FOUNDATIONS FOR TRANSMISSION LINE, AND TOWER ERECTION V—TORONTO POWER COMPANY

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ABSTRACT OF PAPER

There is a broad field open for designing and construction engineers in the design and construction of transmission towers and foundations. The purpose of the paper is to present a brief explanation of the types of towers, tower foundations, etc. along with a few details of field practise used in connection with the construction of two lines of towers carrying six 190,000-cir. mil. seven-strand copper conductors between Niagara Falls and Toronto, Ontario.

The question of dispensing with massive concrete foundations for towers is dealt with, and a number of alternatives are presented for consideration.

THE following notes relate to the old and new 60,000-volt lines of the Toronto Power Company, between Niagara Falls and Toronto.

There are several types of towers and foundations used on these lines which are outlined in Figs. 1 to 5 inclusive. Figs. 6, 7, 8, 9 and 14, are reproduced from photographs showing various features of interest of certain of these towers.

Towers enumerated above, with the exception of that of Fig. 3, are designed to carry two circuits of 190-000-cir. mil seven-strand copper cable, for 60,000-volt transmission; pin-type insulators are used. The tower of Fig. 3 is designed to carry four circuits of the same size conductor.

The writer will endeavor to give, from a practical viewpoint, a brief explanation of a few of the foundations used with the above mentioned towers.

Fig. 10, shows foundations used in connection with tower marked Fig. 1. About 100 sets of these footings have been dug up after being in use seven years, and in no instance has the galvanizing deteriorated, and the 3 by 6 by 24-in. impregnated wooden blocks, with a few exceptions, were in a fair state of preservation. These foundations were located in various kinds of soil.

In connection with the tower shown in Fig. 2, we did not use impregnated blocks, nor were any precautions taken, other than the hot-galvanizing, to prevent corrosion of the steel. Six of these towers were erected in low marshy black-muck, no resistance being encountered with borings at 40 ft.

FIG. 1—STANDARD TOWER WITH GROUND SPIRE

A two-inch plank sheathing was driven around each tower-leg location, the muck dug out and a floating foundation built six feet below the ground surface; this consisted of impregnated two-inch planking, the footings being set in concrete, approximately

one yard of cement being placed around and under each stub, the excavations being 30 in. by 30 in. by 6 ft. These towers have been erected for one year and have neither settled nor gotten out of alignment.

I may say that great care was taken in connection with the locating of towers, so as to avoid, where possible, soft marshy

FIG. 2—STANDARD 53-FT TOWER

FIG. 3—FOUR-CIRCUIT
LAKE TOWER

soil and also to equalize the grade. Tower footings in gravel, or a mixture of sand and loam packed tightly, offer a great resistance against upward pull.

A number of towers of the type marked Fig. 2, were erected in rock. This rock was thinly stratified and was easily excavated to a depth of three feet. The stubs were cut down to 3 ft. 6 in.,

and were concreted in with a one-to-four mixture. This construction has proved satisfactory.

In Figs. 6 to 9, are shown a type of narrow-base latticed tower. The foundations for these were built in two ways.

(a) A foundation 6 ft. by 6 ft. by 6 ft. with twelve $1\frac{1}{4}$ -in. anchor

FIG. 4—ANGLE TOWER FOR ANGLES TO 60 DEGREES

bolts 5 ft. 6 in. long. This was a one-three-five concrete mixture.

(b) Foundations 6 ft. by 6 ft. and varying in depths were built in the following manner:

Excavation was taken out, copper grounding-ribbon placed, and 12 inches of one-three-five concrete placed and tamped.

[CONNERY]
FIG. 6—METHOD OF LOWERING STANDARD 40-FT. TOWER—FIRST
POSITION

[CONNERY]
FIG. 7—METHOD OF LOWERING STANDARD 40-FT. TOWER—SECOND
POSITION

No anchor bolts were used, but the tower was erected on this 12-in. base, and then the excavation filled with one-three-five concrete. This method being used on account of the variation in the dimension of the bases of these towers. Minimum depth 6 ft.

FIG. 5—HEAVY 75-FOOT STRAIN TOWER

Construction of Footing. (Fig. 3) Eleven of the above footings were constructed in the waters of Lake Ontario at Burlington Beach, Ontario, the mean depth of water being about three ft.

A double coffer-dam was built of 2 by 8-in. tongued and grooved spruce, driven to a depth of 10 feet below the lake bottom by a small steam hammer. The water was pumped out, and sand and gravel excavated to a depth of six feet below the lake bottom where very coarse gravel was encountered.

The foundations were then constructed as shown, the spruce sheeting being left in to protect against scouring. After the foundations were complete, a talis of 10-inch rock, each piece weighing from 500 to 1500 lb. was built around the two outer footings of each foundation for extra protection, the location of these towers being on a shore where storms from the East are very prevalent.

Method of Setting Stubs. Fig. 15 shows the template used with success in the setting of stubs. This template was carried by the setting-gang, lined up on the center line stakes and levelled by the gang foreman by means

of a carpenter's level, and then blocked up and checked.

The stubs were bolted to the template and the filling in of holes proceeded with. One man back-filled while two men tamped. Special attention on the part of the foreman should be given to the tamping, as workmen are apt to do this in a careless manner.

FIG. 8—METHOD OF LOWERING STANDARD 40-FT. TOWER—
THIRD POSITION [CONNERY]

FIG. 9—METHOD OF LOWERING STANDARD 40-FT. TOWER—
FOURTH POSITION [CONNERY]

FIG. 14—LAKE TOWER FOUNDATIONS, BURLINGTON BEACH [CONNERY]

FIG. 11—FOUNDATION PLAN FOR LAKE TOWER

FIG. 12—MASONRY PLAN AND ANCHOR BOLTS

FIG. 13—FOUNDATION PLAN FOR 75-FOOT HEAVY STRAIN TOWERS

FIG. 15—DETAIL OF TEMPLATE FOR STANDARD TOWER FOOTINGS

From observations extending over ten years, I would say that fully 40 per cent of the guys in use are inefficient, this condition being due to lack of inspection. To obtain the best results in guying, the anchor should be placed at a distance from the base of the pole equal to one third the height.

In using rock-bolts for anchoring, care should be taken, if the rock is covered with a layer of earth, to place the anchor so that the ring is just above the surface of the rock; then fasten a long link to the ring, and guy to this. This method will give much better results than if the ring had been left above the surface of the ground and guy attached to it, as the anchor rod will bend in the latter case. These rock-bolts should be grouted in with hot brimstone.

We are now designing tower footings which include the following points which we submit for consideration and discussion:

(1) A modification of an ordinary screw-type guy anchor, similar to the Matthews or Stombaugh anchor, with the top of the anchor rod shaped to take the tower leg; this for towers of light wind-mill type.

(2) For heavy anchor, long-span, towers, etc. A large foot-plate supported on a shallow concrete footing sufficient to give a good bearing, and an anchor similar to those mentioned above, with the exception that the end of the bolt will be threaded to take a nut and locknut.

(3) For extra heavy, or four-circuit towers. A large section screw-pile with top plate to which the tower foot plate can be bolted.

We also offer for consideration, the question of threading an ordinary wooden pile. There are locations on almost every line where marshy land or muskeg is encountered, and it is usually a very expensive operation to use a pile driving outfit in these locations.

In connection with this method, we have found that it is not necessary to drive a pile to refusal to obtain a good footing for a standard tower, as there is sufficient skin friction developed by the pile in the upper layers of the ground to give satisfactory results. Twenty-five-foot piles have been found satisfactory in very swampy ground, where borings had been taken to a depth of forty feet without striking firm soil.