method required the moving of the smallest quantities of earth, but used the maximum amount of common labor.

While these were the three principal methods used by the contractor, various other methods of depositing spoil, draining the trench sides and sloping the side of the trench were tried. Each section of slide had peculiarities of its own and had to be dealt with as sound judgment and experience directed. In some places special heavy inverts were all that was required to hold the earth in check, while nearby the side pressure was sufficient to move piling spaced

FIG. 7—SLIDE SHOWN IN FIG. 4 REMOVED AND AQUEDUCT CONSTRUCTED

at 3-ft. intervals and cross-braced with 12-in. round timbers. Theoretically, water could be held to be the cause of all these slides, as it destroyed the cohesive qualities of the soft clay; its pressure acted as equivalent of millions of jack-screws and it further helped movement by lubrication; but in such cases as these slides, theory was of little use and reliance had to be placed on experience and sound judgment. In the employment of such, the Winnipeg Aqueduct Construction Co. were fortunate in having Wm. Smaill as field superintendent and manager, while the Greater Winnipeg Water District were equally fortunate in having W. G. Chace as chief engineer.

RECENT PUBLICATIONS

MUELLER BRASS GOODS.—Cloth-bound catalogue, 8¼ by 11 ins., 276 pages and cover, printed on coated paper, profusely illustrated; issued by the H. Mueller Manufacturing Co., Ltd., Sarnia, Ont., describing their water, plumbing and gas brass goods.

CONCRETE TANKS FOR INDUSTRIAL PURPOSES.—A 36-page illustrated pamphlet, 6 by 9 ins., published by the Portland Cement Association, illustrating and describing concrete tanks for water, mineral oils, brine, molasses, vegetable and animal oils, tanning liquids, dairy products, chemical solutions, etc.

QUEBEC STREAMS COMMISSION.—Seventh report, covering year 1918; 120 pages and paper cover; 6¾ by 9¾ ins.; illustrated; accompanied by several folded maps anl diagrams. O. Lefebvre, of Montreal, is chief engineer and secretary of the commission. Two of the three commissioners are civil engineers, namely, W. I. Bishop and Arthur Amos. The chairman of the commission, S. N. Parent, is a lawyer.

WROUGHT TUBULAR PRODUCTS.—Catalogue issued by the Page-Hersey Iron, Tube & Lead Co., Ltd., 100 Church St., Toronto; printed in two colors on coated paper; well illustrated; 76 pages and cover, 4½ by 7½ ins. It includes illustrations, weights, dimensions, diagrams and specifications for lap-welded and butt-welded pipe; pipe with flanged joints and bell and spigot; electric line tubular poles, service clamps, well tubing, etc.

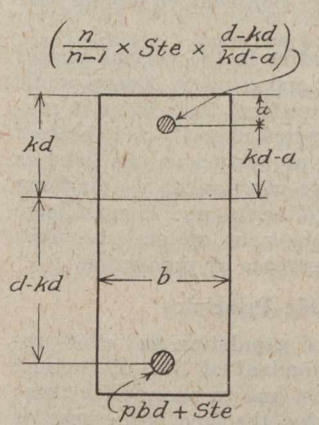
PROVINCE OF SASKATCHEWAN.—Booklet prepared by F. H. Kitto, under the direction of the Superintendent of the Natural Resources and Intelligence Branch, Ottawa; 154 pages and paper cover, 6½ by 9¾ ins. The contents include chapters on historial description, government, transportation, communication, education and religion, climate, soil, agriculture, cities and towns, forests and water powers, minerals, fish and game; illustrated by maps, charts and half-tones.

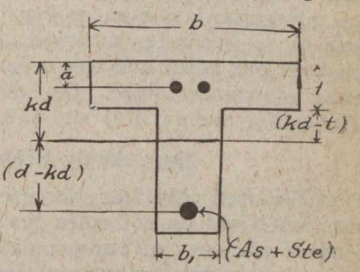
DOUBLY REINFORCED CONCRETE BEAMS

BY E. MONTGOMERY
Regina, Sask.

AT times structural requirements limit the concrete section of a beam and it becomes necessary to add compression steel to enable it to sustain a given bending moment. In such cases the amount of tensile and compressive reinforcement required can be found by the following method.

When compression steel is used, the amount of ordinary tension steel, pbd, is increased by an amount, S_{te}, the first moment of which about the neutral axis is equal to the first moment of the compression steel about that axis. The compression steel can therefore be expressed in terms of the extra tension steel, S_{te}, and *vice versa;* and since the position of the neutral axis in a reinforced concrete section depends only upon the modular ratio and unit working stresses in concrete and steel, when these and the concrete section are given, the position of the neutral axis is fully known.





With the preceding remarks in mind, the theory applied to the solution of the following problem will be clear.

Example.—It is required to reinforce a concrete section 14 by 27 ins. to sustain a bending moment of 1,081,920 inch-lbs. The depth of embedment of both tensile and compressive reinforcement is to be 3 ins.; working stresses in concrete and steel to be 640 lbs. per sq. in., and 16,000 lbs. per sq. in. respectively, and the modular ratio to be 15.

$$I = Mkd/f_c, \text{ or } nM(d-kd)/f_s.$$

Also, $I = b(kd)^3/3+npbd(d-kd)^2+nS_{te}(d-kd)(d-a)$.

For the given stresses and modular ratio, $k = 0.375$ and $p = 0.0075$. Since the effective depth of section is 24 ins., $kd = 9$ ins.; $(d-kd) = 15$ ins.; $(d-a) = 21$ ins.; $pbd = 2.52$ sq. ins.

Substituting and equating:—

$14\times9^3/3+15\times2.52\times15^2+15S_{te}\times15\times21 = 1,081,920\times9/640.$

$\therefore 4,725\ S_{te} = 3,307.5.$

$\therefore S_{te} = 0.7$ sq. in.

$pbd = 2.52$ sq. ins.

$\therefore$ Total tension steel $= 3.22$ sq. ins. and compression steel $= 15/14\times0.7\times15/6 = 1.875$ sq. ins.

In solving for T-beams of given concrete section, the only variation is in the method of computing the amount of ordinary tensile reinforcement. This is done as follows:—

Sum of compressive stresses $= A_cf_c/2 = b_1kdf_c/2+t(b-b_1)[f_c+f_c(kd-t)/kd]\times\frac{1}{2} =$

$$(f_c/2)[b_1kd+t(b-b_1)(2-t/kd)].$$

Casting out $f_c/2$, concrete compression area $= A_c = b_1kd+[t(b-b_1)(2-t/kd)]$. This equation appeared in an article by the writer on page 458 of *The Canadian Engineer* for April 15th, 1915.

Ordinary tension steel $= A_s = A_cf_c/2f_s$.

As before, $I = Mkd/f_c$, or $nM(d-kd)/f_s$.

Also, $I = b(kd)^3/3-(b-b_1)(kd-t)^3/3+nA_s(d-kd)^2+nS_{te}(d-kd)(d-a)$.

The Union of Alberta Municipalities has asked the provincial government to make an investigation of the hydro-electric possibilities of Alberta, with a view to formulating a policy for publicly owned power plants. A resolution to this effect was adopted at the Union's recent convention.