The John A. Roebling Suspension Bridge: Washington Roebling's History

By: Don Heinrich Tolzmann

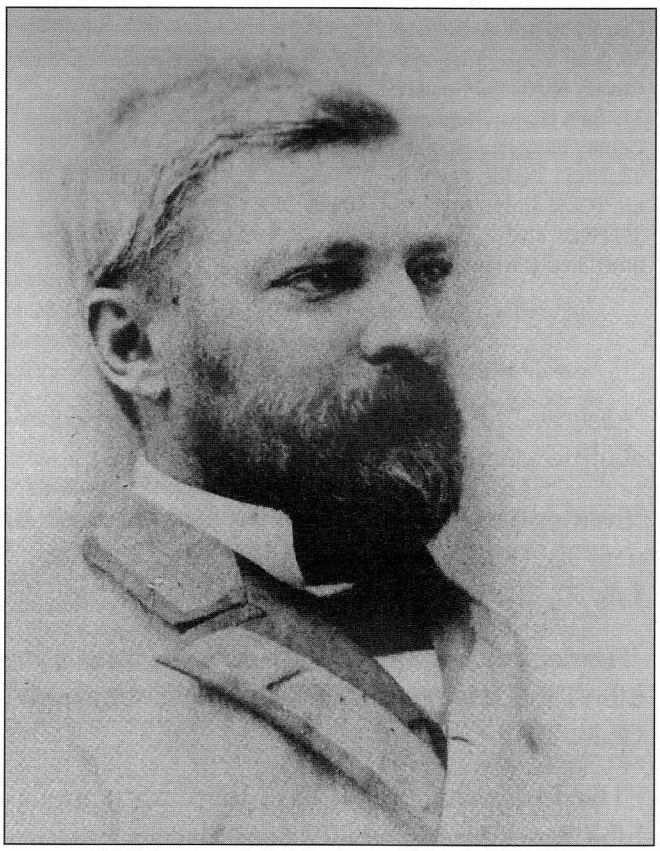
Introduction

My research on John A. Roebling (1806-69) and his Suspension Bridge on the Ohio River has caused me to be ever on the lookout for new items of interest. So, when I came upon a previously unpublished history of the bridge by Roebling's son, Washington (1837-1926), my interest was naturally piqued. Washington had firsthand knowledge of the bridge, as he served as Assistant Engineer for its construction along with his father, its Engineer-in-Chief and Superintendent. In addition to explaining how and where I located his history, this article aims to make it available for the first time in published form.[1]

The Roebling Collection

The Roebling Collection at the Rensselaer Polytechnic Institute in Troy, New York documents the personal and professional activities of John A. Roebling and Washington A. Roebling; and the business activities of the John A. Roebling's Sons Company. The material dates from 1824 to 1926 with the bulk of the material dating from 1844 to 1883, the period when John A. Roebling and Washington A. Roebling were active in the design and construction of suspension bridges and the manufacture of wire rope.[2]

In conducting research on the Covington and Cincinnati Suspension Bridge, now known as the John A. Roebling Suspension Bridge, I have often been in touch with Jenifer Monger, Assistant Institute Archivist, with regard to items in the Roebling Collection. Fortunately, there is an excellent online inventory of the collection, guiding researchers such as myself to relevant items of interest. The collection consists of eleven Series, or sections, with Series II devoted to Washington A. Roebling materials. In going through this part



Courtesy: the author's collection

Washington A. Roebling

of the inventory, I came upon an item titled "Covington & Cincinnati Bridge History," which caught my attention. This particular item is in Sub-Series C, which contains "Project Proposals," and is in Box 14, Folder 8.[3] This is described in the inventory as "Bridge proposals including correspondence, notes, drawings, specifications and estimates made by Washington A. Roebling. The proposals include several military bridges designed by Roebling during the Civil War, consultations on and histories of bridges built by John A. Roebling, and the Hudson River Bridge, which Roebling endorsed."[4]

So, I contacted Jenifer Monger and ordered a copy of the item. It consisted of an 11 page handwritten history of the construction of

the bridge, but was simply labeled: "III. Cincinnati." This indicates that Washington most likely wrote it as the third chapter of a larger work on bridges built by the Roeblings. The Washington A. Roebling part of the Roebling Collection contains numerous folders dealing with other bridges, and the other parts of this work are most likely to be found there.

My focus, of course, was on what Washington had written on the Roebling Suspension Bridge. His history struck me as worthy of editing for publication, and that it would supplement information already available on the construction of the bridge. Additionally, it would shed light on Washington himself, and how he described the bridge.[5]

Washington's style of writing is quite unique, and immediately recognizable to anyone who has closely read the biography he wrote of his father. Donald Sayenga, a fellow Roebling historian, comments on Washington's writing style in his Preface to this work, which he edited for publication. They are equally relevant for Washington's history of the Suspension Bridge.[6] Sayenga describes Washington's style as laconic, ironic, and stoic. The latter two adjectives do not relate to this piece, but the first one, laconic, certainly does. The dictionary definition is "using or marked by the use of few words; terse, concise." This style stands in sharp contrast to the writing style of Washington's father who had written a lengthy report on the construction of the Ohio Bridge that is finely polished, even eloquent at times.

In addition to being too long, Washington felt his father's report was "dry," which it definitely was not, but his thought on this reflects what a different style of writing he had.[7] His writing is decidedly on the lean side. By way of comparison, the two reports on the construction of the bridge by John A. Roebling and E.F. Farrington might be taken into consideration. The former consists of almost ninety pages, the latter of twenty pages of printed text. This compares to Washington's eleven-page manuscript.[8]

Sayenga also writes of Washington's biography of his father: "Washington was neither omniscient nor infallible. The document exhibits significant omissions and quite a few errors."[9] As to omissions, Washington leaves out several topics that were in his father's report. There are eleven chapters in that report, but only eight parts to Washington's history. The topics not covered by him were: social, financial, and commercial questions; engineering and superintendence; and table of quantities. As to errors, there are spelling mistakes, and they have been left to stand as written by Washington. Sayenga also notes that Washington's punctuation "does not follow any standard rule."[10] This is also true for Washington's history. For example, in one sentence Washington writes "Reg" with no period for an abbreviation, which I took to mean: "Regarding." In this and other cases, I added words in parentheses.

In editing Washington's biography of his father, Sayenga found it necessary to create paragraphs where they seemed appropriate. Washington's history does have paragraphs, but in certain places it is difficult to know if there is a paragraph break or not. So, to facilitate reading of the text, I have also created new paragraphs. Sayenga also created chapters for the manuscript he edited, and following his example, I have numbered the various parts of Washington's history.

It is impossible to say when the history was written, as there is no date on it. Since it does not discuss the reconstruction of the bridge in the 1890s, however, it must have been written prior to that.

Washington Roebling's History of the Bridge (General Remarks)

Among the western waters, which form the great commercial channels, the Ohio river is one of the greatest and noblest and most important. Beginning at Pittsburgh and emptying in the Mississippi, its long course is wound through a beautiful country, fertile in soil and rich in mineral wealth. Both shores are lined with many and thriving villages, towns and cities, all of which are places of commerce and industry.

About half way in its course, when at the same time washing the shores of the state of Kentucky and

Ohio, it touches Cincinnati, the Queen City of the West. Hundreds of barges, flatboats, steam tugs and splendid stern wheel steamers collect here, to bring and to take the products of the soil or the fabrics of all kinds of industry.

This extensive navigation demands that no impediments shall be placed in the river; therefore, wherever two communities on opposite shores desire communication by means of a bridge, this bridge should be of great span and at a high elevation. With this view all bridges across this river have been constructed; all are imposing structures, though some fulfil the conditions for free navigation only partially.

Among these we may mention the splendid railroad bridge at Steubenville, Bellair (Bellaire), Parkersburg, Louisville, the great suspension bridge by Wheeling and others, all of which are counted among the largest bridges of the country, which testify of the enterprise and wealth of the communities and of the skill of the Engineers. But eclipsing all in beauty and grandeur, the great suspension bridge, which connected the city of Covington with Cincinnati, the Kentucky with the Ohio shore, stands foremost not only of those already named, but of any other bridge on either side of the Atlantic.[11]

This remarkable bridge was built by John A. Roebling.[12]

General Description

The width of the river at this place is 1005 feet, and the bridge, with a view of offering no obstruction whatever to navigation, was planned with a single span of 1057 feet from the centre of towers and with a clear height of 103 feet above low water. Between the towers and the end abutments there are two small spans of 281 feet each, making the total length of the bridge 1619 feet.

The floor of the bridge is composed of a strong wrought iron frame, overlaid with several thicknesses of plank, and suspended by two cables by means of suspenders attached every five feet. The suspenders are between the roadway and the sidewalks. The latter are 7 feet wide and are protected by iron railings towards the river. The roadway is 20 feet wide and forms two tracks of four lines of tram way, on which the wheels run, each tram being 14 inches wide to accommodate all gauges. The whole width of the floor between the outside railings is 36 feet.[13]

Towers and Anchorages

Each tower rests on a timber platform, 110 feet long 75 feet wide and 12 feet high, composed of 12 courses of all kinds of timber, as white pine, oak, maple, hickory, elm, beech, cottonwood, etc. The excavation for the platforms was carried 12 feet below extreme low water mark, where a solid bed of gravel and coarse sand offered a good foundation, which was deep enough to keep the upper course of the timber always below the low water mark.

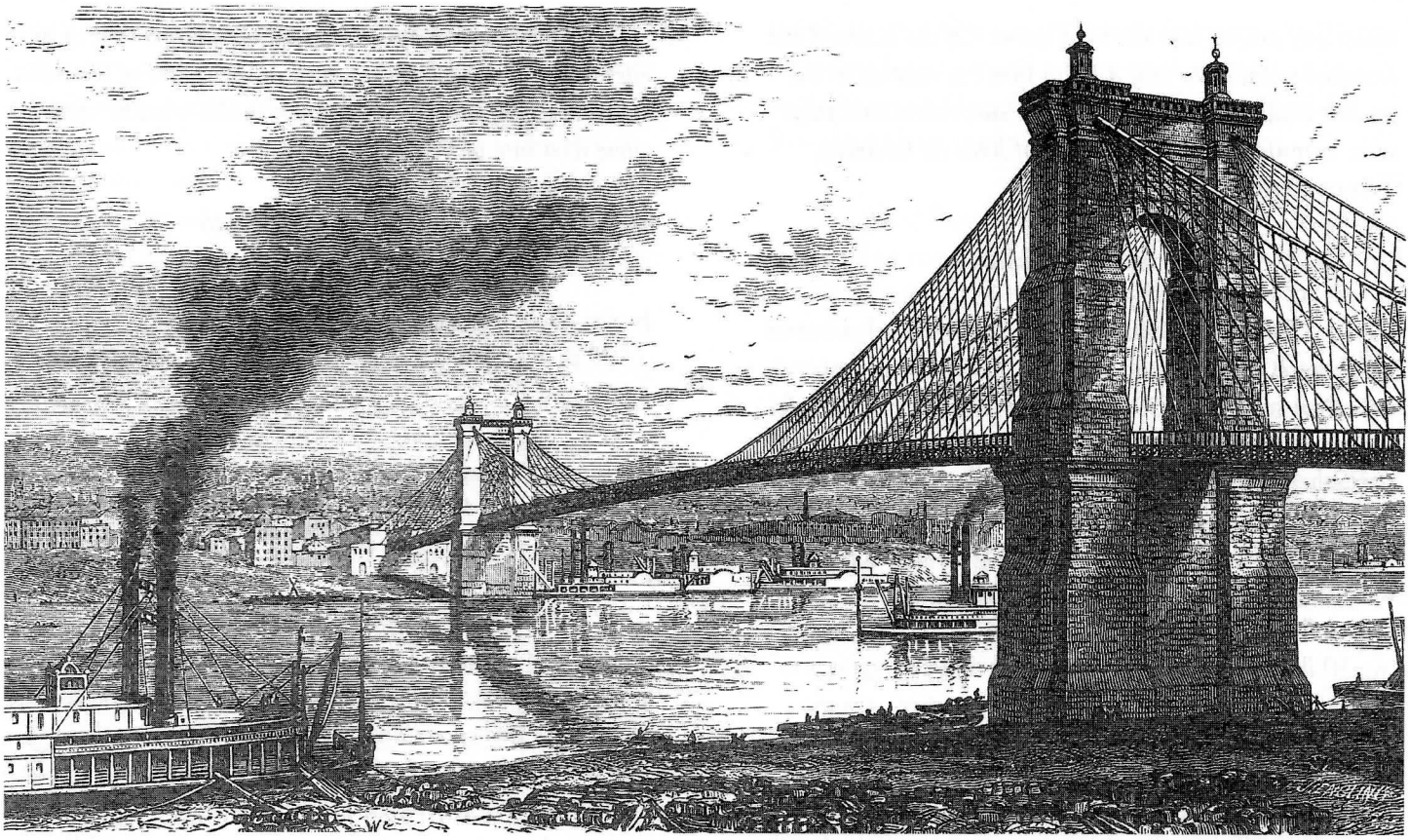
The base of each tower is 82 feet long in the direction of the river, with a width of 52 feet. This mass however is not solid, but intercepted by recesses giving the base the form of a double cross. Above the floor of the bridge, the tower is composed of two solid shafts connected above by a semicircular arch, forming an archway of 30 feet width and 85 feet height. Massive cornices with balustrades crowning the tops, and two ornamental turrets on each finish the architectural appearance of the towers. Their total elevation is 230 feet above the water mark.

Each tower contains about 400,000 cut feet of masonry, consisting mainly of sandstone from the Buena Vista quarries, only the base and upper offset being of limestone.

Four heavy cast iron saddles with an easy curvature for the support of the cables, are placed on the summit of the towers. Each rests upon 32 rollers and these are supported by the bed plate, a casting 11 feet long and 8 feet wide.

The anchor walls consist of bodies of masonry 104 feet long by 58 feet wide at the base, battering towards the top, and built in two parts connected by an arch above the top, the total height above the floor 40 feet. Above the floor they form two parallel walls, each 75 feet long, 12 feet wide and 25 feet high, which enclose the roadway, leaving a space of 24 feet in the clear.

Imbedded in these walls are the wrought iron anchor chains. Each chain is composed of 9 links of 14 and 15 bars alternately at the lower end, increasing to 17 bars at the upper end. Each bar is 10 feet long 9 inches wide and 1 2/3 in. thick, making a solid section of 190 sq. in. in the upper link end of 168 sq. in in the lower link.



Courtesy: the author's collection

The John A. Roebling Suspension Bridge at Covington

Reg (Regarding) the curvature of the chains, the two lowest links are brought into a vertical position and are attached to massive anchor plates, cast of superior quality of cold blast charcoal metal. These plates are of an elliptical shape, one axis measuring 17 ft., the other 14 ft., but radiating in form, like a spoke wheel without rim. The centre part, through which the chain passes, has a thickness of 18 inches and the total weight of one plate is 12 tons.

The body, which may be considered as resting immediately upon the two plates of one anchorage, including the portion above the floor, is about 112,000 cub. ft., weighing 8400 tons.

Cables

The bridge floor is suspended to two cables. Each cable is composed of 5180 wires, No. 9 gauge, and forms a cylinder of 12 1/3 in. diameter. Eighteen feet of this wire weigh one pound and 60 wires have an aggregate metal section of 1 square inch.

The deflection of the cables is 89 feet at a medium temperature. In the manufacture of these cables the same method was employed as for the cables of the Niagara Bridge, which has been described above. It required for the construction of both cables, including the erection of a temporary foot bridge and putting up all the necessary machineries, about one year, 8 months of which were consumed in actual cable making. The total quantity of wire, worked into the cables, including wrapping, amounts of 1,050,183 pounds.[14] *For the wrapping No. 10 annealed wire was used. The wire was manufactured by Richard Johnson & Nephew, Manchester, England.*

Suspenders and Stays

The weight of the floor for a length of 5 feet is 11,365 lbs., which by an ordinary crowd of people may be increased to 16,165 lbs. To support this, there are two suspenders, each of a strength of 45 tons.[15] *Those sent to the towers are reduced in strength to 36 tons, because they are assisted by 19 stays of 2 ¼ in. diameter, which descend from the top of each tower in straight lines to different points in the floor.*

Eight of these stays are attached to the saddle plate, while the remaining 11 pass over the summit of the

tower and extend into the land spans. Of the latter, 8 are fastened to the floor and 3 to an iron bar secured in the anchor wall. All wire ropes for the suspenders and stays were manufactured at the works of John A. Roebling, Trenton, N.J.

Floors and Trusses

The floor planks are supported by 7 inch I beams, weighing 20 lbs. per foot, placed 5 feet apart, corresponding to the suspenders. As no outside cables are employed for the support of the footways, the ends of each beam are strengthened by flat bars 7 ft. long, 6 ¾ in section, riveted to the side of the stem. (16) Under the roadway each beam is further strengthened by truss rods, which pass under the centre girders. The latter are 12 in. deep, weighing 40 lb. per foot. An other line of 9 inch girders weighing 30 lb. per lineal foot, rests on top and corresponds to the lower line. Both are bolted firmly together with the enclosed floor beam and form a continuous girder of 28 inches depth, which adds materially to the stiffness of the floor.

The principal vertical rigidity of the floor is obtained by two trusses, which separate the roadway from the sidewalks. They are 10 feet high and are formed of top and bottom chords, connected by vertical posts and diagonal ties. Each chord consists of two 9 inch channel bars, separated by the upright 7 inch I post. The diagonals are flat bars 3 in. wide by 2/3 in. thick. In order to allow for expansion and contraction in consequence of variations of temperature, "slip-joints" are employed in the splices of all continuous longitudinal girders or chords.

The flooring of the roadway is composed of 3 thicknesses of plank, making a total average thickness of 8 inches. Most of this plank is oak.[17] *The two lower courses are laid lengthwise, the upper crosswise, to every layer a mixture of coal tar and rosin in a hot state has been copiously applied to keep the water out from between the courses.*

The sidewalks are composed of two courses of plank 2 ½ inches thick each; the lower of white pine, the upper of oak.[18]

Neat iron lattice railings, 4 feet high, protect the sidewalks and add to the appearance as well as to the stiffness of the bridge.[19]

The general appearance of the floor is that of an easy curved arch, having its apex in the centre of the main span, to which the ascent from both sides must be overcome at a rate of 4.77 feet in 100 feet.

Weight and Strength

The weight of the main span of the Cincinnati bridge, including cables, suspenders, stays, etc. is nearly 1500 tons adding 30 lb per sq. ft. of floor – 360 – total 1860 tons.[20]

Opposed to this is the strength of the two cables, amounting to 8423 tons, strength of 76 stays 6840. Total 15264 tons.

Taking the stiffness of the trusses in consideration, which support themselves for a considerable distance from the towers, this load will produce a maximum tension in the two cables and stays of 2598 tons or about one sixth of their combined ultimate strength.

Assuming an uplifting wind pressure of 50 lb. per sq. ft, the total force would amount to 900 tons, to which is opposed the weight of the floor and the resistance of the anchors in the towers, amounting together to 1800 tons. Hence the simple weight of the structure itself is ample to resist such a power, while the floor has so much inherent stiffness, that no breaking up in parts can take place.[21] *The horizontal action of the winds is opposed by the "cradling power" of the cables and a number of horizontal floor stays, which are secured to the towers and diverge to different points of the floor.*

Time of Building

`The work on the Cincinnati bridge was commenced in September 1856. The financial crisis of 1857 and later the Civil War causing a check in its progress of 5 years, it was taken up again in 1863 and completed in 1867. Since January 1st of that year, it forms the great public highway between Covington and Cincinnati.[22] *The total cost for the whole structure was 1 ½ millions of dollars.*[23]

Conclusion

The reports by John A. Roebling and E.F. Farrington appeared in 1867, but Washington's history has remained unpublished until now. Of

the three, his is the shortest, consisting only of an eleven-page manuscript. Its brevity reflects not only the laconic nature of its author, but also the fact that it appears to have been written as a chapter of a book on bridges. As such, it most likely did not aim to be an in-depth, lengthy treatment of the topic, but rather a brief survey.

It might be said that Washington's history is of interest for no other reason than that he wrote it. However, it is also of value as it shows what topics and points he considered important enough to be highlighted in his history of the bridge. It also is clear that he had his father's 1867 report in hand while writing his history, and drew from it freely.

In addition to the three works mentioned thus far, there is another more personal account of the construction of the Suspension Bridge by Washington that can be found in his biography of his father. It is in a chapter entitled "The Ohio River." (24) According to Sayenga: "In this chapter Washington has provided us with many details about the erection sequence of the original bridge that are not available elsewhere."[25] In addition to technical topics, Washington covers the human side of the equation, commenting on his father, and other persons as well.[26] So this chapter looks to supplement Washington's history with sequential, as well as personal information. Like his history, it remained unpublished until recently.

Standing alone, however, Washington's history does provide an interesting and informative account of the building of the bridge, but one that is confined to the basic facts. It also demonstrates that Washington is just as fascinating as his father, and the bridges they built.[27]

Acknowledgements

I would like to thank the Institute Archives and Special Collections of the Rensselaer Polytechnic Institute for permission to publish Washington Roebling's history, which is in the Roebling Collection there. The citation for this manuscript is: Roebling collection, MC 4 Institute Archives and Special Collections, Rensselaer Polytechnic Institute, Troy, New York. And I would especially like to thank Jenifer Monger, Assistant Institute Archivist for providing me with a copy of the manuscript, and helping with my research of materials in the Roebling Collection.

Also, I would like to thank Donald Sayenga for reading my article, and his helpful comments on it. He was general manager of Bethlehem Steel's wire rope division, which acquired the Roebling trade name in 1973, and is the author of *Ellet and Roebling* (Easton, Pennsylvania: Canal History and Technology Press, 2001). His comments were especially appreciated, since he was quite familiar with Washington's writing style, having edited *Washington Roebling's Father: A Memoir of John A. Roebling* (Reston, Virginia: American Society of Civil Engineers, 2009).

Endnotes

1. Here it should be noted that Washington served in the Union Army from 1861 to 1864, and that he arrived in Covington on 10 March 1865 to begin work as Assistant Engineer. Prior to that time, John A. Roebling had the assistance of two other civil engineers. He wrote of them as follows: "When the foundations were commenced in 1856, I was assisted by Mr. G.A. Gower, civil engineer, whose connection with the work continued until the year 1863, when he resigned. The services of Mr. George W. Fulton, civil engineer, were subsequently engaged to superintend the laying of the Covington anchorage, and the continuation of the masonry of the tower on that side during the year 1864. My eldest son, Col. Wash. A. Roebling, after four years of service in the Army of the Potomac, was then engaged as my assistant, and he has taken a very active share in its superintendence every since. As engineer-in-chief, I owe all these gentlemen an acknowledgement for their valuable and faithful services." See: John A. Roebling, "*Report of John A. Roebling, Civil Engineer, to the President and Board of Directors of the Covington and Cincinnati Bridge Company, April 1st, 1867,*" in: *Annual Report of the President and Directors to the Stockholders of the Covington & Cincinnati Bridge Company, for the Year ending Feb. 28th, 1867* (Trenton: Murphy & Bechtel, Steam Book and Job Printers, 1867), p. 89.
2. See: http://archon.server.rpi.edu/archon/index.php?p=collections/controlcard&id=78.
3. *Ibid.*
4. *Ibid.*
5. For further information on Washington Roebling, see: Don Heinrich Tolzmann, *The Roebling Suspension Bridge: A Guide to Historic Sites, People, and Places*. (Cincinnati: Archivarium Press, 2017), pp. 27-37 and: Erica Wagner, *Chief Engineer: Washington Roebling; The Man Who Built the Brooklyn Bridge* (New York: Bloomsbury, 2017).
6. See: Donald Sayenga, ed., *Washington Roebling's Father: A Memoir of John A. Roebling* (Reston, VA: American Society of Civil Engineers, 2008), pp. xviii-xxi.
7. *Ibid*, p. 9.
8. For the reference to John A. Roebling's report, see footnote no. 1. For Farrington's report, see: E.F. Farrington, *The John A. Roebling Suspension Bridge: A Full and Complete Description with Dimensions and Details of Construction by E.F. Farrington*. Edited by Don Heinrich Tolzmann. Foreword by Paul A. Tenkotte (Milford, Ohio: Little Miami Publishing Co., 2016), pp. 21-41.
9. Sayenga, p. xix.
10. *Ibid*, p. xx.

11. For more detailed introductory information, see: Roebling, pp. 14-26, and: Farrington, p.21.
12. Here it is interesting that Washington makes no mention of his work on the construction of the bridge, and only praises his father. Farrington, however, does mention that Washington served as Assistant Engineer for this project. See: Farrington, p. 22.
13. For information on the towers and anchorages, see: Roebling, pp. 26-46, and: Farrington, pp. 22-26.
14. This sentence is drawn directly from John A. Roebling's report, and demonstrates that Washington had his father's report in hand while writing this work. See: Roebling, p 53. For Farrington's discussion of the cables, see: Farrington, pp. 28-31.
15. Text from: Roebling, p. 55. See: Farrington, pp. 31-32 for his discussion of suspenders and stays.
16. Text from: Roebling, p. 59. See: Farrington, 32-33 for his treatment of the floors and trusses.
17. Text from: Roebling, p. 62. For Farrington's discussion of planks, see: Farrington, p. 34.
18. Text from: Roebling, p. 62. For Farrington's text on the sidewalk, see: Farrington, p. 34.
19. Text from: Roebling, p. 62. Regarding Farrington's discussion of the railings, see: Farrington, p. 34.
20. Text from: Roebling, p. 69.
21. Text from: Ibid, p. 72. For Farrington's comments on the strength of the bridge, see: Farrington, p. 32.
22. John A. Roebling and Farrington both cover the benefits of the bridge for the region. See: Roebling, pp. 85-88, and: Farrington, p. 37.
23. For a list of various statistics about the bridge, see: Roebling, p. 92, and: Don Heinrich Tolzmann, *John A. Roebling and His Suspension Bridge on the Ohio River* (Milford, Ohio: Little Miami Publishing Co., 2007), p. 53.
24. Sayenga, pp. 195-211.
25. *Ibid*, p. 195-96.
26. For example, Washington writes of his father: "Few people that I ever met possessed such an amount of vital energy, coupled at the same time with an amazing perseverance which never rested, week day or Sunday – from early morn to dewy eve and later. His mind was incessantly at work – We all know that mere thought without expression or action is useless – His every thought was at once put down in the shape of a drawing a plan or in writing…" See: Sayenga, p. 210. Washington also comments on how exhausted he was from the Civil War experience, followed by his work on the Suspension Bridge: "My four years of service had left me with broken down nerves, the incessant excitement, risk of life, and hardships leave their mark. The building of a large Suspension Br. is nearly as bad – There is the constant risk from high winds, the dangerous work aloft, requiring the steadiest nerves to keep from being dashed to pieces below – In recognition of these conditions it was planned that I should make a short trip to Europe with my wife (my first voyage." Washington and his wife then sailed for Europe on 1 July 1867, and spent much of the time there (nine months) in Mühlhausen, his father's hometown in Thuringia. See: Sayenga, p. 210.
27. For a concise history of the Ohio River bridge, see: Ralph Wolff, "John A. Roebling Suspension Bridge," in: Paul A. Tenkotte and James C. Claypoole, eds., *The Encyclopedia of Northern Kentucky* (Lexington: University of Kentucky Press, 2009), pp. 490-93. For information on the reconstruction of the bridge, see: Don Heinrich Tolzmann, ed., *The Roebling Suspension Bridge: Wilhelm Hildenbrand's Report on Its Reconstruction in the 1890s* (Cincinnati: Archivarium Press, 2018).