PROPOSED DAM, ESTABROOK PARK, MILWAUKEE COUNTY

The dam proposed to be built across the Milwaukee River at Estabrook Park, a unit of the Milwaukee County Park System, will be located between stations 12 and 16 on the base line established for the work contemplated, the zero point of the base line being at Port Washington Road bridge, the line extending easterly and southerly nearly in the center of the river channel. Construction of the dam is part of a flood relief project on the Milwaukee River, which has been under way since the fall of 1933. A map of Milwaukee County is submitted herewith, showing the location of the various points referred to herein.

HISTORY

The Milwaukee River, draining a watershed of 840 square miles, has its source about 60 miles northwest of Milwaukee in what is known as the Kettle Moraine District. The Kettle Moraine area is the result of a glacial deposit, and the entire moraine contains thousands of acres of gravel; it acts as a sponge for ordinary rainfall, soaking up the water after each precipitation and discharging it gradually through springs and lakes throughout the year. The lower portions of the river, however, run through country with heavier soil and there is sufficient cover upon the farms and wooded sections to hold back the flow of water caused by normal rains, so that ordinarily the flow in the river is not excessive. Certain combinations of factors from time to time cause trouble with floods in the lower reaches of the river. Very often in early spring, when the ground is frozen and covered with ice, a warm rain will produce a very rapid runoff, causing flood conditions. Occasionally during the summertime heavy storms of a cloudburst nature, extending over a rather large portion of the drainage area, are likely to cause flood conditions along the lower portion of the channel. Such floods have occurred periodically as far back as there has been any record of habitation of the Milwaukee area. When the country was scarcely populated, little thought was given to occasional flooding of the lowlands, but with the metropolitan growth of Milwaukee County along the Milwaukee River to the north of the City attention has been focused upon floods, and some method has been sought of alleviating this condition.

The Milwaukee River enters Lake Michigan at approximately the center of the city of Milwaukee. Flood troubles start to the north of Capitol Drive and from here to the Silver Spring Road floods are a source of annoyance and damage to the built-up urban area, both within and without the city of Milwaukee. From Silver Spring Road north for several miles, damage by reason of floods occurs to the colonies of summer residents located along the river banks and to truck gardens and green houses located on the river flats.

The cause of the trouble north of Capitol Drive is a limestone ledge or outcrop about a mile long, over which the river flows. The elevation of this ledge is approximately 36.00 feet above datum, which is the river level, where it empties into Lake Michigan. The ledge is located approximately 7 miles upstream from the outlet, so that once the water has passed beyond the rock ledge, there is sufficient fall for its rapid disposal. For a distance of 3 miles upstream from this ledge, there is no fall in the river bed; in fact, successive floods have gouged out the river bottom to such an extent that in this 3 mile area the river bed, for the most part, is well below the top of the rock, thereby creating, in effect, a body of still water or a lake as wide as the river, and about 3 miles long. In this area the river banks are only a few feet above the normal water level and at flood stage the water rises above the banks. The area flooded is not large, but the damage due to floods is rather large in proportion to the area flooded, by reason of the urban development adjoining.

One source of trouble in this area is Lincoln Creek, a tributary of the Milwaukee River, draining about 20 square miles of the northerly portion of the County of Milwaukee. Lincoln Creek enters the Milwaukee River about a half mile upstream from the rock ledge and during time of flood water from the river backs up into Lincoln Creek, flooding the storm water sewers of that portion of the city of Milwaukee drained by Lincoln Creek.

As a result of successive floods, individuals, civic associations, and delegations from the flooded district have repeatedly invoked the aid of the Town Board, the City of Milwaukee, Milwaukee County, the State Public Service Commission, and the State Legislature. The City of Milwaukee has made an exhaustive study of the condition, and much of the data contained herein is from the files of the City Engineer of Milwaukee.

In the fall of 1933 removal of the rock ledge was innaugurated as a CWA project, Milwaukee County working on that portion lying east of the Port Washington Road Bridge, and the city of Milwaukee operating the portion to the west of the Port Washington Bridge. The County's operations extended through Estabrook Park, and the City's operations extended through Lincoln Park, then a City park. Under consolidation of City and County parks, effective as of January 1, 1937, Lincoln Park has become a part of the County Park System. The City of Milwaukee continued removing the rock to the west of the Port Washington Road Bridge under the FERA program and under the present WPA program, and the National Park Service CCC Camp, Wisconsin SP5, has been operating on the removal of rock through Estabrook Park. Rock removal is practically completed.

NECESSITY FOR DAM

As mentioned before, there are a number of summer homes and cottages located along the Milwaukee River on the east side of the Green Bay Road north of Silver Spring Road. These homes are located on the bank of the river, which is not high above normal water level. The residents of these homes have use of the river for swimming, boating, canoeing, and the like. The fact that the water is deep enough for such sports is the real reason why these homes are located along the river. In Lincoln Park a bathing pavilion and beach have been used for many years in the past.

It is therefore necessary to maintain the river level during stages of ordinary flow. When the rock ledge or barrier through Lincoln Park and Estabrook Park has been completely removed, the water level upstream will drop to such an extent that all swimming, boating, and recreational facilities of such type will be eliminated, unless a dam is built to maintain the water at its previous ordinary level, and the riparian owners would have grounds for damage suits unless this were done. Such a dam must be designed so that it will adequately discharge the flood waters and permit the flood relief work that has been done by removal of the rock to become effective.

LOCATION OF DAM

The site of the dam is to be in Estabrook Park, located between 1200 and 1600 feet east of the Port Washington Road Bridge. This location was chosen because it is near the point where removal of the rock barrier ends, and it is also the site at which a dam of the type proposed can be constructed so as to harmonize with the landscape. It is the point farthest downstream at which a dam may be constructed without causing damage to adjacent property.

TYPE OF DAM

The dam proposed to be built will consist of a gate section with gates that can be manually operated so as to lower the flood water, and a rather long serpentine crest section, over which the water will flow at normal elevation. This crest section will also discharge a considerable portion of the flood waters when these occur. The ice in the river will also be discharged over this portion of the dam.

ELEVATION OF CREST

The crest of the dam is to be at elevation 36.00 feet (City of Milwaukee Datum). This elevation is required in order to maintain the same water elevation upstream as existed before the rock ledge was removed. Cross sections and elevations taken on the rock ledge before removal show that at the highest point in the ledge the low elevation of the rock was at about 35.4 feet. This low elevation extended across the river for only a short distance, so that the normal elevation of the water as it crossed the rock ledge was at no time less than 36.00 feet. Accordingly, the elevation of 36.00 feet has been selected as the necessary elevation for the crest of the dam.

LAKE TO BE FORMED

The construction of a dam at the point discussed will create a lake having an area of approximately 103 acres. This lake, of elongated shape, following generally the river channel except in the area north of Hampton Road (where an enlargement of the river with a new cut-off channel and islands is being studied), will have a shore line of about 46,400 lineal feet.

The body of water referred to herein as the lake is not a new sheet of water, which is being formed as the result of the construction of the da[m] but is the replacement of the river level to the elevation which existed prior to removal of the rock ledge. The only additional water area being formed at a level higher than that which previously prevailed is that included in the newly deepened river channel from the dam 1200 feet east of the Port Washington Road bridge to a point approximately 1200 feet west of the Port Washington Road bridge. As mentioned above, additional water area is also being planned entirely within the confines of Lincoln Park.

From the dam to Hampton Road private property will have a frontage of 3000 feet on this lake, and from Hampton Road to the north line of Lincoln Park there will be a frontage of 1800 feet privately owned. Based on a total evaporation of 30 inches per year from the free water and ice surface, the total evaporation from the lake will amount to 0.367 cubic feet per second.

VOLUME OF WATER IN THE RIVER

The maximum flood recorded was that of August, 1924, at which time a discharge of 14,700 cubic feet per second took place. There have been any number of lesser floods, ranging from about 4,000 c.f.s. to 12,000 c.f.s. The City Engineer's Office of the City of Milwaukee made a rather extensive study of past floods and probable floods and the following data was supplied by them:

1 percent chance flood (1 in 100 years) (computed)	23,400 c.f.s.
4 " " " (1 in 25 years) (maximum on record 1924)	14,700 c.f.s.
30 " " " (1 in 3 years)	6,400 c.f.s.
Ordinary spring and fall flow	1,000 c.f.s.
Minimum dru weather flow - August 18, 1934	9 c.f.s.

Plan E-9006-2-(6) is a chart compiled from gauge readings made by the U.S.G.S. and shows the maximum and minimum discharge of the Milwaukee River at the Port Washington Road Bridge.

PERMISSABLE FLOOD WATER ELEVATION AT DAM

Elevation 38.00 feet was decided upon as a maximum by the engineers of the city of Milwaukee for a 14,700 c.f.s. flow over the dam. This elevation was determined as the maximum permissable, in order to avoid flooding of the streets of that portion of the city of Milwaukee draining into Lincoln Creek, and thence into the Milwaukee River, and to reduce to a minimum the area which is subject to overflow due to flood flows.

DOWNSTREAM ELEVATION AT SITE OF DAM

At station 16 computations show that with the widened and deepened river channel and without a dam, the water elevation for a 14,700 c.f.s. flood would be approximately 35.30 feet. This elevation was determined, using Manning's Formula, in the investigation of the flow in the river. In this computation the coefficient of roughness was taken at 0.023 for the improved channel and 0.025 for the rest of the river, the latter coefficient being the result of computations from actual gage readings and discharge data obtained along certain sections of the river.

Upstream at Lincoln Creek confluence 40.83 during 14,700 cfs flood

DESIGN OF DAM

Observation of the flood conditions on the Milwaukee River over a period of years, by the engineers of the City and the County of Milwaukee resulted in an agreement that it will be necessary to construct a dam with gates. It was felt that the gate section was necessary in order to avoid an unduly long dam without gates and that flood waters could be better controlled with gates than without them. It was further determined, as a result of these studies, that a wier or crest section should be provided, over which ice could pass. In order to present a completed structure of most pleasing appearance, and one that would blend with the landscape to the best advantage, the County landscape architects suggested that the gate and crest sections of the dam be separated by a small island. The dam has been designed accordingly, with a gate section and a crest or spillway section.

The crest section is to be built in the form of a curved spillway 562 feet long, located in the main channel of the river, and is to be built of reinforced concrete with a stone facing. 513 feet of the spillway is to have a crest elevation of 36.00 feet and 22.00 feet to have an elevation of 35.80 feet, the remainder of the length of this section of the dam being formed by stone covered abutments gradually rising up to elevation of 40.00 feet. The 22 feet of spillway at elevation 35.80

is designed so as to concentrate extremely low water flow at certain points in the dam where it may be readily seen by park visitors. This same plan was used in the Kletzsch Park dam, built by the National Park Service at Kletzsch Park in Milwaukee County, and the results in extreme low water flow are quite satisfactory.

On the face of the stone spillway a fish ladder will be constructed, consisting of a series of small pools, each being at a slight elevation above the other, so as to permit migratory fish to travel upstream.

The gate section of the dam will be located in a channel 155 feet wide, with a 3-1 slope on each side. This section of the dam will be built of reinforced concrete with 10 vertical steel gates of the sliding type, each 11 feet 6 inches wide. At each end of the gate section is a 10 foot 4 inch spillway with a crest elevation of 35.90 feet and an abutment containing stairs leading to the operating bridge, which extends across the dam over the gates. In lowered position the gates form a spillway with top elevation of 36.30. It is desired to force the water over the crest or curved spillway, except for a small amount which will pass over the 10 foot 4 inch spillway with crest elevation 35.9 located at each end of the gate section.

At the entrance to the 155 foot channel containing the gates, there is to be placed a line of reinforced ice guards 11 feet 6 inches on centers, in order to divert the larger blocks of floating ice away from the gates and direct this ice toward the curved spillway.

DISCHARGE OF WATER THROUGH GATES AND OVER SPILLWAY

In computing the discharge of water over the section of curved spillway, the discharge per lineal foot of curved spillway would be approximately the same as if the spillway was, at all points, at right angles to the direction of the flow of the stream. This was established by actual flow measurements made by Mr. M. B. Coifman, Consulting Engineer, retained by the County Park Commission on this project. These experiments were conducted by Mr. Coifman in the Hydraulic Laboratory of the University of Wisconsin in February, 1935, preliminary to the construction of a dam of similar shape at Kletzsch Park. An allowance of 3 percent for curvature losses in the discharge is considered a proper factor of safety. The computations for discharge per lineal foot of crest at elevation 36.00 feet with a headwater level of 38.00 feet are as follows:

$$q_1 = 0.97 \left[C\,(h_c + h_v)^{3/2} - (h_v)^{3/2} \right]$$

v = 2.00 feet - computed for a point a short distance west of the crest and gate sections, and for the hydraulic elevation 38.00

$$h_v = \frac{v^2}{2g} = \frac{4}{64.4} = 0.062 \text{ feet}$$

$$h_c = 38.00 - 36.00 = 2.00 \text{ feet}$$

The coefficient of discharge will be 0.97 to allow for the assumed curvature loss of 3%

Assume conservatively that $C = 3.75$

then $q_1 = \; = 10.7$ c.f.s. per foot of crest

For the condition where $h_c = 38.00 - 35.80 = 2.20$

then $q_2 = 12.3$ c.f.s. per foot of crest

The discharge for the curved spillway exclusive of abutments will then be

$Q = (513)(10.7) + (22)(12.3) = 5760$ c.f.s.

The gate section will be located approximately 350 feet upstream from station 16+00 measured along the 155 foot channel. The hydraulic grade here will vary from elevation 35.66 feet at the dam to elevation 35.30 at station 16+00. This was arrived at by using Manning's Formula with $N = 0.023$ and an average velocity of 7 feet per second, and a bottom elevation of 28.30 feet.

The hydraulic grade on the upstream side of the gates in the 155 foot channel varies from elevation 38.00 at station 11+00 to elevation 37.79 immediately west of the gates. This was also computed from Manning's Formula using a velocity of 5.1 feet per second. The total drop due to friction is about 0.11, to which 0.10 was added for the friction loss at the ice guards. The hydraulic drop at the gates will then be $H = 37.79 - 35.66 = 2.13$ feet. The depth of water on the downstream side of the gates will be

$d = 35.66 - 28.75$ (sill elevation) $= 6.91$ feet.

The discharge coefficient due to end contractions is found from formula

$l_n = l_s - 0.4\, n\ h_c$

Here $l_s = 11.50$ feet for each gate

n = the number of contractions which is 2 for each gate and $h_c = 37.79 - 28.75 = 9.04$

The coefficient for each gate becomes 0.426 and for each foot of dam will amount to 0.937, using 11.50 feet for the length of each gate

Allowing conservatively 6 percent for other discharge losses and a velocity of approach of 5.1 feet per second a discharge per lineal foot of gate of 78 c.f.s. was arrived at by the formula

$$Q = ld\ \left[2g(h+h_v - d)\right]^{\frac{1}{2}}$$

in which $l = 0.937$, computed above; $d = 6.91$ the downstream depth; $h_v = \frac{(5.1)^2}{2g} = 0.404$ and $h = 9.04$ feet

The discharge for the ten gates will then be $10 \times 11.5 \times 78.0 = 8970$ c.f.s.

Allowing conservatively 200 c.f.s. for the curved spillway abutments and gate section spillways, we have the total discharge capacity

5760 + 8970 + 200 = 14,930 c.f.s.

as against the flow of 14,700 c.f.s. to be taken care of with headwater level 38.00.

STRUCTURAL DESIGN

In addition to dead and live vertical loads, hydraulic pressure and expansion stresses, the ice pressure was taken into account as a horizontal force of 10,000 pounds per lineal foot of dam acting at elevation 35.00. In the gate section all the ice pressure is assumed to be concentrated on the piers. Ice pressure in spaces between piers is taken as 5,000 pounds per lineal foot, because adjoining portions of the structure help to relieve it considerably.

The dam is to be built on a solid rock foundation, to which it is to be anchored by means of steel rods grouted into drilled holes. Tests conducted at Estabrook Park show that steel thus embedded in the solid rock develops full strength of the steel.

Four expansion joints are provided in the gate section of the dam, reducing the maximum temperature displacement to 0.20" per section.

A live load of 150 pounds per square foot, in addition to concentrated loads, was assumed for the operating bridge.

Maximum stresses used in the design of the dam are 800 pounds per square inch for concrete and 18,000 per square inch for steel.

The design was made in accordance with the code of the American Concrete Institute and the Wisconsin State Building Code.

Because of the comparative flexibility of the gates, it was assumed that the ice will bridge itself between rigid piers without exerting a continuous pressure along the gates. However, provision was made for a concentrated load of 10,000 pounds in a horizontal direction, assumed to be the equivalent of impact due to floating ice blocks.

Each gate weighs approximately 4300 pounds, and has an initial frictional resistance of about 3800 pounds, and is lifted by two chains, each having an ultimate strength of 23,000 pounds.

A 3/4 inch play is provided between flanges of the gate wheels and the rails to take care of expansion. The gates are sealed by means of rubber belts. Wood covering is provided on the exposed surfaces for thermal insulation.

Each gate is provided with two 2000 w. electrical heaters placed alongside the wheels and rubber seals, and four 1500 w. heaters placed in the body of the gate. All heaters are fed through a single flexible cable, attached to the gate and to the operating bridge. Holes are provided in the horizontal gate beams for warm air circulation and for drainage.

The gate hoisting chains pass around sprocket wheels actuated by a worm gear reducer, designed to take [illegible] the maximum capacity of the chains. The reducer is operated by hand, and it will take about 20 minutes to lift each gate. All gears and particularly the steel worm can easily be greased before operation.

Electrical switches for all gates are located on one panelboard near the center of the operating bridge, where provision is made for connections to a portable ammeter, which will permit a check of the heaters on each gate.

SPECIFICATIONS

GENERAL

Except where called for otherwise, the latest standard specifications of the Wisconsin State Highway Commission relating to structures shall apply to the construction of the Estabrook Park Dam.

CONCRETE WORK

Concrete used in dam construction shall be designed to obtain compressive strength of not less than 3500 pounds per square inch in 28 days. Concrete in the upper three feet of overflow spillways shall contain not less than 1.5 barrel of cement per cubic yard. All concrete shall be vibrated.

Immediately upon removal of forms all crevasses or honey-comb surfaces shall be filled with 1:2 cement mortar, and on all submerged surfaces a plastic mixture of cement and water shall be trowled smooth.

Forms for all exposed concrete surfaces shall be lined with or built out of plywood or masonite.

ELECTRICAL WORK

This work shall include the installation of heaters on the gates, lighting and service circuits on the operating bridge and the feeders from transformers.

Fourteen "Nofuse" type switches shall be installed on the panelboard on the operating bridge. Ten heater circuits, 1 service circuit, 2 light circuits, and 1 circuit for possible future use will be controlled by these switches.

Provision shall be made at the panelboard for connections to a portable ammeter to measure the current in any feed line.

The panelboard shall be in a weatherproof cabinet having 2 doors with minimum 1 inch space between the doors. The outer door shall have a rustproof padlock.

The wires shall be installed in conduits having a maximum size of 2 inches placed in the concrete slab, minimum 7 inches on centers.

Four duplex type weatherproof service outlets shall be installed on the inside of the downstream side of the operating bridge not more than 60 feet apart.

Wiring shall be provided for 2 future light circuits, one on each side of the bridge, each with six 300 w. outlets in top of the 3'8" piers.

ELECTRIC DAM GATE HEATERS

Provide and install ~~2000 w.~~ two 230 volt, waterproof immersion heaters on inside face of each steel dam gate. Heaters are to be approximately 64 inches long and shall consist of flat conduction type strip heater elements approximately 1-5/8 inch wide with a cross sectional thickness of approximately 3/8 inch, in which the heating element wire is uniformly distributed across the cross section, and insulated from the steel inner sheath by semi-vitrified refractory insulation compacted under hydraulic pressure of approximately 100 tons per foot of strip heater element length - the finished element being fired to semi-vitrify the refractory at 1500° F. These strip heater elements to be encased in seamless copper sheath. The terminals are to be enclosed in water and rustproof terminal box. All heaters are to be securely clamped to the steel dam gate face by means of clamps not less than 3 inches wide, and on centers of not more than 10 inches. Heaters are to be located as shown on the engineer's drawings. All heaters are to be connected to the power supply by means of copper or lead tubing, waterproof conduit or other waterproof cable, and in such manner as shall be designated elsewhere in these specifications or as designated by the engineer. All conduit, tubing, or waterproof conductors shall be securely clamped to the face of the gate.

Provide and install one 1500 w. 230 volt waterproof immersion heater in the roller compartment at the end of each dam gate, as shown on the drawings. All heater specifications shall be same as above, except the length shall be as shown on the drawings.

RUBBER

Rubber belts for water seals shall be a standard product of recent manufacture. They shall be of solid rubber of minimum 3000 pounds per square inch in tensile strength with a substantial duck backing, and shall be 3/8 inch thick. The belts shall be equal to the "Armadillo" Chute Lining manufactured by Goodyear Rubber Company, or "Armorite" by Goodrich Rubber Company, or similar lining manufactured by U. S. Rubber Co.

EMERGENCY BULKHEAD

Material shall be provided for one emergency bulkhead that can be erected in the slots of the upstream ends of the piers. It shall consist of the following:

One 10 inch Carnegie C.B. steel section at 23# - 12'3" long with four 7/8" web holes, 1 near each flange at each end, and all with 1 coat of primer and 2 coats of paint. The C.B. section shall be placed in the slots shown in section "B-B" of plan sheet No. 4 of 6. The 7/8" web holes are placed in the C.B. section to facilitate handling.

Eighteen 3"x8" creosoted planks, each 10'0" long with two 7/8" holes at each end, these planks shall be placed diagonally with lower end in slot and upper end resting against CB section.

One 18'x18' heavy waterproof tarpaulin with eyelets along all edges. This tarpaulin shall be placed over the planks to prevent seepage.

This emergency bulkhead is being provided, should repair work on any gate become necessary.

SPECIFICATIONS FOR GATES AND HOISTS

This item includes construction of 10 gates, 10 hoists, and all the necessary chains, guides, and anchor bolts, the galvanized angles on the ice guards, all complete as shown on drawings, except as specified below.

This item doesnot include wooden enclosures of the gates, electric heaters with clamps and rubber belts. However, all the necessary holes, tapped or plain, bolts and bars for fastening rubber belts shall be provided.

Except where called for otherwise, the latest standard specifications of the Wisconsin State Highway Commission pertaining to structural steel shall apply to the construction of gates and hoists.

All metallic surfaces shall receive a coat of "Tnemec" #6 Red Primer with cement pigment and two coats of "Tnemec" industrial coating, except that machine surfaces in frictional contact shall receive a heavy coat of white lead and tallow.

All work shall be done in accordance with the best engineering practice and true to dimensions. All bearings shall be perfectly centered and there shall be no play in any parts of the assembly.

A suitable lubricating compressor shall be furnished for alemite fittings.

Cast iron flanged wheels on the gates shall be of the "solid" type with chilled treads.

The chains shall be a combination of malleable iron links and steel side bars with forged steel pins. Suitable grease pockets shall be provided in the links. The chains shall have a 3.075" pitch and shall be guaranteed for an ultimate strength of 23,000 pounds.

Sprocket wheels shall be of the driving type with teeth capable of taking the full load of the chain.

DESIGN DATA

Computation of stresses developed under maximum loading condition in the structure of the Estabrook Park Dam

In the following computations all symbols and notations have the same meaning as in the "Structural Engineer's Handbook Library" by Hool & Kinne, which is practically the same as the notation of the American Concrete Institute).

It is assumed that the reader has access to the volume "Structural Members and Connections" of the above mentioned library and all formulas conform to those used in this book in order to avoid detailed demonstrations in this report. The working stresses of concrete being below 800 pounds per square inch, it was assumed n = 15. In all cases where the stresses are obviously within the limits set by the Code of the American Concrete Institute no computations were made, as for instance the bond for dowels over 45 bar size in length, etc.

CURVED SPILLWAY

The exterior forces per lineal foot of the spillway are: Ice pressure 10,000 pounds, horizontal at El. 35.00. Water pressure, with water level 36.00, resultant approximately 2000 pounds, horizontal at El. 30.66. Weight of the section approximately 2000 lbs. Horizontal reaction of the bottom 12000 pounds, assumed at El. 27.58. Vertical reactions of the bottom.

First critical horizontal section considered is at the bottom of the spillway assumed at El. 26.50 with d = 45". The moments at the center of the section are

Ice	(10,000)(8.5) =	85,000	
Water	(2,000)(4.16) =	8,320	93,320
Weight	(2,000)(0.5) =	1,000	
Horizontal reaction	(12,000)(1.08) =	13,000	14,000
		M =	79,320 ft. lbs.

We have at this section

$$p = \frac{As}{bd} \quad \frac{1.56}{(14)(45)} = 0.00248$$

KXMXBXRXK $K = \sqrt{2pn + (pn)^2} - pn = \sqrt{(2)(15)(0.00248) + [(15)(0.00248)]^2} - (15)(0.00248)$

$K = 0.238$

$$J = 1 - \frac{K}{3} = 1 - \frac{0.238}{3} = 0.92$$

$$fs = \frac{M}{A_s\, jd} = \frac{79,320 \times 12}{(1.56)(12/14)(0.92)(45)} = 17,500 \text{ lbs. per sq. in.}$$

$fc = 2\ fs\ \frac{p}{K} = (2)(17{,}500)(\frac{0.00248}{0.238}) = 365$ pounds per sq. inch

The critical section for shear is at elevation 31.25, with d = 24"

Here the hydrostatic pressure is $(62.3)(\frac{\overline{4.75}^2}{2}) = 700$ lbs

and $p = \frac{1.56}{(24)(14)} = 0.00465$

$$k = \sqrt{(2)(15)(0.00465) + (15)(0.00465)^2} - 15 \times 0.00465 = 0.372$$

$$j = 1 - \frac{0.372}{3} = 0.896$$

$$V = 10{,}000 + 700 = 10{,}700$$

$$v = \frac{V}{jbd} = \frac{10{,}700}{(0.896)(12)(24)} = 42 \text{ pounds per square inch}$$

which is permissable with the material and anchorage used.

The bond stress is $u = \frac{10700}{(24)(0.896)(5)} = 99$ poUnds per square inch

<u>SLUICE GATE PIERS</u>

~~Thexsamexforcesxtoxbexactingxasxinxthexspillwayxsection~~

Assuming the same forces to be acting as in the spillway section (in the direction of the stream) and with the piers 15'2" o.c. we have approximately

$$M = (15.16)(79.320) = 1200.0 \text{ ft. kips}$$

$$V = (15.16)(12.0) = 182.0 \text{ kips}$$

With a reasonable approximation on the safe side we can substitute for the purpose of computation of stresses a rectangular pier 13'5" long with 6-1-1/4" sq. bars at the end. Then d = 158" b = 44"

$$p = \frac{9.4}{(158)(44)} = \frac{1.35}{10^3}$$

$$k = \sqrt{\frac{(15)(2)(1.35)}{10^3} + \left[\frac{(15)(1.35)}{10^3}\right]^2} - \frac{(15)(1.35)}{10^3} = 0.182$$

$$j = 1 - \frac{0.182}{3} = 0.94$$

$$fs = \frac{(1{,}200{,}000)(12)}{(9.4)(0.94)(158)} = 10{,}300 \text{ pounds per square inch}$$ 20000

$$fc = \frac{(2)(10{,}300)(1.35)}{(0.182)(10^3)} = 153 \text{ pounds per square inch}$$

For the shear taking the 5 inch grooves into account b = 34" 40" shear

$$v = \frac{182{,}000}{(34)(158)(0.94)} = 36.0 \text{ pounds per square inch}$$

The actual stresses are somewhat lower than those computed above

For the lateral pressure on the piers assuming, due to the stabilizing effects of adjoining portions, an ice pressure 5,000 poinds per lin. ft., and disregarding the bridging above and the hydrostatic counter pressure

Ice	(5,000)(8.5)	=	42,500
Water	(2,000)(4.16)	=	8,320
			50,820

Horizontal reaction

	(7,000)(1.0)		7,000
	M	=	43,820

$d = 40"$ $b = 12"$ $As = \frac{(1.56)(12)}{20} = 0.935$ sq. in.

$p = \frac{0.935}{(40)(12)} = \frac{1.95}{10^3}$

$K = \sqrt{\frac{(2)(15)(1.95)}{10^3} + \left(\frac{(15)(1.95)}{10^3}\right)^2} - \frac{(15)(1.95)}{10^3} = 0.214$

$J = 1 - \frac{0.214}{3} = 0.93$

$fs = \frac{(43,820)(12)}{(0.935)(0.93)(40)} = 15,200$ pounds per sq. in.

$fc = \frac{(2)(15,200)(1.95)}{0.214 \times 10^3} = 277$ pounds per square inch

<u>OPERATING BRIDGE</u>

<u>REINFORCEMENT BARS MARK 60</u>

The gate weighs 4300 lbs. and has an initial frictional resistance of 3800 lbs. - total 8100 lbs. Allowing an additional 100 percent for ice, etc., we have 16,200 lbs. or 8100 lbs. per chain.

Bars Mark 60 are assumed to reinforce a beam 6'0" long, b = 18", d = 7", that carries at its center a concentrated load due to chains and supports of 4500 lbs. in addition to a live load of 150 pounds per sq. ft.

uniform load = (9)(18) + (1.5)(150) = 390 lbs.

$M_1 = \frac{(0.39)(6)^2}{8} = 1.75$

$M_2 = \frac{(4.5)(6)}{4} = 6.75$

$M = 8.50$ foot kips

$V = \frac{(0.39)(6+4.5)}{2} = 3.95$ kips

$A_s = 0.92$

$$p = \frac{0.92}{(7)(18)} = \frac{7.3}{10^3}$$

$$K = \sqrt{\frac{(2)(15)(7.3)}{10^3} + \left[\frac{(15)(7.3)}{10^3}\right]^2} - \frac{(15)(7.3)}{10^3} = 0.37$$

$$J = 1 - \frac{0.37}{3} = 0.88$$

$$fs = \frac{(8500)(12)}{(0.92)(0.88)(7)} = 18{,}000 \text{ lbs. per square inch}$$

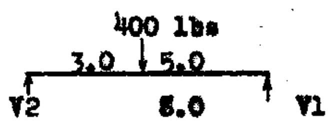
$$fc = \frac{(2)(18000)7.3}{(0.37)(10^3)} = 710 \text{ lbs. per square inch}$$

$$v = \frac{3950}{(7)(18)(0.88)} = 35.5 \text{ lbs. per square inch}$$

Actually these stresses will be considerably reduced by the distribution of loadings in other directions of the slab.

SLAB UNDER HOIST

The hoist weighs approximately 1600 lbs. The reaction of the spur gear is not considered because it would reduce the moments in the slab. It is assumed the hoist is carried by a strip 4'0" wide, or 400 lbs. per feet of slab



Uniform load (Live load = 150
(slab = 108
258 lbs. per sq. ft.

$$V_1 = \frac{(258)(8)}{2} + \frac{(400)(2.0)}{8} = 1130 \text{ lbs.}$$

$$V_2 = \frac{(258)(8)}{2} + \frac{(400)(6.0)}{8} = 1330 \text{ lbs.}$$

$(1130)(5) = 5650$

$$\frac{(0.258)(5^2)}{2} = 3230$$

$M = 2420$

$d = 7.75, \; B = 12, \; A_s = 0.39$

$$p = \frac{0.39}{(12)(7.75)} = \frac{4.2}{10^3}$$

$$K = \sqrt{\frac{(2)(15)(4.2)}{10^3} + \left[\frac{(15)(4.2)}{10^3}\right]^2} - \frac{(15)(4.2)}{10^3} = 0.30$$

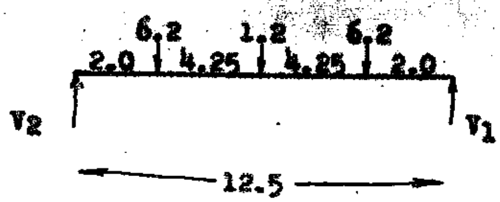
$$J = 1 - \frac{0.30}{3} = 0.90$$

$$f_s = \frac{(2420)(12)}{(0.39)(0.90)(8.75)} = 9250 \text{ lbs. per square inch}$$

$$f_c = \frac{(9250)(2)(4.2)}{(0.30)(10^3)} = 260 \text{ lbs. per square inch}$$

RAILING BEAMS

On the basis of chain loads discussed above, in connection with bars Mark 60, we have the following approximate loading for this beam.



Uniform Load
Slab and LL (298)(7.2) = 860
Beam 450
1310 lbs per ~~sq. in.~~ lin. ft.

$$V = 6.2 + 0.6 + \frac{(1.310)(12.5)}{2} = 8.20$$

Taking into account continuity, we have for maximum moment

$$M_1 = \frac{(1.31)(12.5^2)}{10} = 20.5$$

$$M_2 = (6.2)(2)(4/5) = 9.9$$

$$M_3 = \frac{(1.2)(12.5)}{5} = 3.0$$

$$M = 33.4 \text{ f. k.}$$

$d = 38.$ $b = 7.5.$ $A_s = 0.88$

$$p = \frac{0.88}{(7.5)(38)} = \frac{3.1}{10^3}$$

$$k = \sqrt{\frac{(15)(3.1)}{10^3} \times 2 + \left[\frac{(15)(3.1)}{10^3}\right]^2} - \frac{(15)(3.1)}{10^3} = 0.30$$

$$j = 1 - \frac{0.3}{3} = 0.9$$

$$f_s = \frac{(33.400)(12)}{(0.88)(0.90)(38)} = 13.400 \text{ lbs. per square inch}$$

$$f_c = \frac{(2)(13.400)(3.1)}{(0.30)(10^3)} = 280 \text{ lbs. per square inch}$$

The reinforcement is provided rather generously because of the additional temperature stresses, which might develop cracks in the structure.

STEEL GATES

Horizontal Beam, second from the bottom

Assuming a water level 38.00 and disregarding additional strength due to the welded 3/8" plate, we have a water pressure of about

(62.5)(7)(2) = ~~8.70~~ 870 lbs. per lin. ft. of beam

$$M = \frac{(0.870)(11.68^2)}{8} = 14.8$$

For a 6" H at 27.5 lbs.
SM = 16.4

$$fs = \frac{(14,800)(12)}{16.4} = 10,800 \text{ lbs. per square inch}$$

TOP BEAM

Stresses in horizontal 8" S.B. [at 28.2 lbs. and attached members

Considering the assembly consisting of the 8" S.B. [at 28.2, the 6 x 3-1/2 x 3/8 ∠ and a portion of the 3/8" plate - 8" long we have a total section modulus of about 28.0 cubic inches.

With the water level 38.00 we have a uniform horizontal pressure of about 280 lbs. per lin. ft. of this member and

$$M_1 = \frac{(11.75^2)(0.280)}{8} = 4.6 \text{ foot kips}$$

A concentrated ice load of 10,000 lbs. in the center will give

$$M_2 = \frac{(10,000)(11.75)}{4} = 29.4 \text{ foot kips}$$

$$M = M_1 + M_2 = 4.6 + 29.4 = 34 \text{ foot kips}$$

and the stress

$$fs = \frac{M}{Sm} = \frac{(34,000)(12)}{28.0} = 14,600 \text{ lbs. per square inch}$$

Job 3 - Form 7 No. 122
Estabrook Park, SP-5

COST ESTIMATE:
W.P.A.C. FUNDS:
MATERIALS

2,080	Bbls. Cement @ 2.20	$ 4,576.00
620	Cu. Yds. Sand @ 1.90	1,178.00
147,300#	Reinforcing Steel @ 0.0288	4,242.24
	(Details of size, weight, etc. on following page)	$ 9,996.24

SKILLED LABOR

400 Hrs. Skilled labor (Carpenter at 1.20)	480.00
	$10,476.24

LOCAL PARTICIPATION:
MATERIALS

700 Bbls.	Cement	$ 1,540.00
200 Yds.	Sand	380.00
160 Bgs.	Lime	64.00
60 M	Lumber at 40.00 per M.	2,400.00
	Nails, wire, etc.	135.00
	Primary cable	4,760.00
	Transformer	689.00
	Heaters-Lighting equipment	3,000.00
10	Gates hoist, ice guards	9,700.00
2	Walk Gates	50.00
500#	Dynamite	50.00
1000	Caps	38.00
	Miscell. Bulkhead paint	163.00
600 Yds.	rubble @ 4.00 per Yd.	2,400.00
930 Yds.	Crushed rock @ 2.00	1,860.00
	Contingencies	936.00
		$18,165.00

LABOR

2 Electricians	(600 Hrs. @ 1.30)	780.00
1 Helper	(300 Hrs. @ .85)	255.00
		1,035.00

Total $29,200.00

Job 8 - Form 7 No. 122
Estabrook Park M-5

Steel List

See plans for details of the bending

Size	Mark	No.	Length	Length x No.	W/ft.	Total Weight
1¼" □	1	459	16'-3"	7,458.75		
	2	90	14'-3"	1,282.50		
	3	24	16'-0"	384.00		
	4	4	14'-6"	58.00		
	7	84	10'-9"	903.00		
	15	91	12'-0"	1,092.00		
	16	78	14'-9"	1,150.50		
	17	91	15'-9"	1,433.25		
	61	34	13'-0"	442.00		
				14,203.50	5.313	75,463.195#
1" □	24	143	15'-6"	2,216.50		
	25	21	19'-0"	399.00		
	26	24	19'-6"	468.00		
	27	109	12'-9"	1,389.75		
	28	21	16'-3"	341.25		
	29	24	16'-9"	402.00		
				5,216.50	3.4	17,736.1#
5/8" ø	83	8	16'-6"	132.00		
	54	40	17'-0"	680.00		
	60	68	8'-0"	544.00		
	67	12	8'-6"	102.00		
	68	32	7'-0"	224.00		
				1,682.00	1.043	1754.33#
1/2" ø						
	11	28	7'-6"	210.00		
	12	28	6'-6"	182.00		
	13	28	5'-6"	147.00		
	14	28	4'-3"	119.00		
	30	112	12'-3"	1,372.00		
	31	32	14'-9"	472.00		
	32	64	11'-9"	752.00		
	35	16	19'-6"	312.00		
	36	124	6'-3"	775.00		
	37	16	16'-9"	268.00		
	38	91	10'-0"	910.00		
	39	26	12'-6"	325.00		
	40	52	9'-6"	494.00		
	41	56	7'-6"	420.00		
	42	80	6'-6"	520.00		
	43	12	10'-0"	120.00		

Job 8 - Form 7 No. 122
Estabrook Park [illegible]-5

Size	Mark	No.	Length	Length x No.	w/ft.	Total Weight
1/2" Cont'd.	45	110	6'-0"	660.00		
	46	16	2'-9"	44.00		
	49	138	9'-6"	1,311.00		
	81	24	16'-6"	396.00		
	51	280	6'-0"	1,680.00		
	55	130	17'-0"	2,210.00		
	56	10	10'-0"	100.00		
	57	30	16'-3"	487.50		
	58	60	13'-0"	780.00		
	59	120	17'-0"	2,040.00		
	62	136	19'-6"	2,652.00		
	63	88	18'-0"	1,584.00		
	64	48	19'-6"	936.00		
	65	128	6'-6"	832.00		
	66	12	20'-0"	240.00		
	69	12	13'-0"	156.00		
	70	24	7'-6"	180.00		
	71	24	4'-6"	108.00		
	75	14	10'-0"	140.00		
	76	60	7'-0"	420.00		
	77	98	9'-0"	882.00		
				25,236.50	.668	16,857.98#
3/8"	6	164	30'-0"	4,920.00		
	10	644	3'-6"	2,254.00		
	33	77	8'-3"	635.25		
	34	77	3'-9"	288.75		
	78	40	4'-6"	180.00		
	79	62	6'-0"	372.00		
	80	62	1'-9"	108.50		
				8,758.50	.376	3,293.196#
7/8" ø	5	170	30'-0"	5,100.00	2.044	10,424.40#
3/4" ø	8	224	11'-9"	2,632.00		
	9	112	11'-0"	1,233.00		
	18	56	16'-9"	938.00		
	19	28	9'-6"	266.00		
	20	14	5'-6"	77.00		
	21	48	17'-9"	852.00		
	22	24	10'-0"	240.00		
	23	12	6'-0"	72.00		
	44	116	8'-3"	957.00		
	47	102	30'-0"	3,060.00		
	48	94	14'-9"	1,386.00		
	52	40	17'-0"	680.00		

Job No. 8-(122) Estabrook Park, Wisconsin SP-5

Equipment Requirements:

The following items of equipment are essential for the completion of the job:

1 - cu. yd. Gas Power shovel with drag line attachment
14- 1½ Ton Dump Trucks
1 - Model K A.C. Tractor with bulldozer attachment.
1 - 14S Concrete Mixer
10- Concrete buggies 6 cu. ft. capacity.
2 - concrete Vibrators
1 - Platform Scale
1 - Bar bending machine
2 - Centrifugal Pumps
1 - 310 cu. ft. Air Compressor
1 - Universal Drill rig 1¼" steel.
2 - Jack Hammers 1" steel.
2 - Concrete breakers 1-1/8" steel
1 - Derrick

All of the above equipment is now on hand or available by transfer from one of the other SP camps operating under the Milwaukee County Park Authority.

FIELD TECHNICIAN'S COMMENT

STATE - Wisconsin   PROJECT NO. SP-5   PROJECT NAME - Estabrook Park

JOB NO. E.C.W. 123   JOB NAME - Dams, Concrete.   DATE - April 19, 1937

The historical background of this development is quite thoroughly covered in the accompanying report by the Park Authority and in the justifications for the original job of removing the rock and earth barrier from the bed of the Milwaukee River in this location.

As set forth therein the need for flood control in this portion of the river has been a recognized fact from the first and the construction of some form of dam has also been recognized as an essential part of the development necessary to that control.

The particular type, location and controlling elevations of the dam itself have been very thoroughly discussed at conferences between the engineers for the Park Authority and the City of Milwaukee, Mssrs. Nason and Osthoff of the Regional Office, Mr. Jenkins, Mr. Hollister, Mr. Schellie and myself; and the plans now being presented are in accordance with decisions arrived at these meetings.

Only a small portion of the computations incident to the coordinations of data and to the design of the structure itself is included in the report and a complete check of the mathematics has not been made by your engineer, but sufficient examination has been made to give assurance that the reasoning used and results arrived at are fundamentally sound.

The estimate of cost is based upon the latest quotations available for the materials to be used which may change to some extent before the time of purchase, but the total shown will probably not be exceeded to a marked degree.

The distribution of costs between the National Park Service and the cooperating agencies is not a subject for comment by your engineer.

Approval of the plans and of the job itself is hereby recommended.

L. I. Johnstone
Assoc. Engineer.

c.c.-R.O. 2
Howard-2
Dist."A"
Hollister