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on something much more formidable and substantial. Chemical research, concentration of capital, thorough technical education, improved industrial organization have made in recent years greater advance in America than here. It is with the product of these combinations, and not with the assumed stupidity of Indian officials, that the British engineer has to contend."

A Question of Water Rights.

In 1736 two colonists in the Rhode Island Plantations agreed to build a dam 5 feet high across the Pocasset River. This was to furnish power to run a grist mill on the east bank, while for the property owner on the west bank the right was reserved to draw the water necessary for a blacksmith's hammer and a pair of bellows. The grist mill was followed by a saw mill, and the remains of the latter were torn down in 1855. Many dams were built at the site, four within the memory of one man, and there was a period of many years when the water was not used in any way for power. In the course of time the old grist mill property passed into the control of the Cranston Print-Works Company, which built up a large establishment requiring so much water that the company also constructed regulating reservoirs up the stream to make the flow reasonably uniform and certain. The heirs-at-law of the property on the other bank have built no industrial plant, but have industriously engaged in legal warfare with their transfluvial neighbor. The last of their many suits involves an interesting point in the rights of tenants in common of a water-power, and was recently decided by the Rhode Island Supreme Court substantially as follows:

The point at issue was, in effect, the alleged right of the company to use more than half the average flow of the river. Previous decisions of the Supreme Court had fixed the ownership of the dam and water rights as divided equally between the riparian properties. The plaintiffs in the latest suit (Dyer et al. v. Cranston, 48 Atl. Rep. 791), farmed the land on their side of the river, and had no mill or manufactory of any kind on the property. They claimed to be desirous of using their share of the water-power, but the court found no indication of any steps toward doing so. The print works of the defendant company, on the contrary, needs and actually uses large quantities of water, yet the plaintiffs asserted in substance that an injunction should be issued compelling the company to desist from using more than one-half the flow. Both parties, as riparian owners, are tenants in common of the use of the water, and the question reduces to the right of one such tenant to use what the others do not need.

The court finds that neither party owns the water itself, and, unless he has a use for it, cannot exercise his right. If both have use for it, it must be equally divided; but, if only one can use it, his use of the whole works no harm to his cotenants. The granting of an injunction limiting the defendant to the use of one-half of the water of the river, and permitting the complainants to open wantonly such a passage as would allow half the stream to run to waste, would be, the court says, a useless and oppressive exercise of its powers. The complainants are entitled to a decree establishing their right to use for all hydraulic purposes half the water of the river, but that is all. This decision is one to be applauded from the point of view of business interests, apart from legal considerations, for any other opinion might subject companies to great annoyance by speculators. The latter could acquire title to property on one side of a river and then force the establishment on the opposite side to buy them out at a high price to escape annoyance.

The International Bridge, Buffalo.

The Grand Trunk Railway crosses the Niagara River at Buffalo, N. Y., on a single-track iron bridge begun early in 1870 and finished in October, 1873. At this point the river is about 1,900 feet wide and 44 feet deep, with a rocky bottom and a current of six miles an hour in the middle, and carries great quantities of thick ice in the spring. These conditions made it very difficult and expensive to build the substructure which comprised one octagonal pivot pier 34½ feet wide, and seven rectangular piers 29½ feet long and from 7½ to 12 feet wide. They are all of ashlar built in closed caissons and have satisfactorily withstood the action of ice and water and are now in good condition.

The superstructure consists of one 358-foot draw span, four 193-foot 11-inch and three 244-foot 7-inch fixed channel spans, besides one 218-foot draw span and one 219-foot 3-inch fixed span of similar pattern over the adjacent Black Rock Harbor. The old spans had double-intersection Pratt trusses with Phoenix-column compression members and cast-iron connection blocks at panel points, and were designed for much lighter loads than are now required. It was therefore decided to replace the superstructure by a heavier and stronger one of modern design with deeper trusses of the same length and about the same distance apart from out to out. Contracts were let in July, 1899, and the work was essentially completed in May, 1901, without materially interrupting the passenger traffic.

In order to maintain the train service during the removal of the old spans and the erection of the new spans, two riveted steel trusses were built which were deeper and longer than the largest trusses of either old or new structures. These trusses were erectd on falsework in shallow water, outside of the old trusses of the first span. They were connected together, over the old span, by horizontal beams at top-chord panel points, and, being supported from the abutment and first pier, were swung clear of the falsework and the latter removed.

Temporary steel floorbeams were swung under the old span and suspended from the lower-chord panel points of the falsework trusses: two lines of steel stringers were laid across them and on them the floor system of the old span was wedged up. A boom-derrick traveler running on the top chords of the falsework trusses disconnected the old span and delivered its members to trucks running on the railway track between regular trains. The same traveler erected the new span, which, until swung, was supported from the suspended temporary floorbeams; the latter at the same time carried the undisturbed floor of the old span and the track on which train service was maintained. After the new trusses were swung the railway track was transferred to the new permanent floor, the old floor was removed, and the traveler was run off the falsework trusses and on a transfer table, which rolled on rails elevated above the top chords of the old trusses of the adjacent span. Five eight-wheel trucks with 17-foot wheel bases were set on rails laid on the top chords of the new permanent trusses, and the falsework trusses were jacked up so that their crossbeams took bearing on them at the hips and at three intermediate points. The span was pulled forward and the trucks moved from the new span to the track on top of the old span and across that until the advancing end of the falsework trusses reached the second pier and they were blocked up there and on the first pier, the jacks slacked off, the trucks released and moved forward to the next span, the second new span erected as the first one had been, and so on. By this method the 420,000 pounds of falsework trusses were distributed over the old span so as not to cause stresses larger than those due to regular train service. The work was carried on from one end of the bridge only, and all parts except the draw span of the river crossing were erected by this method, which obviated the use of falsework in the river, provided for the easy removal of the old spans and the unimpeded erection of the new ones, and utilized in the falsework trusses much of the material from the falsework spans used by the same contractors in the rebuilding of the Victoria bridge at Montreal, as described in The Engineering Record of November 5, 12 and 19, 1898.

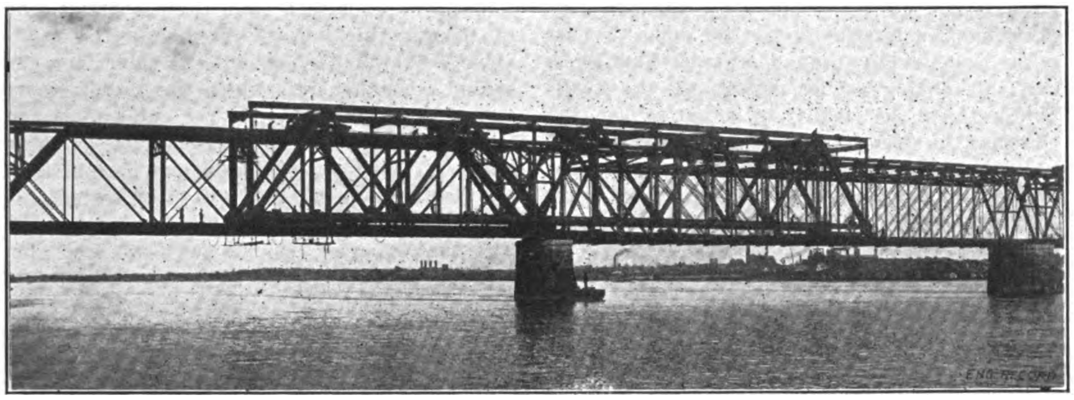
The erection of the falsework span on shore was made impracticable by an obstructing building. The draw span was erected on the protection pier, while the old draw span was closed and carrying trains, then both old and new draw spans were turned 90 degrees on the new turntable and the old span was taken down on the protection pier. The two spans over the Black Rock Harbor were erected on falsework. It was at first intended to erect the two draw spans while navigation was closed in the winter of 1899 and 1900, and then follow with the erection of the fixed spans, but as it was impossible to get the steel from the mills in time, the work was delayed nearly a year and much time was lost by bad weather and especially by high winds.

The new spans all have through Pratt trusses 30 feet deep and 18 feet apart on centers, with the same connections and details throughout, the members in the different length spans being made from the same drawings and varying only by some differences of panel lengths and in cross-sectional area. In all the spans the middle or end panels or both vary a few inches in length from the other panels which are regular. In the 219-foot and 244-foot spans the regular bottom-chord panel length is 27 feet 1 inch and in the 193-foot span it is 27 feet 11⅛ inches; all top chord panels are ⅛ inch longer than their corresponding bottom chords. The bridge was built under the standard specifications of the Grand Trunk Railway for 1897, and was proportioned for a live load of two 284,000-pound consolidated locomotives followed by a train-load of 4,000 pounds per lineal foot. The dead loads per lineal foot were assumed to be 3,700 pounds for the 193-foot spans, 4,050 pounds for the 219-foot spans, and 4,400 pounds for the 244-foot spans. All rivet holes were reamed, and all material was medium open-hearth steel, painted two coats after erection, with twelve pounds of red lead and ten ounces of lamp black mixed with each gallon of raw linseed oil.

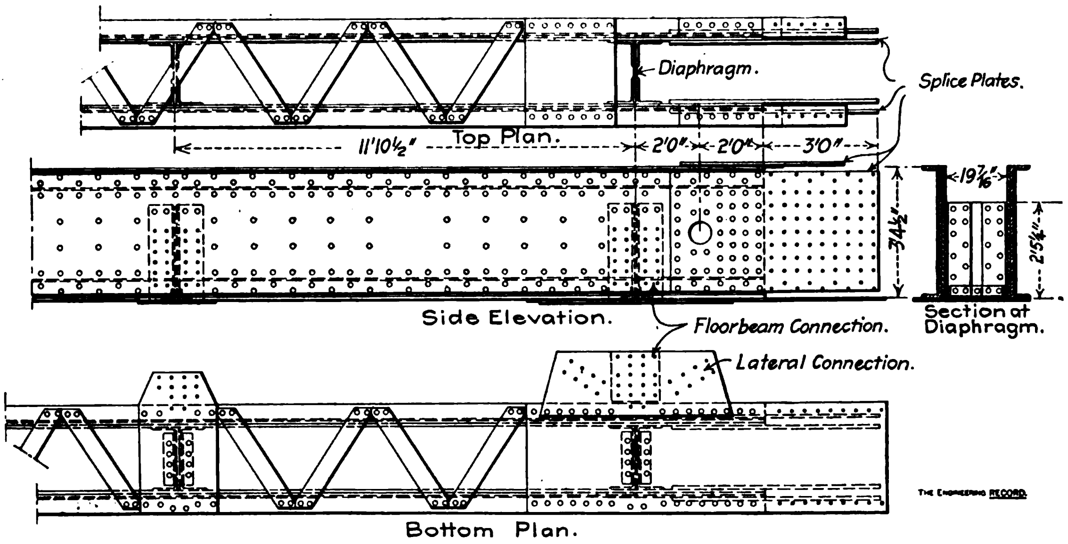
The pin-connected trusses have eyebar diagonals, stiff bottom chords, and stiff top and bottom laterals with riveted connections. The floorbeams are riveted to the lower-chord webs 20 inches from the panel points and midway between these points. The top and bottom chords are made in single panel lengths with splices having a large number of machine-driven field rivets. Both trusses and stringers are seated on cast-steel pedestals, which distribute the load on the masonry and are made of different heights to conform to variations in the surface of the masonry. There are overhead lattice girder sway-brace frames between the trusses at the vertical posts. The maximum sectional areas and materials in the 244-foot trusses are as follows: Top chord, 110.4 square inches; one 27½ x ⅝-inch top plate, two 7½ x ⅝-inch bottom plates, two 20 x ⅝-inch side plates, and two 24-inch 100-pound I-beams. End diagonal, 42 square inches, four 8 x 5/16-inch eyebars; vertical post, 35.5 square inches, two 18-inch 60-pound I-beams. Bottom chord, 190.5 square inches; two 40 x ⅞-inch, two 38 x 7/16-inch, and two 27½ x ⅞-inch web plates and four 6 x 6 x ⅞-inch angles, this section including 61 square inches added for bending. End lower-chord pins, 8 inches in diameter. Top lateral diagonals throughout, four 3½ x 3½ x ⅜-inch angles. End bottom lateral diaognals, two 5 x 3½ x 9/16-inch angles. End stringers, maximum bending moment, 78,000 foot-pounds; shear, 23,250 pounds; four lines of 15-inch, 100-pound I-beams.

The bottom chords are substantially double plate girders with reinforced webs, having their top and bottom flanges connected together by lattice bars and long tie plates. They are 41½ inches deep and 33 inches wide over all, and have horizontal plates shop-riveted to the lower inside flanges for the lateral connections and to receive the bottom flanges of the floorbeams. On the center line of each floorbeam the webs are connected by a vertical transverse diaphragm with one ¾-inch plate and four 8 x 8 x ⅝-inch angles, and there are twenty-four ⅞-inch field rivets connecting the inside web to the end vertical angles of the floorbeam. At the middle splice there are two 6 x ¾-inch top-flange splice plates, one 33 x 1½-inch bottom-flange cover splice plate, and on each web, two 1-inch splice plates 5 feet 5 inches long, with 81 field rivets, making with those in the flange a total of 111 ⅞-inch field rivets on one side of the splice. The ends of the bottom chords do not receive the lower pins in the inclined end posts which serve merely for bearings in the shoes. Their webs are cut to clear the end-post webs, and are each riveted with 86 field rivets to a 59 x 75-inch connection plate 1 inch thick, which is part of the pin reinforcement plate on the end post and is shop-riveted to it. The top chords and end posts are 27½ inches wide and 25¼ inches deep over all, and their webs are 24-inch 100-pound I-beams throughout; the variation of sectional area is effected entirely by the addition or omission of web reinforcement plates on the outsides only of the webs. All the bottom flanges are reinforced by 7½ x ⅝-inch plates and are connected by 3½ x 2½ x ⅜-inch angle lattice bars. Two small connection plates for the lateral struts and diagonals are shop-riveted to the top flange, and two to the bottom flange at each panel point, and the chord splices are made with double web and single cover plates having a total number of 49 field rivets at each joint.

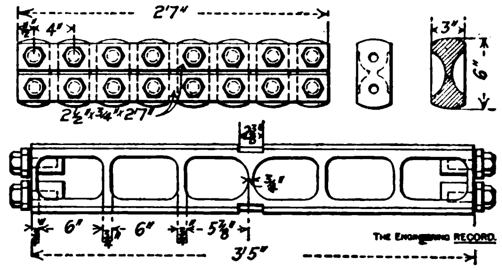
Each floorbeam was calculated for a maximum bending moment of 393,000 foot-pounds and 60,000 pounds shear, and is a 24-inch 100-pound I-beam about 16 feet long with two 15 x ⅞-inch reinforcement plates on each flange. The web is ¾-inch thick and there is shop-riveted to it at each end a pair of 8 x 8 x ⅝-inch vertical angles for the chord connection. There are ten field rivets in each stringer connection, and there is a 33 x ½ x 51-inch plate shop-riveted to the middle of the bottom flange to re-



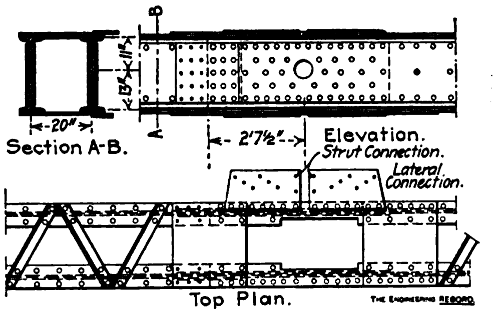
View of Falsework while being Moved from New to Old Trusses.



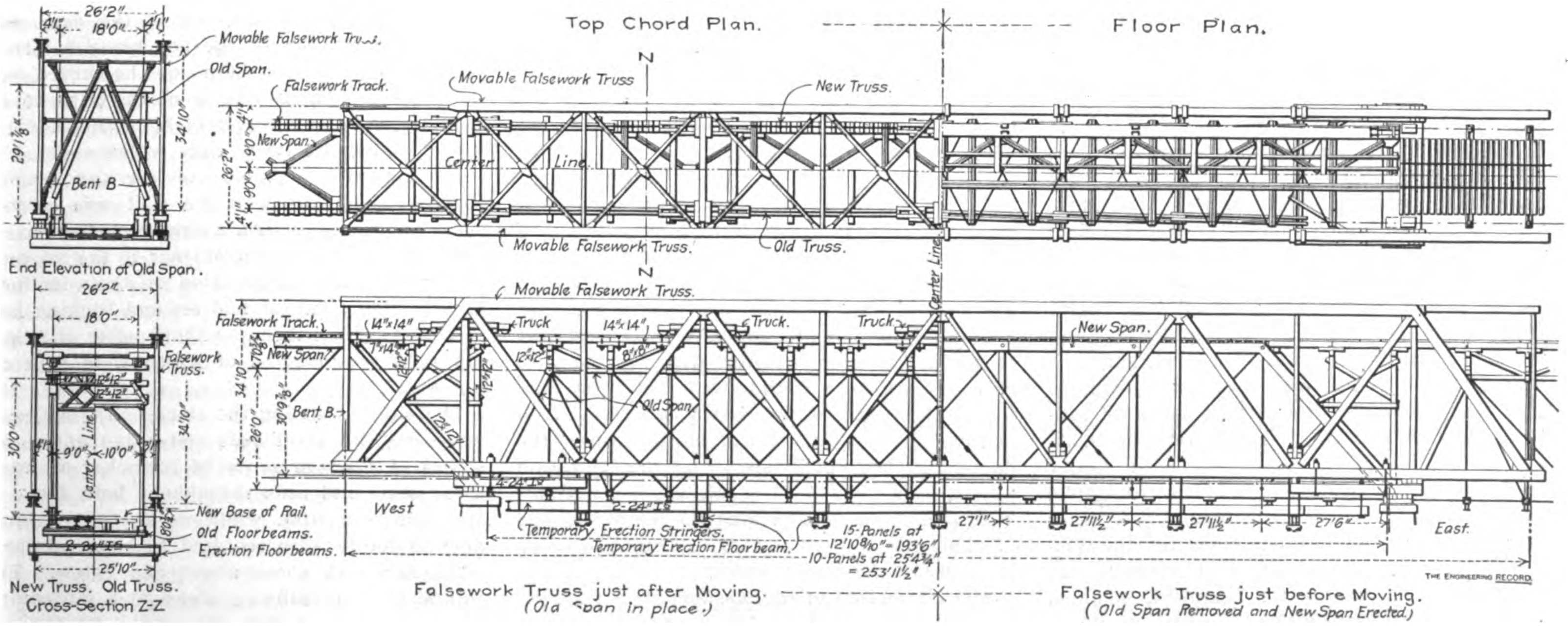
Details of Lower Chord and Floorbeam Connections.



Rocker Bearing.



Detail of Top Chord.



FALSEWORK TRUSSES AND RELATIVE LOCATION OF OLD AND NEW SPANS, INTERNATIONAL BRIDGE.

MR. JOSEPH HOBSON, CHIEF ENGINEER, GRAND TRUNK RAILWAY; DETROIT BRIDGE & IRON WORKS, CONTRACTORS.

ceive the ends of the bottom lateral diagonals, which are cut to clear each other and the floorbeam at their intersections.

The top lateral diagonals are of the same depth as the top chords, and are each made of two pairs of angles latticed together. At intersections, one strut is cut to clear the other, and both are riveted to top and bottom flange splice plates, which are shop-riveted to the continuous strut and field-riveted to the ends of the other strut. The portals are lattice girders 10 feet deep with T-shape chords made of a web plate and two angles, and with single 3½ x 3½-inch angle diagonals; at each end there is a solid web knee-brace 6 feet deep with a pair of curved flange angles. Each panel of sway-bracing has an upper transverse strut similar to the top lateral diagonals and a T-shape bottom strut about 6 feet below it, which has a 12-inch web plate and two 5 x 3½-inch flange angles. The top and bottom struts are latticed together by single 3½ x 3½-inch X-brace angles field-riveted to the web of the lower strut and to projecting tie plates in the upper strut.

The truss shoes are of the usual type, with three bearing-webs connected by outside transverse diaphragms. At the expansion ends they are seated on nests of eight segmental rollers, 6 inches high, 3 inches wide and about 3½ feet long. These rollers are made of cast-steel with cylindrical spaces cored out of their sides and separated by ¾-inch vertical webs. The rollers are tap-bolted at each end to two horizontal 2½ x ¾-inch guide strips, with a clearance of 3/16 inch between them so as to enable the rollers to rock back and forth far enough to allow for temperature elongations and contractions, and to lock the rollers fast and prevent their turning through too large an arc. The fixed end shoes are seated on cast-iron pedestals from 5 to 9 inches high, which have a bottom plate 2¾ inches thick and vertical cross webs 1½ inches thick. These divide the pedestal into wells about 6½ inches square and have their upper edges planed to receive the bottom of the shoe plate, which has a narrow longitudinal rib fitting a corresponding slot in the top of the pedestal. The ends of the stringers rest on webbed cast-iron abutment pedestals, each of which has guide ribs to receive one stringer at each end.

The erecting traveler had a four-post timber tower about 32 x 27 x 26 feet high over all. Each of the four vertical sides was trussed with X-braces and vertical rods between the 12 x 12-inch corner posts, making two-panel Howe trusses; the top was braced horizontally with two panels of X-bracing between the caps and a center longitudinal strut. The bottom longitudinal sills were double, and the 12 x 12-inch floor-beams rested across their tops; at each end they projected 5 feet beyond the corner posts and carried a pair of 12 x 12-inch transverse beams on which there was seated a derrick mast close to each corner post. A gudgeon in the top of the mast took bearing in a horizontal ¾-inch corner plate which was bolted between the under side of the longitudinal and the upper side of the transverse strut, and connected them. The fittings were made with ¾-inch side plates and the derrick had a 12 x 12-inch boom 24 feet long. There were three 22-inch double-flange wheels under each corner of the tower and two in the middle of each side, sixteen in all, and derrick fittings and other ironwork from the erection plant for the Victoria bridge were used here. Field riveting was done by Boyer pneumatic hammers, supplied with air from a 12 x 12 x 12-inch compressor made by the Ingersoll-Sergeant Drill Company.

The bridge was designed and constructed under the direction of Mr. Joseph Hobson, chief engineer of the Grand Trunk Railway, Montreal, and was built and erected by the Detroit Bridge & Iron Works, Mr. A. L. Colby, engineer, and Mr. J. W. Stoughton, superintendent of erection.

Some Dams Recently Built by the Spring Brook Water Supply Company.

About five years ago the Spring Brook Water Supply Company was organized to furnish water for domestic, manufacturing and mining purposes to the district between Scranton and Nanticoke, Pa. The territory covered with the company's pipes is about 50 square miles and has a population of nearly 225,000. A large quantity of water is used for collieries, coal washers and other industries for which a supply somewhat inferior to that for domestic purposes is delivered through separate pipe lines, and this double service permits all the available water in the vicinity to be put to use. The company is steadily increasing its storage capacity, and in the "Transactions" of the Association of Civil Engineers of Cornell University for 1900-1901 there is an interesting description of some of the dams, contributed by Mr. John H. Lance, chief engineer. An abstract of some of his notes is here presented.

What is known as the Mill Creek dam No. 1 was built in 1897-98, about 9 miles from Wilkes-Barre. The watershed above the reservoir has an area of about 7 square miles, mostly wild land, and practically without inhabitants. The reservoir has a water surface of 100 acres and is formed by a dam 1,300 feet long, built of masonry in the central portions and earth embankments on either wing.

There was very little soil over the greater part of the reservoir site, which made it comparatively easy to clear the basin. All trees and brush over the flooded area and on a strip 15 feet wide outside the flow line were cut down; the large trees were cut into logs and the brush piled in heaps which were burned when dry. Stumps more than 6 inches in diameter were blown out with dynamite and the smaller stumps were pulled with a tripod and differential pulley. The sods and small roots were grubbed out and piled on the stumps, and these heaps were burned when dry, crude petroleum being added when necessary.

The masonry dam is 284.6 feet long, 100 feet at the east end forming the spillway and the remainder the main dam. The east embankment is 572 feet long and the west embankment 443 feet, both of them having heavy core walls and masonry wing walls at their junction with the masonry dam. The west embankment and the masonry dam are straight, while the east embankment has a curve of 26 degrees upstream from the axis of the other divisions.

The main dam is 8 feet wide at the top, which is 3 feet above the overflow level, and has a maximum height of 73 feet from bedrock to crest. Its greatest width is 53 feet, and the width of the foundation masonry is 47½ feet. The downstream face has a batter of 8 inches per foot from the foundation to within 27 feet of the top, where it is curved with varying radii to a vertical face beginning 3 feet below the top. The upstream face has a batter of 1 inch per foot to within 27 feet of the top, where the dam is 16 feet thick, and from this elevation upward it is vertical. The spillway has a slightly heavier cross-section than the main dam and is stepped in courses of varying height to break the force of the falling water.

The foundation of the masonry dam was prepared by removing all loose rock, care being taken not to disturb any projecting points of sound stone. The maximum depth at which rock was found was 7 feet, and the material was a sandstone with irregular beds and cleavage planes. The earth and rock were removed by derricks and the rock suitable for masonry was saved for such use. All cracks and seams in the bedrock were grouted. A cut-off trench was excavated along the upper toe to a depth of about 4 feet. The foundation was thoroughly scrubbed with brooms and washed with water under pressure from a hose to remove clay and dirt and ensure a good adhesion of mortar. On this the beds were made for the stones, which were thoroughly cleaned and wet before being swung into place by derricks. The vertical spaces between the stones were packed with mortar and spalls of such size and number that the joints were tight without wasting the mortar.

Stone was obtained from three quarries, one of them furnishing a very seamy red sandstone weighing 166.7 pounds per cubic foot, the second a conglomerate which was rather seamy and weighed 163.5 pounds per cubic foot, and the third a very hard conglomerate weighing about 167 pounds. The main dam was built of the soft conglomerate to within 38 feet of the top and finished with the hard conglomerate. The quarries were 400, 900 and 6,000 feet from the dam and were connected with it by 3-foot railways. Sand was found within 800 feet of the site. With the exception of a small amount of Improved Union cement in the core wall of one of the embankments, Portland cement was employed, the brands being Atlas, Giant and Dragon. It was mixed to form a 1:3 mortar, except for pointing, where equal parts of sand and cement were used. The concrete was mixed in the proportion of 1:3:5, the stone being broken to about 2½ inches by hand.

The masonry of the main dam is rough rubble with quarry-faced broken-range work on both upstream and downstream faces, with the exception of the spillway, where the downstream face is quarry-faced range work. The masonry of the main dam and spillway was mostly laid by derricks and the stones weighed from ½ to 4½ tons, the latter being as heavy as the plant could handle. As no attempt was made to lay the backing stones in courses, the work was always left rough and irregular, securing a good bond with the masonry laid upon it. The wall was kept moist at all times, and that part of it on which the masons were employed was kept free from dirt, dry mortar and stone dust. The upstream face stone of the dam were laid with horizontal beds, while the downstream face stones were cut square and laid with their beds at right angles to the face of the dam, the greatest inclination of the bed being 8 inches in the foot. The face stones on the curved section were brought to line by means of a curved batter board about 4 feet high, having a scale marked along its lower edge which enabled it to be set with a plumb bob for any desired elevation. In this way the wall was carried up as accurately as with a straight batter board, and with no more inconvenience to the masons Stones were held in position on their inclined beds until the mortar had set and backing had been laid against them, by short pieces of 2-inch pipe, different lengths of which were kept on the wall.

The stones forming the steps of the spillway were set with level beds and a lap under the stones of the step above of 12 inches at least. The joints and beds throughout both faces of the dam and wing walls were about 1 inch, and all joints were required to break at least 12 inches with those above and below. The joints of the spillway steps and all coping joints were filled with 1:1 grout. On the upstream face of the dam the pointing was made smooth and slightly rounded, but on the exposed surfaces it was hollowed and burnished