridge" to the printer and to the county officials the bridge companies were trying to reach. Jim Steely, conversation with author, 23 Aug. 2000; R. L. Polk and Co., *Texas State Gazetteer and Business Directory*, vol. 4 (St. Louis: R. L. Polk & Co., 1892), 256, 276; Brown, "Cahle-Stayed Texas Bridges," 40.

[13] A tightly wrapped parallel strand cahle is more efficient than wire rope. If the extant examples are representative, then most cahles strung hy Texas huilders were not wrapped very tight. While this raises questions of the comparative efficiency, it suggests that the costs of transporting and stringing individual strands may have been more advantageous than using the much more hulky premanufactured wire rope.

further hindered public construction.[14]

The success of prefabricated trusses, the dominant form of bridge construction from the 1880s until the creation of the Texas Highway Department in 1917, also gave energy to the counter-trend of the suspension bridge. Most metal trusses were fabricated by bridge companies outside the state in more heavily industrialized midwestern and northeastern states. It was a measure of the resentment over its dependence that the state legislature created a special tax for "clairvoyants, fortune tellers, cock-fighters" and bridge salesmen.[15]

Taxing the bridge salesmen did not solve the problem because the taxes would have ultimately been borne by the counties. The solution was for Texas to train its own engineers and establish bridge-building companies. Despite its name, however, Texas Agricultural and Mechanical University only began to depart from its initial curriculum centered on classics, literature, languages, and math in 1879. Progress came with the organization of a new Department of Civil Engineering in 1885. Significant program enhancements followed during the rest of the century. Nevertheless, less than fifty percent of A&M's graduates could find good positions in the mid-1890s. The University of Texas established its College of Engineering in 1894.[16] Graduates of these young programs would require substantial experience and capital before they could compete on their own with out-of-state bridge companies. The problem of indigenous bridge building capacity was significantly addressed with the establishment of the Texas Highway Department in 1917.[17] As its universities developed a pool of trained civil

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[14] Joseph E. King, *A Historical Overview of Texas Transportation, Emphasizing Roads and Bridges,* unpublished T.S. on deposit with Environmental Division, Texas Department of Transportation, Austin, Tex. (Lubbock, Tex.: Center for History of Engineering and Technology, Texas Tech University, n.d.), 58-9; Shannon Miller, *The First 50 Years: 1918-1968,* (Dallas: Austin Bridge Company, 1974), 171. It was not long after the completion of the Waco Bridge that citizens resented the toll and this too may have shaped politicians' attitudes towards long-span bridges and their tolls; see Conger, "Waco Suspension Bridge," 199.

[15] King, *Historical Overview of Texas Transportation,* 29.

[16] Henry C. Dethloff, *A Centennial History of Texas A&M University, 1876-1976* (College Station, Tex.: Texas A&M University Press, 1975), 98-9, 134, 138, 242; Samuel B. Hamlett, "University of Texas at Austin," in *The New Handbook of Texas,* vol. 6 (Austin: The Texas State Historical Association, 1996), 644.

[17] The growth of highway departments had the consequence of greatly reducing, if not eliminating, opportunities for Texas civil engineering students. On the impact of highway departments on entrepreneurial engineering, see James L. Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942,* (n.p.: privately printed, 1997), chapters II, IV, V.

engineers, the extant suspension bridges forcefully demonstrate that Texas continued a tradition of highly inventive citizenry. The success of Waco Bridge established the many advantages of suspension bridges and offered a real alternative to prefabricated trusses.

INVENTORS

Ironically, it was the arrival of railroads in the 1870s and 1880s that increased an existing demand for better roads and bridges. The railroads offered access to distant markets and contributed to cotton displacing grain and cattle as the dominant agricultural product in Texas. Railroads also contributed to the emergence of early industrial centers. Financing hindered politicians seeking to accommodate rural demands for improved railroad access. In a series of measures and amendments between 1884 and 1887, the legislature empowered counties to issue road and bridge bonds backed by property taxes. At the same time, however, the legislature limited bonded indebtedness to control tax rates. In 1893, the counties' limited construction programs dramatically expanded when the bonding limits were raised at least six hundred percent.[18] In light of the legislative history, it does not seem coincidental that Joseph Mitchell, E. E. Runyon, and William Greer each received their first bridge patents in 1887, 1888, and 1889, respectively. That each sought to build strong bridges using a minimum of material points to the limits imposed by the legislature. Each developed wire-based systems that reduced prefabrication expenses and facilitated transportation to often remote construction sites.

JOSEPH MITCHELL

Joseph Mitchell was a bridge builder in Montague, Montague County, Texas, whose work first appears on the historical record in March 1887. While no examples of his work survive, he may have had an influence on the remarkable work of E. E. Runyon. The 1880 census for Montague County records that Joseph Mitchell was a 43-year-old farmer from Illinois with a wife, four daughters, and three sons. In 1887, Mitchell filed his first bridge patent in March, received the patent on 16 August 1888, and was ordered by the Montague Commissioners' Court "to repair all Bridges built by him in this County" in November. The only other reference to Mitchell in the Commissioners' Minutes is from 1888, which once again

[18] Stocklin, "Historic Bridges of Texas, 1866-1945," Section E, 17-18.

speaks only of repairing existing bridges.[19] He seems to have had better luck immediately to the east in Cooke County – Runyon's home. Cooke County commissioned a total of four bridges from Mitchell in 1887 and 1888. Mitchell's bridge is of special interest because the same day it was accepted by Cooke County, 10 September 1888, is also the first reference to a Runyon bridge commission.[20] All of this information about Mitchell might be of mere antiquarian interest given that Mitchell's patent was not for a suspension bridge *per se*, and given that the name Mitchell is rather common, but for the fact that Mitchell was paid for "Three Cable Bridges of his Patent of 16 August 1887," in Fulton County, Indiana, on 27 October 1888. Minutes recording later transactions made it clear that the Joseph Mitchell Bridge Company was based in Independence, Kansas.[21]

More germane to the discussion of Texas suspension bridges is that in 1889, Mitchell constructed a cable-stayed bridge with pipe towers over the Whitewater River in Richmond, Indiana, that is strikingly similar to Runyon's cable-stayed work in Erath County of the following year. The bridge at Richmond consisted of six 25' panels, stiffening trusses based on either the Howe or Pratt pattern fabricated from strap-iron and rounds, and pipe tower bents. A local engineer and college professor thought it novel that:

> the cables were brought to a proper tension by thrusting a lever through the strands and then twisting it up to the supposedly proper stress; to hold it, the lever was then pushed through until it bore upon the ground.[22]

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[19] Mrs. Frank G. Hankies, [Abstract of] *1880 Federal Census Montague County from Microfilm T9-M1320*, TS, n.d., on deposit in the Bowie Public Library, Bowie, Tex., p. 216; Joseph Mitchell, "Bridge," U.S. Patent No. 368,483 (16 Aug. 1887); Montague County, *Minutes of the Montague County Commissioners' Court* (County Clerk's Office, Montague County Courthouse, Montague, Tex.), C: 595 (18 Nov. 1887), D: 8 (17 May 1888).

[20] Cooke County, *Minutes of the Cooke County Commissioners' Court* (County Clerks Office, Cooke County Courthouse, Gainesville, Tex.), 4: 542 (13 Aug. 1887), 615 (29 June 1888), 5: 67-8 (10 Sept. 1888).

[21] Mitchell built bridges in Collin and Denton counties in 1886 and 1887 respectively (County Bridge Files, Environmental Affairs, Texas Department of Transportation, Austin, Tex.) ; Fulton County, *Commissioners' Record Books*, 1887-89 volumes (Auditor's Office, Fulton County Courthouse, Rochester, Ind.), 229 (27 Oct. 1888), 230 (23 Nov. 1888), 263-64 (12 Dec. 1888).

[22] "Bridges Over the Whitewater River at Richmond, Ind.," *Engineering News* 41, no. 25 (22 June 1899): 390.

It also probably had hand-twisted wire cables running beneath the deck. Longitudinal cables were a central feature of Mitchell's patent, but at Richmond he substituted a metal truss for the wood-and-metal variant of a king-post system in his patent. In 1890, Runyon would use a truss similar to that depicted in Mitchell's patent at Barton Creek. Mitchell's pipe towers were similar, but not identical to, Runyon's patents. The similarities between Mitchell's Whitewater River Bridge and Runyon's bridges raise the question of influence. Were Mitchell and Runyon familiar with each other's work? Did they adapt, license, or share technology?[23]

E.E. RUNYON

The work of Runyon and Greer will only be summarized in this overview because it has been discussed at greater length elsewhere.[24] Edwin Elijah Runyon's first recorded appearance is In 1879, in southeastern Cooke County, Texas, as a schoolteacher and then as a shopkeeper. He moved to Pilot Point in nearby Denton County in 1890. Between December 1888 and March 1893, Runyon earned six bridge patents.[25] Runyon developed a structural vocabulary based on gas-lighting pipe, handtwisted cables, and elaborate connection castings, while consistently seeking structural simplicity and economy. While other Texas suspension bridge builders made extensive use of pipe, and while Mitchell made use of handtwisted cables, Runyon's connections

[23] Mitchell apparently settled in the Fulton County seat of Rochester, Indiana, where he was issued a second patent, "Construction of Bridges," U.S. Patent No. 440, 490 (11 Nov. 1890). Special thanks to David Simmons, Ohio Historical Society, for sharing research on Joseph Mitchell in Indiana compiled by James L. Cooper, Victor C. Darnell, and Shirley Willard, Fulton County Historical Society. Cooper, to author, 5 July 2000, also reports Mitchell Bridge Company receiving contracts in Carroll and Pulaski counties, Indiana, in 1889 and 1890, respectively. The minutes of the Wayne County Commissioners, further document the construction of a "wire Bridge erected by the Mitchell Bridge Company at Tests Ford south of Richmond." They also indicate some hesitation by the Commissioners in accepting the bridge, especially since there is no evidence that the county authorized or funded construction. Perhaps Mitchell constructed the bridge as a promotion. The long panels and the low elevation surely contributed to its high deflection and its washing away in 1897. Wayne County, *Commissioners' Record Books* (Commissioners' Office, Wayne County Office Building, Richmond, Ind.), 18: 390 (2 Oct. 1889), 18: 391-92 (8 Oct. 1889).

[24] "Bluff Dale Suspension Bridge," No. TX-36; Brown, "Cable-Stayed Texas Bridges," 42-45.

[25] The patents are: Edwin Elijah Runyon, "Suspension-Bridge," U.S. Patent No. 394,940 (18 Dec. 1888); "Needle-Beam for Bridges," U.S. Patent No. 400,874 (2 Apr. 1889); "Device for Twisting Wire Cables of Suspension-Bridges," U.S. Patent No. 404,934 (11 June 1889); "Bent for Suspension-Bridges," U.S. Patent No. 410,201 (3 Sept. 1889); "Suspension-Bridge," U.S. Patent No. 446,209 (10 Feb. 1891); "Side Rail for Suspension-Bridges," U.S. Patent No. 493,788 (21 Mar. 1893). In addition, Runyon was also awarded: "Cotton-Cultivating Machine," U.S. Patent No. 412,980 (15 Oct. 1889) and "Lawn-Mower," U.S. Patent No. 445,616 (3 Feb. 1891).

are extraordinary accomplishments in design and founder's execution. Runyon's connections have an unusual complexity that suggests a lack of formal engineering training. He seemed to get an idea for a connection only to find he needed another part to keep the first in place, and perhaps a third to keep the second in place.[26] But if Runyon's wonderful and inventive mind developed visually striking and appealing connections, it is his use of a pure cable-stayed suspension system that is his most striking and telling achievement. The concept of connecting the towers directly to the deck panel-points dates at least to the late Renaissance. Throughout the nineteenth century, bridge designers experimented with a variety of suspension arrangements including pure cable-stayed and hybrid parabolic and cable-stayed systems. Examples of the latter include the Brooklyn and Waco bridges. In a situation closely parallel to north central Texas, blacksmiths in Scotland and Ireland built a series of short-span cable-stayed structures before 1834.[27] Cable stays lost favor with academically trained engineers in 1823. In that year Navier published his *Memoir sur les ponts suspendus,* arguably the most influentially treatise on suspension bridges. His negative assessment of cable-stayed bridges severely limited future development.[28] Likely neither Mitchell nor Runyon was aware of this. Regardless, they perceived a community need, seized an opportunity provided by the legislature, and sought appropriate solutions for their conditions. Despite his inventive work and despite the demand for bridges in north central Texas, Runyon's known output was only between four and six bridges.

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[26] Justin Spivey, conversation with author, fall 1997.

[27] Tom F. Peters, *Transitions in Engineering: Guillaume Henri duFour and the Early 19th Century Cable Suspension Bridges* (Boston: Birkhauser Verlag, 1987), 28; Ted Ruddock, "Blacksmith Bridges and Scotland and Ireland, 1816-1834," in *Proceedings of an International Conference on Historic Bridges to Celebrate the 150th Anniversary of the Wheeling Suspension Bridge*, ed., Emory L. Kemp (Morgantown, W. Va.: West Virginia University Press, 1999), 133-46.

[28] See David P. Billington and Aly Nazmy, "History and Aesthetics of Cable-Stayed Bridges," *(ASCE) Journal of Structural Engineering* 117, no. 10 (Oct. 1991): 3103-04.

WILLIAM GREER

William Henry Clay Greer was the last of the Texas suspension bridge patentees.[29] A resident of Sherman, Texas, Greer was neither as prolific nor as energetic an inventor as Runyon. He received four patents between 1888 and 1912, with a sixteen-year hiatus between the second and third. With his last two patents, Greer clearly had a working relationship with the Sherman Ironworks – the only documented relationship between a north central Texas suspension bridge builder and a supplier. While the Choctaw Creek Bridge is the only known surviving example of his work, Greer built bridges in Montague and Grayson counties. In many respects, his design work is in the tradition of his peers. He used such readily available materials as pipe, castings, metal rods, and wire rope. Wire rope, while cheaper than site-fabricated cables, was more cumbersome to transport and made less effective use of the strength of each wire.[30] Greer's patents make it clear that his concern was not loadbearing strength, but rather vertical oscillation of the deck. In fact, two of his patents explicitly acknowledge that the previous patent proved ineffective. His interest in this problem is understandable, because even to this day Texans refer to short span suspension bridges as "swinging bridges." From the perspective of the late twentieth century, Greer's patent designs could have been effective, or at least more effective, if he had made adjustments to his construction procedures and/or used more material. For example, the trusses Greer depicted in his second and third patents could have substantially stiffened the designs. Consistent with the origins of vernacular bridges, which are the focus of this study, Greer had neither the training to do the former, nor clients who could afford the later

When the Texas vernacular suspension bridge era came to an end, its inventors had experimented with a wide range of systems. While the designs were not always highly stable, the inventors often dared to do what "proper" engineers "knew" not to do. For a brief time, demand and limited local resources motivated these inventors in their competition with prefabricated trusses. The patent system that suspension bridge inventors shared with many truss inventors was not sufficient to guarantee either of them success. Nevertheless, Texans were grateful to have their suspension bridges, and Runyon's work in particular foreshadowed the international development of cable-stayed bridges after 1950.[31]

[29] The patents are: William Henry Clay Greer, "Suspension Bridge," U.S. Patent No. 411,499 (24 Sept. 1889); "Suspension Bridge," U.S. Patent No. 513, 389 (23 Jan. 1894); "Suspension Bridge," U.S. Patent No. 968,552 (30 Aug. 1910); "Suspension Bridge," U.S. Patent No. 1,019,458 (5 Mar. 1912).

[30] "Contextual Essay on Wire Bridges," No. NJ-132.

[31] For a brief elaboration on this point see David P. Billington and Aly Nazmy, "History and Aesthetics of Cable-Stayed Bridges," *(ASCE) Journal of Structural Engineering* 117, no. 10 (October 1991): 3103-3134; especially 3103. Texas also has an understudied tradition of timber bridges. Unlike eastern states, it does not seem

BUILDERS: WILLIAM FLINN

William Flinn was the most successful suspension bridge builder in nineteenth-century Texas.[32] Flinn was a Kansan who arrived in Weatherford, Parker County, Texas, in the early 1880s. In 1885, he was a carpenter with a small single story building at 105 Dallas Street, just northwest of the courthouse square.[33] His bridge building career can be documented from at least 1885 until his death in 1904, during which time he built bridges in at least eleven counties.[34] In November 1885, "Wm. Flinn, Contractor," was paid for three bridges and contracted to build two additional ones by the Parker County Commissioners.[35] A sign from a building completed in 1888 styles Flinn a "Contractor for Bridges and Buildings."[36] His reputation as a contractor and bridge builder may have attracted E. E. Runyon's attention. Runyon and Flinn became partners by 1890, perhaps solely for the Erath County contract of that year. Whatever the case, there is no further evidence of the partnership after the completion of the Erath County bridges. That Flinn built a ferryboat for Brannon's Crossing, later the site of a Mitchell & Pigg bridge, on the Brazos River in Parker County is an indication that he kept up his carpentry.[37] In what might have been his biggest contract to date, Flinn agreed in 1893 to build a bridge at an unspecified Parker County Brazos River crossing for $12,500. Flinn did not have the capital to finance the startup of such a costly project and offered to post a bond for $3,125. The county gave him an equal advance in return. In the 1890s, Parker County was an important cotton center and clearly had

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to have produced many covered bridges. Stocklin, "Historic Bridges of Texas, 1866-1945," Section E, 3. For another experience with timber bridges, see Donald Fraser, "Evolution of Timber Truss Road Bridges in New South Wales, Australia," in *Proceedings of an International Conference*, 157-70.

[32] For more on William Flinn see "Clear Fork of the Brazos Suspension Bridge," HAER No. TX-64. The present treatment of Flinn's career focuses on new information.

[33] *Tariff of Minimum Rates for Weatherford, Texas. To take effect Oct. 12, 1885* (Austin: Frank Stanley, Printer, n.d.), 14; Sanborn Map Company, *Weatherford, Texas* (New York: Sanborn Map Company, 1885).

[34] The counties were: Wise, Denton, Shackelford, Palo Pinto, Parker, Comanche, Erath, Johnson, Navarro, San Saba, and Bell. County Bridge Files, Environmental Affairs, Texas Department of Transportation, Austin, Tex.

[35] Parker County, *Minutes of the Parker County Commissioners' Court* (hereinafter cited as PCCC *Minutes*), (County Clerk's Office, Parker County Annex, Weatherford, Tex.), 1: 793 (11 Nov. 1885).

[36] Timothy L. Flinn Collection, Strawn, Tex.

[37] PCCC *Minutes*, 2: 285 (6 Apr. 1891).

the ambition to build such an expensive bridge. The county could finance such an undertaking bridge because of the legislature's significant county debt limit liberalization the same year. What is of further interest is that the county initially contracted with William Flinn and A. A. Moyer, but for unspecified reasons Moyer withdrew from the contract.[38] Beginning about 1896, Flinn and Moyer were regular partners on many bridge contracts. Nevertheless, Flinn often built bridges on his own despite his partnership with Moyer.[39]

In March 1904, almost three months prior to his death, Flinn was commissioned to build two monumental bridges across the Brazos River in Palo Pinto County (see Appendix Table 2). Not only do they represent the crowning achievements of his career, but they also marked the beginning of the period that saw the construction of substantially larger suspension bridges in Texas. The smallest of the two bridges, 873' long overall, crossed the Brazos River at the town of Brazos near the Texas & Pacific Railroad's bridge, and cost $15,000. Its 300' main channel span was flanked by two 150' side spans, and had 272'-6" of approaches that carried the 16'-wide roadway. The second bridge carried the Palo Pinto-Graford Road across the Brazos near the mouth of the Dark Valley Creek. The still extant south anchorages are embedded in a cliff approximately 60' above the river. Two main channel spans of 250' were flanked by 125' side spans. An additional 80' suspended span and 234' approach completed the bridge on the north. It too had a 16'-wide roadway, but cost $20,000. While both bridges had the distinctive Howe stiffening truss fabricated of pipe associated with much of Flinn's work, the towers, and the piers they rested on, were built not of pipe as at Clear Fork and Beveridge, but of riveted sheet metal filled with concrete.[40]

[38] PCCC *Minutes* 2: 494-6 (14 June 1893).

[39] No additional information came to light about Moyer in the course of the research for this report. In late August 2000, however, yet another Flinn-Moyer suspension bridge came to light. The 450' long, 280' clear span, stiffened catenary bridge crossed the Colorado River between Mills and San Saba Counties, probably on the San Saba-Goldthwaite Road. For a small picture, see Charles E. Simons, "Texas' Obsolete Roads and Bridges," *Texas Parade* 1, no. 7 (Dec. 1936), 10. Special thanks to Robert W. Jackson for calling this image to my attention. See also "Sketch, Existing Suspension Bridge, Colorado River," Texas State Highway Department, n.d., in Suspension Bridge files, Bridge Builders cabinet, Environmental Affairs Division, Texas Department of Transportation, Austin, Tex. This bridge is probably the one reproduced in the HAER Photograph No. TX-64-18.

[40] Palo Pinto County, *Minutes of the Palo Pinto County Commissioners' Court* (County Clerk's Office, Palo Pinto County Courthouse, Palo Pinto, Tex.), E: 559-67 (19 Mar. 1904), E: 627 (17 Dec. 1904), F: 6 (31 Mar. 1905). Huge concrete cylinders with the impressions of the rivet heads still visible can still be seen.

While it is not exactly certain who completed the Palo Pinto bridges, it is clear that Flinn assembled a talented team, or teams, that could complete major projects in his absence. Even today, the ruins of the Dark Valley Crossing are impressive. Most of the metal has corroded or was removed when the bridge was replaced by the Texas Highway Department in 1957, but the dramatic site, the south anchorages and the concrete that once filled the piers are testimonials to a forgotten high point in the history of Texas suspension bridges.[41]

FLINN'S SUCCESSORS: MITCHELL & PIGG

Similarities between the larger suspension bridges by Mitchell & Pigg of Parker County and Flinn's 1904 Palo Pinto County bridges suggest a continuity of personnel and technical experience. Between 1905 and perhaps the early 1920s, H. F. Mitchell and J. W. Pigg built a series of suspension bridges. Little else is currently known about the firm. The situation is further aggravated by the fact that not a single positively identified example of their work stands today. A phone directory places H. F. Mitchel in Weatherford, Texas, in 1916, and he is in Fort Worth by the 1920s. Less is known of Pigg, except he is styled "Col." in a history of the Austin Bridge Company of Dallas. Austin Bridge emerged in the 1910s as the major bridge contractor in the state. In the 1920s, Austin Bridge hired several Mitchell & Pigg employees who gradually evolved into a suspension bridge division.[42]

Surviving images and contracts give us some idea of Mitchell & Pigg's bridges. In 1905, they constructed the practically identical Brannon's Crossing and Hightower Valley bridges across the Brazos in Parker County. The former was a 440' clear span while the later, also known as Tin Top, was 400'. The 20'-high towers were made of laced steel angles resting on stone piers. Each had 600 wires per main cable and a 6' high Pratt stiffening truss. Flinn, it will be remembered, used Howe trusses, but both companies show a kinship in the manner in which the trusses are fabricated and assembled. In addition to the main cables, each bridge had two additional "floor cables" that ran at just about the level of the 3-1/2" diameter pipes that served as deck beams for the 16'-wide roadways. The contracts make no mention of the function of these cables, but each held 200 strands. These cables were certainly used as platforms during construction and were not a part of the deck system as in Runyon and Joseph Mitchell's patents. This conclusion is supported by construction photographs of what is almost certainly the Dark

[41] Rowe R. Howard, "Dark Valley Bridge," *Texas Highways* (June 1958): 5-10.

[42] *Telephone Directory of Weatherford, Texas* (N.P.: Southwester Telegraph and Telephone Company, 1916); Miller, 170-78. Miller, writing in 1974, uses the name Pigg & Mitchell, but bridge contracts use Mitchell & Pigg.

Valley Crossing Bridge and the presence of similar, but much smaller, cables at the Rock Church Bridge that carry no load.[43] Rather inexplicably, however, the contracts mention tension rods running the length of the bridge under the Brannon's Crossing and Hightower Valley decks.[44] Several other interesting features should be pointed out. Many of Mitchell & Pigg's bridges had a few wires separated out from the backstays. These wire were attached to a hook a little below the saddle castings. Engineering consultant Steven Buonopane has suggested that these may have supported the towers during construction.[45]

In 1908, Young County purchased a pair of Mitchell & Pigg's suspension bridges to cross the Brazos near Newcastle and at South Bend. Here, Mitchell & Pigg used concrete-filled steel cylinders for the towers. The main span of the Newcastle Bridge was a stunning 700', suspended from main cables of 700 wires. Mitchell & Pigg used 500 wires in each cable to support the 400' main span at the South Bend crossing of the Brazos. Consistent with practically every extant Texas suspension bridge using parallel-wire cables, and contrary to long standing practice among professional engineers, the cables in Young County were not continuously wrapped like a spool of thread. Rather, they were wrapped with a smaller gauge wire with one turn every two

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[43] "Rock Church Bridge." HAER TX-No. 81.

[44] PCCC *Minutes*, 4: 202, 203, 209-10, 312-17; T. Lindsay Baker, "Tin Top's Forgotten Twin Spanned Brazos . . . ," *Weatherford Democrat*, 18 April 1983, 7, includes a historic photograph from the William W. Tanner Papers Research Center, Panhandle-Plains Historical Museum, Canyon, Tex. The total contract price was $28,000. Photos of the construction of the Dark Valley Bridge are in the Palo Pinto County Historical Association collections, Palo Pinto, Tex., and in the Timothy L. Flinn Collection. See also HAER, Photograph No. TX-64-24 of an unidentified Flinn bridge, possihly the Brazos Bridge in Palo Pinto County.

[45] Steven G. Buonopane to William Pete Brooks, 26 June 2000. Such hooks are also found at Rock Church, further raising the possibility that it was built hy Mitchell & Pigg, or someone associated with them at one time. The saddle castings, which show evidence of a roller nest, are visually similar to Mitchell & Pigg's hridges. On the other hand, the metal work on the towers at Rock Church is distinctly substandard to the workmanship visible in the historic photographs of Mitchell & Pigg bridges. It might also be noted that the stirrups which connect the suspender rods to the deck beams at Rock Church match those used by the Austin Bridge Company (see below) at Clear Fork of the Brazos in 1926 and seen in photos of the Newcastle Bridge after it collapsed. (Photos: New Castle Bridge file, Young County, Photo Library, Texas Department of Transportation, Austin, Tex.) Austin Bridge replaced the pipes that originally served as deck beams at Newcastle during a 1925 repair. Young County, *Minutes of the Young County Commissioners' Court* (hereinafter cited sa YCCC *Minutes),* (County Clerk's Office, Young County Courthouse, Graham, Texas), 8: 104-7 (8 Dec. 1924). On the other hand, a photograph of a bridge almost identical to Rock Church is found in the Timothy L. Flinn Collection.

inches.[46] The Young County contracts give us rare details of the anchorages. At Newcastle, a 20' x 20' x 10' block of concrete encased an 18' long, 10" diameter pipe. South Bend's anchorage was a bit smaller at 20' x 20' x 6', with a 14' x 10" pipe. The last known work that can be attributed to Mitchell & Pigg was the 98th Meridian Suspension Bridge across the Red River between Clay County, Texas, and Jefferson County, Oklahoma, near Byers, Texas. It had three 567' spans, one 107' span, and could only have been financed by a toll company.[47]

FLINN'S SUCCESSORS: AUSTIN BRIDGE COMPANY

The Austin Bridge Company entered the suspension bridge business by repairing the bridges built by Mitchell & Pigg as well as those by William Flinn. Examples of their repair work can be seen at Clear Fork of the Brazos and Beveridge suspension bridges. In 1924, Austin contracted with the Nocona Bridge Company to build a 700' suspension bridge across the Red River north of Nocona, Montague County, for Harry F. Mitchell & Associates of Fort Worth. Surely this was the same Mitchell of Mitchell & Pigg then acting as a developer of Red River toll bridges. If so, it is somewhat ironic that he was using former employees at Austin Bridge. The bridge itself appears to have been an unstiffened version of Newcastle.[48] Perhaps it was difficult to maintain a stiffening truss made of pipe. Certainly, improved transportation and trail systems meant it was very easy to get rolled steel sections in Texas, but for whatever reason, Austin Bridge did not use stiffening trusses in its original construction or most major repairs.[49] In the 1920s and 1930s, Austin Bridge expanded its suspension bridge business with jobs that included many other bridges across the Red River, the 1926 Hidalgo-Reynosa Bridge across the Rio

[46] Barton Creek has one turn every four inches.

[47] YCCC *Minutes*, 6: 309 (24 Oct. 1907), 313 (31 Jan. 1908), 319-22 (10 Mar. 1908); Miller, *First 50 Years*, 170.

[48] Mary Lee Nix, "Ketchum Bluff Bridge," in *The Story of Montague County, Texas: Its Past and Present*, ed. Melvin E. Fenoglio, (n.p.: Montague County Historical Commission, 1989), 189; Miller, *First 50 Years*, 171.

[49] Another possibility is that Austin's engineers – for Austin did have professionally trained engineers in the firm--may have accepted Leon S. Moissieff's Deflection Theory that down played the need for stiffening trusses on long span bridges -- a theory generally discredited by the dramatic collapse of the Tacoma Narrows Bridge in 1940.

Grande, and the recently rehabilitated Regency Suspension Bridge of 1939.[50]

CONCLUSION

The short-span wire supported bridges of Mitchell, Runyon, Flinn, Greer, and other builders not yet documented, represent a remarkable body of inventive bridges built in response to a strong demand by a public with very modest governmental resources. These inventors responded with solutions outside the learned traditions of academic engineers and more within that of covered bridge builders and of James Finley. In 1808, Finley, a prosperous farmer and jurist living in Western Pennsylvania, patented a chain-link suspension bridge with a level roadway and a truss-stiffened deck that is generally considered the first modern suspension bridge. But the Texas inventors shared other concerns with Finley besides broad formal characteristics of their bridges. Both Finley and the Texans sought financially remunerative designs for often remote areas that could be simply constructed without the need for sophisticated mathematics.[51] Because the Texas inventors did not move in such rarified circles as Finley and because they did not publish their work or findings save as patents, we have little direct knowledge of their design methods. Whether they worked with drawings, models, or small-scale construction, however, these designers were both liberated by their apparent unfamiliarity with academic traditions and hindered by their limited conceptual knowledge of structural behavior. The results where a fascinating range of variations on an ancient theme.

The suspension bridge seems to have had a short efflorescence in Texas. While the story

[50] Miller, *First 50 Years*, 171-78; Peter Flagg Maxson, "Roma-San Pedro International Bridge," National Register of Historic Places Nomination, 1983; Texas State Highway Department, *Report, Toll Bridges & Ferries Across the Rio Grande between State of Texas and Republic of Mexico*: Texas State Highway Department, 1937), copy on file Environmental Affairs Division, Texas Department of Transportation, Austin, Tex.; No. TX-61, "Regency Suspension Bridge," The Hidalgo-Reynosa Bridge was one of four suspension bridges built across the Rio Grande by toll bridge promoter Joseph Eratus Pate. The others were Mercedes-Rio Rico (1928, 260' main span), the Zapata-Guerrero (1928, 540' main span), and the long-suffering Roma-Miguel Alemán (formerly San Pedro) (1928, 630' main span) bridges. While Austin Bridge officially claims the Hidalgo-Reynosa, and George E. Cole of Houston, Texas, is the engineer of record for Roma-San Pedro, the two bridges had a similar appearance to the Regency. The other two, namely Mercedes-Rio Rico and Zapata-Guerrero, were very different in their use of similar slender towers and very thin deck systems. Roma-San Pedro is the last survivor from the Rio Grande toll era and its rehabilitation is tied up pending international funding. For more information, see the National Register of Historic Places and the Division of Architecture files, Texas Historical Commission, Austin,Tex.

[51] Eda Kranakis, *Constructing a Bridge: And Exploration of Engineering Culture, Design, and Research in Nineteen-Century France and America* (Cambridge, Mass.: MIT Press, 1997), chapters 1 and 2.

seems to have started in the 1870s with the construction of Waco, it did not gain much strength until legislation in the late 1880s provided for a funding mechanism. Between the topography of North Central Texas and the concentration of inventive designers and entrepreneurial builders, the short span suspension bridge had some success competing with out-of-state metal truss builders. Momentum shifted away from suspension bridges and more firmly toward trusses about 1905 – shortly after the death of William Flinn. The establishment of the Texas Highway Department in 1917, in turn, had a significant impact on the variety of truss types and bridge companies in Texas.[52] By then, suspension bridges were largely limited to long-span crossings that required private funding. The age of the short-span suspension bridge in Texas came to a definitive close with World War 11.

[52] For a discussion of how the rise of state high departments impacted bridge design culture see "North Bosque River Bridge," HAER No. TX-83.

SOURCES CONSULTED

Allen, Richard Sanders. "California's Old Wooden Truss and Suspension Bridges," Paper presented at the annual meeting of the Society for Industrial Archeology, Sacramento, California, 1 June 1996.

Baker, T. Lindsay. "Tin Top's Forgotten Twin Spanned Brazos . . . ." *Weatherford Democrat*, 18 April 1983, 7.

Billington, David P. and Aly Nazmy, "History and Aesthetics of Cable-Stayed Bridges." *(ASCE) Journal of Structural Engineering* 117, no. 10 (October 1991): 3103-3134.

"Bridges Over the Whitewater River at Richmond, Ind." *Engineering News* 41, no. 25 (22 June 1899): 390.

Brown, Mark M. "Nineteenth-Century Cable-Stayed Texas Bridges." In *Proceedings – Fifth Historic Bridge Conference*, edited by David A. Simmons, 38-46. Columbus, Ohio: Fifth Historic Bridge Conference Organizing Committee, 1997.

Buonopane, Stephen G., to William Pete Brooks, 26 June 2000.

Cooke County, Texas. *Minutes of the Cooke County Commissioners' Court.* County Clerks Office, Cooke County Courthouse, Gainesville, Tex.

Cooper, James L. *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942.* n.p.: privately printed, 1997.

________. To author, 5 July 2000.

Detbloff, Henry C. *A Centennial History of Texas A&M University, 1876-1976.* College Station, Tex.: Texas A&M University Press, 1975.

Frankland, F. H. *Suspension Bridges of Short Span.* New York: American Institute of Steel Construction, 1934.

Fraser, Donald. "Evolution of Timber Truss Road Bridges in New South Wales, Australia." In *Proceedings of an International Conference on Historic Bridges to Celebrate the 150th*

Anniversary of the Wheeling Suspension Bridge, edited by Emory L. Kemp, 157-70. Morgantown, W. Va.: West Virginia University Press, 1999.

Greer, William Henry Clay. "Suspension Bridge." U.S. Patent No. 411,499 (24 Sept. 1889).

________. "Suspension Bridge." U.S. Patent No. 513, 389 (23 Jan. 1894).

________. "Suspension Bridge." U.S. Patent No. 968,552 (30 Aug. 1910).

________. "Suspension Bridge." U.S. Patent No. 1,019,458 (5 Mar. 1912).

Griffith, Thomas M. "Suspension-Bridge." U.S. Patent No. 285,257 (18 Sept. 1883).

Hamlett, Samuel B. "University of Texas at Austin." In *The New Handbook of Texas*. Vol. 6. Austin: The Texas State Historical Association, 1996.

Hankins, Mrs. Frank G. [Abstract of] *1880 Federal Census Montague County from Microfilm T9-M1320*, TS, n.d., on deposit in the Bowie Public Library, Bowie, Tex.

Howard, Rowe R. "Dark Valley Bridge." *Texas Highways* (June 1958): 5-10.

Jakkula, Arne A. "A History of Suspension Bridges and Bibliographical Form." *Bulletin of the Agricultural and Mechanical College of Texas*, 4th ser., vol. 12, no. 7 (1 July 1941).

King, Joseph E. *A Historical Overview of Texas Transportation, Emphasizing Roads and Bridges*. Unpublished T.S. on deposit with Environmental Division, Texas Department of Transportation, Austin, Texas. Lubbock, Tex.: Center for History of Engineering and Technology, Texas Tech University, n.d.

Kranakis, Eda. *Constructing a Bridge: An Exploration of Engineering Culture, Design, and Research in Nineteen-Century France and America*. Cambridge, Mass.: MIT Press, 1997.

Maxson, Peter Flagg. "Roma-San Pedro International Bridge." National Register of Historic Places Nomination, 1983. Copy on file, Environmental Affairs Division, Texas Department of Transportation, Austin, Tex.

Miller, Shannon. *The First 50 Years: 1918-1968.* Dallas: Austin Bridge Company, 1974.

Mitchell, Joseph. "Bridge." U.S. Patent No. 368,483 (16 Aug. 1887).

________. "Construction of Bridges." U.S. Patent No. 440,490 (11 Nov. 1890).

Montague County, Texas. *Minutes of the Montague County Commissioners' Court.* County Clerk's Office, Montague County Courthouse, Montague, Tex.

Nix, Mary Lee. "Ketchum Bluff Bridge." In *The Story of Montague County, Texas: Its Past and Present,* edited by Melvin E. Fenoglio, 189. n.p.: Montague County Historical Commission, 1989.

Palo Pinto County, *Minutes of the Palo Pinto County Commissioners' Court.* County Clerk's Office, Palo Pinto County Courthouse, Palo Pinto, Tex.

Parker County. *Minutes of the Parker County Commissioners' Court.* County Clerk's Office, Parker County Annex, Weatherford, Tex.

Palo Pinto County Historical Association Collections. Palo Pinto, Tex.

Photo Library, Texas Department of Transportation, Austin, Tex.

Polk, R. L. and Co. *Texas State Gazetteer and Business Directory.* Vol. 4. St. Louis: R. L. Polk & Co., 1892.

Ruddock, Ted. "Blacksmith Bridges and Scotland and Ireland, 1816-1834." In *Proceedings of an International Conference on Historic Bridges to Celebrate the 150th Anniversary of the Wheeling Suspension Bridge,* edited by Emory L. Kemp, 133-46. Morgantown, W. Va.: West Virginia University Press, 1999.

Runyon, Edwin Elijah. "Suspension-Bridge." U.S. Patent No. 394,940 (18 Dec. 1888).

Sanborn Map Company. *Weatherford, Texas.* New York: Sanborn Map Company, 1885.

Simmons, David A. "'Light, Aerial Structures of Modern Engineering': Early Suspension Bridges in the Ohio Valley," in *Proceedings of an International Conference on Historic Bridges to Celebrate the 150th Anniversary of the Wheeling Suspension Bridge*, edited by Emory L. Kemp, 73-86. Morgantown, W. Va.: West Virginia University Press, 1999.

Simons, Charles E. "Texas' Obsolete Roads and Bridges." *Texas Parade* 1, no. 7 (Dec. 1936): 10-11.

Steely, Jim. Conversation with author, 23 Aug. 2000.

Stocklin, Barbara. "Historic Bridges of Texas, 1866-1945." National Register of Historic Places Nomination, 1966. Copy on deposit with Environmental Division, Texas Department of Transportation, Austin, Tex.

Suspension Bridge files, Bridge Builders cabinet, Environmental Affairs Division, Texas Department of Transportation, Austin, Tex.

Tariff of Minimum Rates for Weatherford, Texas. To take effect Oct. 12, 1885. Austin, Tex.: Frank Stanley, Printer, n.d.

Texas State Highway Department. *Report, Toll Bridges & Ferries Across the Rio Grande Between State of Texas and Republic of Mexico.*: Texas State Highway Department, 1937. Copy on file with Environmental Affairs Division, Texas Department of Transportation, Austin, Tex.

Timothy L. Flinn Collection, Strawn, Tex.

Historic American Engineering Record (HAER), National Park Service, U.S. Department of the Interior. "New Portland Suspension Bridge," No. ME-3.

________. "Contextual Essay on Wire Bridges," No. NJ-132.

________. "Lower Bridge at English Center," No. PA-461.

________. "Kellams Bridge," No. PA-470.

________. "Waco Suspension Bridge" No. TX-13.

________. "Bluff Dale Suspension Bridge," No. TX-36.

________. "Beveridge Bridge," No. TX-46.

________. "Regency Suspension Bridge," No. TX-61.

________. "Clear Fork of the Brazos Suspension Bridge," No. TX-64.

________. "Rock Church Bridge," No. TX- 81.

________. "North Bosque River Bridge," No. TX-83.

________. "Choctaw Creek Bridge," No. TX-85.

________. "Barton Creek Bridge," No. TX-87.

________. "Structural Study of Texas Cable-Supported Bridges," No. TX-104.

________. "Chow Chow Suspension Bridge," No. WA-5.

________. "Nisqually River Suspension Bridge," No. WA-44.

Vogel, Robert M. *Roebling's Delaware & Hudson Canal Aqueducts*. Smithsonian Studies in History and Technology, No. 10. Washington, D.C.: Smithsonian Institution Press, 1971. Reprint, Philadelphia: Eastern National Park and Monument Association, 1994.

Wayne County, Indiana. *Commissioners' Record Books*. Commissioners' Office, Wayne County Office Building, Richmond, Ind.

Young County, Texas. *Minutes of the Young County Commissioners' Court*. County Clerk's Office, Young County Courthouse, Graham, Tex.

Table 1. Extant Suspension Bridges Built in Texas Before 1940.
Compiled by J. Philip Gruen, 1996; revised by Mark M. Brown, 2000

BRIDGE	HAER No.	LOCATION	BUILDER	TYPE	SPAN	YEAR
Waco	TX-13	Over the Brazos River, Waco, McLennan County	Thomas M. Griffith	Catenary with stays	475' clear span	1870; rebuilt 1914
Barton Creek Bridge	TX-87	Off County Road 119, Erath County	Runyon Bridge Co., Weatherford, Texas	Cable-stayed	100' clear span	1890
Bluff Dale Suspension Bridge	TX-36	County Road 149 over the Paluxy River, Bluff Dale, Erath County	Runyon Bridge Co., Weatherford, Texas	Cable-stayed	140' clear span	1891; moved 1935
Clear Fork of the Brazos Suspension Bridge	TX-64	County Road 179 over Clear Fork of the Brazos River, Shackelford County	Flinn-Moyer Co., Weatherford, Texas	Catenary, probably with stays	140' clear span	1896
Beveridge Bridge	TX-46	County Road 112 over San Saba River, San Saba County	Flinn-Moyer Co., Weatherford, Texas	Catenary with stays	140' clear span	1896
Choctaw Creek Bridge	TX-85	Over Choctow Creek, Grayson County	William Greer, Sherman, Texas	Catenary	120' clear span	ca. 1915
Rock Church Bridge	TX-81	Over the Paluxy River, near Tolar, hood County	Unknown	Catenary with stays	110' clear span	ca. 1917
Roma-Roma-Miguel Alemán (formerlySan Pedro) International Bridge	--	Over Rio Grande, Roma, Starr County, and Ciudad Alemán, Mexico	George E. Cole, Engineer	Catenary	630' clear span	1928
Regency Suspension Bridge	TX-61	Over Colorado River, near Bend, San Saba-Mills Counties	Austin Bridge Company	Catenary	340' clear span	1939

Sources: County Bridge Files, Environmental Affairs Division, TxDOT, Austin, Texas; HAER reports.

Table 2. William Flinn's 1904 Palo Pinto County Suspension Bridge Specifications

	Dark Valley Crossing Bridge	Brazos Crossing Bridge
Overall length	1064'	873'
Main span(s)	two spans @ 250'	300'
Secondary spans	two 125' side spans & 80' span on north	two 150' spans
Approaches	234' iron approach on north	58'-6" approach on west & 214' approach on east
	400* wires per cable	300 wire per cable
Price	$20,000	$15,000
Date accepted	17	31 March, 1905
Common features: 16' roadways; 7" diameter x 10' long pipe anchor bars; concrete filled channel piers 6' diameter at base; roller saddles; No. 9 galvanized steel wire; 1" diameter suspender rods 10' intervals connected to 3" diameter pipe floor beams, truss-stiffened spans.		

Source: Palo Pinto County, *Minutes of the Palo Pinto County Commissioners' Court*, E, 559-67 (19 March, 1904). (Contract included a third bridge for $1,200.)
*Diameter of cables embedded in the south anchorages is approximately 6".