Design and Construction of Youngs Bay Bridge

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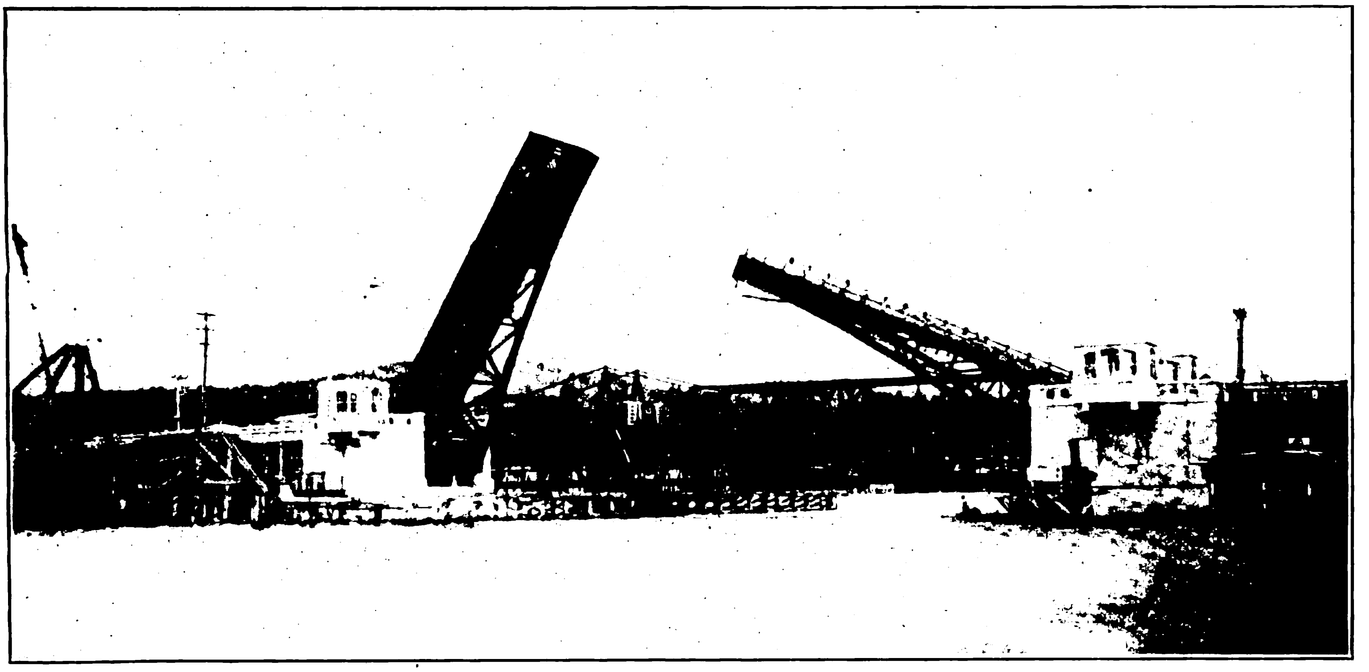
The Columbia River Highway crosses the mouth of Youngs River about three miles above the junction with the Columbia River at Astoria, Oregon. At the point of crossing the bay is about half a mile wide and has a depth of channel of about twenty-five feet at low water. This channel leads to a very desirable anchorage for the small craft in and around the entrance to the Columbia River and also serves as the outlet for the logging operations farther back in the hills. The War Department required a 150' clear channel at this point on account of the possibility of future development up the bay. The State Highway Commission, therefore, decided to build a double leaf bascule in order to adequately care for the river traffic without serious delay to the people using the highway. After thorough investigation and an extensive series of studies the type adopted was the double leaf simple trunnion bascule with deck roadway and fixed counterweight underneath the approach floor.

In apportioning the cost of the structure among the interested parties advantage was taken of the thirty-three and one-third percent Federal Aid allowed on post road projects. The remaining sixty-six and two-thirds percent was divided equally between the state highway commission and Clatsop county. In the maintenance of the structure the state pays all maintenance cost and the county pays the cost of operation.

The total length of the structure is 3376 feet. Beginning at the Astoria end there is fifty feet of hydraulic fill to the bulkhead line, then 874 feet of pile trestle from the bulkhead line to the north side of the pier. The distance out to out of piers, or in other words, the total length of the permanent portion is 227 feet. From the south side of the south pier to the south bulkhead line is 665 feet of pile trestle. From there to the existing road on the south shore is 1560 feet of hydraulic fill.

The hydraulic fills are made by means of the sheer board method utilizing the sand and silt dredged from the channel. They are 24 feet wide on top and will be thoroughly settled before the paving is laid on them.

The trestle approach is designed to carry two fifteen ton trucks and a uniform live load of one hundred pounds per square foot. The roadway is twenty feet wide and there is a four foot sidewalk on the north side. The floor of the trestle is a two and one-half inch layer of asphaltic concrete laid on a subfloor of laminated 2"x6". The stringers are especially heavy for trestle work, consisting of eight lines of 6"x 20". There are four timber piles to each bent and the bents are tower-braced in pairs making one space open for small boats and the next closed by sway bracing and longitudinal girts. All hardware used in the approaches was heavily galvanized and all cuts, daps and contact surfaces of the timber were painted with two coats of hot carbolineum to protect them from decay. Fire protection is provided by means of a four inch galvanized pipe wtih hose connections every three hundred feet. The pipe is carried along side the handrail in a wooden box filled with sawdust to prevent its freezing.



YOUNGS BAY BRIDGE NEAR ASTORIA, OREGON, SHOWING PRACTICALLY COMPLETED STRUCTURE, JUNE 10TH, 1921, OLD BRIDGE IN BACKGROUND

Especial care was taken to secure an attractive design and careful workmanship for the handrail. Chamfered 12x12 posts are used at each bent with two straight 8x8 posts between each bent. The rails are 6x8 framed into the center of the posts and the whole heavily painted and sanded. The results obtained fully justified the effort as the handrail has a beauty and dignity rarely found on trestle work.

The piers had to be founded on the soft bottom of the channel and as there was no indication of solid foundation at elevation minus 100; fir piles were used and designed for a safe bearing power of twenty tons. Also on account of the porous nature of the foundation it was impossible to pump out a cofferdam so a tremie seal was used. Each tremie seal is nineteen feet thick and rests upon 210 piling which project from three to five feet into the concrete furnishing sufficient bond to admit of leaving off three feet of the calculated depth of seal. The depth ordinarily required is .43 times the static head against the bottom or the ratio 62.5÷145. The outside dimensions of the seal are 40'-6"x 36'-8" and the three feet difference in depth represented quite a saving in material. No reinforcement is used in the seal although when the cofferdam was pumped out a mat of bars was laid across the top of the tremie concrete and dowels placed for the columns and then a layer of concrete poured to level up the top of the seal. From here the work was designed to be carried on in the dry. Columns and walls were left clear of the inside of the cofferdam to allow space for forms until well above high water mark, when the brackets to support the operating houses were brought out. The rear end of the counterweight swings down to about elevation —1.0 whch required a watertight pit to allow the bridge to be opened at high tide. In general the make up of the pier can best be described as a waterproof concrete box approximately forty by thirty-six feet in plan and twenty feet deep supported upon and built around six heavy concrete columns. These columns rest upon the tremie seal and the whole is supported upon the piling. The main columns are on opposite sides of the roadway slightly forward of the center of the pier and support the trunnions and the whole of the dead load of the moving leaf. The forward columns are on the center lines of the trusses and support the shoes which carry the live load. The rear columns are also on the center line of the trusses and are built around

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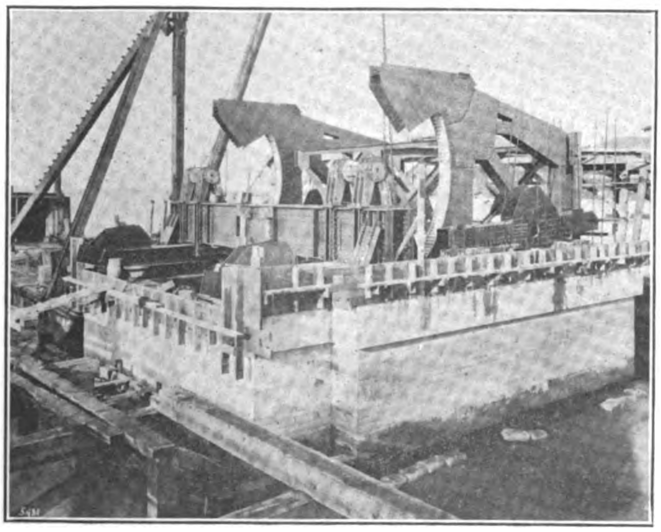
structural steel anchor columns extending nearly to the top of the seal. These anchor columns engage brackets built on the rear end of the counterweight and prevent the moving leaf tipping about the forward or live load shoes when the live load becomes sufficient to move the center of gravity of the combined dead and live load out beyond the forward bearing. The maximum uplift on these anchor columns under full live load is about thirteen tons on each or twenty-six tons for the leaf. Above the high tide line the sides of the pier are lightened and support only the operating houses and railings. The thickness of eighteen inches used in the watertight portion is decreased at elevation +19.0 to eleven inches and this again tapered to eight inches at the roadway level. Particular care was taken in the treatment of the operating houses and handrail to secure a simple yet ornamental structure. This is a feature not ordinarily found in movable bridges and the progressive results obtained by the City of Seattle in their bascules as they went from the Ballard to the Fremont and finally to the University bridge fully justified the effort to secure a structure that would represent architectural as well as structural achievement. The operating houses are on the north pier. The one on the east is fitted up as living quarters for the operator while the one on the west or ocean side is equipped as the operating house proper with the controls for operating both leaves. The two houses on the south pier are vacant for the present although one is provided with plumbing to be used when it becomse necessary to provide for two operators. The other is to be used as a store room for the tools and equipment needed about the bridge. A fog bell and navigation lights are provided for the convenience of water traffic and two electric sirens and electrically operated roadway gates are provided to safeguard the highway traffic. One of the important features of a bascule of this type is that the floor of the moving leaf completely closes up the roadway when the span is opening. There is at no time a larger opening than three feet from the fixed floor to the lower end of the moving arm making it absolutely impossible for any vehicle to ever break through the barrier and then fall into the water.

The moving leaf is a simple cantilever structure from the forward support to the center line of the channel. Back of the forward support it is also a cantilever after it passes



YOUNGS BAY BRIDGE NEAR ASTORIA, OREGON, SHOWING MOVABLE LEAF PARTIALLY ERECTED AND ILLUSTRATING MAIN CROSS GIRDER, TRUNNIONS AND TRUNNION BEARINGS. MAIN RACK COUNTERWEIGHT, END OF TRUSS, ANCHOR COLUMNS AND GENERAL DETAILS OF PIER TAKEN NOVEMBER 1920.

the main bearing. The rear cantilever supports the counterweight and the uplift due to over-balance from live load. The portion of the moving truss between the counterweight and the forward bearing is so arranged as to allow a heavy girder to be carried from side to side of the pier and supported on the main columns. This girder carries the four trunnion boxes which support the two trunnions, one through each of the two main trusses. It also supports the forward end of the fixed floor of the roadway; the break between the fixed and moving floor being about five feet ahead of the trunnions. The rear ends of the fixed floor stringers are carried on the rear wall of the piers. The machinery floor is hung underneath this fixed floor between the main cross girder and the counterweight and is supported at the forward end by the main girder and at the rear end by hangers from the fixed floor.

The final transmission of power to the leaves is by means of an internal rack of nine feet pitch radius bolted to the trusses in the opening provided for the main cross girder. The counterweight swings down past and underneath this machinery floor which remains stationary at all times. The counterweight is of concrete cast in place and provided with galleries and pockets to allow balance blocks to be put in or taken out to adjust the counterweight to the seasonal differences in weight of the forward arm. This forward arm has a laminated 2" x 8" wood floor covered with two inches of asphaltic concrete keyed to the floor by the uneveness of the rough 2x8 laminations. The summer heat dries out the wood and the winter rain soakes it up making quite a difference in the weight which the concrete has to balance. The original computations for balance take into consideration every item in the moving leaf even to the rivet heads and the paint on the steel work. Test blocks of the concrete contemplated for use in the counterweight were made and carfully weighed at intervals to determine the exact amount required and when all the weights were known and checked by shop weights of the steel work a design for the counterweight was made so that the center of gravity of the whole moving system is placed just 1⅜" above and 1⅛" forward of the exact center of the trunnion. This causes the bridge to be slightly overbalanced on the forward end so that it will drift shut from about one-quarter open and drift fully open from about three-quarters open. This makes it very easy to seat without jarring. The calculations for balance are the most exacting part of the design and required the time of from two to three men for over a month.

The total weight on the each pair of trunnions is 420 tons, of which 244 tons is counterweight. To move this mass in the time limit of one minute to fully open and one minute to fully close, two thirty-seven H. P. motors are provided on each leaf. Ninety per cent of the capacity of one of these motors is sufficient to operate the leaf in a fifty-six mile gale or a load of ten pounds per square foot on the surface of the upturned leaf. The second motor is in the nature of a spare and is wired and attached to the machinery in order to keep it dry and in running order. The machinery is so arranged that for power operation no bevel gears are used; all the gears being of the spur type. Cast steel is used for all the gears and machinery frames and forged steel for all main shafting over 4 inches in diameter. Cold rolled steel is used for minor shafts. The hand operation uses three sets of bevel gears and requires some two hours for two men to open the bridge. This, however, is only intended for emergency use. There is a five H. P. motor at the center of the channel on the north leaf for the purpose of driving and pulling the pins which lock the two leaves together when the bridge is down. These pins transfer shear only and no moment and are merely for the purpose of keeping the floor on the two sides of the break at the same elevation during the passage of a load. They are controlled from the main operating house as are all the other operations on the bridge. It is not necessary for the operator to move from his control manual to close the gates, draw the center lock pins, raise and lower the leaf, drive the pins and again open the gates. All these operations are electrically interlocked and limit switches are provided which cut off the power and apply automatic brakes in time to prevent the bridge coming into contact with the shoes at high speed. Tell-tale lights are located on the operator's manual to indicate the on and off condition of each set of navigation lights, and to indicate the position of the roadway gates and also to indicate the different positions of each leaf during the operation. In the main operating house is located the main switch board which receives the outside line current and distributes it to each leaf and to the different controls. The motors are handled by means of master switches and remote control switches through heavy resistances, the remote control board and resistances being located on the machinery platform underneath the fixed floor. This machinery room is completely enclosed in metal lath and plaster walls with fireproof metal doors and windows. The concrete floor of the fixed roadway floor forms the roof of the machinery house. In this floor directly above the motors and main gear frame is a removable slab which will allow the machinery to be taken out if repairs should become necessary. Access to the machinery for maintenance and ordinary care is had by means of a manhole in the floor of the operating house which leads to the machinery floor level by means of a steel ladder and gratings.

The watertight pit is reached by means of another steel ladder and in this pit about four feet above the floor is located the pit pump and motor for removing any splash from the waves and what water drains into the pit from the roadway. It will also take care of any seepage should the walls become leaky in the future although to date there has been no leakage. It is reasonable to suppose that, barring shocks sufficient to crack the walls, the pit will continue to be absolutely watertight.

The new bridge replaces an old steel swing span built in 1892. The old span and portions of the old draw rest are seen in the background in the illustration of the new bridge. The channel arms of the new span are very shallow at the center to give all possible waterway clearance and for this reason plate girders were used in the two end panels of each leaf. The same handrail is used on the center span as on the approaches and produces a very substantial appearance. The piers will be protected by pile and plank sheer walls. Behind the sheer wall of the north pier is located the platform carrying the transformers which take the three phase 25,000 volt current from the power company's lines and deliver the four hundred forty volt current to the bridge. The power and controls for the south leaf are carried across the channel in submarine cables buried three feet in the bed of the stream.

Work was commenced on the structure in February 1920 and practically completed by May 31, 1921; the time limit set in the contract. At that time it was impossible to proceed further till the paving contract could be put under way, the new bridge paved and the old swing span removed.

The early days of the contract were spent in building gridirons for supporting the mixing plant and ways for building and launching the caissons and in general assembling the construction plant. Test piles were driven and tested during the week of March 27th 1921 and the caissons were started the same week. The piling drove to elevation -93 and -100 with the aid of the jet and showed a safe load of 20 to 27 tons. They could not be pulled and were left as part of the permanent pier. During the next week the north caisson was launched, having by this time grown large enough to float during the rest of its construction, and the south caisson started and built high enough to launch. This one was launched about May 1, 1920. Excavation started in the north caisson about May 15th and was completed on May 25th. Pile driving started in the north caisson during the week ending June 19, 1920. The piling were driven to cut-off elevation by means of a jet and a follower. The first follower was built of ¾-inch rivetted structural plate and did not last through the first pile. A heavy cast steel follower was then made and proved a great success. It drove all the rest of both piers and is still as good as new. It is about eighteen inches in outside diameter and six feet long. The shell is tapered from three quarter of an inch in thickness at the ends to two inches at the center and has a four-inch thick diaphragm across the middle.

While this follower was being made the north approach was brought out to the north pier, the driver moved to the other end and practically all of the south approach driven and capped, and the south caisson sunk and partially excavated.

Pile driving was finished in the north caisson on June 7th, 1920. Most of these piles went to about elevation -104 or over 100 feet below low water and seventy feet below cut off and developed an average bearing value of over thirty tons each. Pile driving started that week in the south caisson which had by this time been sunk to place and excavated. Driving in this caisson was completed August 3rd, 1920.

The 210 piles in this crib were driven in 166 working hours or an average of 47½ minutes per pile. The best day was 25 piles or 36 minutes per pile and the best shift was 14 piles or 32 minutes per pile.

The pouring of the tremie seal in the north pier was started on Wednesday noon July 28th, and continued without interruption until Friday evening, July 30th, at which time it was completed. The seal in the south pier was poured in 39 hours between Wednesday noon August 18th and Friday morning August 20th. This took 1128 batches from a 1 yd. Smith mixer running about ¾ cu. yds. per batch or an average of 29 batches or 23.6 cubic yards per hour. The best shift during this time was 384 batches in 10¼ hours making 37½ batches or 30.5 cu. yds. per hour or a total of 313 cu. yds. in 10 hours, 15 minutes.

The north pier was pumped out on August 23, and forms started the same week for the balance of the pier. The caisson leaked slightly when pumped out but was soon plugged and gave no further trouble. These caissons were of 12x16 and 12x14 timbers near the bottom decreasing to 12x12's at the top. They were very solidly constructed and braced and the success of the whole undertaking is in no small measure due to the foresight used in their construction and placing.

The south pier was pumped out on September 4th and proved somewhat tighter than the north.

On Monday, September 13, a storm filled the north crib with water and stopped work till Tuesday afternoon when it was again pumped out. At that time the forms were completed to well above the high tide line and most of the reinforcement was in place for that much of the pier. The fact that the forms and reinforcing were not harmed in the least by this severe treatment speaks volumes for the ability and workmanship of the contractors.

From this time on work went very smoothly and without serious interruption. The steel girders were placed early in November and on March 8th, 1921, the two leaves were lowered for the first time, having been erected in the open position in order not to obstruct the channel. Very little field fitting had to be done and when lowered the computed clearance of 2 inches between the extreme ends of opposite leaves was checked within one-quarter of one inch, the measurement being 1¾ inches. This is considered an absolute check for all practical purposes and shows careful and conscientious work both in the shop and in the field.

From March 8th to May 31, was taken up mainly with the finishing of the pier walls and operators' houses, the installation of the mechanical and electrical equipment and the completion of the approaches.

The best day's work in pouring the pier concrete above the seal was on September 10, when 281 batches were poured in nine hours or 31 batches per hour.

In driving the trestle approach the best day was June 9th, 1920, when four bents of four piles each were driven and capped in eight hours. The average day's work on driving the approaches was slightly over three bents driven and capped.

The main quantities in the structure are as follows:

Excavation, 1700 cu. yds.; foundation piling, 23,000 lin. ft.; tremie concrete, 2600 cu. yds.; 1:2:4 concrete, 1170 cu. yds.; reinforced steel, 163,000 lbs.; structural steel, 600,000 lbs.; counterweight concrete, 237 cu. yds.; machinery, 64,000 lbs.; balance blocks, 400 (1 cu. ft. each); pit pumps and motors, 2; main motors, 4 at 37 H. P. each; approach piling, 21,000 lin. ft.; approach lumber, 500 MFBM.

The state highway commission was represented on the work by R. A. Furrow, resident bridge engineer, and C. P. Richards as assistant both under the direction of L. P. Campbell, assistant bridge engineer in charge of all construction in the state.

The contractors were The Gilpin Construction Company, of Astoria of which J. F. Gilpin is vice-prseident. Mr. Gilpin devoted his whole time to this work and is responsible for the entire success and speed with which the work was done.

The design was prepared in the state highway bridge department at Salem by the writer under the direction of C. B. McCullough, bridge engineer representing Herbert Nunn, state highway engineer. The mechanical and electrical design was prepared in the same office and under the same direction by J. A. Dunford, now with the city engineer's office, Seattle, Washington.

The outstanding features of the whole work have been the thorough and workmanlike manner in which it was handled by the contractors, the high class of material furnished and lastly and deserving of especial mention the amicable relations which have existed at all times between the contractors and their agents and the state highway department.

Electrical Men Convene

The fourteenth annual convention of the Northwest Electric Light & Power Association was held at Portland June 15, 16 and 17. The convention was attended by executives and managers of public utility corporations carrying on operations in Oregon, Washington, Idaho, Montana and Utah. Many discussions of interest were features of the sessions. A paper was read on "Some Essentials of Power Development," by L. T. Merwin, vice-president and general manager of the Northwestern Electric Company, Portland, and a report was rendered by the executive committee of the technical section of which George E. Quinan, chief engineer of the Puget Sound Power & Light Company, Seattle, is chairman. There was an extended discussion following the presentation of each of these papers. The executive committee of the public relations section made a report and "Winning Public Support and Confidence in the Public Service Industry" was discussed in a paper prepared by George L. Myers of Portland. Robert Sibley, editor of the Journal of Electricity, San Francisco, talked on the water power and electrical development possibilities of the Pacific Coast and inter-mountain states.