Volume 29. Toronto, October 14, 1915.

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## The Canadian Engineer

A weekly paper for engineers and engineering-contractors

## WORLD'S LARGEST REINFORCED CONCRETE ARCH SPAN

UNIQUE DESIGN AND CONSTRUCTION METHODS NEW TO WESTERN ENGINEERS EXEMPLIFIED IN THE LANGWIES VIADUCT, SWITZERLAND.

## By ALBERT M. WOLF, C.E.

THE construction methods used in the building of the Langwies viaduct in Switzerland in 1912-14, whose main arch span is the largest in the world, when span, rise and load to be carried are considered, are unique, and present great possibilities for adaptation to American conditions.

The viaduct was built in connection with the new Chur-Arosa electric railway to accommodate Swiss resort crossed close to its confluence with the Sapüner Brook at an elevation of 4,330 ft. above sea level by the viaduct.

General Description.—The entire viaduct, 935 ft. long, is of reinforced concrete construction, consisting of a 314-ft.  $11\frac{1}{2}$ -in. arch span with a rise of 134 ft. 3 in. and four continuous girder approach spans at each end, carried on high concrete bents 52 ft. 6 in. apart. At one end are three additional girder spans separated from the



Fig. 1.-The Langwies Viaduct, Chur-Arosa Railway, Switzerland.

travel to Arosa, which is noted as a health and winter sport resort. Previously, this place could be reached only by stage, after a slow journey of six hours over narrow and steep roads, while now only 1½ hours will be consumed in making the journey. Increasing business demanded a better mode of travel and the electric road was built by the hotel interests to meet the demand.

The new line has a length of 16.15 miles with a rise of 3,650 ft. in an almost unbroken 6% grade. The construction involved some very heavy and expensive work, including 19 tunnels, with a total length of 7,710 ft., 27 large stone bridges, 3 steel bridges and two large concrete arch viaducts, one having an arch of 282-ft. span, and the other, the Langwies viaduct, an arch of 315 ft. clear span. From Chur to Langwies the railroad runs along the right bank of the Plessur River; at the latter point the river is main structure, for esthetic reasons, by a wide abutment pier. Two of these latter are of 42 ft. 8 in. clear span and one of 32 ft.  $9\frac{1}{2}$  in. clear span.

The arch is composed of two reinforced concrete ribs with fixed ends, braced at intervals by transverse struts, with an overall width at the crown of 16 ft.  $6\frac{1}{2}$  in. These ribs are 7 ft. deep and 3 ft.  $3\frac{1}{2}$  in. wide at the crown, the depth and width being increased from crown to spring to keep the thrust line within the middle third of the rib and give added lateral stiffness. The roadway deck over the arch is carried by continuous girders supported on double column bents of reinforced concrete resting on the arch ribs and spaced about 29 ft. 6 in. centres. The general appearance of the structure is shown in Figs. 1 and 2.

Comparison With Other Concrete Arches.-The developments made in the last decade in the design and