CHAPTER 3

PROTOTYPE TEST

3.1 GENERAL

It is the usual practice to test prototype towers proposed to be used on new transmission lines. Although the practice of testing towers has been in vogue in many countries, the methods of testing are not specific or uniform and many items are left to be finalised by the parties interested in the test.

3.2 NECESSITY FOR PROTOTYPE TESTS

It is recommended that tests be performed if

1. a large number of structures of the same or similar design are to be furnished or it is necessary to assure that proper design and fabricating procedures have been used, or both,

2. new, unique or radical design or detail concepts have to be used; in such a case it may be advisable to consider a series of tests before acceptance of the new concepts,

3. a new material or an insufficiently understood material is used.

3.3 PURPOSE OF PROTOTYPE TEST

The purpose of the prototype test is to assess

1. whether the structure can sustain the design loads, including specified over loads over a reasonable period of time,

2. whether the deflections are within the limits of the clearance requirements and any other limits that might have been set by the engineer,

3. whether sufficient confidence can be reposed in the fabricating, bolting and welding techniques used,

4. whether safety of erection can be ensured.
3.4 COMPOSITION OF TEST STRUCTURE

The test structures should comprise the following:

1. structure of specified height manufactured of the same material grade as those to be furnished on the project
2. structures fabricated by the same means and to the same tolerances as those to be furnished on the project
3. structures galvanized if required on the project
4. coated structures, if the tests results might be affected by the coating
5. structures erected plumb within the limitations of the specifications if tested vertically
6. all appurtenances, cross arms, base plates etc., attached and functioning in accordance with the design and specifications

3.5 CONDITIONS OF TESTING

Tests should be performed

1. preferably in a vertical position, as testing in the horizontal position requires special consideration to insure that dead loads have been duplicated in the testing procedure,
2. preferably by applying loads at attachment points in the same directions as indicated by the design specifications,
3. by applying such loads at increments called for in the specifications,
4. in a manner, safe for all personnel conducting and witnessing the test,
5. using recently calibrated instruments in adequate numbers to accurately read all applied loads simultaneously,
6. by locating instruments in such a manner that loss of accuracy as a result of the rigging system is minimised.
3.6 **COMPLETION OF TESTS**

The test should be considered complete

1. when the structure successfully sustains statically the loads including the full over loads specified for a reasonable time (usually 5 minutes),

2. if after the loads have been removed, the structure returns to its original position within a reasonable tolerance,

3. if after complete dismantling and thorough inspection, no failure of the bolts or welds is detected,

4. if material from the test structure passes all physical, chemical and dimensional checks required by the test specifications,

5. when all instruments are recalibrated and indicate proper adjustment.

3.7 **TEST SET UP**

The test set-up and procedure adopted by C.P.R.I. in their tower testing station [88] is summarised below. The tower is erected on a rigid base comprising of two steel joists placed at an angle beneath each leg of the tower. The joists in turn are bolted on to the test bed. The legs of the tower are welded on to the steel joists along with stiffeners.

3.7.1 **Test bed**

This is located in an abandoned quarry of granite rock. Matrices of anchor bolts have been grouted deep into the bed rock to ensure adequate strength against pull out. The anchor bolts have been so arranged as to accommodate square and rectangular based towers.

Placed on the test bed and clamped firmly to the uplift bolts are the tower footings (4 in number) which are designed to withstand uplift compression and shears in the legs of a loaded test tower.
Facilities for stub-setting which is the primary work required in tower erection, are provided in the test bed.

3.7.2 Loading system

Equally important as the test bed is the loading system capable of applying, measuring and controlling the loads with high accuracy. The transmission tower under testing is connected to pulley anchor through anchor structures and pulley blocks. The loading equipment are the electrically operated winches which are interfaced with the pulley block-wire rope system.

3.7.3 Anchor towers

There are two anchor towers, one in the longitudinal direction and the other in the transverse direction. The designs are identical. The height of the anchor tower is kept more than the tallest tower that is to be tested in the test bed and it is a welded structure. The anchor towers have loading channels which can accept guides at levels to match with the levels of load application on the test tower. The design of the anchor tower is such that load application on the test tower will be practically horizontal. The pulls applied by the loading equipment are transmitted to pull off points on the test tower by steel wire ropes passing over guides.

3.7.4 Pulley anchors

Associated with each anchor structure, there are eight pulley anchors with a monoblock concrete foundation. Each anchor has been designed for a load of 40 tonnes. Suitable provision have been made for bolting the multisheave pulley blocks.

3.7.5 Winches

Electrical winches have been installed in transverse and longitudinal winch houses. Most of these are of two speeds. The winches are remotely controlled from the control room. Thermal and overload cut offs have been incorporated.
3.8 TEST CONTROL ROOM

The test control room accommodates controls for remote operation of winches, recording loads at the various pull of points of the towers, observation of test towers and other control operations during test. Load cells are attached at the pull off points of the test tower for load measurements. The indicators are housed in the control room. Control cable links the load cells with these read-outs. The read-outs indicate pull at various points directly in kilograms. The control room has also been provided with transparent glazing for viewing the complete set-up of the test tower, wire ropes, instruments on the tower etc. Optical instruments such as binoculars are also available in the control room.

3.9 THEODOLITE STATION

Two theodolite stations house instruments for visual observations on the test tower and also for deflection measurement. The theodolite stations are located in longitudinal and transverse directions. The graduated scale fixed on the test tower can be conveniently read using theodolite from the theodolite stations for deflection measurements.

3.10 CALIBRATION

Calibration of dynamometers is carried out a day prior to the test. This is carried out by applying tension on load cells through a U.T.M. which in turn is connected to the dynamometer. The load cells are of differing capacity. The dynamometers and the corresponding load cells are allocated to the different loading points on the vertical, longitudinal and transverse directions. Fig.3J shows the twenty pull off points in the three different directions at various locations. In all, twenty five dynamometers are calibrated and five are kept as spare.

Transverse loadings comprising of the wind loading on ground wire at top and on conductors at top, middle and bottom cross arms left and right as well as the wind loadings on the tower body at three points are applied by load cells attached to the respective points on
FIG. 3.1 Tower loading showing twenty pull off points
the tower. In addition transverse loadings due to wind on tower body are applied at tower level A (TWLA) and tower level B (TWLB) by connecting the load cells to the two right end legs of the tower at these levels. The longitudinal loading comprising of the unbalanced pull due to broken wire conditions (occurring one at a time) is applied by attaching the load cells at ground wire peak, top cross arm right, middle cross arm right and bottom cross arm right in the longitudinal direction. The vertical loadings are applied at ground wire top, top, middle and bottom cross arms left and right and the corresponding load cells are taken below and placed exactly in line with loading points. Load cells attached on the transverse side at ground wire, top, middle and bottom cross arms left and right are connected by wires that lead to the anchor tower on the same side and then through pulleys on to winches. A similar procedure is adopted by taking the wires connecting the load cells on the longitudinal side and then through pulleys on to winches at bottom. All the dynamometers with corresponding loading points marked are installed in the tower control station. Loads are applied by hand as well as electric winches. Graduated scales are placed at the ground wire top, top, middle and bottom cross arms, both on the transverse and longitudinal sides to measure transverse and longitudinal deflections.

3.11 TESTING OF THE PROTOTYPE TOWER

3.11.1 Bolt-slip test

In the bolt-slip test, test loads are gradually applied up to design loads in the vertical and transverse directions and kept constant for 2 minutes at the design load and then gradually released. The initial and final readings on the scales before application and after the release of loads are recorded with the help of theodolite. The difference between these readings is taken as the value of bolt-slip.

3.11.2 Normal loading condition: (Factor of safety 2.0)

Vertical loads are gradually increased to the ultimate design load (200% design load). Simultaneously, transverse loads are increased in steps of 50%, 75%, 90% and 100% of ultimate design loads. The
tower is kept under observation for 2 minutes for the intermediate steps upto and including 90% and deflection readings are recorded.

3.12 DETAILS AND RESULTS OF THE PROTOTYPE TOWER TESTED

A 220 KV double circuit tangent transmission line tower, proposed for one of the grid lines in India, has been tested for the four loading conditions. However, due to failure of some of the instrumentation during testing the results for middle conductor right broken wire and bottom conductor right broken wire conditions could not be obtained properly. The configuration, the geometry and the loading pattern for normal and top conductor right broken wire conditions along with the respective deflection profiles obtained are presented in Figs. 3.2 and 3.3.

These results have been used as basis for comparison with the corresponding analytical, results in chapter 4.