EVOLUTION OF THE GEODETIC CONTROL NETWORK OF SRI LANKA

Mr A Dissanayake
Deputy Surveyor General, Geodetic Branch, Surveyor General Office, Colombo

Geodetic control network provides a common reference system for establishing the coordinate positions of all geographic data. The main features of geodetic control network are geodetic control stations, which are precisely measured horizontal or vertical locations on monumented points used as a basis for determining the position of other points. These stations have published the datum values derived from observations that tie them together in a network of triangles. Establishing a network of stations with precise horizontal locations in Sri Lanka commenced in 1857 by selecting these stations on top of prominent hills and forest areas which were not fairly possible to reach, with two base lines, one being at Negombo between Kandawala and Halgasthota and other being at Baticaloa between Vaunativu and Tavelamunai. The two base line distances were measured and pre-determined accurately using INVAR tapes.

This network of horizontal stations comprised of 110 locations formed with 159 triangles across the country starting from Negombo base line and ending up with Batticaloa base line, computing sides of each triangle of the network by physically measuring its included angles with the help of accurately measured initial base line distance of Negombo. Finally, the computed distance based on included angle observations of the side of triangle comprising of Battcaloa base line was compared with its pre-determined distance and the network of triangles were adjusted fixing the pre-determined distances of the two base lines. The computation of this horizontal network was done by Mr. J. E. Jackson, and published in 1932, in which the accuracy was found around 1:20,000. In the computation, the shape of Sri Lankan region was approximated to the local ellipsoid - Everest 1830 - to determine the geographical coordinates in Latitude and Longitude, and finally Transverse Mercator projection was applied to derive Two Dimensional (2D) horizontal coordinates. In 1992, with the advancement of survey measurement technology, the network was recomputed and adjusted physically by measuring all the sides of triangles in addition to measuring included angles of all the triangles of the network, known as Triangulateration. In this technique, the included angles were measured using Wild T3 survey instrument while MRA7 distance Tellurometer was used to measure distances between stations, which were apart at significant distances. It was able to improve the horizontal accuracy of the network to around 1: 40,000 with the method of Triangulateration. In this approach, the network adjustment of observations was performed by using a special geodetic network adjustment software.

During the period of 1996 - 1999, a new horizontal control network was established by using Global Positioning System (GPS) observations with establishing eleven (11) principal stations known as AA points in the country at the accuracy of 1: 700,000 and densifying the network further, it was carried out establishing two hundred and seventy-three (273) primary control stations, known as A points. In determining these control stations, GPS baseline observations were adjusted using the same network adjustment software used in Triangulateration. Due to the prevailing unrest of the Northern part of the country at that time, densification was not able to be carried out in that region. However, in between 2010 and 2012, primary control network was expanded to establish control stations in Northern area, adding 69 points. The secondary control network, comprising of stations known as B points to the accuracy of 1:100,000 and the tertiary control network comprising of stations known as C points to the accuracy of 1:50,000 were established in further densification. The new horizontal network is based on global ellipsoid WGS84 and SLD99 datum, which was established using seven (7) parameter transformation (Bursa Wolf) to select Everest 1830 local ellipsoid as the reference ellipsoid for subsequent determination of horizontal coordinates.

Due to the refinement of the old systems with Triangulation and Trilangulateration and the establishement of the present horizontal control network using GPS, some control stations have three different sets of coordinate values, and stations which were not incorporated in establishing present coordinate system have only coordinates on old systems. As a result, all the coordinates of old surveys and maps prepared based on such surveys have to be transformed into the present system in order to be aligned with the SLD99 datum.

With the difficulties of maintaining the horizontal control network due to the cost involved in its establishment and maintenance, which would mainly include cost for monumentation, replacement of damaged or destroyed control stations and densification, a necessity arose to move to a more robust and reliable system. Moreover, with the increase of users in the application of geographical information with ubiquitous computing supported by high use of Mobile Phones and Personnel Digital Assistants (PDAs) connected on the Internet for various Geographical Information System (GIS) based applications and advancement of state of the art of surveying equipment, control stations are required to be established efficiently to meet the accuracy standards at various levels depending on the purposes and time lines of the tasks.

Considering the high demand for geospatial applications by GNSS users, who need control stations to meet expected spatial accuracies to collect reliable terrain information, Survey Department took an initiative to establish a Continuously Operating Reference Station Network (SLCORSnet), which comprises of GNSS reference receivers installed at well-established control stations at designated places, each is spaced approximately at a distance of 30-50 Km. These stations transmit continuously collecting GNSS raw data live to the control center based in Colombo at the Surveyor General's Office. The advantage of this system is that, it provides accurate position real-time position at any place within the corpus of this network with a survey grade Global Navigation Satellite System (GNSS) receiver, known as a rover receiver to accuracy less than 2-3cm. The present network is operational only in the Western part of the country with six reference stations established in Colombo, Kaluthara, Katana, Awissawella, Rathnapura and Kegalle. In determining position with this method, a rover position is determined through Virtual Reference Station (VRS) technology by applying RTCM correction transmitted from the control centre software based on the raw data collected continuously at reference stations. Also the online delivery of GNSS raw data in RINEX format and online post processing services of GNSS static observations are provided as online web services from the SLCORSnet website of the Survey Department. Once registered under the SLCORSnet website, a user can obtain these services during the subscription period. It should be emphasized that with a single receiver, a user connected to the system can perform RTK positioning, setting out surveys and establishing control points for subsequent detail surveys depending on the type of application.

Furthermore, the vertical control network of Sri Lanka is another essential reference network to determine the elevation of points of interests for various development projects. It consists of control stations with a series of Benchmark heights connected to the Mean Sea Level (MSL). MSL had been determined by great Trigonometrical Survey of India by observing sea level fluctuations with Tide Gauges established near coast in Colombo, Galle and Trincomalee during the period of 1884 to 1895. Establishment of the primary level net was carried out during 1926 to 1930 with fifty seven (57) Fundamental Benchmarks on large masses of rocks and seven (7) Standard Bench Marks built on large concrete blocks using precise levelling. The present vertical control network consists of fifty-two (52) FBMs, three (3) Secondary Benchmarks (SBMs) and twenty-one (21) new SBMs.

In future, possibility of establishing mobile CORS networks as and when required depending on the magnitude of the survey tasks and applications has to be studied. Another important task ahead in the responsibility of the Survey Department is to model height anomalies known as undulation using a GEOID model, through which orthometric height (heights based on MSL) at any place can be determined once ellipsoidal height of such a place in reference to global ellipsoid (WGS84) or local ellipsoid (Everest 1830) is known.