strength. Fig. 3 shows two of the completed approach girder spans and centering in place for two others.

The approach piers each consist of two posts 4 ft. 4 in. wide with battered faces, founded on stepped footings carried down to rock. The posts or columns of the higher piers are tied together at intervals by cross-struts with heavy fillets at ends. The columns of the approach piers and the double piers over the abutments are carried up above the deck as projecting pilasters, thereby defining more clearly the approaches from the main arch construction. The three additional approach spans at the Langwies end are not shown in Fig. 2; their construction, however, is the same as that of the other spans, but they are designed to act independently of the others, being separated from the main approach by a wide abutment pier.

The entire structure has an appearance of extreme lightness in spite of its great size, due to slender proportions of the high approach spans and the arch spandrel system. The architectural treatment of the viaduct is along simple but impressive lines with very little embellishment in any of the parts.

General Construction Features.—Actual work on the viaduct was begun in August, 1912, but the arch centering was not started until the spring of 1913. The arch ribs and the approach at the Langwies end of the bridge were completed before stopping work for the winter, in November, 1913. (See Fig. 7.) The spandrel construction over the arch and the approaches at the Arosa end were completed in the next spring, the entire work having been finished in July, 1914. The excavation for foundations was carried down through compact moraine and glacial drift deposits which were very difficult to penetrate.

General Details of Falsework and Centering for Arch Ribs.—The centering used to support the arch ribs during construction was one of extraordinary design and entirely different from anything ever used in America for such work, not because it is not adapted to use on this side but rather because engineers are in general slow to adopt radically different methods of construction from those ordinarily used.

The centering used consisted of a central fan-like wooden falsework of radial ribs, securely braced both diagonally and horizontally and supported on a central reinforced concrete tower consisting of four bents connected by rigid framing and two single reinforced concrete bents, one near each abutment, supporting wooden falsework in the shape of a half fan with ribs radiating toward the abutments. The wooden timbers used were round and half-round, unhewn material, the timber on the site being cheap, of good quality and obtainable in long lengths. The general design and appearance of the centering is shown in Fig. 4, which shows the centering completed and the arch ribs being concreted.

Concrete has been put to a great number of uses in America where the industry has grown with enormous strides, but there are no instances on record where such large concrete structures have been built for temporary bridge construction purposes. Where the conditions are somewhat the same as at the Langwies bridge, as cited below, there is no reason why temporary towers of concrete could not be used to economical advantage, consequently there is much of interest to be found in the construction details.

In spite of the fact that timber was plentiful on the site, reinforced concrete towers designed as latticed bents were adopted as the most economical for the lower part of the centering for the following reasons:

(1) On account of the great danger of flood to which the location is subjected during the melting of the snow, situated as it is at the juncture of two rapid streams which often carry enormous quantities of water and driftwood, boulders, etc., it was necessary to restrict the waterway as little as possible. For this reason it was impossible to use vertical bents for the falsework and the tower system had to be used. Wooden towers would not have been as safe as the adopted concrete towers and would have reduced the waterway considerably more.

(2) Even if wooden towers had been used to support the centering, the foundations would necessarily have had to be of concrete, as the driving of piles through the moraine deposits of gravel and large boulders was absolutely impossible.

(3) It was desired to reduce the vertical deformation (compression) of the centering during pouring of the arch

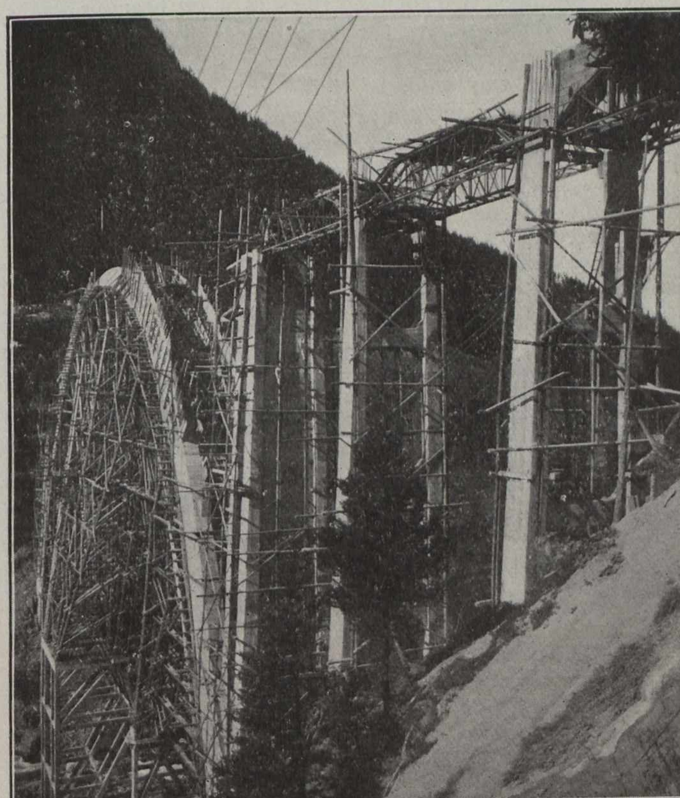

Fig. 6.—End View of Falsework, Showing Transverse Bracing—Approach Span Piers in Foreground.

ring to a minimum. This could be obtained much better by the use of reinforced concrete towers than by using wooden towers. That the adopted design was a success in this particular is witnessed by the fact that after the arch ribs were completed a total settlement of a trifle less than ¾ in. was observed in the centering.

Central Tower Framing.—The three-story tower carrying the central portion of the arch centering, consisted of four reinforced concrete bents, 77 ft. high and 60 ft. 8 in. wide resting on concrete footings, framed together with horizontal concrete ties. The two middle bents were spaced about 20 ft. apart with the outer bents about 10 ft. beyond, the two main vertical bents of timber falsework resting directly over the former, while the radially inclined timber bents were carried on beams between the intermediate and outer concrete bents.

The concrete bents were designed as stiff latticed frames, with intermediate members set on the diagonal