

## ACCIDENTS TO RESERVOIR DAMS.

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The late washout at the reservoir dam at Middlefield, Mass., and that at Chicoutimi, Que., can only avail as lessons in "The Instructiveness of failure" when the way in which they occurred can be made known to the profession.

True, it has been shown that in the Middlefield case, where the dam was but 20 feet high, and the level of the spill-way 15 feet, the gates over the spill-way could not be opened due to their faulty construction and that the water rose till it poured over the dam and caused its destruction; but how the erosion could have caused the wreck is not explained, in view of the fact that between the outer walls of the dam which was 30 feet in breadth and abundantly heavy and strong to resist any pushing or forcing of the dam forward as at Boazey in France, Austin in the United States and elsewhere, there were two intermediate bulk heads or walls of 2-inch matched sheet piling on boarding.

No gradual erosion from the top downwards could therefore have occurred on account of these intervening water tight partitions. The only way then of explaining the washout through and through the dam, is this: the overflowing water, first wore away the outer, lower or down stream of the three vertical sections of earth work into which the dam was divided by the bulk heads, taking with it the rubble work of the revetment wall, the component stones from which were found as far as 500 feet down the river.

When this outer or lower portion of the dam had crumbled away, the lower of the two bulk heads followed suit, after which the over-pour of water immediately attacked and scoured away the middle section of the earth work, followed by the overthrow of the upper or inner bulk head, and this by the immediate cutting through and down, by erosion, of the inner or up-stream section of the earth filling with its protective wall of dry rubble.

Where a portion of the clay filling was resistant enough to hold its own against the scour, up to a certain height from bottom level of reservoir, the portions of the bulk heads above that level, were of course broken off at level of top of remaining clay by the direct pressure of the water behind them.

The Middlefield mishap is therefore a case not of the bursting of a dam, not of a bodily pushing away of the dam as at Austin, but one where the dam failed, as do the levees along the Mississippi, by erosion of the water from above downwards.

We shall now see that the accident at Chicoutimi is a case of erosion from below upwards. The dam across the Chicoutimi, which is one of the out-flows or discharges from Lake Kinogami and its smaller companion as expressed by the diminutive "Schish" Kenogamischish, is about a mile from the city or town of Chicoutimi, the Metropolis of the Saguenay District.

The dam is built at right angles across the stream, a powerful one emptying into the Saguenay river. It is a wooden structure of crib work with a base up stream of about 3 to 1, planked over with a water tight flooring and relying for its stability on being kept down and in situ by the very weight of water above it, some 20 feet higher than on the down side, and though, the higher the water within the reservoir the greater the thrust outward or downward, the greater also the weight upon the dam and its adherence to the bottom on which it rests and is probably bolted to.

Above the dam proper is a superstructure some 10 feet or more in height answering as a bridge or roadway between the opposite sides of the river and to the upper or up stream side of this superstructure are adapted a series of some 20 gates or more, but which as at Middlefield, must have been inoperative due to their great size under a head of some 10 feet of water against them; for the water on the occasion of the accident about to be related rose to 10 feet above its normal freshet level and evidently pressed hard against the dam superstructure which is entirely too narrow, it being but 12 feet wide instead of 20 which it

should have been; and to proof, it is now bulged down stream, wriggled and out of plumb as well as out of line.

Now while this dam of some hundreds of feet in extent across the river was solidly abutted against the river's high and rocky bank at one or its eastward end; the western end of it rested on or a few feet into the face of a bank of quite a different nature on the opposite side; where not only does the rock rise to or crop out at level of bed of river; but the material above it and for a height of some 50 to 60 feet is nothing but the most ir-resisting soft clayey sand and vegetable mold.

Had the precaution, an expensive one of course, been resorted to, as was done at Grand Mère on the St. Maurice, in an absolutely similar case, of rip-rapping the face of the cliff from the dam to some distance up stream or of a wooden revetment against wash and scour of river, the accident likely might not have happened. It would certainly not have occurred had this cliff revetment been made water tight to a certain height, even though it should have cost an extra \$20,000 or more to do so along a stretch of 200 to 300 feet.

What happened is this: the water having on the occasion risen to 30 feet, a pressure of 13 pounds to the square inch or close upon 2,000 lbs. to the foot, a great tendency to filtration through the bottom of the bank (where the strain was irresistible by material of the light and loose structure alluded to) was brought about, and a leakage through and around the western end of the dam was seen to occur. Under such pressure and through such friable material it may easily be imagined how quickly the scour did its work, increasing in a few hours the water way through the bottom of the bank to the dimensions of a sewer and then enlarging sideways and from below upwards, to the vastness of a tunnel, when of course the roof or over-lying earth caved in—the out rushing water in the mean time wearing away the side hill from below and causing the cliff to go piece by piece almost vertically in slices from 4 to 6 feet thick at a time, till the gap up stream from the dam reached to a distance of some 200 feet, while in the direction of the length or axis of the dam prolonged, the hill was cut into by not less than 300 feet and the scour down stream or below the dam wore away the bank of the river to a distance of more than 700 feet.

The quantity of material carried away—the cliff as already stated being some 60 feet high—is not less than 300,000 cubic yards discoloring the water of the Saguenay for miles below the town and rendering it for the time being unfit to drink.

The dam will of course now have to be extended by some 300 feet or more to the opposite bank or to the present site thereof, while a temporary dam will have to be built to confine the water to passing over the present dam till the extension is put in; but the whole structure should be widened out down stream by say 20 feet, to support a bridge and gate superstructure of some 25 to 30 feet in breadth and capable of holding its own against any subsequent rise of like magnitude in the river; and this should be done at any cost and in the company's own interests; for as the area of the reservoir or breadth of water upheld will hereafter be of so much greater an extent westward, a second accident of the kind might sweep down upon the city and destroy thousands of dollars worth of property, with probably or at any rate possibly loss of life for which the company might be held responsible—and a stitch in time saves nine.

I would also say here in relation to the new concrete dam at the Chaudière—it was quite a question this spring whether it would not give under the immense ice pressure against its almost vertical inner or upper face, and my surmises of last fall when writing on the subject have now become a certainty, and to the effect that inward of this concrete rampart should be made an inclined apron of crib-work of two or three feet of base to one of height boarded over with deals or plank laid parallel to the flow of water, and such that any future tendency of an ice jam against the dam will be done away with by the certainty that the swell of the ice forward or down stream will shove it up the incline and topple it over the dam in a way to do no damage to the permanent structure.