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Travelers swing 62-ton center sections into place for new Akron bridge (see p. 18)

TAMING TEXAS' WILD TRINITY RIVER

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GOOD ROOF DRAINAGE SAVES MONEY

Beauty, economy and simplicity of fabrication were designed into . . .

Akron's High-Level Cantilever Bridge

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THROUGHOUT THE DESIGN of the new $2,000,000 high-level bridge at Akron, Ohio, prime importance was placed upon economy of materials, fabrication and erection.

Opened to traffic in July, the new bridge crosses the Cuyahoga River 220 ft. above streambed, just east of an old seven-span arch bridge erected in 1913. Total length is 900 ft., made up of two 210-ft. anchor spans, two 180-ft. cantilever spans, with a 120-ft. suspended span. Trusses are spaced 40 ft. c. to c., with top chords horizontal and bottom chords on a parabolic curve. They carry two 26-ft. roadway lanes separated by a 4-ft. median strip, and two 6-ft. sidewalks. Panel lengths are constant at 30 ft.

The bridge is of deck-type, designed for the S-20-40 lane loading of the Ohio Department of Highways' specifications. Structural steel, required to meet ASTM A7-42 specifications, was designed for a tensile strength of 18,000 psi.

The 210-ft. anchor arms required anchorage at the abutments by prestressed bars attached to a grillage system embedded in the concrete. In addition to the usual downward reaction, each truss reaction at the abutments is subjected to a net uplift of 500,000 lb. This occurs under full live load on the cantilever and suspended spans, with no live load on the anchor arms.

To fulfill specifications, the abutments are held down by a minimum weight of 1½ times the uplift, in weight of concrete above the grillage systems. The four grillages are each made up of six 12" WF 133-lb., and four 12" WF 100-lb. beams spread over an area of 16x17 ft. Each truss is connected to its grillage system by a 7-in. pin through two links, each with a cross-section of 2x8 in. In order to prevent excessive vertical movement and to furnish a direct transfer of load from the links to the pin a close tolerance of 0.020-in. was specified between the diameter of the pin and the hole in the links. Monel bushings were inserted in the links to reduce wear.

The links holding the trusses to the abutment are prestressed to the uplift load, and an adjustment by movable wedges holds the bars fixed in position. Access to the links attached to the grillage system is by a vertical passageway in the abutment to make for easy maintenance and painting.

Bottom chords pinned at piers

Pin connections in the bottom chords at each pier were designed to reduce secondary stresses and to facilitate erection. These pier hinge supports are the fixed reactions, and their design and construction were of some concern. Two alternate methods were considered.' One involved a central pin pivoting on the pier shoe with all members riveted to a large gusset plate.

The other method—which was adopted—utilizes a fixed shoe with the two lower chords pinned to the shoe and the vertical post riveted to a gusset plate which is attached to the shoe. Calculation to determine the secondary effects on the end connections of the members indicated clearly the benefits of the pinned chords.

One load condition was used for the study: for example, the dead load plus the live load that produced the greatest stress in the lower chords. It was found necessary to use 10-in. pins at the end connections of the lower chords to the pier shoe. From an erection point of view it was considered more desirable to anchor the shoe completely and to rivet the 85-ft. vertical post to the gusset plate than to support all three members while inserting the large pin.

The piers were designed as two vertical sections tied together at the top with a hollow box section to form a rigid frame. The vertical members have a cross-section shaped like an I-beam for economy of material.

The roadway is 5-in. open I-beam steel grid, welded to the stringers which are spaced 4 ft. 0 in. c. to c. This type of flooring was selected because of its high strength-weight ratio, simple replacement, and easier winter maintenance. Since the grid is placed in convenient section lengths, a ¼-in. expansion joint is allowed between sections to account for temperature effects.

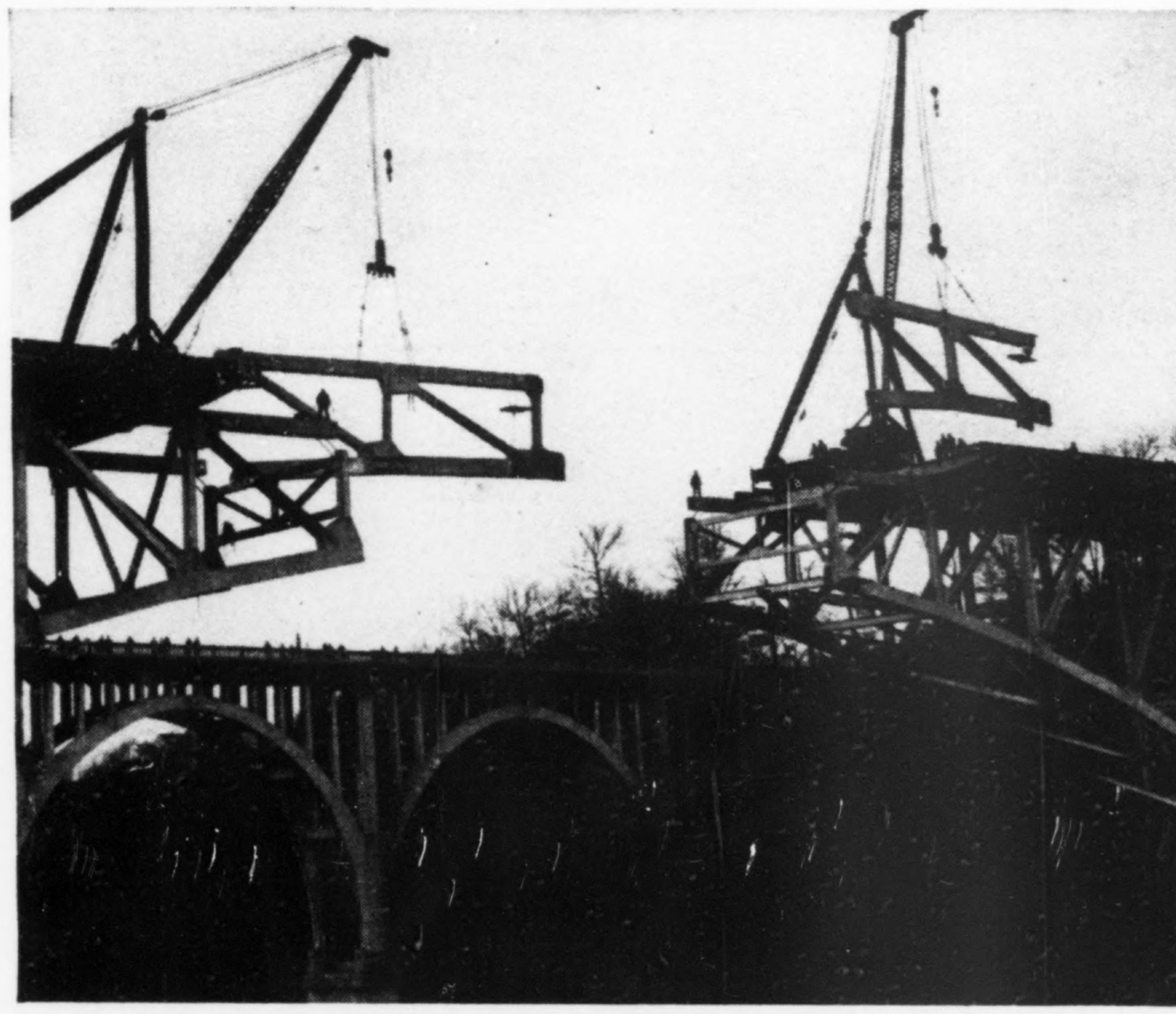
Sidewalks are 2-in. steel grid welded to the stringers and filled with lightweight concrete to form a composite slab. They drain toward the roadway on a slope of $\frac{3}{16}$-in. per foot.

Truss member details

Top and bottom truss-chords are designed as box sections with four corner angles, cover plates and web plates. The maximum size angles are 6x6x1-in., while the thickness of webs and cover plates never exceeds 1-in. The chords are constant depth. Top-chord depth is 2 ft. 8 in. out-to-out of cover plates, and depth of bottom chord is 3 ft. 2 in. out-to-out. Access holes are provided in the bottom cover plates at 4-ft. intervals.

Diagonals and verticals are of the built-up I-beam type, except the vertical post at the piers and the two adjacent verticals, which are box-sections. These sections were designed for economy, with minimum gage angles and plates.

The top and bottom lateral systems were designed for the usual wind load, treated as a moving load of 30 lb. per sq. ft. on a 1½ times the exposed area. The sliding support for lateral bracing



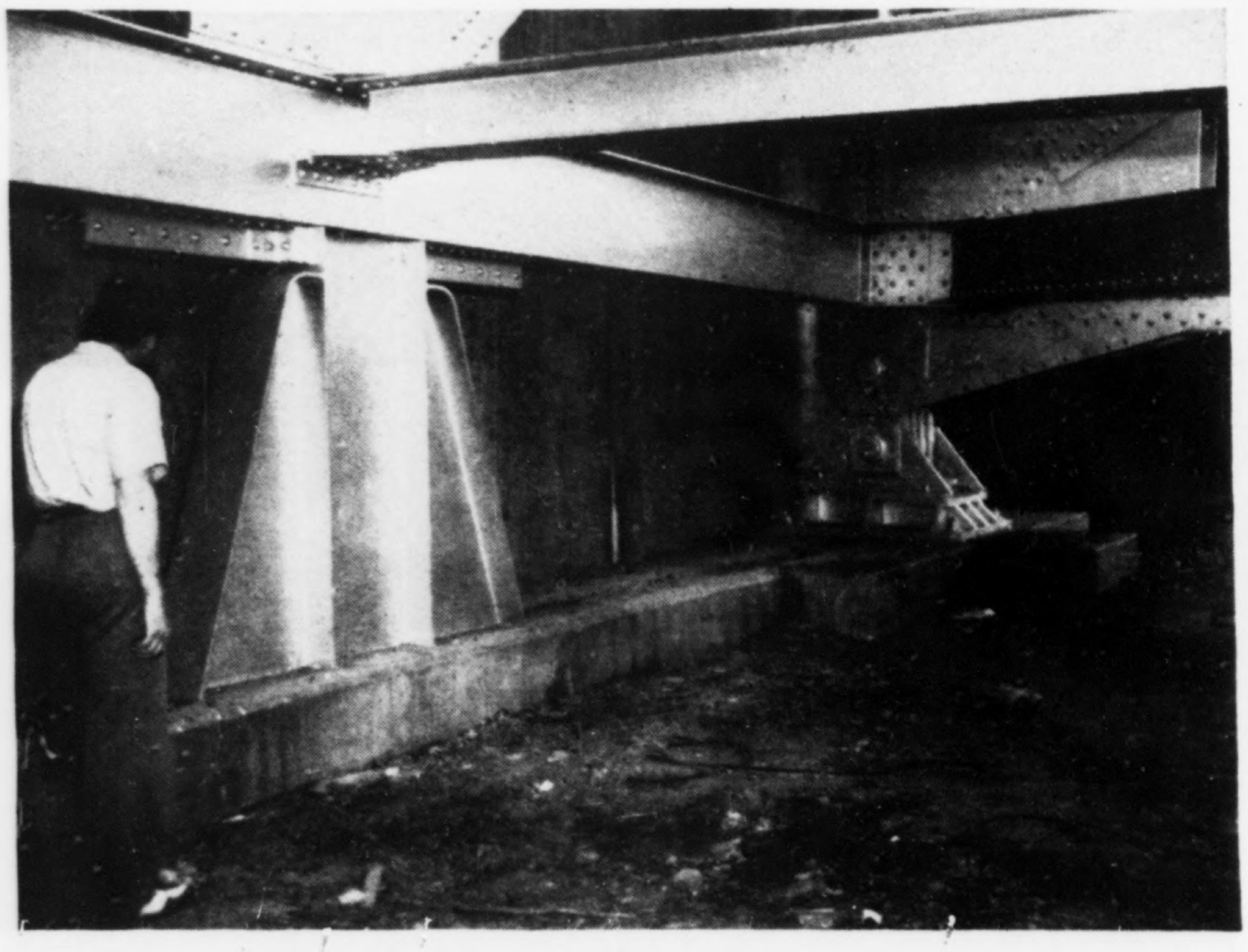
TRAVELLERS SWING 60-ft., 40,000-lb. sections of the suspended span into position (at top), for closure at the center of the middle span. Small gusset plates add beauty to the bridge by accentuating the constant-depth chords. (Akron Beacon-Journal photos)

OPEN STEEL-GRID FLOORING for the two 26-ft. roadways—separated by a 4-ft. welded steel-plate—was adopted for its high strength-weight ratio, excellent drainage and low maintenance in the winter.

is at the same end of the suspended span as the expansion support for the main trusses. A similar support is located at the abutment ends at the center of the lower lateral member. The attachment at the piers is considered to be of the hinge type and is ridigly attached. The K-truss type vertical members in the wind-bracing system are designed to transfer the wind loads to the lower lateral system. The wind effect was not of sufficient magnitude to govern the design of the main truss members.

The size of the structure may be realized from the quantities involved. They include 5,500,000 lb. of structural steel, 325,000 lb. of reinforcing steel, and 5,000 cu.yd. of concrete. Oddly enough the new structure uses the same quantities of concrete and reinforcing steel that were required in the original bridge.

In order to fabricate the trusses as



WIND STRESSES in the anchor spans are transmitted from the bottom chord lateral system to the abutments through a sliding support embedded in the center of the bridge seat. Truss anchorages, designed to permit expansion at both abutments are prestressed for a 500,000-lb. uplift.

easily as possible, a constant distance of 25½-in. was maintained between the gusset plates. This is also the out-to-out distance of the webs of the chords. The thicknesses of the gusset plates were made ½ in. and ¾ in. depending upon the magnitudes of the loads at the respective connections. To realize economies of material, additional plates were attached to the heavily loaded diagonals and verticals which makes the connecting rivets critical in double shear thereby reducing the size of the gusset plate.

The small gusset plates also add to the beauty of the structure by being less noticeable, thereby accentuating the main members. Filler plates were necessary when the additional connections plates were used. Since some of the gusset plates were necessarily large, it was advisable to stiffen the free edges against lateral instability and buckling by adding reinforcing angles when the unsupported length exceeded 60 times the thickness.

The possibility of a future city park in the ravine made it desirable to consider the architectural treatment of the bridge and the abutments. The abutments were styled for apparent massive strength and durability together with beauty of proportions. To complete the picture of straight-line functionalism, channel railings with turned-down ends were specifically designed for the abutments.

Trusses were fabricated with horizontal top chords plus a permanent camber for 100 percent dead load and 25 percent uniform live load. Bottom chords—on a parabolic curve—closely follow the natural slopes of the gorge. Top chords were made narrower than the bottom chords to simulate a sense of strength and sturdiness in the lower chord. Diagonals and verticals were designed with increasing widths towards the piers.

Pier locations on each side of the ravine were selected on the basis of pleasing proportions of anchor spans to center span.

The abutment support links were prestressed by four jacks acting on a system of beams attached to the upper pin. A tension stress of 500,000 lb. was exerted by the jacks and the adjustable block was locked in position. The anchor span was then constructed with jacks acting as intermediate supports at the 60-ft. panel points from the end reaction.

The center suspended span was erected by lifting two 60-ft. sections each weighing 40,000 lb. and holding them in position while workmen inserted the necessary drift pins and erection bolts.

Old bridge was inadequate

There was little question that the 45-year old bridge needed replacement. It was on a poor alignment for high-speed traffic and its 26-ft. roadway, with two 4-ft. sidewalks were inadequate for the volume of traffic. But the inadequate strength of the old bridge and its progressive exterior deterioration were more serious. It had been posted for a 10-m.p.h. speed limit for several years.

The old bridge contains five full-centered 127-ft. span reinforced concrete arches and two 73-ft. end spans. Arch ribs are spaced 20 ft. c. to c. Design loads included a 40-ton interurban car with 40 percent impact, an 18-ton truck with 30 percent impact, a uniform live load of 100 lb. per sq. ft. on the roadway and 75 lb. per sq. ft. on the sidewalks. The wind force was 30 lb. per sq. ft. of the projected area. Design stresses in the old bridge were 750 psi. for concrete and 16,000 psi. for reinforcing steel.

Repair needed

The deterioration of the thin sections of the concrete structure has progressed to the point where portions have necessitated intermittent replacement. This condition may be attributed to the salt type of winter maintenance which is harmful to concrete, and to the increased loads and speeds of present day vehicles, resulting in greater vibration and impact effects than were considered originally.

The new bridge was built as a regular federal aid project with five agencies cooperating. Total contract cost was $1,933,600 and the costs of damages and right-of-way were $185,000.

The Public Roads Administration contributed 50-percent of the cost; the Ohio Department of Highways, 25-percent; and Summit County 25-percent. Of the 25 percent allotted to Summit County, the cities of Akron and Cuyahoga Falls contributed right-of-way and relocated various public utilities. Surveys and design plans were furnished by Summit County and construction engineering by the Ohio Department of Highways.

Design plans were prepared by Wilbur Watson Associates, consulting engineers, Cleveland, Ohio, under the supervision of T. E. Terry, partner, and S. O. Forsmark, chief engineer. The author was employed as a designer for Wilbur Watson Associates during summer vacations.

Bates and Rogers Construction Corp. was the general contractor. C. T. Smith was general superintendent and M. C. Warmbier, general foreman. Structural steel was fabricated and erected by the Bethlehem Steel Co., under a subcontract. Harry Hiscott was superintendent of erection.

Summit County was represented by A. F. Ranney, county engineer; and Ralph VanBrimmer, bridge engineer. For the Ohio Department of Highways, C. M. Newhall was project engineer and William Wardman, division construction engineer.