

City Surveying

PART I

By

A. DeGROOT

Fellow, American Society of Civil Engineers
Former Director, Civil Engineering School
International Correspondence Schools



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International Correspondence Schools, Scranton, Pennsylvania

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City Surveying

PART I

General Features of City Surveys

Classes of City Surveys

1. The usual kinds of surveying and mapping that must be done by city engineers or surveyors may be divided into the following two general classes: 1) control, or basic, surveys and 2) dependent surveys, or surveys necessary for construction and maintenance. Control surveys are run for the purpose of determining accurately the horizontal positions and elevations of a number of control stations that may be used to govern the accuracy of, and definitely fix the positions and elevations of, points in subsequent dependent surveys. Surveys for construction and maintenance include surveys for locating property lines, surveys for street, block, and lot grading, and surveys for buildings, bridges, and sewerage and water-supply systems. Surveys for locating the boundaries of private property are obviously dependent on surveys of public property. The relation that a control survey bears to the entire system of surveys for a city is comparable to the relation that the steel frame of a building bears to the completed building.

Many American cities have included, or are planning to include, the work of running control surveys as a part of the regular activities of their engineering departments. The stations of a control survey are permanently established, and a new control survey is needed only when the area of the municipality is expanded. Each new construction or maintenance project, on the other hand, usually requires its own dependent survey. Consequently, dependent surveys are far more numerous than control surveys.

Kinds of Control Surveys

2. Control surveys for locating stations horizontally are known as horizontal-control surveys, and control surveys for determining elevations are called vertical-control surveys. In every city where control surveys have been made, the schedule of required information, the specifications governing the surveys, and the procedure in carrying out the work have been practically the same. Ordinarily, the horizontal-control survey for a city is made before the vertical-control survey. Many of the specifications, explanations, and instructions on city control surveys that are given in these texts on city surveying are based on the recommendations in Manual No. 10 of the American Society of Civil Engineers, which is entitled *Technical Procedure for City Surveys*.

Surveys for horizontal control are of two general types, namely triangulation surveys and traverse surveys. These surveys are sometimes called merely triangulation and traverse. In a triangulation survey, the points or stations are located at the vertexes of triangles. The lengths and the directions of one or more lines

called base lines, are determined by direct measurements and astronomical observations. Then the lengths and the directions of other lines in the triangles are determined by measuring the angles between the various lines and applying the principles of trigonometry. In a traverse survey, the courses are not sides of triangles. It is therefore necessary to determine the length of each line, or course, by direct measurement and to determine the relative directions of the courses by direct measurement of the angles between the courses. In a vertical-control survey, elevations of important points are determined by precise spirit leveling.

Basis for Horizontal-Control Surveys

3. A horizontal-control survey for a city consists of triangulation surveys and traverse surveys that form a network in which all errors of closure are distributed so as to balance the entire survey. Stations in each control survey are marked in a suitable manner, and the positions of these stations are usually established by their plane coordinates. The positions of stations in horizontal-control surveys for cities are determined by three grades, or classes, of surveying. The most accurate grade is known as first-order triangulation or first-order traverse; the intermediate grade is second-order traverse; and the least accurate is third-order traverse. Only first-order triangulation should be used for the principal control survey in a metropolitan area.

The United States Coast and Geodetic Survey has covered the entire country with such an extensive interconnected network of first-order triangulation surveys and first-order traverse surveys that a city is generally within a few miles of one or more stations of such a survey. In fact, one purpose of running the original precise surveys was to establish good control points for other surveys, and a special effort was therefore made to establish monuments with known coordinates either in or near each city area. Thus a city may tie in its local control surveys with monuments of the national control net of the Federal Government. Since these established monuments and data pertaining to their positions are available for public use, it is highly probable that most future surveys of city governments, county governments, state highway departments, railroads, the United States Army engineers, and private corporations and surveyors will also be tied into the basic control surveys conducted by the Federal Government. When this standardization is attained, every survey will be usable by all agencies.

Since the control surveys of the United States Coast and Geodetic Survey extend entirely across the country, it is necessary to allow for the curvature of the earth's surface in such surveys. A survey in which actual distances on the surface of the earth are determined by making accurately computed allowances for the effect of the curvature of the earth is called a *geodetic survey*. Usually, the area covered by a city survey is so limited that the effect of the earth's curvature is negligible, and city surveys are generally conducted as plane surveys without allowance for this curvature.

For some time it was the usual practice for each city to adopt an origin of plane coordinates and a reference meridian for its own local survey. In 1934 and 1935, however, the United States Coast and Geodetic Survey established one or more systems of plane coordinates with definite origins and reference meridians for each state. Tables that facilitate the use of these state plane-coordinate systems are now available to the public. It is usually desirable for a city to adopt the state plane-coordinate system as the basis for the city control survey, because the city surveys and the surveys of other public and private organizations may then be tied in with the federal surveys.

North American Datum of 1927

4. The method of geographic positions is the only method for defining precisely and satisfactorily on the spheroidal surface of the earth the locations of stations of extensive triangulation surveys or traverse surveys, such as the transcontinental control surveys of the United States Government, the international boundary surveys, the state boundary surveys, and the Great Lakes control surveys. The geographic position of a point is sometimes referred to as the geodetic position. The point is said to be located by geographic coordinates, geodetic coordinates, or spherical coordinates.

When the federal triangulation surveys in the United States were first begun, the latitude and the longitude of one or more stations of each separate triangulation survey were determined by astronomical observations. However, when the isolated surveys were tied into a large network, it was found that the measurements of the surveys were of a much higher degree of accuracy than were the determinations of the geographic positions by astronomical observations. Accordingly, it was decided to establish, near the center of the national triangulation network, a station that would have its geographic position based on the mean of the many individual geographic positions which were established by astronomical observations. The station finally chosen for this purpose is a place in Kansas called *Meade's Ranch*. The mean geographic position of this station became the origin for the exact geographic positions of all the stations in the network. This entire system of geographic positions is known as the North American Datum of 1927, and is used by the United States, Canada, and Mexico, whose national surveys are connected at their respective border lines.

Basis for Vertical-Control Surveys

5. The vertical-control survey is usually routed along the lines of the horizontal-control survey, in order that the monuments marking triangulation stations and traverse stations may be used also as bench marks. In vertical-control surveys for cities, only two orders of accuracy are utilized. The more accurate class of spirit leveling is known as first-order leveling, and the less accurate as second-order leveling.

All bench marks of city control surveys should be of a permanent nature, and

their elevations should be established accurately. The elevations should preferably be referred to *mean sea level* as the datum. This datum is denoted as *m-s-l datum*. Numerous bench marks have been established throughout the United States by the United States Coast and Geodetic Survey. Elevations based on *m-s-l datum* may be obtained satisfactorily by running lines of levels from bench marks established by the Coast and Geodetic Survey by first-order leveling. The bench marks of the Coast and Geodetic Survey are generally so close together that a tie line of levels more than a few miles long will seldom be required.

In a number of cities, the vertical-control surveys for local use were instituted before the Coast and Geodetic Survey had established vertical-control stations within reasonable distances, and it was necessary to establish local planes of reference for bench-mark elevations. A local reference plane is called a *city datum* or *city base*. In some cities these local planes of reference are still being used. The tendency, however, is to change to the *m-s-l datum*, and presumably the vertical-control surveys of all American cities will eventually be based on that datum. When mean sea level has been adopted as the datum by all cities, it will no longer be necessary to add or subtract a correction in order to compare two sets of elevations. If no datum is specified, mean sea level is understood.

As the national level net has been augmented from time to time by new lines, the elevations of previously established bench marks have been adjusted in order to make all elevations consistent. However, the national net is now so nearly completed that no further general readjustment is likely to be necessary. It is therefore believed that the datum established in the last adjustment, which is known as the 1929 general adjustment, will be held fixed. In isolated cases, however, changes in the configuration of the ground surface caused by drainage, engineering construction, earthquakes, or other operations may necessitate revision of the elevations of individual bench marks. Where a vertical-control survey is tied in to a bench mark whose elevation with respect to mean sea level is furnished, it is necessary to be certain that this elevation is based on the last general adjustment. To make sure that an established bench mark has not been disturbed, it is the usual practice to run a line of levels between that bench mark and some other previously established bench mark.

Methods for Making Dependent Surveys

6. City surveys for construction or maintenance are made by the usual methods of plane surveying. The instruments that are used and the care that is taken in making the various measurements in a particular survey depend on the required degree of accuracy, and this in turn is determined by the nature of the survey. Property surveys usually require a higher degree of accuracy than do surveys for routine construction or maintenance. However, construction-layout surveys for important structures, such as bridges and tunnels, must be of the highest order of accuracy.

