is no doubt that the builders of this bridge long experienced, long experienced in such work, and particularly with the "Hennebique" construction, were entirely competent to install these foundations which were on the "Compressol" system, and yet there is little question but that limited time and appropriation is responsible to some extent for the lack of more substantial abutments, such as used in many of the other "Hennebique" bridges.

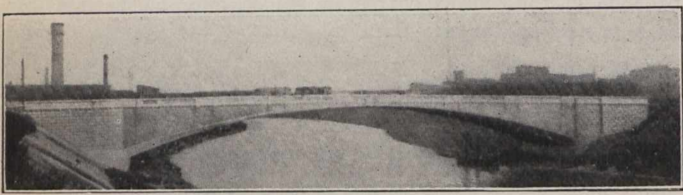

Fig. 2.—Risorgimento Bridge, Rome.

(2) Flat Arch.—Arches with small rise are generally not a desirable form, for they not only have excessive lateral thrust, but they plainly display their weakness in this respect. The beautiful Alexander III. bridge in Paris, which is a model in almost every way, is lacking in this one particular, for it fails to impress the beholder with its strength and security. Its span of 353 feet is only a little more than the latest one over the Tiber. Since other bridges at Rome have one or more river piers, it would seem that at least two piers at this site would have been permissible and would have greatly decreased the horizontal pressure on the abutments, at the same time making arches with a greater relative rise approaching the proportion of the beautiful Trinity bridge at Florence, which for more than 300 years has been accepted as ideal. A rise of about one-quarter of the span gives a very pleasing proportion when it can be obtained, an excellent illustration being that designed by Alexander Nimmo at Limerick, known as the Wellesley bridge. The desire among engineers and designers for making bridges of record proportions is well known, and while this motive may not have been an influencing one on the Risorgimento, three spans would certainly have made a much better appearance.

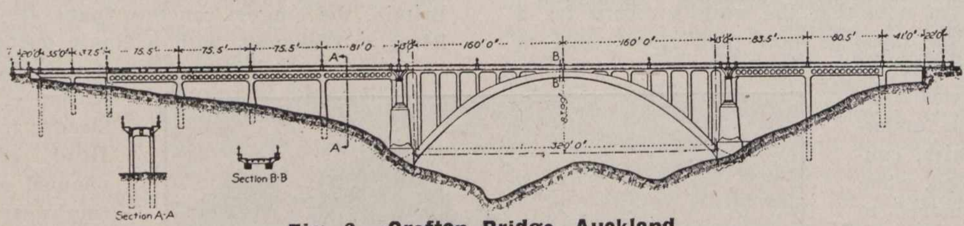

Fig. 3.—Grafton Bridge, Auckland.

(3) Hollow Spandrels.—The cellular type with hollow spandrels, which may be quite effective in the present case, is a violation of truthful construction, the general principle being that structures should, as nearly as possible, exhibit their real action and condition, and should appear to be just what they are. Concealment or deception should be avoided, and wherever consistent with construction, the general type and arrangement of parts should be evident. The accepted form in America for ribbed arches and open spandrel construction is to support the deck either on a series of spandrel columns, as in the Meadow Street bridge (Fig. 5.) in Pittsburg, or on longitudinal walls, as at Sandy Hill, over the Hudson (Fig. 6). For slab arches, the almost universal rule now is to use open spandrels with transverse arcades of colonnades. Lightness can as well be secured in these latter forms as in the more obscure and uncertain cellular type that was used in the bridge under discussion. The small thickness of the arch ring, varying from only 8 inches at the centre to 20 inches at the springs, contrasts greatly with the crown thickness of 48 inches and 72 inches on the Stein-Tuefen and Spokane bridges.

In the year 1896 Mr. Edwin Thacher made designs for two reinforced concrete bridges with hollow spandrels, enclosed on the face with curtain walls, one of the designs having a length of 150 feet. (Fig. 7). This resembles in some respects the Risorgimento bridge, and is one of the very few of this kind appearing in America. Unlike the Tiber River bridge, the American design showed only two longitudinal face walls, and those two were provided with expansion joints, making the stress conditions definite.

(4) Uncertain Stress Conditions.—Certainty of action and definite stress conditions are well known principles of bridge design. In the new Tiber River bridge with curved arch slab without hinges, rigidly connected to seven vertical ribs, it would seem that the stress condition was indefinite and the amount of thrust taken by the vertical ribs indeterminate. It is customary now, where a slab arch is used, to omit the vertical rib, or, if vertical ribs are used, to omit the slab. But the Tiber River bridge is a combination, and from the drawings which are shown in the reports of the "Ponts et Chasees" its action in this respect is indefinite. It is the practice in some bridges in America, notably those at Paterson and Clifton over the Passaic River, to make the arches continuous over the piers and anchor them securely back into the abutments, for the purpose of developing cantilever action. One of the first and perhaps most interesting experiments in this direction was that made by Brunel in 1836, when he erected a half cantilever arch of brick and cement at Rotherhithe when he was chief engineer of the Thames Tunnel. Brunel used no centering, the curve of the arch being formed by face moulds or sweeps. His experimental half arch stood on a 10-foot base, the long arm being 60 feet, while the rear or cantilever end was only 30 feet. The longer end had a rise of 10 feet 6 inches, and was balanced at the shorter end by a suspended anchor of about 31 tons. The upper and lower portions of the arch were 4 to 5 feet in width, while the spandrel wall was only 18 inches thick. He used hoop iron bands one inch wide and one-sixteenth inch thick, laid horizontally on the brick courses, and the strength of his experimental cantilever was proven by the fact that it continued standing for about two years. This interesting ex-

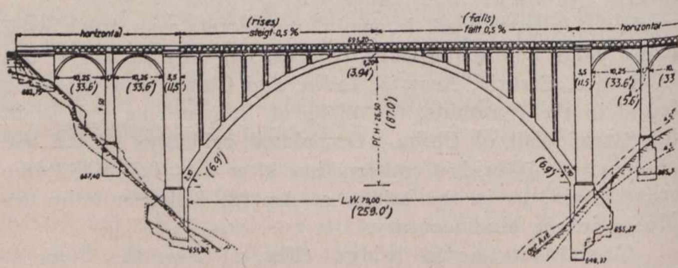

Fig. 4.—Stein-Teufen Bridge, Switzerland.

periment, which was probably the first of its kind, has been followed in more recent years by the construction of concrete cantilever bridges with members properly arranged for definite stress computation. While the Tiber River bridge was doubtless carefully designed, its stress conditions are certainly indefinite, owing to the combination of curved arch slab and vertical ribs, fastened rigidly together.