richer the mixture is in cement, the greater is the volume change, so that there is a differential expansion between the top coat and base of sidewalks which is often sufficient to split the two apart. So also rich stucco may be split from brick. In damp climate irregular expansion occurs apparently for as long as twenty years. Its harmful effects may not appear for many years. Large expansion joints are necessary in sidewalks and pavements.

Rich stuccos will inevitably crack through expansion and contraction, and may be ruined. The few experiments made indicate that integral waterproofing compounds do not prevent or lessen the changes in volume. The only safety seems to lie in the use of lean mixtures whose volume change is slight. A stucco coat is inadequate as a protection for metal lath. If it is rich enough to keep water out it will crack. If it is lean enough to avoid the cracks water will go through it freely. In a dry climate the tendency is for sidewalks and stuccos to shrink more than they expand. Under these circumstances they will be much more durable, because of the slower corrosion stucco may be permissible as a protection for wire lath

AMERICAN IMPRESSIONS OF THE RISORGIMENTO BRIDGE AT ROME.

By Henry Grattan Tyrrell.*

Since the publication of my treatise on "Concrete Bridges and Culverts" in 1909, rapid progress has been made in the direction therein indicated, in the design of concrete bridges. Instead of the heavy masonry bridge with many piers, solid arch slabs and earth filling, practice has swung to the other extreme where reinforced concrete is used with individual members and outlines similar to those in steel, the framing in some cases being extremely light, as in the recent Mizenhead bridge in Ireland.

It is interesting to note that the world's record for a masonry arch, after the lapse of more than 2,000 years, is again at Rome. Pons Aemilius, (Fig. 1) which was completed 142, B.C., after undergoing numerous repairs, continued in use until 1890, when most of it was removed to make room for a new steel bridge with its deck supported on horizontal girders, the new structure now being known as Palatine bridge. Many of the old Roman bridges which were known as stone arches, were really only faced with stone, the body of the arch and piers in many cases being concrete; and the same system of construction was carried out in Roman buildings and other works. It is, indeed, known that concrete was much used many years before the Christian era, not only in Rome, but in Greece, Etruria, Assyria, India, and China, and it is also found in the Pyramids, the Walls of Babylon, as well as in the Great Wall of China. Occasional evidences of the use of concrete in bridge construction after the fall of Rome still remain, as in the bridge at Amalfi, Italy, built by the Moors in the sixth century.

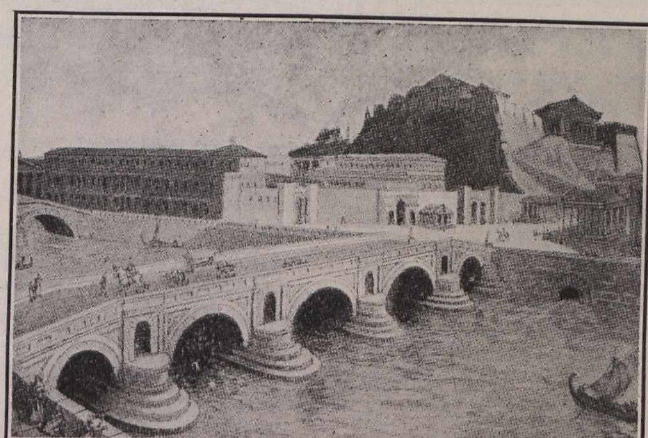

Fig. 1.—Pons Aemilius.

The Risorgimento bridge (Fig. 2) over the Tiber at Rome, with its clear span of 328 feet (100 meters) is in many ways a striking contrast to those adjoining it, and it is probable that if the old Roman engineer, Lucius Fabricius, who built bridges over the Tiber in the early part of the first century, could examine the latest one, he would likely view it with suspicion and disapproval.

The new bridge has a deck 65½ feet wide at a height of 47 feet above low water, and it crosses the Tiber with a single span. Compared with other concrete bridges, the next longest one Fig. 3) is at Auckland, New Zealand, with a span of 320 feet, and its deck 147 feet above water. In America the longest concrete spans are those at Larimer Avenue Pittsburg; Monroe Street, Spokane, and Detroit Avenue, Cleveland, with spans of 312 feet, 281 feet and 280 feet respectively. In Continental Europe the next longest concrete arch is that at Stein, Switzerland, over the Sitter River, with a length of 259 feet, (Fig. 4) though the stone arch at Plauen, Germany, has a span of 296 feet. In Great Britain, the longest concrete spans are those over the Nore River at Kilkenny, with a single opening of 140 feet, and a very flat rise, completed in November, 1910; and the slender foot bridge at Mizen Head, crossing the narrow channel to an island at the southwest extremity of Ireland, the length of span being 172 feet, and the deck 150 feet above water.

The most interesting features of the Risorgimento bridge are: (1) foundations, (2) flat rise, (3) hollow spandrels, (4) uncertain action, (5) surface treatment, (6) falsework.

(1) Foundations.—The chief requisite of an arch should certainly be an unyielding foundation. It has, in fact, become almost an axiom of design, that arches, especially those of small rise, are suitable only when such a foundation is obtainable, as at the crossings of the Niagara and Zambesi Rivers where rock cliffs rise on one side. Where arches are used on foundations other than rock, semi-circular ones, or forms nearly approaching to them are the best, and as the proportion of rise to span diminishes, the arch with its heavy lateral thrust becomes less desirable. The bed of the Tiber River, at the site of the new bridge, is composed of sand and clay underlaid to unknown depth with soft mud, necessitating pile foundations, covered with reinforced concrete grillage. This condition of subsoil would in itself, in most cases, lead to the use of shorter arch spans with greater relative rise, or to a girder bridge with only vertical reaction. Instead of heavy and massive abutments to resist the lateral thrust of so flat an arch, we find in the Risorgimento bridge, cellular construction with comparatively thin face walls backed up by seven 12-inch vertical walls, one of which is in line with each of the seven ribs on the bridge. There

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