

Statement, showing W. M. Roberts' tunnel experience before bidding in Brazil.

Public Work	Length	Width	Height	Area	Arch	Temporary Timbering	Kind of Material	Remarks
	Feet	Feet	Feet	Square Feet				
Union Canal Pennsylvania	729	18	14	252	none	none	Hard, slaty Limestone.	Canal boats, small size.
Cremansville ditto inside of (Canal) Pennsylvania	850	23	22	506	} Part of afterwards most of the tunnel.	} none	} Sandstone.	Side Walls and Arches 18 inches thick. The rock in this tunnel was self supporting, but as blocks of rock occasionally fell from the roof, it was decided, after the Canal had been opened for use, to arch it.
Masonry	18, 16	18	about 300					
Portage R. Road ditto inside of Pennsylvania	901	25	21	525	} 300	} none	} Sandstone	All the rock was self sustaining, but the Engineer in Chief, Sylvester Welch Esq, required 150 ft. at each end to be arched, Con- trary to my judgment. I saw no necessity for more than 50 ft. at each end.
Masonry	22	18	about 350					
Grant's Hill. Pittsburgh. (Canal) Pennsylvania	810	22	22	about 430	} 810	} Partially in spots.	} Slate Rock and Earth	This tunnel was first driven through under a hope that the rock in most of it would be sufficiently strong without artificial support. It eventually proved quite different and very troublesome. At length the entire hill was excavated as an open cut. It was then arched, and the hill again filled in over it. Side Walls and Arch 2 feet thick.
	18	18	about 290					
Harrisburg and Lancaster Rail Road. Pennsylvania	*900	25 *23 15	19 *17 16	425	} 800	} Sands Much of it timbered.	} Sandstone Rock - sand, & boulders & trap rock.	The Harrisburg and Lancaster Tunnel, was originally tunneled 900 ft; then 100 ft. at the South End Caveed, and was made open cut. Shaft in middle 64 feet deep. This was the most dangerous and troublesome tunnel ever executed in Pennsylvania, owing to the treacherous nature of the sand and parts of the rock. It had to be timbered on a large portion with heavy timber: set so that the bottoms of the timber were higher than the top of the arch. After completion, ready for opening, the Directors, yielding to a senseless outside clamor, resolved to reduce the size to a single track only 15 feet wide inside; making the side walls 5 feet thick. The arch was 2 feet thick. A temporary track, with 250 feet per mile grades, was laid over the hill, and used for about 9 months.
Inside of Arch								
Sandy Beaver Canal Little Tunnel. Ohio	870	19 15	19 16	330	All arched.	All timb- ered.	Slate Rock and Coal horizontal strata	This was an exceedingly troublesome tunnel; the pressure in many places bending the heavy Caps - 12 x 14 inches, white oak, and breaking some; although the posts were 12 inches square, and braces 10 x 12 inches; and the bents set in only 2 feet apart. The bottoms of the Caps were set so as to be 6 inches above the top of the arch. In some cases they bent till they were below the top of the arch. They then had to be cut off or removed. The Contractors were paid regular tunnel price to 6 inches above top of arch, and for the

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Portage R. Road ditto inside of Pennsylvania	901	25	21	525 about 350	300	none	Sandstone	All the rock was self sustaining, but the Engineer in Chief, Sylvester Wetch. Esq, required 150 ft. at each end to be arched, Com trary to my Judgment. I saw no necessity for more than 50 ft. at each end.
Grant's Hill. Pittsburgh. (Canal) Pennsylvania	810	22	22	about 430 about 290	810	Partially in spots.	Slate Rock and Earth	This tunnel was first driven through under a hope that the rock in most of it would be sufficient strong without artificial support. It eventually proved quite different and very troublesome. At length the entire hill was excavated as an open cut. It was then arched, and the hill again filled in over it. Side walls and Arch 2 feet thick.
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Sandy & Beaver Canal Big Tunnel. Ohio	3270	16	17	272	None	None.	Sandstone Rock.	The Big tunnel, had 3 working shafts - 100 to 110 ft deep. 2 of them inclined planes, with Steam Engines. On a horse-ga

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Pittsburgh and Lebensville Rail Road, x a little over.	3000	18	20	320	Much of it.	Much of it in intervals.	Rock & Coal & Slate.	This tunnel had one shaft, about 150 feet deep. Stratification of rocks horizontal. Some parts of roof and sides much safer than others. No great distance without regular timbering with Posts 12 x 12 inches and Caps 12 x 12 x 12 x 14 inches. Some falls of roof. Roof generally 1 1/2 feet above top of arch. In some cases more. The Contractors were paid tunnel price to the height of 20 feet, and for falls, &c. at the estimate of the Engineer. Side walls and arch in no case less than 18 inches thick.
Pennsylvania Iron Mountain Rail Road	830	18	19	300	none	none	Hard Limestone	On the Iron Mountain Tunnel, I was engaged as one of the principal Contractors, and had personal charge of it. On all the other tunnels here mentioned I was engaged as Assistant, or Chief Engineer. The first 1/2 as Assistant.
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Besides the foregoing tunnels, I used to visit, during their progress, the two large tunnels through the range of the Allegheny Mountain - one on the State Rail Road, 1800 feet long; and one on the Pennsylvania Central rail road 3700 feet long. These were about 25 feet wide, and 22 feet high, (where they had to be arched) showing an area of about 500 feet each.

In glancing at the experience I had in tunnels, and in regard to tunnel areas, is it any wonder that I was surprised to find in the printed specifications for the Dm Penn R. Railroad, a tunnel area given <sup>only</sup> of 200 to 250 square feet. The largest being smaller than the smallest railroad tunnel I had been engaged in, and smaller even than the smallest Canal tunnel I was acquainted with. I pointed it out at once to Col. Garnett, the Chief Engineer, in my first business interview with him. He then handed me a copy of his estimate of the quantities, and pointed out to me that he had put the tunnel area at 270 feet = 10 Cubic yards per foot run, and remarked "If they are changed from that, they will be made larger." It was in view of dimensions not less than 10 Cubic yards (270 feet) per foot run, that our proposal was made out. There was no intimation given that short tunnels would be any less than 270 feet area.

W. M. Roberts  
Macacos, March 30<sup>th</sup> 1863

In substance, copied from a paper made out in April, 1861.