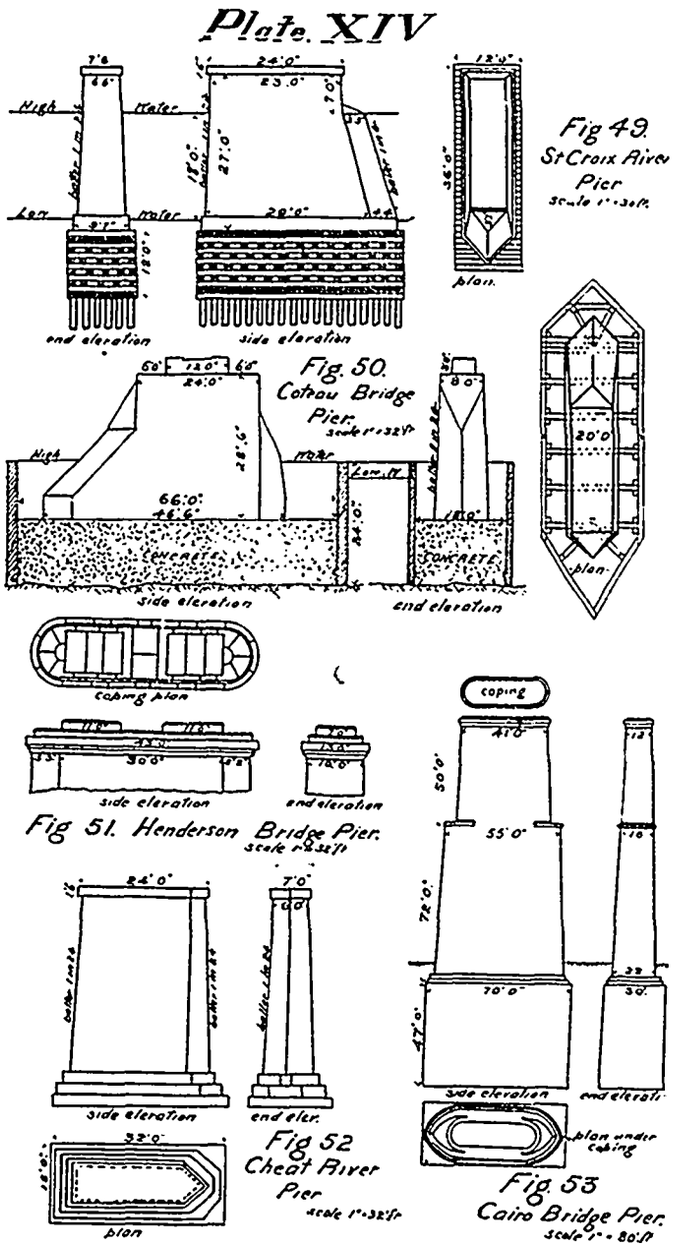
blowing on the truss and pier only, and the vertical loads of an *unloaded* span and the weight of the pier itself, the same criterion for stability should be applied as in (*a*), and in either case the remedy for instability would be to increase the batter, or introduce steps or offsets of, say, 6 inches every 10 or 12 feet, which would have the same effect. The stability of a pier at right angles to the bridge is practically never in question unless of very great height, in which case similar tests would determine what the necessary length of base should be.



(3) Cutwater designs:—Wherever there is any appreciable current in a river, it is necessary to construct the up-stream end of the pier of such a form that it will divide masses of driftwood, ice, logs, etc., as well as the current itself. Probably the simplest form is that shown in Fig. 52, which will not cost appreciably more to construct than a square pier, as the nose is a right angle and the faces of ordinary quarry-faced ashlar, but such a form is suitable only for streams carrying light ice or moderate jams of logs; in place of this the more ornamental forms shown in Figs. 51 and 53 would be equally satisfactory, especially the latter, but cost considerably more, and should therefore be used only on very important structures.

Where piers are to be placed in swift currents, or in any stream carrying heavy jams of logs, or thick floes of ice, their cutwaters should be of designs similar to Figs. 49 or 50. The cutwater of the former hardly extends high enough and is not flat enough for Canadian rivers, and besides it lacks the valuable addition of a small pointed lower end, which is introduced to eliminate an eddy at that point in swift currents, which tends to undermine the end of the pier, unless on solid rock. Probably the St. Croix pier and cutwater are suitable for the conditions they were designed for, but the intention of the design on Fig. 50 is that the jams will rise on the nose and split in two, passing on harmlessly.

Stone masonry bridge piers will cost from $9 to $15 per cubic yard, depending on their height, size and the cost of quarrying, transporting and cutting suitable stone. If expensive cutwaters are needed this will add to the cost; those used under severe conditions being of a first-class cut stone construction of large dimensions, clamped together and dowelled also, with a strip of boiler plate added to the nose to prevent dislodgement of stones. The following specification of first-class bridge masonry will apply to both abutment and pier construction, but in many cases a less severe specification has resulted in satisfactory and durable work.

Specification for First-Class Bridge Masonry.—"This class of masonry will be ranged rockwork of the best description, from stone of approved weathering qualities, and will be laid in suitable cement mortar (1 to 2 natural, or 1 to 3 Portland). The face stones will be accurately squared, jointed and bedded, and laid in courses not less than 12 inches thick, decreasing in thickness from bottom to top of walls; the joints and beds to be less than half-inch and joints well broken, no break to be less than nine inches. The stretchers to average at least 3½ feet in length with 3 feet as a minimum, to have at least 16 inches bed, and always at least as much bed as rise. The headers to have a width of not less than 18 inches, and to hold the size back into the heart of the wall that they show on the face; they shall occupy at least one-fifth of the area of the face of the wall, and be practically evenly distributed over it, so that the headers in each course shall divide equally or nearly so, the spaces between the headers in the next course below. When the walls are not more than 3½ feet thick, the headers shall run entirely through, and when between 3½ and 6 feet thick, there shall be as many headers of the same size in the rear as the front of the wall, and the front and rear headers must alternate and interlock at least 12 inches with each other. In walls over 6 feet thick, the headers shall be at least 3½ feet long, alternating front and back as just described, their binding effect being carried through the wall by intermediate headers of a similar character. The stretchers in the rear of the wall, and the stones in the heart of the wall shall be of the same general dimensions and proportions as the face stones with equally good bed and bond, but with less attention to vertical joints, and must be well fitted to their places, and carry the course evenly quite through the wall; a header shall in no case have a joint directly above or below it, but rest entirely on a stretcher at the face; any small interstices that may remain in the heart of the wall shall be carefully filled with mortar and spauls. The face stones shall be left rough on the face, with no projection of more than three inches from pitch lines, and two-inch drafts will, in general, be carried up and around all projecting angles. In the construction of piers, it is understood that the description above given for face work shall apply to both ends and both sides of the pier. Copings are to be cut and dowelled or clamped according to coping plans furnished, the top shall be crandalled and pean-hammered,