Global Positioning System and Strengthening of Geodetic Network of Nepal

Krishna Raj Adhikary
Chief Survey Officer , Geodetic Survey Branch Kathmandu Nepal
email: astrogeo@htp.com.np, krishna_adhikary@hotmail.com
and
Shree Prakash Mahara
Deputy Director General Geodetic Survey Branch Kathmandu Nepal

Abstract

Nepal is a country of mountains The higher order geodetic points were mostly established on the top of mountains and these points were used for the geodetic network extension. Lower order geodetic control networks were established at different times and used for the surveying and mapping activities of the country. It has been found that the rate of convergence between north and south borders of Nepal to be 21±2 mm each year and the rate translation of Kathmandu to 55±3 mm/year to the plates. The most intense deformation in Nepal occurs along the belt of high mountains along its northern border resulting in a strain contraction rate normal to the Himalayan Arc. This belt is approximately 40 km wide and extends into southern Tibet.(13). Recently Survey Department of Nepal has lunched a program of strengthening the existing geodetic network of Nepal and re-observed the position of higher order geodetic points by using geodetic GPS receivers to evaluate their position and thus to define the precision of the control points once again. This paper describes the observation procedure and the adjustment results of the existing higher order control network of Nepal established in different time using different types of equipment and techniques; and highlights the observation procedure and the result obtained after the post processing of the GPS observation results. Attempt has been made to give the procedure and identify the methodology for the re observation of existing higher order geodetic points by using GPS receiver and post processing the observed data so that the existing higher order geodetic points are within the given accuracy standard.

Key words: Geodetic control , Global-positioning system, Gravity survey, strengthening geodetic control net, post processing

1.Introduction:

In Nepal, for the first time, Survey of India has established survey frameworks of trigonometric ground control points as an extension of great trigonometric network of India during 1954-60 under the Colombo plan agreement. These controls are then used by Survey of India for the preparation of topographic base map of whole kingdom of Nepal at 1" to a mile. In order to have a new précised geodetic net of the country, Survey department of Nepal has carried out the geodetic Survey fieldwork during 1981-1984 to establish Geodetic Survey control net covering the 800km east-west extent of Nepal and the subsequent mathematical adjustment was completed on 1986 with the Nepal geodetic reference system (Everest1830 reference spheroid, modified UTM projection 3 degree belt). The advantages of Nepal geodetic reference system over the Survey of India Reference System used in Nepal , was that it avoids complication of longitude correction and orientation of Nepal geodetic reference will change by no more than 1.5 second arc from Indian reference (3m at points 400km of datum origin). Elevation / heights was taken from fundamental benchmarks of Survey of India values relative to the mean sea level.

Global positioning system (GPS) was introduced in Nepal by the Japanese consultant in 1988 for the establishment of control points for photogrammetric triangulation in Lumbini zone mapping project(JICA). Latter on Survey department with the collaboration of various donor agencies has carried out the work of precise GPS observation and established the GPS Higher order ground control points in Nepal for their specific purposes. As a result of these experiences, in 1994 Survey Department has introduced the GPS technology for the extension of geodetic network of Nepal. Now a day's GPS is the main techniques for the extension of higher order controls in Nepal.

2.Geodetic control net 1981-84

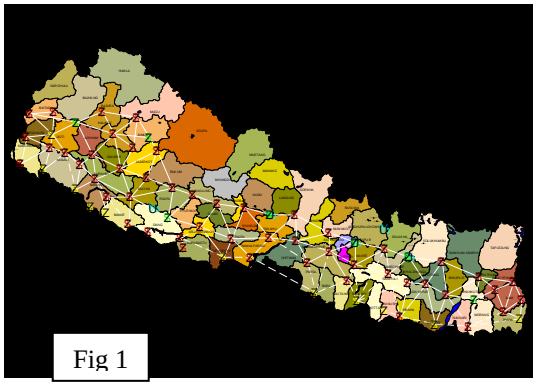

Fig 1

High precision geodetic control point network was established at 68 different places distributed all over the country (fig.1). The control net includes Doppler Stations established in 1980-81, existing stations of survey framework of 1954-60 and newly monument survey stations. The control net also includes microwave communication tower with an associated ground station sites in the terai region of Nepal. In 1976-77 astronomic observation for position and azimuth at 7 station in Nepal was carried out and these laplace stations were also included in the geodetic net of 1984. The distribution of geodetic points is limited only on the assessable ground points. Himalayan part of Nepal was not possible to cover by the geodetic points as this portion of land is still inaccessible or difficult to establish the ground points for the surveyors. Geodetic control net of Nepal has the following characteristics:

- The observational data accepted for the final plan adjustment are 224 horizontal angles at main stations of the net,250 microwave measured lengths on 198 lines,6 short lengths ate local connection,6 Geodometer measurement length,50 Laplace azimuth values on 23 different lines,5 angles & lengths of Doppler translocation lines and 16 latitude & longitudes of Doppler positions at 13 stations.

- The Standard error of unit weight determines in the solution is 1.15 and standard error uncertainly of each azimuth value was based on the estimated positional accuracy of ±0.5 metre over the length of the line concerned.

- Standard error(se) uncertain in the adjusted–positions of the stations relation to the fixed origin station (i.e. Nagarkot) vary from zero up to ±0.30m in latitude and ± 0.45m in longitude at the east and west extremes.

- Values of the combined curvature and refraction correction factor were derived in seconds of arc per kilometers of line length.Standard derivation of an observed value of the combined curvature and refraction correction is ± 0.2 sec/km.

- Misclosure value i.e. mean value of the height differences observed on each line, range from a minimum of less than 0.1m to 4.1m with an average value of 1.1m.The typical standard error uncertainly in an observed height difference was of the order of ±1.0m for a line of 40km in length.

3. GPS Geodetic Control Survey

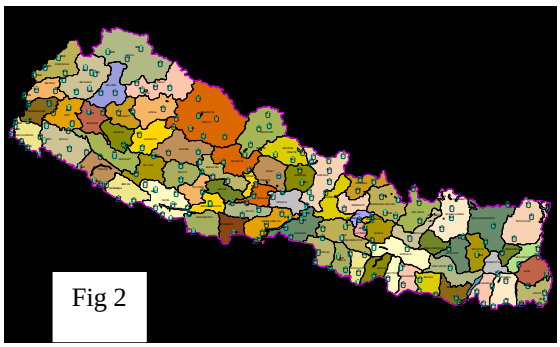

Fig 2

The University of Colorado and Massachusetts Institute of Technology (USA) established the precise Global Positioning system (GPS) geodetic points during 1991. Geodetic Control over the eastern Nepal area was established on the 13 new geodetic primary stations with the help of existing 16 geodetic first order points by using the static relative GPS Survey. Altogether 29 primary stations (fig 2) were established and observed by using Astech LD_SLL GPS receivers. Astech Inc's

Geodetic Post Processing Software version 4.4.01 with fill net version 3.0.00 adjustment program was used for the processing and adjustment of data. Transformation of WGS4 co-ordinates to UTM (Nepal geodetic reference System) was done by affine transformation. Similarly, the Geodetic control net of the western Nepal based on GPS(Global Positioning System) measurement was established on 51 primary GPS stations(fig 2) and computed as free network using existing point of eastern net of the country. Observation were made by four dual frequency GPS receiver using station relative positioning. The accuracy was controlled over 1-sigma accuracy of the base line. These varied mainly between 0.9 to 2.2 ppm

4. Strengthening geodetic control network

The work of Strengthening of Geodetic Network of Nepal includes extension of geodetic control network, the gravity survey and preparation of gravity anomaly of the country , and updating three dimensional geodetic control network with defined positional accuracy. The development of Global Positioning System using satellite techniques for point positioning has given us the various opportunities for the strengthening geodetic control network of Nepal.

4.1 Extension of Geodetic control network

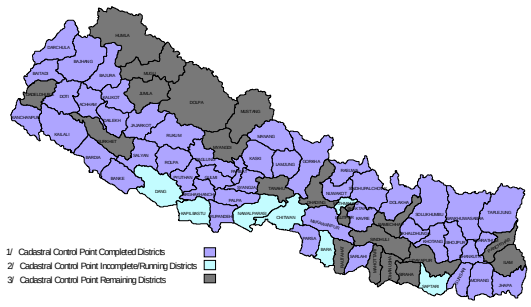

fig3

Survey Department initiated during 1972 to use the geodetic control points to prepare the cadastral map of the country. In order to provide the ground control plotted sheet for the preparation of large scale cadastral map of the country, establishment and extension of ground control network was carried out by using the traditionally established method of surveying i.e, triangulation and traversing. Survey department initiated during 1994 AD to use the global positioning system technology to provide the control points of third order in the Jhapa district of Nepal and continue to other districts of Nepal for the control network extension program of the country. First order /Second order geodetic points were used as the reference points and the results were satisfactory. GPS third order control networks of 8 districts were completed and 11 districts were partially completed. These GPS control points are used for theodolite traversing/triangulation to provide further extension of fourth order controls required for the plane table survey. Out of 75 districts of Nepal, 47 districts (fig 3) are completed to provide the Lower order geodetic net of the country.

4.2 Gravity Survey :

Gravity surveys were made to establish a gravity base station net and to observe gravity values for detail stations of geodetic Survey Control Net of Nepal. Gravity reference system used for the gravity values in IGSN71, modified 1979. International Gravity Standardization Net 1971 was modified in accordance with IUGG Resolution. The Lacoste Romberg Model G gravity meter was used for gravity observation..The standard error uncertainty of the scale factor determine for each of the first two gravity meters was of the order of ±0.00005. A gravity transfer was made from station Kathmandu airport to an IGSN71 station 06230A BANGKOK (**g = 978300.10 ± 0.032 m gal**.). Kathmandu airport station gravity value **g is 978661.22±0.047 mgal.** The adjusted g values of the base stations is calculated and relative to the fundamental base station. The maximum standard error uncertainty in the g-values of a base satiation is ±0.037 m Gal. Values of observed gravity were determined at a total of 375 detail stations.

4.3 Updating the geodetic control net:

It has been found that the rate of convergence between north and south borders of Nepal to be 21±2 mm each year and the rate translation of Kathmandu to 55±3 mm/year to the plates. The most intense deformation in Nepal occurs along the belt of high mountains along its northern border resulting in a strain

contraction rate normal to the Himalayan Arc. This belt is approximately 40 km wide and extends into southern Tibet.(13). Survey Department of Nepal has lunched a program of strengthening the existing geodetic network of Nepal and re-observed the position of higher order geodetic points by using geodetic GPS receivers to evaluate their position and thus to define the precision of the control points once again. It has been shown on the previous paragraph that the high precision GPS geodetic control survey has been carried out first and the extension of ground control is done for the preparation of topographical base map of the country at different time.

5. Conclusion and recommendation

The development of Global Positioning System using satellite techniques for point positioning has given us the various opportunities for the strengthening geodetic network of Nepal. New technique of airborne gravity/ GPS surveys can also be used to determine the precise Geoid of Nepal and the height datum of the country and investigation towards the geophysical changes as well as for the strengthening supplement and expand the existing geodetic control network system of Nepal. Strengthening the geodetic control network of the Geodetic Survey of Nepal should carried out using the developed technology for the work of establishment of National geodetic datum of Nepal and determination of precise geoid of Nepal to strengthen, supplement and expand the existing geodetic control network system.

It has been found from the preliminary report of GPS and gravity observation in Nepal during 1998 that rate of convergence between north and south borders of Nepal to be 21±2 mm each year and the most intense deformation in Nepal occurs along the belt of high mountains along its northern border. In order to accept the results more explanation has to be given to the international community which needs more measurements. It is recommended that further GPS measurements/gravity measurements should be carried for the strengthening the geodetic control net of Nepal and as well as to confirm the deformation along the Himalayan region with rate of convergence between north and south of Nepal. Survey department is willing to go ahead on this type of research project and all the international community are invited to join us in this endeavor.

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