PREPARATION OF TOPOGRAPHIC MAP USING TOTAL STATION AND GNSS

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled **"Preparation of topographic map using Total Station and GNSS"** is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

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Dedicated to our parents, teachers and all our guiding lights

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SYMBOLS AND ABBREVIATIONS

Symbols	Abbreviations
º	Degree
!	Factorial
-	Minus
‘	Minutes
/	Per
%	Percent
:	Colon
+	Plus
‘’	Second
ºc	Degree Celsius
Km^2	Kilometre square
Cm	Centimeter
DEM	Digital Elevation Model
DGPS	Differential Global Postioning System
dept.	Department
et al.	and all others
etc.	etcetera
fig.	Figure
GIS	Geographic Information System
GPS	Global Positioning System
ie.	That is
h	hour
ha	Hectare
m^3	Cubic meter
min	Minute
mm	Millimetre
R	erosivity index
MJ	megajoule
Mg	mega
SRTM	Shuttle Radar Topographic Mission

WGS84	World Geodetic System 84
EGM96	Earth Gravity Model 96
RMS	Root mean square
SPOT	Satellite Positioning and Tracking
AS2	Accounting Standard 2
HDOP	Horizontal Dilution of Precision
PDA	Personal Digital Assistant
RFID	Radio Frequency Identification
LBS	Location Based Service
GPRS	General packet radio service
SBAS	Satellite-Based Augmentation System
PC	Personal computer
SD card	Secure Digital card
LiDAR	Light Detection and Radiation
LS	Length slope
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
2D	Two dimension
3D	Three dimension
TOPODEM	Topographic Digital Elevation Model
INEGI	National Institute of Statistics and Geography
TGO	Trace Gas Orbiter
RTK	Real Time Kinematics
GE	Google Earth
PDOP	Position dilution of precision
GNSS	Global Navigation Satellite System
RMSE	Root mean square error
EDMI	Electronic Distance Measurement Instrument
EDM	electronic distance measuring device
TPS	Testing procedure specification
ATR	Attenuated Total Reflectance
FNC	Function
Hr	Height of reflector
HO	Height of object

USB	Universal serial bus
Cont	Continue
ASCII	American Standard Code for Information Interchange
Dxf	Drawing exchange format
Gsi	Geo serial interface
Csv	Comma separated values
Xml	Extensible markup language
TBC	Trimble Business Centre
MSL	Mean Sea Level
GMT	Greenwich Mean Time
Init	Initialisation
Esc	Escape
ICAR	Indian Council of Agricultural Research
Ppm	Parts per million
D	Distance
RX	reception
KCAET	Kelappaji College of Agricultural Engineering and Technology

INTRODUCTION

Chapter 1

INTRODUCTION

Topographic map is an important prerequisite for Agricultural Engineers as their sphere of activities include soil and water conservation, design and execution of irrigation systems, drainage network, location decisions of farm infrastructures, local and regional agricultural planning among other things. Areas of the land parcel, relative elevation, nature of the terrain and land use are the important information that a topographic map generally will provide. Among the various applications of topographic maps in Agricultural Engineering, soil and water conservation may be the most important item. When the area involved is large, planning of water harvesting, erosion control etc. will be made on a map and later on those will be transferred to the field.

Soil, the weathered portion of earth crust, is one of the most important natural resources that support all forms of life on earth. Conservation of this resource assumes great significance as it is very much prone to various types of soil erosion processes such as wind and water erosion. Soil erosion is defined as the detachment, transportation and deposition of soil particles from one region to another under the influence of erosive agents. According to estimates by ICAR, the loss due to water erosion is 53.34 million ha annually. The erosion status of the state reveals that 83500 ha is severely eroded, 973245 ha is moderately eroded, 1064879 ha is moderately to slightly eroded, 307708 ha is slightly eroded and 620965 ha is under permanent vegetation and is well protected. Soil erosion process is influenced by a number of factors. Land slope and climate are the two important factors governing the rate of soil erosion. In a humid climate with undulating terrain, any agricultural activity should be preceded by soil erosion control measures. Susceptibility of soil erosion depends upon the nature of the soil and the topographic factors. To plan soil erosion control measures, estimating the erosion potential of different land parcels are very essential. A topographic map of the area is the primary pre-requisite of soil erosion studies and for planning any other agricultural infrastructures.

A topographic survey is the means of producing a topographic map. The preparation of topographic map can be done by means of theodolite, aerial photography, Total Station, GNSS etc. High accuracy, efficiency and less time requirement give more predominance and acceptance to Total Station and GNSS. Theodolite and other conventional surveying techniques are very slow and laborious and practically not feasible for a large area. Total station surveying is advancement to theodolite surveying. Many field operations such as angle and distance measuring and their field recording have been automated in Total Station surveying.

Total Station surveying is defined as the use of electronic survey equipment used to perform horizontal and vertical measurements in reference to a grid system. Total Station is a form of an electronic theodolite combined with an electronic distance measuring device (EDM). Its primary function is to measure slope distance, vertical angle, and horizontal angle from a setup point called instrument station to a foresight point. Most Total Stations use a modulated near infrared light emitting diode which sends a beam from the instrument to a prism. The prism reflects this beam back to the instrument .The portion of wavelength that leaves the instrument and returns is assessed and calculated. Distance measurements can be related to this measurement using the principle of travel of light energy through air. Angle accuracy can range from 2'' to 5". Distance accuracy can range from +/- (0.8+1ppm* D) mm to +/- (3+3ppm* D) mm, where D is the distance measured.

Some of the advantages of Total Station surveying are:

- Reduce error: Manual errors involved in reading and recording can be eliminated.
- Time saving: Field work is carried out very fast.
- Accuracy of measurement is high.
- Precision data.
- Calculation of coordinates is very fast and accurate. Even corrections for temperature and pressure are automatically made.
- Computers can be employed for map making and plotting contour and cross section. Contour intervals and scales can be changed at any time.

DGPS (Differential Global Positioning System) is an advanced version or the enhancement to Global positioning System or the GPS. DGPS provides better and improved location accuracy than GPS from a nominal GPS accuracy of 15 meters to that in the best implementation of about 10 cm. It increases the accuracy of the locations or the coordinates derived from the GPS receivers. The principle behind DGPS is to use the reference location of the base receiver to correct for the location error of the unknown rover position. Since the base station is fixed, we can use the difference between the measurement of the base and the rover receivers to create an error correction vector. The precise location of the rover can then be calculated if we apply the error correction over all the satellite data. DGPS can be achieved through real-time telemetry links between a base and a rover or through post-processing the data. DGPS application include topographic surveys, control establishment and densification, positions, lines and levels setting out, azimuth determination and collar pick-ups (x; y; z).

Advantages of DGPS are:

- Use of DGPS increases the accuracy (+/-0.045m)
- Real time data
- Worldwide coverage
- 3D survey results
- 24 hours availability

Disadvantages of DGPS are:

- Most of the errors are completely eliminated or made negligible, however atmospheric errors are RX based errors would still exist. DGPS error sources are satellite clocks, orbital error, ionosphere, troposphere, RX noise and multipath.
- The coverage area to take advantage is limited.
- To ensure greater coverage area more DGPS stations need to be added.

In this context, an attempt has been made in this project work to prepare a topographic map using Total Station and DGPS to facilitate erosion studies with given below specific objectives:

- To study the principle and operations of Total Station and GNSS
- To prepare a topographic map of KCAET campus using Total Station and DGPS
- To prepare a land slope map from topographic map for erosion studies.

REVIEW OF LITERATURE

Chapter 2

REVIEW OF LITERATURE

A critical review of some of the important research work done in the area of topographic surveying using total station, GNSS and soil erosion studies are presented in this chapter.

Colosi *et al*. (2000) carried out a series of topographical surveys in the Salto Valley (Rieti -Lazio) and provided much interesting data regarding local archaeological sites, particularly along the southern slopes of the Breccioso Hills which rise between the Corvaro and Spedino plain. The nature of the site was not clear and its structure is hazy, as a result of the deterioration of the surrounding ground and increased vegetation coverage. So a detailed survey of the southern incline and the plateau associated with the site was suggested. The objective of the survey was to highlight topographic variation and to bring to light any traces of human construction or manipulation. The survey was carried out using a DGPS Leica SR 510, and a Total Station. The integration of these two instruments produced satisfactory and innovative results. The processing of the Digital Terrain Model (DTM) of the area highlighted several characteristics of the site and the consequent production of thematic maps from this data were done.

Jeyapalan and Bhagawati (2000) conducted a study on Total Station, Differential Global Positioning System (DGPS), Videologging, soft photogrammetric and virtual reality methods of collecting data on road side features of urban, city and rural roads for creating a Geographic Information System (GIS). The first 15 highest priority road side features were: intersections, signs, pavement markings, signals, curbs, guard rail, number of lanes, rail road crossings, shoulders, side walk, road names, pavement distress, roadway geometric, bridges and Right of way. The videologging system gives the digital image and the X, Y, Z coordinates of the camera locations, using this information and soft photogrammetry it is possible to determine the location of any feature. Virtual reality is the mode in which a user can view in 3D, fly through the virtual model, modify in real time and view or measure its effect. The conclusion of the study was, Total Station can be used to collect data for creating 2D GIS showing roadside features at a scale of 1!=25" or larger and or smaller. DGPS can be used for mapping at scale 1! = 50" or smaller. Both systems are time consuming in the field. Soft Photogrammetry with digital videologging imagery can be used to map roadside features at 1! = 25" or smaller. It saves field data collection time; however, it requires calibration and stereo data collection time in the office.

Casasnovas*et al*. (2001) developed a method that can be used to quantify and map soil losses at field scale produced by extreme rainfall events. The amounts of sediment produced by overland flow and concentrated overland flow (inter-rill, rill and gully erosion)at the agricultural plot scale are evaluated from elevation differences computed from very high resolution digital elevation models (DEMs) , from data obtained before and just after an extreme rainfall event. Multi-temporal spatial data are analysed by GIS techniques. A mechanised vineyard plot located in the Alt Penedes–Anoia region (Catalonia, Spain) is used as the reference for case study. According to the obtained data the rainfall event, which occurred in June 2000, registered 215 mm, 205 mm of which fell in 2 h 15 min. The average intensity of the downpour was 91.8 mm/h, with a maximum intensity in 30-min periods of up to 170 mm/h. The erosivity index R reached a value of 11,756 MJ/ha mm/h, 10 times greater than the annual value for this area. The volume of soil detached by the rainfall, as measured by the proposed method, was 82819 m^3. About 57% of the detached soil particles were deposited with in the same plot. The balance was negative, with a total 35236 m^3 of soil loss from the plot, which represented a rate of 20721 Mg/ha. The paper analyses the characteristics of the rainfall event in relation to historical data and discusses the proposed method for soil erosion mapping at plot scales in relation to other measurement methods.

Agrawal R *et al*. (2006) have validated SRTM DEM with differential GPS measurements in this study. It deals with the accuracy assessment of the interferometric terrain evaluation data (DEM) from SRTM mission. The data was compared with reference to ground control points of differential GPS measurements at three different types of terrains (ranging from plain, moderately undulating and hilly region). Since the SRTM elevation values are orthometric height values in WGS84 datum, for the purpose comparing with DGPS co-ordinate were converted to WGS84 ellipsoidal value using EGM96 geoidal height model. The error statistics was generated between DGPS measurements and SRTM WGS84 ellipsoidal heights. It was observed that for the plain area like Ahmedabad (Gujarat) the errors were quite small (3.55m) ,whereas in the cases of moderately and hilly terrain like Alwar (Rajasthan) and Chamoli (Uttaranchal) the RMS errors were of the order of 11.44m and 19.64 m respectively. It is concluded that SRTM DEM can be used for any application depending upon the accuracy demand.

Ehioroboa and Izinyona (2006) located the position of all major rills and gully sites and georeferenced them using hand held GPS receiver. Based on severity rating and geopolitical considerations, six of the erosion gully sites were selected for monitoring. Control points were established around each of the gully sites by method of Differential GPS (DGPS) surveys and detailed topographical survey of gully sites were carried out using reflectorless Total Station instruments. In combination with GIS and Total Station data SPOT imageries were used and location maps, contour maps along with DEM were generated using ARCGIS 9.2 software. The morphological parameters of the gullies were then determined. Volumetric estimate of the amount of soil loss from gully erosion was also carried out. Soil samples recovered from the gully sites were used to determine their erosivity and other properties to be used for soil loss modelling. The results of the studies were used as an indicator for determining the gully initiation point, slope-area relationship, and threshold of gully initiation was also established. The minimum AS2 value was 345 while the maximum was 3,267. This shows that the results lie within the two boundary layers of 41 and 814 (m^2) and 500-4000 m^2 established by Poesen et al.

JUNG Rea Jung (2006) studied the method of DGPS applications for the cadastral surveying in Korea. A DGPS beacon system was implemented at the coastal area for the marine ship navigation purpose. The study focused on suggesting the practical possibility of DGPS in the cadastral survey. For this, several field tests were conducted. It was found that the accuracy in horizontal components averages 74 cm in the readjustment of arable land and 228cm in the forest. In the forest, the rate of Differential GPS Fix of Beacon DGPS was low and HDOP (Horizontal Dilution of Precision) was high. It was also found that DGPS doesn't cover the cadastral boundary surveying, however it will be expected that possibility to play a role as a part of device for the ubiquitous cadastre, such as finding control points and boundary points, connected with PDA, RFID on the site could be obtained. And also, this study showed that DGPS will be applicable for high-precision-position-based services like LBS (Location Based Service), and ubiquitous cadastral surveying.

Rodriguez*et al*. (2006) conducted a study on comparison of GPS receiver accuracy and precision in forest environments and practical recommendations regarding methods and receiver selection. This study compares recreational GPS receivers (GARMIN eTrex Euro, GARMIN 12XL, GARMIN Summit, GARMIN Geko 201)and more precise GPS receivers (Topcon Hiper+). It was aimed to determine the most suitable method and receiver for position assessment under different forest canopy covers, in terms of easiness of use, accuracy, reliability, and the ratio accuracy/cost. Several positioning techniques were compared: autonomous, real-time differential, and post-processed differential modes, as well as the effect of using an augmentation system. The test course consisted of 19 points sited under different tree canopies and one point without any obstacle. Test procedure was identical for all twenty points, days and receivers. GPS positioning was repeated five times at each test point using, twenty minutes before receivers were turned on.

Results showed that there were significant differences between the receivers regarding accuracy and precision measuring coordinates; moreover, accuracies were different depending on the canopy cover and forest characteristics. Therefore, practical recommendations for each case were settled in order to help foresters to select the most suitable receiver.

Filjar *et al*. (2007) studied the DGPS Positioning Accuracy for LBS (location based services).This study was based on experimental data analysis. A vehicle was equipped with two Garmin GPSIII+ receivers, one working in standard and the other in differential GPS positioning mode. Differential GPS corrections were delivered from the Prague differential station through the EUREF-IP network and using the mobile Internet GPRS connection. Additional software was developed inorder to support both the NMEA-0183 acquisition and the DGPS corrections delivery using the same serial port for GPS receiver running in differential GPS mode. Every positioning sample consists of: GPS time of sampling, Latitude, Longitude, Horizontal positioning error estimate (calculated by GPS receiver), and Number of visible satellites. The conclusion of the study was Differential GPS positioning improves the LBS positioning performance, compared with the standard (un-assisted and un-augmented) GPS positioning. However, general LBS positioning accuracy still cannot be improved in a way that would satisfy high-level requirements by deployment of differential GPS positioning alone.

Hayakawa *et al*. (2007) conducted an accuracy assessment of a post processing differential GPS device. Here they used a portable DGPS device, Mobile mapper pro by Magellan Navigation Inc. This DGPS device is capable of differential correction of GPS signals by two means; real-time SBAS (Satellite-Based Augmentation System) correction (2-3 m accuracy) and post processing correction (1m accuracy). At Kaman, the measurements were taken with a relatively short duration; 131 measurements in one day. At Hacitugrul, measurements were taken with a relatively long duration; 114 measurements over 10 days. After the field measurements, the DGPS data were imported into a PC via SD memory card, and the DGPS log data of the base and mobile devices were post processed using bundled software (mobile mapper office). It was found that 2 minutes is the minimum necessary time to enable efficient post processing differential correction for the DGPS device used. The position accuracy of SBAS based differential correction is several meters, even when the measurements are taken over a period as long as 6 hours.

Mottershead *et al*. (2007) surveyed small scale terrains on salt materials with a Total Station and a series of digital elevation models (DEMs) constructed. Eight months apart two sets of observations were made, during which the terrains underwent significant erosion. The difference in elevation shown by the DEMs is a measure of surface erosion of the salt terrains. The erosion rate was analysed with respect to four terrain parameters calculated in the software. High erosion rates, and their strong control by terrain slope, are demonstrated, supporting an earlier study using erosion pins. Indications show that slope profile curvature is also having some influence. The combination of scanning Total Station and DEM software is found to be an effective tool for investigating rapid geomorphic change at this scale of study.

Baptista *et al*. (2008) conducted a DGPS survey on beach profiles using a DGPS mounted on a vehicle and a traditional pole-mounted DGPS. A vehicle mounted DGPS provided a highly accurate non time consuming measurement campaign (easily repeated). Measurements were taken using a pole-mounted DGPS in areas where the vehicle could not reach. The area surveyed was approximately 10,000m^2. A mesh measurement regime was used since beach profiles have relatively smooth features. Profile features should be the base for profile mesh size used. The volumes of points are represented by the amount of morphological change in the survey site. Due to increased elevation variability in the site, it requires more measurement points than a smoother site. Very high resolution meshes may not significantly improve the quality of a DEM and a mesh too wide will not pick up the topographic features in a site. In this study, when different mesh sizes were analysed, the highest density mesh provided the best results.

Rayburg *et al*. (2009) assessed the quality of DEMs derived from LiDAR, DGPS and spot heights taken from a 1:100,000 topographic map. The area studied was Narran Lake Ecosystem in north western New South Wales, Australia. The DGPS survey done consisted of 20,000 points having a spatial resolution of approximately 1m along survey lines and 200m between survey lines. LiDAR survey consisted of approximately 650,000,000 data points, with a spatial resolution of 1m^2 and a vertical accuracy of 8 - 11cm. All DEMs were created using the kriging interpolation model. The LiDAR-derived DEM represented a wide range of topographic features and the DGPS-derived DEM gave considerably less details, but in some areas they gave similar results to the LiDAR. LiDAR- and DGPS-derived DEMs differ by a minimum of 25cm and maximum of several metres in areas. DGPS-derived DEM is of varying quality as considerable fewer points were measured compared to the LiDAR survey. This limitation was mainly due to the challenges associated with ground surveying, as the terrain was difficult to navigate. The LiDAR-derived DEM provided the best results. This resulted in the representation of more features including macro- and micro-channels, flood plains, clay pans, sand dunes, and subtle variations in lake topography.

Dattaand Kirchner (2010) used a digital elevation model (DEM) to derive the topographical characteristics of a study area. Usually, a DEM is incorporated into erosion models as a given parameter and it is not tested as extensively as the parameters related to soil, land-use and climate. In this study, they compares the erosion relevant topographical parameters (elevation, slope, aspect, LS factor) derived from 3 DEMs at original and 20 m interpolated resolution with field measurements for a 13 km^2 watershed located in the Indian Lesser Himalaya. The DEMs are: a TOPO DEM generated from digitized contour lines on a 1:50,000 topographic map; a Shuttle Radar Topography Mission (SRTM) DEM at 90-m resolution; and an Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) DEM at 15-m resolution. ASTER DEM was found to be poorest whereas, TOPODEM produced similar results to the coarser SRTM DEM, but failed to produce an improved representation of the watershed topography. Comparison with field measurements and mixed regression modelling proved SRTM DEM to be the most reliable among the tested DEMs for the studied watershed.

Ortiz *et al*. (2010) have done comparison of regional elevation heights in the Aguascalientes basin using DGPS technique with INEGI’s digital terrain model. The purpose of this paper is to compare DGPS surveys using both two and three receivers, and to determine the error bar between the DTM (Digital Terrain Model) and the DGPS technique using as an example the city of Aguascalientes and surroundings. Two base receivers (Trimble 5700), and one portable receiver (Trimble 5800) were used. From this control point, elevations of the other benchmarks were determined using the TGO software. The research presented here shows that if adequate satellite coverage is available, two DGPS receivers generate an acceptable DTM model for the area under study. Three receivers give redundant information and allow the user to close the polygons offering increased confidence on the measured values. DTM models are an approximation and may be used as an initial value. Based on the results presented here, they suggest that DTM’s may only be used for regional studies, and cannot be used to estimate the hydraulic gradient in aquifers in Mexico.

Smuleac *et al*. (2010) used the Leica TPC 805 Total Station for the topographic and land survey measurements, and the data were downloaded with LEICA Geo Office Tools special software. The following plans were executed after the measurements were taken: dimension site plan - 1:500; plot plan - 1:1000; development site plan - 1:10000. Generally, a geodesic network has at least two old points that in the first stage help determine the coordinates of the "new" points with the help of a certain method. A direct link is created between the older points through horizontal angular observations. Distances and orientation must also be determined between these points and they will be used in the compensation calculations. The calculations of the geo-topographic support networks were done with the TOTAL 2.0 software. The compensation of the support network is done with the least squares method, the indirect measurement method. The software creates a DXF file that can be used with the AutoCAD package at a later time. TOTAL 2.0 calculates and, where necessary, compensates any combination of direction and distance measurements, from the easiest (cancellation of registration, multiple intersection, multiple resection) to the most complex ones (various traverses, polygonometric networks, triangulation).

Connemara *et al*. (2011) carried out topographic survey at four historic bridges. Site survey control was established using a Trimble Differential GPS (R6). Subsequent surveying was carried out using both a Total Station (Leica TCR 407, Penmap Software, and Panasonic Toughbook Tablet PC) and a Trimble Differential GPS (R6). The survey data was edited in AutoCAD to create a hachured ground plan and a single representative elevation drawing. The four bridges were surveyed in three dimensions and the majority of the ground plan and topographical details were collected using the Trimble Differential GPS (R6) and supplemented with the Total Station and detail pole where necessary due to poor GPS signal. So majority of the elevation data were collected by means of the Total Station's red laser feature.

Jeong*et al*. (2013) conducted accuracy and efficiency tests for four different beach-profile surveying methods of: (i) spot measurement using a Total Station; (ii) spot measurement using a RTK-GPS system; (iii) continuous walking measurement using a RTK- GPS backpack system; and (iv) continuous measurement using a RTK-GPS system mounted on an all-terrain vehicle (RTK-GPS ATV system) at the Gosapo macro-tidal sand beach, South Korea. The test results indicates that the RTK-GPS spot measurement method have the lowest vertical error of about 2 cm, which includes equipment and operation errors, while the rest of them have similar vertical errors with a range of 3 to 6 cm. Compared to other surveying methods, RTK-GPS ATV system have advantages in surveying time and operational manpower with a reasonable vertical error of about 3 cm, which increases their surveying efficiency. As a result, The RTK-GPS ATV system is the most suitable surveying method for examining the beach volume and morphologic changes in a macrotidal sand beach, while the spot measurement methods using the Total Station or the RTK-GPS system are adequate for accurate beach profile change.

Pradeep Kumar *et al*. (2013) made an attempt to assess the accuracy of DGPS by comparing the data obtained from the Total Station at Indian School of Mines, Dhanbad campus. With DGPS the maximum error of 0.013m, minimum error of 0.002m and average error of 0.004m with standard deviation of 0.00554m was observed in Northing. In Easting maximum error of 0.017m, minimum error of zero meters and average error of 0.005m with standard deviation of 0.00674m was observed. The maximum error of 0.027m, minimum error of 0.005m and average error 0.007m with standard deviation of 0.01526m was observed in Reduced Level. The variation of average area from DGPS data with reference to Total Station data is $1.058m^2$. The DGPS provides the more reliable and accurate data which can be used for medium to small scale maps. The accuracy of data became improved with repeated observations and it depends on the taking of averages of data.

Ragab Khalil (2013) studied the accuracy of GIS tools for transforming assumed total station surveys to real world coordinates. In this paper the effect of using Georeferencing tool, Spatial Adjustment tool (Affine and similarity) and CHaMP tool on the precision and relative accuracy of total station survey were studied. The effects of using geodetic GPS, hand-held GPS, Google Earth (GE) and Bing Base maps as sources for control points on the precision and relative accuracy of total station survey was also studied. These effects have been tested by using 111 points from a covered area of 60,000 m^2 and the results have shown that the CHaMP tool was the best tool for preserving the relative accuracy of the transformed points. The Georeferencing and spatial adjustment tools gave the same results and their accuracy were between 1/1000 and 1/300 depending on the source of control points. The results have also shown that the cornerstone to preserve the precision and relative accuracy of the transformed coordinates is the relative position of the control points.

Diwakar *et al.* (2014) investigated the horizontal accuracy of Differential-GPS (DGPS) survey with comparison of Total Station instrument data. In this study they investigated the effect of observation time and the PDOP value on the accuracy obtained. The variation of accuracy with time and PDOP value has been analysed by curve fitting technique. For this work 19 points were established and observations were taken by using Total Station; TRIMBLE M3 and DGPS; TRIMBLE R3. Trimble Business Centre and the GNSS solution software are used for processing of raw data collected using DGPS. Terra Model software was used for processing Total Station data. Distance and height between established points is calculated using Total Station instrument using angle and distance method. Distance calculated for successive points from DGPS data is compared with the distance calculated using Total Station. Afterward mean error, RMSE, standard deviation of distance calculated from DGPS is estimated from Total Station. The conclusion of the study was 25 minute observation time is sufficient as the accuracy in horizontal measurement for 25 minute observation Standard deviation and Standard Error is 0.013 meter and 0.003 meter respectively. Accuracy of DGPS survey is dependent upon the observation time and PDOP value. It is found in this study that for poor PDOP even long observation time does give better accuracy.

MATERIALS AND METHODS

Chapter 3

MATERIALS AND METHODS

3.1 Study area

The study has been conducted in KCAET campus, Tavanur, Kerala, India having a geographical location of 10°52’30” North latitude and 76° East longitude. The area is characterized by sloping and undulating terrain with moderate vegetative cover. Total area comes to about 40 ha of which 50% is upland and the balance low lying paddy fields. Climate is humid tropic with an average annual rainfall of 3000 mm.

3.2 TOTAL STATION

Total Station is an optical instrument used in modern surveying. A Total Station surveying system consists of an electronic theodolite with an integrated Electronic Distance Measurement Instrument (EDMI), coupled with a precision retro reflector. There are reflectorless Total Stations available, but they tend to measure distances with a lesser degree of precision. Total Stations have been in use by the surveying community since the 1970s and are a proven technology. Total Stations are designed for outdoor usage and is capable of working in extreme weather conditions. It should not be exposed to heavy precipitation. Some Total Stations have robotic capabilities, enabling remote or programmed operations. These should be applicable to automated co-location surveys or monitoring. The primary function of Total Station is to measure slope distance, vertical angle, and horizontal angle from a setup point called instrument station to a foresight point.

Plate 3.1 Instrument setup

3.2.1 Main accessories of Total Station

3.2.1.1 Tripod

The most important criterion for a good tripod is its stability, more precisely, the torsional rigidity. Other requirements include the height stability under load and the minimal horizontal drift, long life, optimal vibration dampening, water resistance, outstanding behavior in solar radiation and their light weight in relation to load bearing capacity.

3.2.1.2 Tribrach

The most important criterion for a good tribrach is its good torsional rigidity or hysteresis. This hysteresis is the relative movement between the top plate and the base plate of a tribrach that occurs through the rotation of a TPS instrument. The hysteresis has direct influence on the angular accuracy of the instrument.

3.2.1.3 Prism

The range of a prism results from its coating and the glass geometry. A number of original prisms have a special coating on the reflective surfaces – the Anti-Reflex Coating, and a copper coating on the reverse side. Without these, the range of distance measuring, ATR and power search would be reduced by up to 30%. The workmanship and the durability of the copper coating are decisive for a long life. The glass dimensions, the position in the holder and the spatial orientation with it are important for measuring accuracy. Even under the most extreme environmental conditions, a long life span and maximum range of the highest accuracy are the most important criterion for prism.

3.2.2 Instrument Setup

3.2.2.1 Important features

• It is always recommended to shield the instrument from direct sunlight and avoid uneven temperatures around the instrument.

• The laser plummet described in this topic is built into the vertical axis of the instrument. It projects a red spot onto the ground, making it appreciably easier to center the instrument.

• The laser plummet cannot be used with a tribrach equipped with an optical plummet

3.2.2.2 Tripod

When setting up the tripod, attention should be paid to ensure a horizontal position of the tripod plate. Slight corrections of inclination can be made with the foot screws of the tribrach. Larger corrections must be done with the tripod legs. For this, clamping screws are loosened on the tripod legs, and the legs are pull out to the required length and the clamps are tightened.

a) In order to guarantee a firm foothold, the tripod legs have to be sufficiently pressed into the ground.

b) When pressing the legs into the ground, it is to be noted that the force must be applied along the legs.

Careful handling of tripod involve

• Checking of all screws and bolts for correct fit.

• Use the cover supplied while on transport.

1. Extend the tripod legs to allow for a comfortable working posture. Position the tripod over the marked ground point, center it as best as possible.

2. Fasten the tribrach and instrument onto the tripod.

3. Turn on the instrument, and, if tilt correction is set to **On**, the laser plummet will be activated automatically, and the **Level & Plummet** screen appears. Otherwise, press the **FNC/Favourites** key from within any program and select **Level &Plummet**.

4. Move the tripod legs and use the tribrach footscrews to center the plummet over the ground point.

5. Adjust the tripod legs to level the circular level.

6. By using the electronic level, turn the tribrach footscrews to precisely level the instrument

7. Centre the instrument precisely over the ground point by shifting the tribrach on the tripod plate.

8. Repeat steps 6 and 7 until required accuracy is achieved. Use the tripod only for surveying tasks.

Plate 3.2 Measuring height of instrument

3.2.2.3 Electronic level

1. Turn the instrument until it is parallel to two foot screws.

2. Centre the circular level approximately by turning the foot screws of the tribrach.

3. Turn on the instrument, and, if tilt correction is set to On, the laser plummet will be activated automatically, and the **Level & Plummet** screen appears. Otherwise press the **FNC**/Favourites key from within any program and select **Level & Plummet** by turning the two foot screws. Arrows show the direction of rotation required. The first axis is levelled, when the bubble is exactly between the squared brackets [] of the single axis bubble tube.

a) The bubble of the electronic level and the arrows for the rotating direction of the foot screws only appear if the instrument tilt is inside a certain leveling range.

4. Centre the electronic level of the first axis .The electronic level can be used to precisely level up the instrument using the foot screws of the tribrach.

a) When levelled correctly, checkmarks are displayed. For the Color and Touch display only; if the instrument is not levelled to one axis, then the icons for the single axis bubble tube and the circular bubble are framed red, else black.

5. Centre the electronic level for the second axis by turning the last foot screw. An arrow shows the direction of rotation required.

a) When all three bubbles are centered, the instrument has been perfectly levelled up.

6. Accept with Continue.

3.2.3 Working with Total Station:

i. Set up the tripod and mount the instrument.

ii. Switch on the instrument.

iii. Level and center the instrument.

iv. In the main menu select **Programs →Surveying→set job.**

v. Press **F1**to create new job.

vi. Give job name → ok. Then job is set.

vii. Go to **Surveying→station set up→set job→start→orientation with angle→coordinate entry.**

viii. Give point id and values to east, north, and height a 1000, 1000, 100 respectively.

ix. Height of the instrument is given. Horizontal angle is taken as 0 → station and orientation set.

x. Give point id, height of reflector and remarks if needed.

xi. Measure maximum number of possible points from that particular position.

xii. Determine the next station by taking into consideration the relief, accessibility and visibility of the region.

xii. Measure the point. Note down the horizontal angle.

xiii. Change the station setup.

xiv. Select **Orientation with Coordinates** (Known Back Sight)

xv. Select target point id from list →**coordinate entry**→ give height of reflector (**hr**).

xvi. Sight target point.

xvii. Note the horizontal angle. See if there is any variation in the angle. If there is difference in the values, then repeat the above steps. If there is no error set the point by pressing **Set**.

xviii. Next a window opens asking **HO already exists**→ select **old → station and orientation set.**

xix. Continue the survey.

Plate 3.3 Working with TS

3.2.4 Exporting of data

Job data, format files, configuration sets and code lists can be exported from the internal memory of the instrument. Data can be exported via:

- The RS232 serial interface

A receiver, such as a laptop, is connected to the RS232 port. The receiver requires Flex-

Office or another third-party software.

- The USB device port
- For instruments fitted with a Communication side cover. The USB device can be connected to the USB device port housed in the Communication side cover. The USB device requires FlexOffice or another third-party software.
- A USB memory stick

  For instruments fitted with a Communication side cover. A USB memory stick can be inserted and removed from the USB host port housed in the Communication side cover. No additional software is required for the transfer.

3.2.4.1 Access

- Select Transfer from the Main Menu.
- Select Export.

3.2.4.2 Export

- Select as shown in the figure. Select→ To → USB stick

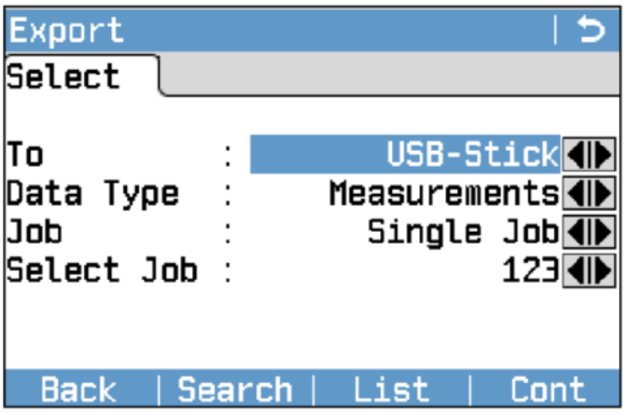

Fig.3.1 Export window

- The other steps are as shown in the table below:

Table 3.1 Steps during export

Field	Description
To	USB memory stick or RS232 serial interface
Data Type	Data Type to be transferred. To USB memory stick or RS232 serial interface: Measurements, Fix points, Measure and Fix points. Only to USB memory stick: Road Data, Code, Format, Configuration, Backup
Job	Select whether to export all job-related data or a single job data file.
Select job	Displays the selected job or road alignment file.
Format	If Data Type: Format. Select whether to export all formats or single format
Format Name	If Format: Single Format. Name of the format to be transferred.

3.2.4.3 Export data step by step

1. Press **Cont** in the Export screen after selecting the export details.

2. If export is to a USB memory stick, select the desired file location and press **Cont**

Data type: Default folder on USB memory stick

Job data: Jobs

Format files: Formats

Codes: Codes

3. Select the data format, enter the file name and press **Cont** or Send. If the data format is ASCII, the Define ASCII Export screen appears. Continue with step4. For all other data format types, a message will display confirming the successful export of data.

4. Define the delimiter value, the units and the data fields of the file and press Cont. A message will display confirming the successful export of data.

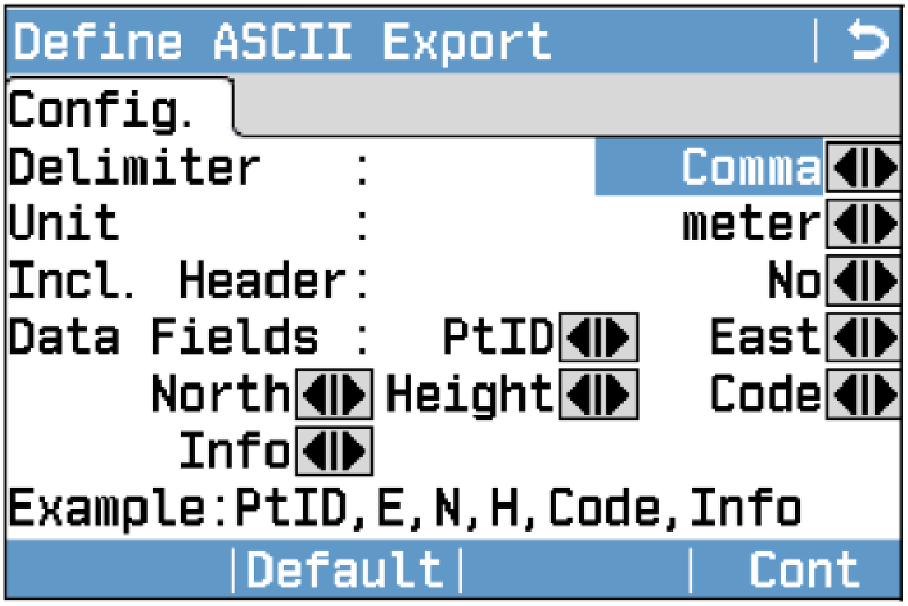

Fig.3.2 ASCII Export Window

5. Job data can be exported from a job in dxf, gsi, csv and xml file types, or any other user-defined ASCII format.

3.3 DGPS

DGPS is an advanced version or the enhancement to Global positioning System (GPS). DGPS can be achieved through post-processing the data or real-time telemetry links between a base and a rover. Real-time methods include (a) medium frequency beacon differential service, (b) L-Band satellite differential service, (c) frequency modulation sub- carrier differential service, (d) on-site, radiofrequency telemetry link. All the real-time services have a coverage area and a range limitation and require a local radio/receiver to obtain the transmitted service. Method requires operation of a transmitter by the user in addition to the radio/receiver. Post-processing differential techniques relies on two GPS receivers with storage capacity. The kinematic post-processing method relies on the base station as the reference receiver and the rover as the unit that can move around without restriction. The user will post-process the data on a computer after the GPS data have been collected. Kinematic post processing is the most preferred method of tracking motion in DGPS when accuracy and precision are a major issue.

Post-processing is used to obtain precise positions of unknown points by relating them to known points such as survey markers. The GPS measurements are usually stored in computer memory in the GPS receivers, and are subsequently transferred to a computer running the GPS post-processing software. The software computes baselines uses simultaneous measurement of data from two or more GPS receivers. The base line represents a three-dimensional line drawn between the two points occupied by each pair of GPS antennas. The post-processed measurements allow more precise positioning because most GPS errors can be cancelled out in calculations as they effect both receiver more or less equally. Differential GPS measurements can also be computed in real-time by some GPS receivers if they receive a correction signal using a separate radio receiver, for example in Real Time Kinematic (RTK) surveying or navigation.

Main features of DGPS survey are:

- Position is determined by distance from at least four satellites.
- Time taken by signal to travel from satellite to antenna is used to determine the distance.
- The base station calculates the difference between the specified coordinates of its location and those indicated by the satellites.
- The base is continuously broadcasting a signal to the rover of this difference.
- The rover then uses this same difference to accurately determine its location.

GNSS is basically a Global Navigation Satellite System. GNSS includes GPS, GLONASS, GALILIO and COMPASS satellite systems. The GPS is a US based satellite system which is having more than 32 satellites and they are available 24 hours. GLONASS is a Russian Satellite System which is available 24 hours and having around 24 satellite system. Galileo is a European satellite system and COMPASS is a Chinese Satellite System which is under testing.

There are three types of survey which we can do using GNSS:

1. Static Survey (Control point establishment)

2. PPK Survey (Post Processed Kinematic Survey)

3. RTK Survey (Real Time Kinematic Survey)

3.3.1 Static Survey

Static Survey is basically used to establish the control points or network in the field. We normally do Triangulation method for the setting up of control survey as mentioned in below drawing. The processing of Data will be done in TBC (Trimble Business Center) software.

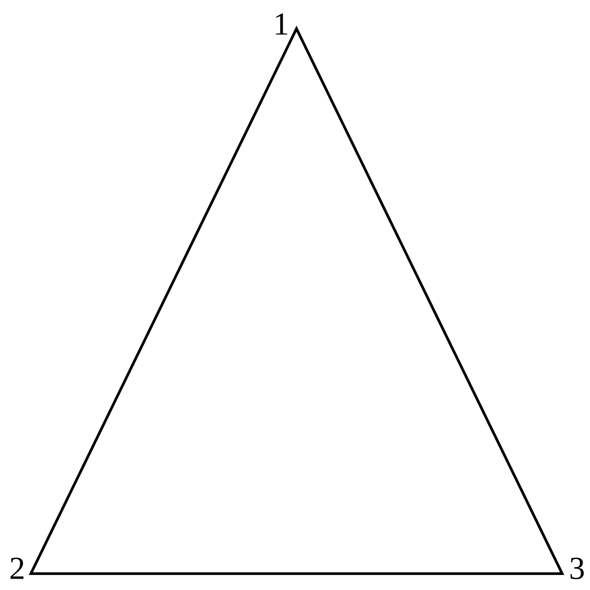

Fig. 3.3 Triangulation method for setting up control points

3.3.1.1 Starting Procedure of Static Survey

1. Base Startup:

a. Find a best, safe, secure and open location to setup the base. If possible, find high point place with open sky.

b. Setup Tripod on Known Base Point mark on field.

c. Mount Tribrach and Prism Base on The Tripod.

d. Mount 2.5 meter Short Pole on the Prism Base.

e. Mount R6 GNSS receiver on the Short Pole and Controller on the Tripod with Fixing Bracket.

f. The Setup should look like below mentioned setup image.

Plate 3.4 Base setup in static survey

g. Now switch on the R6 GNSS Receiver.

h. Switch on the Controller and Set the local time from Start → Setting →Systems →Clock. After setting the Clock as per the Country setting (GMT 05:30 New Delhi)

i. To start the Trimble Access software go to Start →Program →Trimble Access.

j. Go to General Survey. You will get six options.

k. After opening this software, just click on the Settings.

l. Go to Survey Style. The setting for the Static survey is as below:

STATIC SURVEY: **ROVER OPTION**	Page 1
Survey Type: Fast Static	Logging Device: Controller
Logging Interval: 1 Sec	Auto File Name: ☑ (If you want to give Auto file name than correct the check box)
Elevation Mask: 15°	PDOP Mask: 6.0
Page 2	
Antenna Type: R6 2 Internal	Measured To: Bottom of Antenna Mount
Antenna Height: 2.00 M	
Page 3	
Use L2e: ☑	Use Glonass: ☑

Fig. 3.4 Base settings window for static survey

m. After doing all above setting, accept all the setting and store the survey style settings.

n. Now go to Connect →Bluetooth →Configuration →☑ click the check box for turning on the Bluetooth. Select the receiver →Next →Next→OK.

o. Connect the GNSS receiver to Rover →R6XXXXXXX →Accept.

p. Go to Trimble Access→ General Survey→ Jobs→ create New Job.

q. Give Job Name

r. Select the Coordinate System as per the survey location and zone. Also link your Feature Library if you are using for your survey.

s. Give approximate project height (MSL) of location.

t. Accept to save the changes you made in new job

u. Go to Survey →Static →Start Base Receiver → Give a Base Point Name and Code →Start

v. Now the base will start collecting the data.

2. Rover Startup:

i. Find a best, safe, secure and open location to setup the Rover.

ii. Setup Bipod on Point mark on field.

iv. Now switch on the R6 GNSS Receiver.

v. Switch on the Controller and Set the local time from Start → Setting →Systems →Clock. After setting the Clock as per the Country setting (GMT 05:30 New Delhi).

The Setup should look like below mentioned setup image.

Plate 3.5 Rover set up in static survey

vi. Go to General Survey. You will get six options.

vii. To start the Trimble Access software go to Start →Program →Trimble Access

viii. After opening this software, just click on the Settings.

ix. Go to Survey Style. The settings for the Static survey are as below:

STATIC SURVEY: ROVER OPTION Page 1	
Survey Type: Fast Static	Logging Device: Controller
Logging Interval: 1 Sec	Auto File Name: ☑ (If you want to give Auto file name than correct the check box)
Elevation Mask: 15°	PDOP Mask: 6.0
Page 2	
Antenna Type: R6 2 Internal	Measured To: Bottom of Antenna Mount
Antenna Height: 2.00 M	
Page 3	
Use L2e: ☑	Use Glonass: ☑

Fig. 3.5 Rover settings window in static survey

x. After doing all above setting, accept all the setting and store the survey style settings.

xi.. Now go to Connect →Bluetooth →Configuration →☑ click the check box for turning on the Bluetooth. Select the receiver →Next →Next→OK.

xii. Connect the GNSS receiver to Rover →R6XXXXXXX →Accept.

xiii. Go to General Survey. You will get six options.

xiv. Go to Job →Create New Job.

xv. Give Job Name

xvi. Select the Coordinate System as per the survey location and zone. Also link your Feature Library if you are using for your survey.

xvii. Give approximate project height (MSL) of location.

xviii. Accept to save the changes you made in new job

xix. Go to Survey →Static →Measure Points → Give a Point Name and Code →Start

xx. Now the Rover will start collecting the data. For a good survey keep the rover for ½ to 1 hour for each control points.

xxi. Repeat the same procedure for different Control Points.

3.3.1.2 Ending the GNSS survey

i. First do the ending of Survey in Rover.

ii. Go to Survey and Select End GNSS Survey. Now exit the Trimble Access software and off the controller.

iii. Secondly press the end option in Base. Now exit the Trimble Access software and switch off the controller.

iv. Repeat the all above procedure when you change the base location.

3.3.2 PPK Survey

PPK Survey is called Post Processed Kinematic Survey in which we are doing Topography. After collecting all the points, we have to do the post processing in software.

3.3.2.1 Startup procedure of PPK Survey

1. Base Setup:

i. Find a best, safe, secure and open location to setup the base. If possible, find high point place with open sky.

ii. Setup Tripod on Known Base Point mark on field.

iii. Mount Tribrach and Prism Base on The Tripod.

iv. Mount 2.5 meter Short Pole on the Prism Base.

v. Mount R6 GNSS receiver on the Short Pole and Controller on the Tripod with Fixing Bracket. The Setup should look like below mentioned setup image.

Plate 3.6 Base setup in PPK survey

vi. Now switch on the R6 GNSS Receiver.

vii. Switch on the Controller and Set the local time from Start → Setting →Systems →Clock. After setting the Clock as per the Country setting (GMT 05:30 New Delhi)

viii. To start the Trimble Access software go to Start →Program →Trimble Access.

ix. After opening this software, just click on the Settings.

x. Go to Survey Style. The settings for the PPK survey are as below:

PPK SURVEY: BASE OPTION	Page 1
Survey Type: PP Kinematic	Logging Device: Controller
Logging Interval: 1 Sec	Auto File Name: ☑ (If you want to give Auto file name than correct the check box)
Elevation Mask: 15°	Antenna Type: R6 2 Internal
Page 2	
Measured To: Center of Bumper	Antenna Height: (Measured with Tape)
Page 3	
Use L2e: ☑	Use Glonass: ☑

Fig. 3.6 Base settings window in PPK survey

xi. After doing all above setting, accept all the setting and store the survey style settings.

xii. Now go to Connect →Bluetooth →Configuration →☑ Click the check box for turning on the Bluetooth. Select the receiver →Next →Next→OK.

xiii. Connect the GNSS receiver to Base →R6XXXXXXX →Accept.

xiv. Go to General Survey. You will get six options.

xv. Go to Job →Create New Job.

xvi. Give Job Name

xvii. Select the Coordinate System as per the survey location and zone. Also link your Feature Library if you are using for your survey.

xviii. Give approximate project height (MSL) of location.

xix. Accept to save the changes you made in new job

xx. Go to Survey →PPK →Start Base Receiver → Give a Base Point Name and Code →Start

xxi. Now the base will start collecting the data.

2. Rover Setup:

i. Find a best, safe, secure and open location to setup the Rover for Initialization.

ii. Setup Bipod on Point mark on field.

iii. Now switch on the R6 GNSS Receiver.

iv. Switch on the Controller and Set the local time from Start → Setting →Systems →Clock. After setting the Clock as per the Country setting (GMT 05:30 New Delhi).

The Setup should look like below mentioned setup image.

Plate 3.7 Rover setup in PPK survey

v. To start the Trimble Access software go to Start →Program →Trimble Access

vi. After opening this software, just click on the Settings.

vii. Go to Survey Style. The settings for the PPK survey are as below:

PPK SURVEY:	
ROVER OPTION	Page 1
Survey Type: PP Kinematic	Logging Device: Controller
Logging Interval: 1 Sec	Auto File Name: ☑ (If you want to give Auto file name than correct the check box)
Elevation Mask: 15°	PDOP Mask: 6.0
Page 2	
Antenna Type: R6 2 Internal	Measured To: Bottom of Antenna Mount
Antenna Height: 2.00 M	
Page 3	
Use L2e: ☑	Use Glonass: ☑
TOPO POINTS	
Auto Point Step Size: 1	Quality Control: QC1
Auto Store Point: ☐ (Do not Click the Option)	Occupation Time: 0 M 5 Sec
No of Measurements: 15	

Fig. 3.7 Rover setting window in PPK survey

viii. After doing all above setting, accept all the setting and store the survey style settings.

ix. Now go to Connect →Bluetooth → Configuration.☑ Click the check box for turning on the Bluetooth. Select the receiver →Next →Next→OK.

x. Connect the GNSS receiver to Rover →R6XXXXXXX →Accept.

xi. Go to General Survey. You will get six options.

xii. Go to Job →Create New Job.

xiii. Give Job Name

xiv. Select the Coordinate System as per the survey location and zone. Also link your Feature Library if you are using for your survey.

xv. Give approximate project height (MSL) of location.

xvi. Accept to save the changes you made in new job

xvii. Go to Survey →PPK →Measure Points → Esc

xviii. Again Go to Survey →PPK → Initialization →Init→New Point →Give a Point Name and Code →Start →now wait for 8 min to get the Fixed Solution.

xix. After getting fixed solution just store the point and proceed for Topo Survey.

xx. For Topo Survey again go to Survey →PPK →Measure Points →Point Name and Code →Measure →Wait till 15 sec →Store the point.

xxi. Now go to next point.

xxii. Repeat the same procedure for different Topo Points.

3.3.2.2 Ending the PPK Survey

i. First do the ending of Survey in Rover.

ii Go to Survey and Select End GNSS Survey. Now exit the Trimble Access software and off the controller.

iii. Secondly press the end option in Base. Now exit the Trimble Access software and switch off the controller.

iv. Repeat the all above procedure when you change the base location.

3.3.2.3. Post process of data in Trimble Business Center

The Data collected in the field are processed in the Trimble Business Center which is office software. For doing the post process of data the below are the steps.

1. How to download the data:

i. Open the TBC software and plug the software key to the USB port of computer.

ii. Create a new project. Go to Project →Project Setting → Set all the parameters like company name, coordinate system, feature code library etc.

- Give company name and feature code if needed.
- To change the co-ordinate system→ select change→ UTM → 43 North → OK.

iii. Save all the settings while selecting OK.

iv. Connect the BASE controller to PC. The active sync will connect the instrument.

v. In TBC, the device menu will open. Select the file to download → Just drag the file in software and select the appropriate geoid model (EGM96 global) → keep the existing co-ordinate →Now the check in list of base data will appear. Check all data like antenna height and receiver type. Ok to confirm the download.

vi. Same way connect the rover controller to PC and download the data.

2. How to process the Data:

i. Single click on the BASE point and right click on the point to view properties. Add coordinate of BASE while pressing  button. Now make the base coordinate as control coordinate.

ii. Now you see will the baseline in the plan view. Go to Select →Select All. Go to Survey →Process Baseline.

iii. Now the Baseline processing will start and save the result. After completion of the data, check the report for fixed solution. For seeing the report → select report icon from main menu→ select the required type (point list or base line processing) →save the report in the required form.

iv. To export the point data to CSV/DWG/DC /etc. Go to Menu → Export. Select the format to export as per your requirement.

3.3.3 RTK Survey

3.3.3.1 Startup procedure of RTK Survey

1. Base Setup:

i. Find a best, safe, secure and open location to setup the base. If possible, find high point place with open sky.

ii. Setup Tripod on Known Base Point mark on field.

iii. Mount Tribrach and Prism Base on The Tripod.

iv. Mount 2.5 meter Short Pole on the Prism Base.

v. Mount R6 GNSS receiver on the Short Pole and Controller on the Tripod with Fixing Bracket.

vi. Connect PDL 450 radio with receiver.

vii. Now switch on the R6 GNSS Receiver.

viii. Switch on the Controller and Set the local time from Start → Setting →Systems →Clock. After setting the Clock as per the Country setting (GMT 05:30 New Delhi)

ix. To start the Trimble Access software go to Start →Program →Trimble Access

x. After opening this software, just click on the Settings.

xi. Go to Survey Style. The settings for the RTK survey are as below:

RTK SURVEY: **BASE OPTION** Page 1	
Survey Type: Real Time Kinematic	Broadcast Format: CMRx
Station Index: (User Defined)	Elevation Mask: 15°
Antenna Type: R6 2 Internal	
Page 2	
Measured To: Center of Bumper	Antenna Height: (Measured with Tape)
Page 3	
Use L2e: ☑	Use Glonass: ☑
BASE RADIO Page 1	
Type: Trimble PDL450	Receiver Port: Port1
Baud Rate:9600	
After doing the setting press Connect	
Frequancy: 433.025	Radio Operating Mode: Base/Rover
Base Radio Mode: TTL 450 at 9600 bps	Sensitivity: Moderate

Fig. 3.8 Base settings in RTK survey

xii. After doing all above setting, accept all the setting and store the survey style settings.

xiii. Now go to Connect →Bluetooth →Configuration. ☑ Click the check box for turning on the Bluetooth. Select the receiver →Next →Next→OK.

xiii. Connect the GNSS receiver to Base→R6XXXXXXX→Accept.

xiv. Go to General Survey. You will get six options.

xv. Go to Job →Create New Job.

xvi. Give Job Name

xvii. Select the Coordinate System as per the survey location and zone. Also link your Feature Library if you are using for your survey.

xviii. Give approximate project height (HAE) of location.

xix. Accept to save the changes you made in new job

xx. Go to Survey →RTK →Start Base Receiver → Give a Base Point Name and Code→Start.

2. Rover Setup:

i. Find a best, safe, secure and open location to setup the Rover for Initialization.

ii. Setup Bipod on Point mark on field.

iii. Now switch on the R6 GNSS Receiver.

iv. Switch on the Controller and Set the local time from Start→ Setting -→Systems →Clock. After setting the Clock as per the Country setting (GMT 05:30 New Delhi).

v. To start the Trimble Access software go to Start→Program →Trimble Access

vi. After opening this software, just click on the Settings.

vii. Go to Survey Style. The settings for the RTK survey are as below:

RTK SURVEY:	
ROVER OPTION	Page 1
Survey Type: Real Time Kinematic	Broadcast Format: CMRx
Station Index: Any	Prompt Station Index: ☑
Elevation Mask: 15°	PDOP Mask: 6.0
Page 2	
Antenna Type: R6 2 Internal	Measured To: Bottom of Antenna Mount
Antenna Height: 2.00 M	
Page 3	
Use L2e: ☑	Use Glonass: ☑
Rover Radio	
Type: Trimble Internal	Method: Trimble 450/950
After doing the setting press Connect	
Frequancy:433.025	Base Radio Operating Mode: TTL 450 at 9600bps
TOPO POINTS	
Auto Point Step Size: 1	Quality Control: QC1 & QC3
Auto Store Point: ☐	Occupation Time: 0 M 5 Sec

Fig. 3.9 Rover settings in RTK Survey

viii. After doing all above setting, accept all the setting and store the survey style settings.

ix. Now go to Connect →Bluetooth →Configuration.☑ Click the check box for turning on the Bluetooth. Select the receiver →Next→Next→OK.

x. Connect the GNSS receiver to Rover →R6XXXXXXX →Accept.

xi. Go to General Survey. You will get six options.

xii. Go to Job →Create New Job.

xiii. Give Job Name

xiv. Select the Coordinate System as per the survey location and zone. Also link your Feature Library if you are using for your survey.

xv. Give approximate project height (HAE) of location.

xvi. Accept to save the changes you made in new job

xvii. Go to Survey →RTK →Measure Points → Esc

xviii. After getting fixed solution just store the point and proceed for Topo Survey.

xix. Measure each point for every 5 sec logging of data.

xx. Now go to next point.

xxi. Repeat the same procedure for different Topo Points.

3.3.3.2 Ending the RTK Survey

i. First do the ending of Survey in Rover.

ii. Go to Survey and Select End GNSS Survey. Now exit the Trimble Access software and off the controller.

iii. Secondly press the end option in Base. Now exit the Trimble Access software and switch off the controller.

iv. Repeat the all above procedure when the base location is changed.

3.4 ArcGIS

ArcGIS is a Geographic Information System (GIS) for working with maps and geographic information. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the web.

It is used for:

- Creating and using maps
- Compiling geographic data
- Analyzing mapped information
- Sharing and discovering geographic information
- Using maps and geographic information in a range of applications
- Managing geographic information in a database

Steps involved during map formation in ArcGIS are:

Excel file input

↓

Display points

↓

Export to shape file

↓

TIN

↓

1. SLOPE MAP
2. CONTOUR MAP

ArcMap window is shown in the figure 3.10

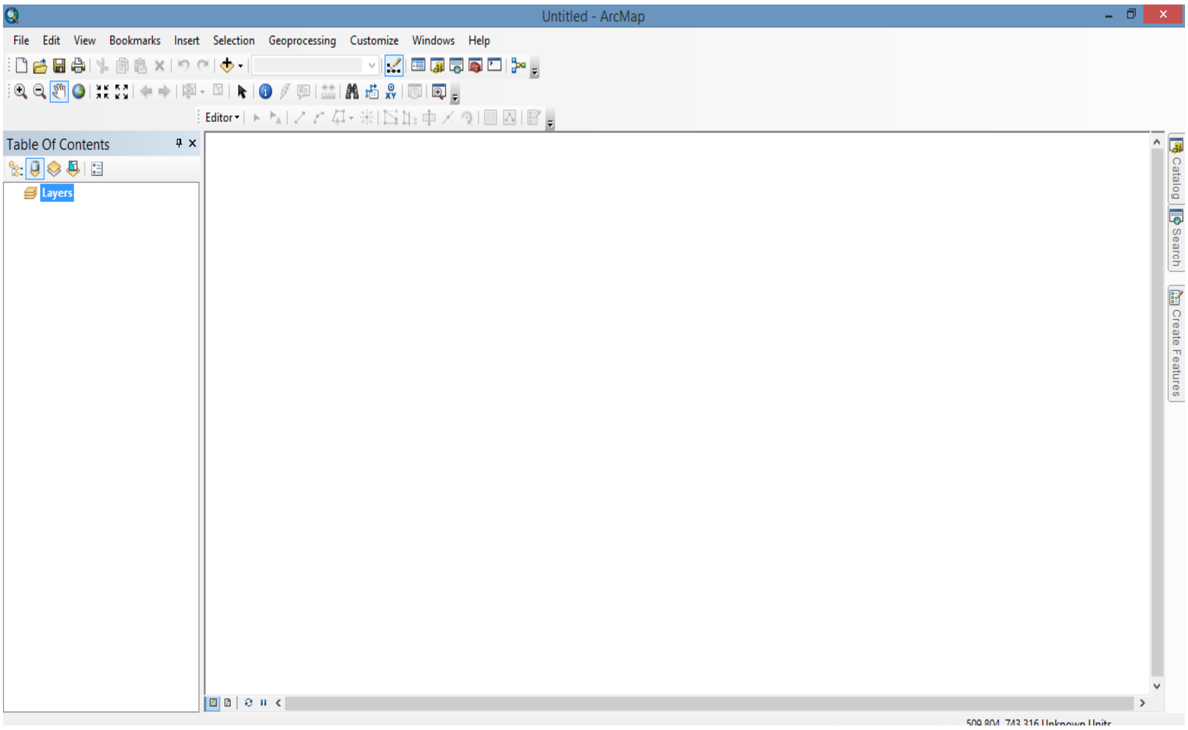

Fig. 3.10 ArcMap window

RESULTS AND DISCUSSION

Chapter 4

RESULTS AND DISCUSSION

4.1. TOTAL STATION SURVEY RESULTS

4.1.1. Co-ordinates of field data

Total Station data were processed in PC. After processing, co-ordinates of surveyed points were obtained ie, 419 points. The co-ordinates of some of the points are tabulated in Table4.1.

Table 4.1 Total Station survey data

Point ID	Easting (m)	Northing (m)	Elevation (m)
1	975.062	1000.871	99.7722
2	977.0329	999.504	99.1158
3	974.0394	1011.53	99.7494
4	974.6311	1019.191	100.6057
5	974.0793	1024.98	102.0542
6	968.3189	1032.932	102.6568
7	990.4641	1031.422	102.4094
8	992.462	1021.072	101.9938
9	992.1904	1012.84	100.7373
10	993.172	1001.219	100.0018
11	993.0968	999.7573	99.2124
12	992.6835	996.5233	99.0019
13	992.6579	996.5107	98.9986
14	1008.956	1029.329	102.0371

15	1008.92	1016.254	101.0573
16	1008.553	1001.649	100.3051
17	1015.828	998.0311	100.2934
18	1007.502	985.6181	99.4944
19	999.3703	980.6228	99.0383
20	972.1819	981.0881	98.8974
21	991.1756	970.1641	98.9677
22	1006.571	969.8031	98.4563
23	1032.925	1014.816	102.1329
24	1032.941	1012.753	101.0007
25	1032.866	1000.463	99.7549
26	1054.558	1010.191	100.8623
27	1005.261	940.0196	96.6313
28	1004.639	928.0462	96.2184
29	1004.931	915.6289	95.514
30	999.7136	915.9408	95.7369
31	991.2148	912.9656	95.5513
32	965.9513	915.1267	95.7604
33	923.772	919.1866	95.3085
34	921.2432	937.6461	95.9716
35	921.1797	948.8388	96.509
36	926.6654	961.725	96.3817
37	964.7083	943.2336	96.0598

38	966.1101	956.0936	96.3006
39	991.4049	953.5079	96.29
40	990.1599	943.4791	96.2224
41	989.1541	922.1144	95.6836
42	1014.316	953.8418	97.4759
43	1009.934	960.0128	97.7201
44	1010.84	927.8311	96.264
45	1016.433	911.333	96.3793
46	930.7034	965.235	97.943
47	1025.522	916.9516	96.3526
48	1034.714	921.8979	96.6987
49	1040.144	909.7098	96.1863
50	1062.257	908.1539	96.5619

4.1.2 Map preparation in ArcGIS software

Using ArcGIS software, points were plotted and from that plot different DEM's and contour map of the area were created. Distribution of points surveyed by TS is shown in Fig. 4.1.

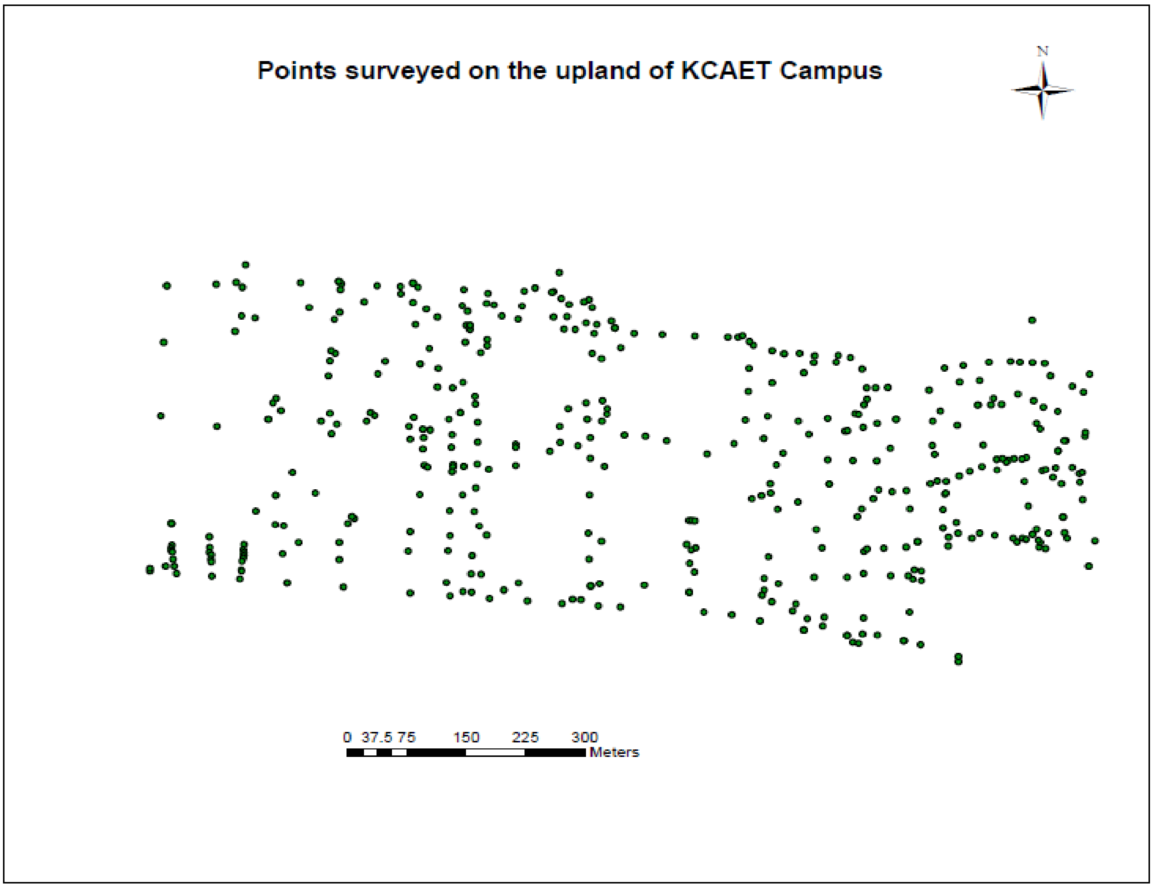

Fig. 4.1 Points surveyed on the uplands of KCAET campus

419 points were surveyed over an area of 15 ha. The points were observed in such a manner that more points were collected in regions with more undulating topography where as in a plane area the spacing of points were farther. Most closely spaced points were taken near the South-West boundary point where as the least number of points with more spacing was taken in the main ground which is one of the plane areas of KCAET campus.

TIN (Triangulated Irregular Network) was generated using ArcGIS. TIN is the vector-based representation of the physical land surface, made up of irregularly distributed lines with 3D coordinates(*x*, *y*, and *z*) that are arranged in a network of nonoverlapping triangles. The Fig. 4.2.shows the TIN generated.

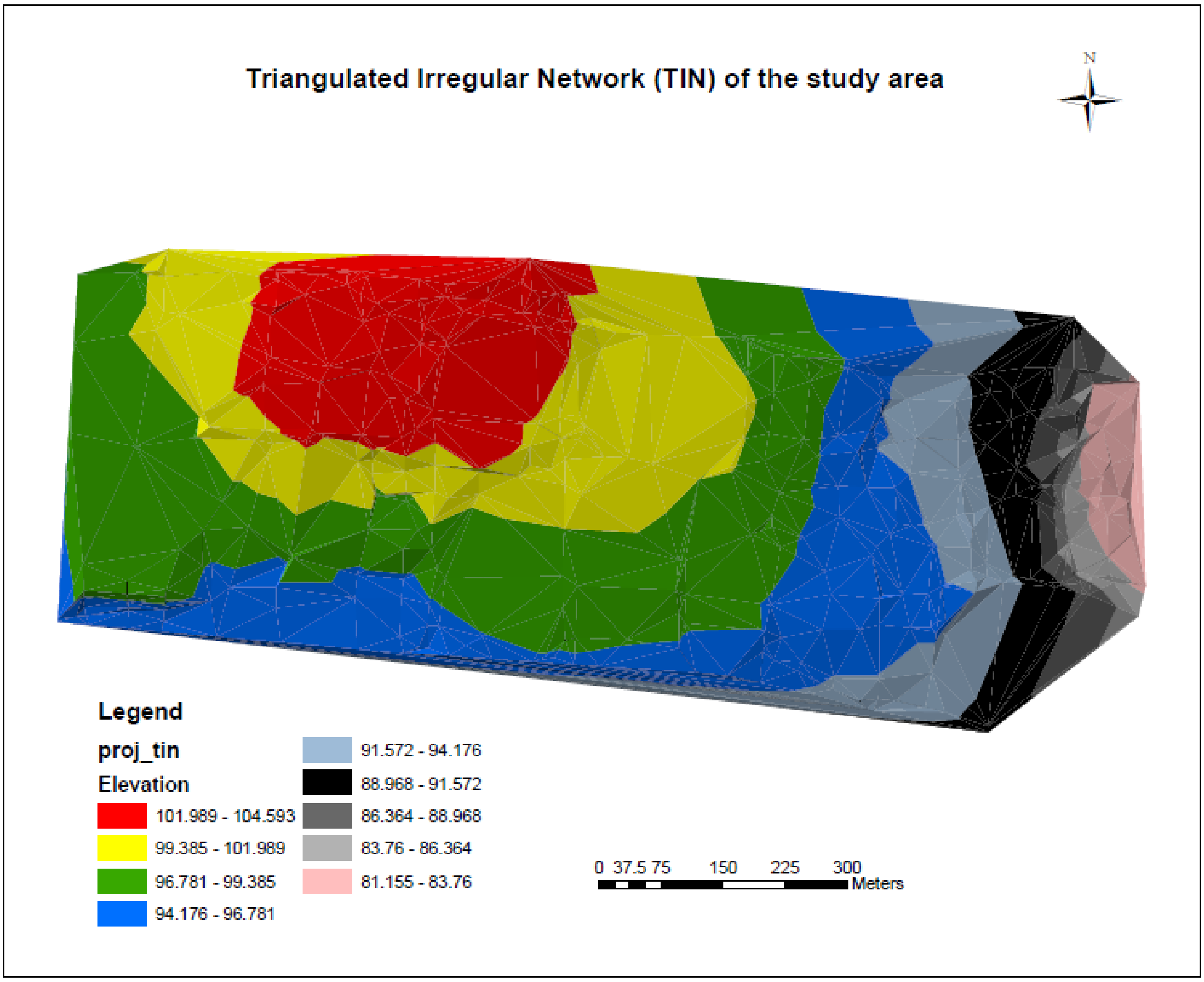

Fig. 4.2 TIN of the study area

From the Figure 4.2, it can be noted that in regions where there is little variation in elevation, the points were widely spaced whereas in areas of more intense variation in elevation the point density was more. The regions with high elevation are shown in red colour in this TIN map. It has an elevation ranging between 101.989m to 104.593m. The lowest elevation points of surveyed area were in between 81.155m and 83.76m. It is shown in pink colour in the TIN map.

Contour map plotted using ArcGIS in which contour lines represents points of equal elevation (height) above a given level (arbitrary datum, mean sea level etc). A contour interval of 1m has been chosen. Fig. 4.3 shows the contour map of the area surveyed using Total Station.

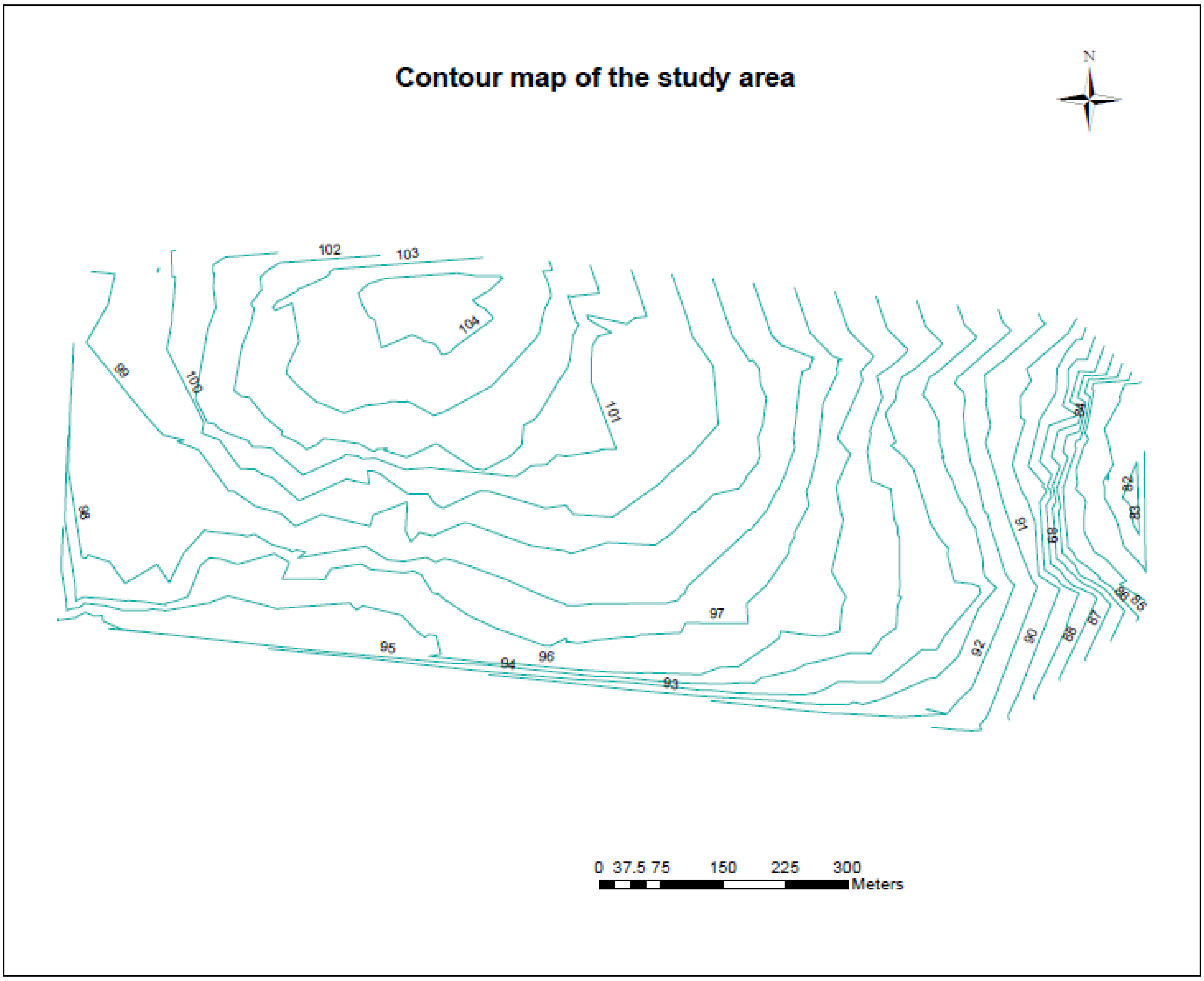

Fig. 4.3 Contour map of the study area

In this contour map, the innermost loop shows the highest elevation area where as the outermost loop shows the lowest elevation area. In this contour map, the contour line having 104m is the highest point and that with 82m is the lowest point.

Slope map was created from the surveyed points and is shown in figure 4.4. A slope map is a map displaying the topography of the area, along with discussion of the topographic features. The region with higher slope is represented by dark coloured patches which range between 7.0 to 9.0 %, whereas regions with lowest slope are shown by light coloured patches. It ranges between 1.0 to 2.0 %.

r

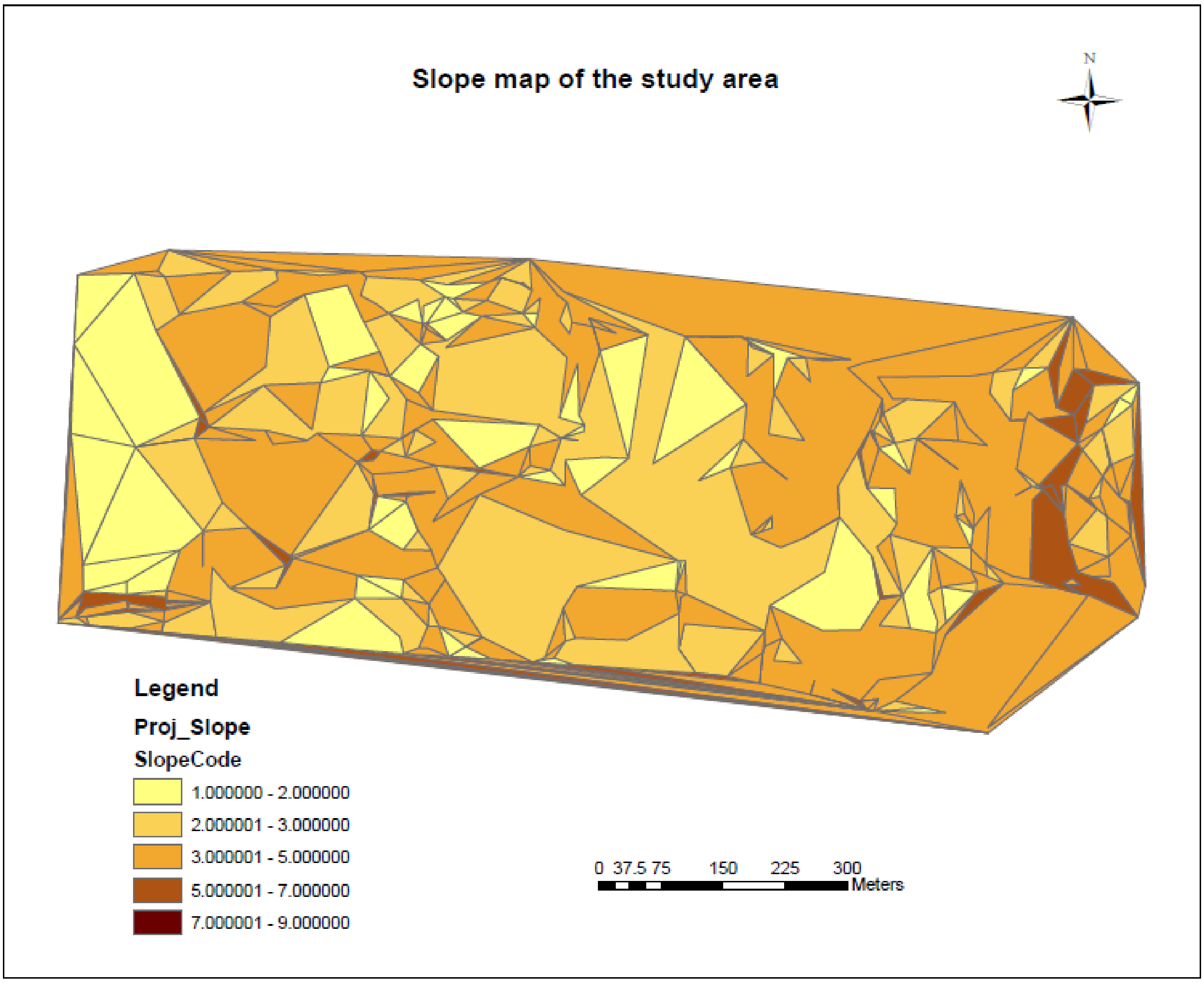

Fig. 4.4 slope map of the study area

Areas having slope less than 2% requires only ordinary management practices to maintain their level of productivity. Overland flow is the main problems faced by those areas. Pastures can be maintained and cover crops can be adopted for reducing overland flow. Areas having slope between 2 to 5% is more susceptible to water erosion, frequent surface runoff accompanied with crop damage. Strip cropping, contour bunding, cover cropping and water disposal can be adopted for the conservation of fertile top soil. Areas having 5 to 10% slopes are having steep slopes and are more susceptible to erosion. Careful management practices are required in this area.

Major problem faced by KCAET at present is its acute water shortage in summer. Construction of recharge pits and percolation ponds in regions of lower elevation can help to solve this problem. It helps to recharge the ground water table.

4.2 GNSS SURVEY RESULTS

Post processing of data collected by DGPS was done by Trimble Business Center software. Distribution of points on the area is shown in the figure 4.3 and point list is given in the table 4.2.

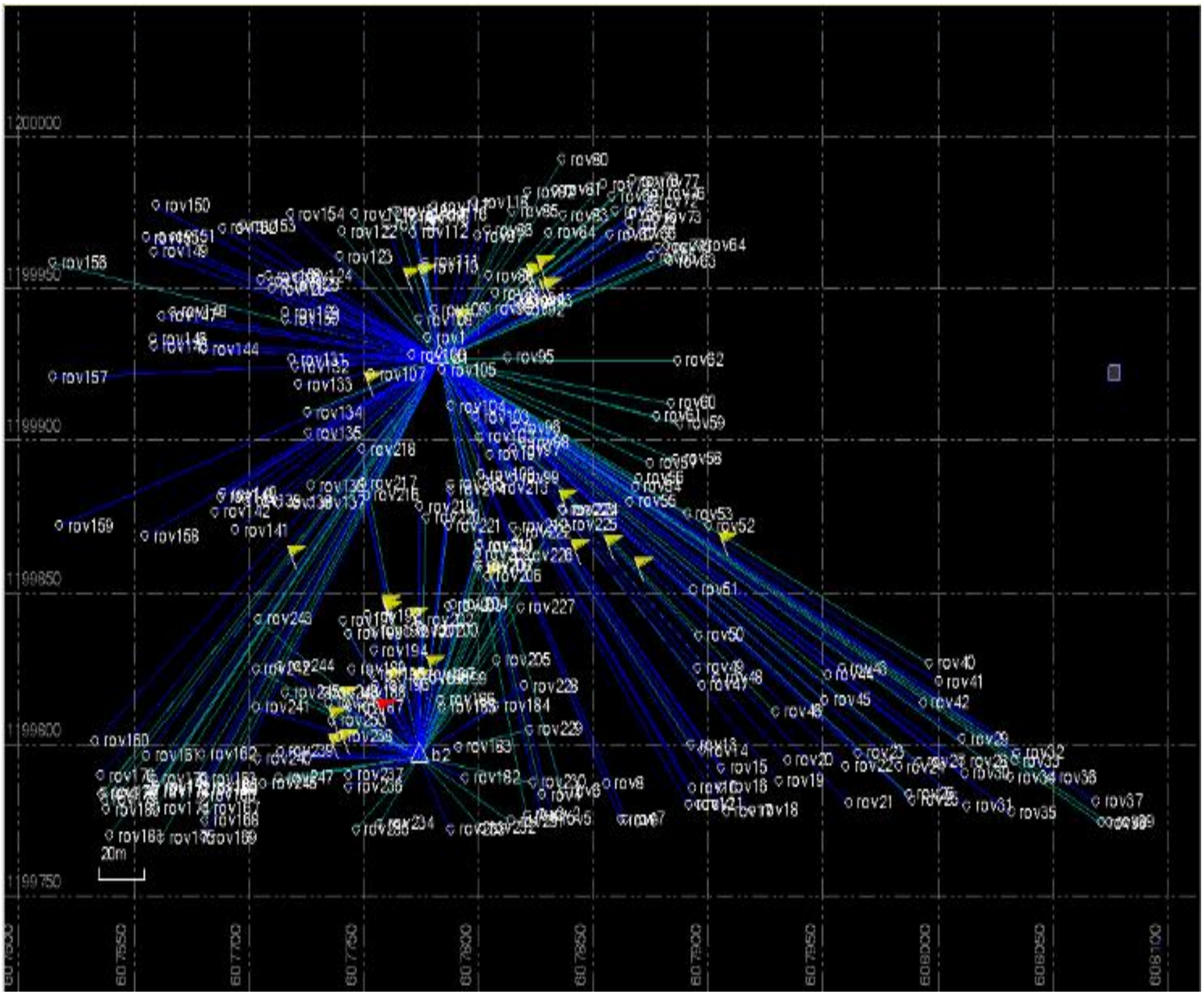

Fig. 4.5 Point plotted using GNSS

In this figure two base stations are shown in triangular symbols. With respect to Base b1, 181 points are surveyed and 69 points were surveyed with respect to base b2. In the above figure unprocessed data is shown.

Table 4.2 GNSS survey data

ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)
b1	607783.271	1199926.638	28.176
b2	607774.330	1199795.692	21.022
rov1	607777.959	1199933.607	28.303
rov2	607827.434	1199776.656	20.168
rov3	607821.112	1199776.553	23.640
rov4	607827.581	1199782.981	24.413
rov5	607832.428	1199775.195	20.830
rov6	607836.639	1199784.338	24.224
rov7	607864.142	1199775.090	20.672
rov8	607855.648	1199786.419	21.213
rov9	607861.762	1199774.743	20.594
rov10	607892.910	1199785.194	21.306

The Horizontal precision, Vertical precision, Geodetic azimuth etc, can be obtained from the processing summary. The processing summary of some of the points are given in the table 4.3.

Table 4.3 Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
rov1 (B1)	b1	rov1	Fixed	0.005	0.011	322°52'11"	8.765	0.126
rov2 (B2)	b1	rov2	Fixed	0.035	0.058	163°46'42"	156.389	-8.007
rov5 (B5)	b1	rov5	Fixed	0.054	0.093	162°12'10"	159.262	-7.346
rov7 (B7)	b1	rov7	Fixed	0.023	0.031	152°05'59"	171.820	-7.503
rov8 (B8)	b1	rov8	Fixed	0.024	0.030	152°53'03"	157.837	-6.962
rov9 (B9)	b1	rov9	Fixed	0.036	0.037	152°51'30"	171.020	-7.581
rov10 (B10)	b1	rov10	Fixed	0.026	0.031	142°24'19"	179.007	-6.869
rov11 (B11)	b1	rov11	Fixed	0.025	0.032	142°41'16"	184.923	-7.083
rov12 (B12)	b1	rov12	Fixed	0.049	0.052	143°50'13"	182.582	-7.050
rov14 (B14)	b1	rov14	Fixed	0.035	0.040	138°44'48"	172.311	-6.412

Here, Geodetic azimuth refers to a vector measured from true north at any given point on the earth. If field is set to ellipsoid then a correction is applied and all distances are calculated as if on the local ellipsoid which is called ellipsoid distance.

Vector components of rover points with respect to base station is shown in the table 4.4

Table 4.4 Vector components of rover points

From:	b1				
Grid		Local		Global	
Easting	607783.271 m	Latitude	N10°51'11.65719"	Latitude	N10°51'11.65719"
Northing	1199926.638 m	Longitude	E75°59'09.96007"	Longitude	E75°59'09.96007"
Elevation	28.176 m	Height	-63.975 m	Height	-63.975 m

To:	rov1				
Grid		Local		Global	
Easting	607777.959 m	Latitude	N10°51'11.88461"	Latitude	N10°51'11.88461"
Northing	1199933.607 m	Longitude	E75°59'09.78588"	Longitude	E75°59'09.78588"
Elevation	28.303 m	Height	-63.849 m	Height	-63.849 m

Vector					
ΔEasting	-5.312 m	NS Fwd Azimuth	322°52'11"	ΔX	4.845 m
ΔNorthing	6.969 m	Ellipsoid Dist.	8.765 m	ΔY	-2.437 m
ΔElevation	0.126 m	ΔHeight	0.126 m	ΔZ	6.887 m

In Trimble business center, Global latitude or longitude heights are in terms of a “Global co-ordinate datum” which in most modern cases is synonymous with the WGS84 datum. A Global co-ordinate datum is an approximation of the entire globe.

Local latitude or longitude heights are in terms of a “Local co-ordinate datum” which is a datum that is a regional best fit, rather than a global best fit. An example for local co-ordinate datum is Australian Geodetic Datum.

SUMMARY AND CONCLUSION

Chapter 5

SUMMARY AND CONCLUSIONS

The main purpose of this project work is to prepare the topographic map of upland regions of KCAET campus. The topographic map is very important while planning for agricultural infrastructures and for soil and water conservation studies. For this purpose, the main equipments used were Total Station and DGPS. During this project the principles and working of Total Station and DGPS were studied. Using Total Station, upland areas of KCAET campus were surveyed and the coordinates of 419 points were taken. Using the field collected data, a topographic map was plotted using arcGIS10.3 software. Total Station data lacks geographic coordinates and this give rise to difficulty plotting the data using GIS software. Using the field collected data three maps were generated: TIN, contour map and slope map. GNSS was also adopted for surveying the same area. But due to the dense canopy of the plot, the survey was further confined to the open areas of the study area. During the GNSS survey two base points were taken and with respect to this 250 points were surveyed. Post process kinematic survey was adopted for this. These points were post processed in PC using Trimble Business Centre Software. Due to some inevitable reasons maps for this survey could not be made. The processed reports were exported to the required file format. The data of the base line report helped in knowing the longitude, latitude, elevation, easting and northing and other details of the point. Geographical coordinates taken by GNSS were used during plotting maps of Total station collected field coordinates in ArcGIS.

From this project, it can be concluded that Total station and DGPS are two efficient equipments that can be used for surveying in a short span of time in a more accurate manner. Even though the use of TSS reduces the manual errors involved, it has limitations regarding the visibility and lacks references of geographical co-ordinates. In the case of DGPS, the measurements of points more fast and gave more precise data than TSS. DGPS can cover wider areas than of TSS but shows limitations in places with dense canopy and is weather dependent. In Kerala terrain, working with DGPS alone does not give good results whereas that in combination with TSS give better and satisfactory results. A map with good accuracy and great speed could be generated. Contour map can be made interactive to accommodate various engineering planning requirements. TIN has been generated using the co-ordinates of TSS and it can act as a prerequisite for generating customized maps such as degree of slope, aspect, slope curvature, contour etc. A slope map was prepared from data collected using TSS. From the slope map, it was known that the highest slope of the area ranges between 7.0 to 9.0 % and lowest slope ranges between 1.0 to 2.0%. Based on the slope ranges obtained, various conservation measures for the area can be planned adopted.

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APPENDICES

APPENDICES

Appendix I

Point list of Total Station survey

Point ID	Easting (m)	Northing (m)	Elevation (m)
1	975.062	1000.871	99.7722
2	977.0329	999.504	99.1158
3	974.0394	1011.53	99.7494
4	974.6311	1019.191	100.6057
5	974.0793	1024.98	102.0542
6	968.3189	1032.932	102.6568
7	990.4641	1031.422	102.4094
8	992.462	1021.072	101.9938
9	992.1904	1012.84	100.7373
10	993.172	1001.219	100.0018
11	993.0968	999.7573	99.2124
12	992.6835	996.5233	99.0019
13	992.6579	996.5107	98.9986
14	1008.956	1029.329	102.0371
15	1008.92	1016.254	101.0573
16	1008.553	1001.649	100.3051
17	1015.828	998.0311	100.2934
18	1007.502	985.6181	99.4944
19	999.3703	980.6228	99.0383
20	972.1819	981.0881	98.8974
21	991.1756	970.1641	98.9677
22	1006.571	969.8031	98.4563
23	1032.925	1014.816	102.1329
24	1032.941	1012.753	101.0007
25	1032.866	1000.463	99.7549
26	1054.558	1010.191	100.8623
27	1005.261	940.0196	96.6313
28	1004.639	928.0462	96.2184
29	1004.931	915.6289	95.514
30	999.7136	915.9408	95.7369
31	991.2148	912.9656	95.5513
32	965.9513	915.1267	95.7604
33	923.772	919.1866	95.3085
34	921.2432	937.6461	95.9716
35	921.1797	948.8388	96.509
36	926.6654	961.725	96.3817

37	964.7083	943.2336	96.0598
38	966.1101	956.0936	96.3006
39	991.4049	953.5079	96.29
40	990.1599	943.4791	96.2224
41	989.1541	922.1144	95.6836
42	1014.316	953.8418	97.4759
43	1009.934	960.0128	97.7201
44	1010.84	927.8311	96.264
45	1016.433	911.333	96.3793
46	930.7034	965.235	97.943
47	1025.522	916.9516	96.3526
48	1034.714	921.8979	96.6987
49	1040.144	909.7098	96.1863
50	1062.257	908.1539	96.5619
51	1080.291	919.7321	96.8602
52	1068.851	910.7459	96.6878
53	1074.095	910.5085	96.5944
54	1085.165	906.6182	96.5559
55	1099.013	905.6862	96.4812
56	1114.222	920.344	96.8778
57	1085.85	921.3513	97.0728
58	1079.193	937.7607	97.8848
59	1086.974	949.779	98.4894
60	1078.716	955.2477	98.5234
61	1079.662	980.7917	99.345
62	1089.045	1000.108	100.7301
63	1080.117	1005.504	100.4919
64	1080.191	1019.199	100.9005
65	1078.048	1031.389	101.3275
66	1061.015	1016.132	100.9432
67	1072.198	1013.927	100.6755
68	1060.828	1026.722	101.9066
69	1066.031	1038.591	101.8311
70	1077.205	1042.749	101.6596
71	1087.459	1030.165	101.2654
72	1090.614	1035.174	101.4422
73	1090.737	1038.692	101.4815
74	1087.846	1044.049	101.5215
75	1101.684	1020.97	100.8294
76	1114.954	1020.215	100.7923
77	1128.46	1017.191	100.3879
78	1084.029	1095.015	102.2366

79	1080.327	919.7311	97.0468
80	1142.711	915.5732	96.6388
81	1140.98	947.6503	98.3502
82	1142.38	963.9724	98.416
83	1144.341	963.8728	98.3849
84	1146.339	963.7804	98.3982
85	1146.716	945.446	97.8475
86	1143.878	943.8853	97.8217
87	1143.013	934.9959	97.3892
88	1145.974	929.291	96.9481
89	1151.97	902.3049	96.0294
90	1188.894	913.493	95.7249
91	1169.457	900.4347	95.766
92	1190.223	925.1655	96.7326
93	1192.972	939.4202	96.6386
94	1199.264	921.3787	95.7826
95	1190.218	917.0629	96.0144
96	1187.271	896.4787	94.7805
97	1215.1	890.4586	93.906
98	1215.148	890.4535	93.9358
99	1210.19	907.8398	95.031
100	1208.173	902.9434	94.8727
101	1194.967	909.2152	95.4202
102	1217.453	897.9634	94.4263
103	1228.328	899.1267	94.0813
104	1242.549	886.7185	93.1946
105	1242.519	886.6958	93.1977
106	1227.339	893.0984	93.7492
107	1253.126	898.5378	94.0461
108	1252.383	887.6967	92.925
109	1246.165	882.0487	92.392
110	1249.831	881.2417	92.3593
111	1261.706	886.8806	92.4433
112	1278.385	882.859	92.066
113	1289.183	880.3412	91.9949
114	1312.961	869.3002	90.7337
115	1312.867	872.4794	90.6715
116	1282.007	902.1927	93.1156
117	1289.642	923.4183	93.7068
118	1284.303	924.2948	94.5594
119	1289.727	929.9494	94.5117
120	1285.101	930.5772	94.6743

121	1287.197	949.5113	94.3554
122	1306.45	946.6497	94.1461
123	1306.781	952.355	93.9144
124	1281.452	926.894	94.5889
125	1269.975	926.8153	94.7165
126	1253.058	928.4307	95.2583
127	1242.63	925.9556	95.7617
128	1221.666	925.7353	96.161
129	1226.681	945.298	96.098
130	1253.298	942.7824	95.7278
131	1255.185	944.554	95.2355
132	1265.788	945.1821	94.8869
133	1279.836	945.8211	94.6912
134	1258.98	978.2322	95.1515
135	1282.337	971.5386	94.2705
136	1303.304	971.074	93.5094
137	1304.435	981.2864	93.4182
138	1304.899	981.8772	92.953
139	1270.986	983.1151	94.5059
140	1280.148	983.6896	94.0215
141	1295.132	988.2204	93.2481
142	1297.906	1007.993	92.7092
143	1269.785	1012.029	94.0864
144	1273.699	1031.294	93.6093
145	1261.401	1003.711	94.9403
146	1246.294	1004.107	95.218
147	1230.29	1004.671	95.8762
148	1218.56	1021.347	96.9065
149	1230.138	1032.249	95.9194
150	1241.149	1023.721	95.7191
151	1242.767	1023.865	95.3091
152	1252.876	1025.989	94.0872
153	1261.623	1028.545	93.9458
154	1247.859	1035.492	94.9324
155	1249.829	1034.968	94.5145
156	1253.346	1041.34	94.5789
157	1255.42	1045.184	93.9278
158	1254.96	1052.766	94.8709
159	1260.5	1052.648	94.0085
160	1268.274	1052.829	93.4128
161	1294.471	1051.221	92.3664
162	1296.541	1030.043	92.3288

163	1296.423	1014.171	92.5787
164	1252.107	1065.125	94.8003
165	1235.737	1069.756	96.6574
166	1231.241	987.9767	96.0091
167	1262.664	984.2068	94.9585
168	1251.757	971.3629	95.5112
169	1248.964	966.5751	95.5666
170	1223.049	957.7233	96.0515
171	1211.466	976.1976	96.6381
172	1198.659	971.2428	97.1726
173	1182.465	978.2984	97.8519
174	1188.433	980.1895	97.501
175	1194.124	982.107	97.7066
176	1193.834	988.2788	97.7187
177	1197.88	1001.096	97.8441
178	1202.245	1008.868	97.8022
179	1189.829	1018.681	98.8252
180	1153.933	1008.194	99.3728
181	1171.107	1015.215	99.5022
182	1178.114	1030.798	99.4335
183	1192.269	1033.603	98.5665
184	1195.029	1055.961	98.5769
185	1202.625	1075.482	98.4137
186	1211.763	1030.114	97.6722
187	1215.083	1062.627	97.679
188	1221.525	1069.593	97.3128
189	1237.072	1074.535	96.6234
190	1244.734	1072.883	96.0829
191	1212.481	1075.802	98.2442
192	1222.064	1074.218	97.3608
193	1195.123	1077.432	98.4728
194	1183.423	1081.142	98.7892
195	1180.903	1083.871	98.6476
196	1173.523	1086.564	98.9418
197	1167.017	1086.619	99.2804
198	1146.362	1087.362	100.1388
199	1125.595	1088.222	100.5927
200	1176.403	1087.436	98.7748
201	1180.549	1065.446	99.3094
202	1180.028	1050.084	99.8159
203	1095.515	1092.76	101.3592
204	1107.973	1089.051	100.9009

205	1099.425	1079.628	100.5204
206	1087.163	1072.246	101.5899
207	1081.226	1075.686	102.0724
208	1082.57	1089.037	102.1232
209	1093.449	1097.418	100.8218
210	1056.793	1100.116	103.2686
211	1063.427	1092.089	103.1318
212	1070.541	1091.77	102.7294
213	1081.316	1106.311	102.116
214	1079.281	1111.924	102.1699
215	1061.785	1112.65	103.7694
216	1066.421	1108.292	103.411
217	1076.021	1110.387	102.6729
218	1077.319	1096.048	102.3864
219	1056.826	1117.002	103.7629
220	1060.496	1129.989	103.4667
221	1045.222	1119.733	104.0041
222	1065.31	1100.24	103.1406
223	1055.635	1116.579	103.7449
224	1038.313	1117.485	104.1942
225	1037.007	1107.256	103.7852
226	1034.45	1098.464	104.2092
227	1024.125	1100.714	104.3413
228	1019.107	1108	104.2584
229	1015.393	1115.874	104.291
230	999.2072	1107.68	104.565
231	1002.259	1104.178	104.4304
232	1001.664	1094.471	104.416
233	1003.829	1091.701	104.5933
234	1003.944	1094.391	104.394
235	1014.282	1109.158	104.287
236	1010.715	1076.348	103.9634
237	1014.776	1081.128	104.0959
238	1014.947	1085.056	104.2008
239	1000.96	1083.244	103.8422
240	999.6146	1056.127	103.721
241	1007.163	1046.897	103.1273
242	1007.449	1041.884	102.896
243	997.8885	1036.155	102.2988
244	992.8207	1052.716	103.0262
245	983.2191	1053.29	103.0403
246	972.6261	1068.421	103.3949

247	983.6962	1065.423	103.4611
248	978.1662	1078.955	103.9512
249	950.2321	1070.513	103.4604
250	945.5815	1061.851	103.4387
251	983.3696	1100.081	104.3545
252	967.8456	1109.915	104.1181
253	969.5869	1095.005	103.7698
254	967.7805	1122.834	103.5067
255	1299.752	990.0238	93.0601
256	1303.305	958.775	93.5328
257	1311.815	962.4448	92.702
258	1312.594	955.2722	92.7313
259	1321.356	951.6119	92.3689
260	1326.525	955.2075	91.5692
261	1336.126	953.7071	90.9658
262	1347.748	951.7385	89.7975
263	1353.661	951.5557	88.5691
264	1355.771	950.8839	88.299
265	1350.129	949.1533	90.0637
266	1364.047	945.8379	88.7237
267	1367.983	944.979	88.4255
268	1364.849	948.8154	87.7209
269	1363.712	950.5013	87.3868
270	1359.723	954.4658	87.1853
271	1362.438	957.8952	85.5205
272	1379.243	966.2338	83.7066
273	1369.987	955.2266	85.2348
274	1380.054	955.4378	84.3731
275	1381.845	951.6798	84.0628
276	1357.413	973.5167	84.3957
277	1354.868	989.7438	84.605
278	1378.19	988.2782	83.2851
279	1391.57	977.7797	82.4273
280	1395.418	933.0267	84.8196
281	1395.396	933.0303	84.8194
282	1399.369	949.9283	83.397
283	1376.096	1010.333	83.155
284	1376.096	1010.352	83.0049
285	976.3211	1105.425	104.4716
286	999.975	1118.436	104.27
287	970.9493	1120.049	103.8613
288	960.311	1115.628	103.6117

289	960.0153	1120.728	103.3487
290	945.1942	1121.141	102.8611
291	936.8991	1110.38	103.2515
292	922.3655	1122.285	102.2931
293	920.8027	1123.909	102.1276
294	921.9966	1118.304	102.3438
295	921.4624	1103.419	103.1806
296	918.0904	1098.308	102.571
297	902.0573	1106.334	101.578
298	918.7476	1075.699	102.7909
299	916.0774	1077.494	102.6883
300	915.4536	1070.758	102.7433
301	914.4413	1060.437	102.4298
302	896.7661	1123.137	101.4533
303	812.1253	1121.194	98.8317
304	812.0627	1121.169	98.7411
305	843.3899	1122.18	99.0867
306	855.9715	1123.343	100.0144
307	860.0053	1120.086	99.8191
308	861.9471	1134.885	99.9329
309	810.1459	1083.185	98.888
310	868.1001	1099.339	100.1756
311	859.5164	1100.769	99.8067
312	855.281	1090.638	99.6278
313	808.309	1033.92	98.7185
314	844.0039	1026.647	98.7163
315	876.1484	1031.338	99.115
316	881.3537	1045.544	101.2899
317	879.3023	1042.695	99.383
318	909.5865	1030.198	101.2563
319	884.2764	1037.423	100.8417
320	868.4546	969.9424	98.1971
321	814.8575	961.8519	97.952
322	881.139	980.4099	97.9962
323	929.1576	966.3976	97.7883
324	891.524	996.0498	98.4515
325	880.8922	961.0202	96.8731
326	886.026	960.1762	96.6039
327	885.2819	941.3897	95.985
328	888.3608	921.8635	95.6615
329	888.3883	921.868	95.261
330	895.6548	948.8696	96.1177

331	906.2129	982.1105	98.2745
332	815.0934	961.695	97.9933
333	978.6796	1024.235	101.8381
334	965.2971	1026.651	101.6406
335	965.9202	1018.063	100.4444
336	938.3613	1030.173	102.3289
337	941.0056	1036.149	102.3804
338	943.6996	1034.022	102.2846
339	919.5766	1028.096	101.1611
340	915.3781	1035.66	101.8035
341	916.3219	1021.977	100.5964
342	1389.818	989.1596	82.1292
343	1389.325	995.3007	81.9859
344	1391.348	996.0058	81.1553
345	1385.173	999.2592	82.0255
346	1393.239	1020.061	82.0439
347	1393.306	1022.506	82.0907
348	1381.08	1017.043	82.5152
349	1379.886	1017.191	83.0737
350	1355.956	1006.004	84.2785
351	1353.273	1004.946	84.7869
352	1348.341	1005.327	86.369
353	1344.693	1004.374	87.9158
354	1343.305	1003.057	89.13
355	1340.754	1005.397	89.2781
356	1337.164	1004.889	89.4102
357	1366.131	997.3446	83.9363
358	1368.227	997.8823	83.2838
359	1374.522	999.1402	83.0916
360	1372.924	992.4128	83.4462
361	1364.919	1025.047	83.6123
362	1362.297	1028.579	84.4638
363	1366.764	1039.668	83.611
364	1375.755	1036.789	82.9736
365	1385.216	1053.626	82.9636
366	1395.997	1061.685	82.8019
367	1392.205	1049.738	82.9078
368	1371.193	1060.59	83.3153
369	1337.499	997.5271	89.6728
370	1328.118	999.831	90.26
371	1320.332	996.906	90.9299
372	1313.537	993.4727	91.6093

373	1305.277	989.7813	92.3844
374	1328.696	1014.211	89.7476
375	1333.516	1041.318	89.9121
376	1325.34	1041.179	90.2929
377	1340.22	1041.629	88.9643
378	1360.573	1044.25	87.9767
379	1350.471	1048.453	88.5037
380	1335.228	1045.636	89.5359
381	1301.63	1037.155	91.6074
382	1312.163	1027.442	90.8555
383	1304.223	1065.652	91.3896
384	1313.834	1056.324	90.7581
385	1326.574	1057.54	90.1813
386	1332.227	1069.739	90.0067
387	1345.922	1070.263	89.7743
388	1351.804	1069.641	88.4463
389	1359.905	1069.579	87.514
390	1367.565	1068.884	87.4118
391	1359.667	1097.829	90.0997
392	1315.978	1067.505	90.5417
393	838.8997	952.5982	98.0051
394	815.3795	947.2219	97.8878
395	814.9577	945.159	97.2485
396	814.7227	943.4722	96.79
397	816.0934	937.9006	95.1749
398	801.3023	929.9479	94.9499
399	801.4287	931.7091	94.9969
400	811.3224	933.0833	94.9688
401	818.182	928.4389	94.7325
402	816.746	933.163	94.7058
403	815.7022	942.5782	96.3376
404	860.8908	947.7612	97.9463
405	839.1092	945.7499	97.8771
406	838.8253	942.3269	96.9215
407	840.0604	940.7464	96.3868
408	839.8286	937.85	96.1896
409	840.7281	926.5197	95.0571
410	840.0494	936.0252	95.4496
411	860.4612	944.1317	97.8458
412	860.8182	942.0644	97.2046
413	860.7221	940.6428	96.758

414	860.6294	940.1618	97.01
415	860.4579	938.4994	96.516
416	859.8057	936.6509	95.8147
417	859.2034	930.6166	95.3988
418	859.3981	929.9581	95.0152
419	858.1533	924.5763	95.0506

Appendix II

Point list of GNSS survey

Point ID	Easting (m)	Northing (m)	Elevation (m)
b1	607783.271	1199926.638	28.176
b2	607774.330	1199795.692	21.022
rov1	607777.959	1199933.607	28.303
rov2	607827.434	1199776.656	30.168
rov3	607821.112	1199776.553	23.640
rov4	607827.581	1199782.981	24.413
rov5	607832.428	1199775.195	20.830
rov6	607836.639	1199784.338	240224
rov7	607864.142	1199775.090	20.672
rov8	607855.648	1199786.419	21.213
rov9	607861.762	1199774.743	20.594
rov10	607892.910	1199785.194	21.306
rov11	607895.811	1199779.962	21.092
rov12	607891.459	1199779.620	21.125
rov13	607892.545	1199799.389	25.296
rov14	607897.281	1199797.496	21.763
rov15	607905.738	1199791.854	21.496
rov16	607905.752	1199785.507	21.329
rov17	607907.717	1199777.467	21.123
rov18	607919.227	1199777.683	21.044
rov19	607930.683	1199787.714	21.257

rov20	607934.612	1199794.133	21.478
rov21	607961.294	1199780.130	20.490
rov22	607959.932	1199792.366	20.953
rov23	607965.210	1199796.700	20.877
rov24	607983.097	1199792.155	20.619
rov25	607989.039	1199781.338	19.926
rov26	607987.414	1199783.114	24.266
rov27	607991.565	1199793.896	24.329
rov28	608010.295	1199793.738	20.065
rov29	608010.792	1199801.318	20.466
rov30	608011.475	1199789.816	19.558
rov31	608012.703	1199779.154	19.098
rov32	608034.530	1199796.694	19.533
rov33	608033.139	1199794.045	23.678
rov34	608031.366	1199788.715	23.317
rov35	608031.727	1199777.119	18.591
rov36	608049.162	1199788.631	23.045
rov37	608068.903	1199780.796	20.382
rov38	608071.165	1199773.714	20.336
rov39	608074.246	1199773.882	20.275
rov40	607996.257	1199826.312	23.380
rov41	608000.318	1199820.292	21.274
rov42	607993.432	1199813.119	21.085
rov43	607958.274	1199824.548	22.590
rov44	607952.088	1199822.239	26.011
rov45	607950.744	1199814.302	24.479
rov46	607929.453	1199810.210	25.265
rov47	607897.180	1199818.878	22.791
rov48	607903.789	1199821.331	25.000
rov49	607895.421	1199824.665	23.001
rov50	607895.695	1199835.457	25.013
rov51	607893.455	1199850.395	23.833

rov52	607900.050	1199871.477	27.648
rov53	607890.841	1199875.417	29.130
rov54	607868.061	1199884.393	28.612
rov55	607865.857	1199879.561	26.644
rov56	607869.551	1199887.228	29.780
rov57	607874.721	1199892.213	30.814
rov58	607885.901	1199893.572	30.185
rov59	607887.554	1199905.258	30.470
rov60	607883.758	1199912.000	30.255
rov61	607877.466	1199907.622	30.296
rov62	607886.678	1199926.080	31.170
rov63	607883.379	1199958.806	31.163
rov64	607896.338	1199964.194	30.801
rov65	607875.053	1199960.127	31.623
rov66	607866.160	1199967.901	31.960
rov67	607856.888	1199967.580	32.105
rov68	607858.259	1199979.935	32.424
rov69	607859.652	1199975.184	31.964
rov70	607865.485	1199971.100	27.677
rov71	607866.966	1199974.100	27.718
rov72	607875.441	1199978.711	27.000
rov73	607877.136	1199972.969	26.880
rov74	607878.026	1199963.348	26.745
rov75	607881.791	1199963.608	26.649
rov76	607878.894	1199981.102	30.395
rov77	607875.790	1199984.562	30.390
rov78	607866.837	1199985.219	31.147
rov79	607854.363	1199984.013	31.814
rov80	607836.519	1199992.131	31.342
rov81	607833.487	1199982.192	32.011
rov82	607821.543	1199981.514	31.387
rov83	607836.744	1199973.518	31.196

rov84	607830.598	1199968.103	31.928
rov85	607814.551	1199975.275	34.289
rov86	607803.727	1199968.712	29.104
rov87	607799.398	1199967.103	29.193
rov88	607804.309	1199953.712	29.068
rov89	607807.214	1199948.054	28.959
rov90	607803.768	1199943.356	28.560
rov91	607814.070	1199944.932	28.861
rov92	607817.207	1199942.806	28.792
rov93	607821.021	1199945.358	28.782
rov94	607817.010	1199946.141	28.816
rov95	607812.770	1199926.978	29.320
rov96	607815.605	1199903.955	27.592
rov97	607815.103	1199896.639	28.716
rov98	607819.562	1199899.149	29.306
rov99	607815.373	1199887.259	29.231
rov100	607801.121	1199888.395	31.229
rov101	607804.621	1199895.065	30.200
rov102	607800.527	1199900.916	28.194
rov103	607798.746	1199907.498	28.211
rov104	607787.840	1199910.751	27.655
rov105	607784.068	1199922.721	28.128
rov106	607771.137	1199927.691	28.149
rov107	607753.173	1199921.374	32.324
rov108	607773.811	1199939.312	30.552
rov109	607780.505	1199942.850	30.020
rov110	607776.550	1199956.870	30.349
rov111	607776.861	1199958.510	33.304
rov112	607771.574	1199968.091	28.850
rov113	607771.145	1199973.884	29.470
rov114	607771.216	1199974.100	28.402
rov115	607772.475	1199972.893	28.689

rov116	607780.402	1199974.260	28.930
rov117	607780.660	1199976.738	29.031
rov118	607798.057	1199978.089	28.997
rov119	607763.526	1199975.293	26.880
rov120	607759.926	1199970.930	28.297
rov121	607746.464	1199974.077	29.462
rov122	607740.415	1199968.318	26.612
rov123	607739.368	1199960.224	28.172
rov124	607721.154	1199953.625	27.895
rov125	607715.952	1199950.995	26.909
rov126	607709.996	1199949.405	26.976
rov127	607705.040	1199952.378	26.541
rov128	607708.344	1199953.892	26.866
rov129	607715.706	1199941.907	27.267
rov130	607715.999	1199939.511	27.307
rov131	607718.878	1199926.278	27.349
rov132	607720.002	1199923.730	27.378
rov133	607721.711	1199917.915	27.529
rov134	607725.519	1199908.779	29.519
rov135	607725.747	1199902.003	27.017
rov136	607726.971	1199884.600	30.897
rov137	607726.956	1199879.093	25.967
rov138	607713.013	1199879.007	26.084
rov139	607699.484	1199879.635	26.261
rov140	607688.669	1199882.101	25.804
rov141	607694.117	1199869.982	24.750
rov142	607685.426	1199876.246	23.838
rov143	607687.630	1199880.941	23.933
rov144	607680.498	1199929.580	24.013
rov145	607658.533	1199930.494	24.021
rov146	607658.164	1199932.945	24.316
rov147	607661.879	1199940.575	24.522

rov148	607666.846	1199942.046	24.864
rov149	607658.703	1199961.894	24.512
rov150	607659.485	1199977.101	24.405
rov151	607661.861	1199966.668	24.769
rov152	607688.460	1199969.617	25.643
rov153	607697.195	1199970.484	26.326
rov154	607718.053	1199974.094	26.829
rov155	607655.037	1199966.599	24.700
rov156	607614.791	1199958.283	27.867
rov157	607614.473	1199920.442	23.529
rov158	607654.686	1199868.219	23.449
rov159	607617.524	1199871.619	23.356
rov160	607633.041	1199800.528	22.765
rov161	607655.178	1199795.711	22.788
rov162	607679.673	1199796.183	22.809
rov163	607680.165	1199787.948	22.490
rov164	607679.895	1199784.861	21.539
rov165	607680.451	1199785.639	25.203
rov166	607679.757	1199782.781	25.735
rov167	607680.896	1199778.467	26.310
rov168	607680.937	1199774.439	24.773
rov169	607680.211	1199768.905	19.926
rov170	607658.799	1199787.953	22.696
rov171	607659.716	1199785.796	25.073
rov172	607659.297	1199784.714	25.642
rov173	607659.271	1199783.780	25.173
rov174	607659.211	1199778.572	28.180
rov175	607661.478	1199768.632	26.264
rov176	607635.255	1199789.199	22.610
rov177	607636.916	1199783.923	27.134
rov178	607636.080	1199783.206	25.606
rov179	607637.110	1199781.130	24.880

rov180	607637.803	1199778.098	22.740
rov181	607639.207	1199769.416	23.038
rov182	607794.362	1199788.441	21.053
rov183	607791.109	1199798.769	21.084
rov184	607807.229	1199812.127	21.161
rov185	607784.152	1199811.740	21.361
rov186	607783.612	1199814.075	21.856
rov187	607743.429	1199811.881	21.348
rov188	607744.798	1199816.754	22.840
rov189	607744.895	1199824.391	23.278
rov190	607743.570	1199836.002	24.279
rov191	607740.728	1199840.290	28.140
rov192	607751.431	1199841.944	28.029
rov193	607753.878	1199836.807	24.019
rov194	607754.268	1199830.347	23.660
rov195	607753.389	1199822.684	23.109
rov196	607754.955	1199819.071	22.787
rov197	607774.634	1199822.327	22.767
rov198	607772.510	1199821.291	22.716
rov199	607780.339	1199821.265	22.794
rov200	607776.454	1199837.217	23.940
rov201	607769.117	1199836.538	23.963
rov202	607774.066	1199840.537	24.278
rov203	607786.929	1199845.113	28.779
rov204	607788.934	1199845.575	23.983
rov205	607807.910	1199827.085	25.947
rov206	607803.884	1199854.862	27.728
rov207	607800.346	1199858.432	29.673
rov208	607799.538	1199858.432	31.389
rov209	607799.373	1199862.273	31.288
rov210	607800.140	1199864.772	31.021
rov211	607800.455	1199865.359	31.346

rov212	607815.003	1199871.209	32.615
rov213	607806.784	1199884.111	26.849
rov214	607787.937	1199883.304	27.177
rov215	607787.691	1199885.278	27.611
rov216	607750.985	1199881.364	26.546
rov217	607749.547	1199885.597	27.560
rov218	607749.184	1199896.745	33.031
rov219	607774.524	1199877.921	26.242
rov220	607777.284	1199874.111	31.818
rov221	607786.782	1199871.497	30.951
rov222	607816.739	1199869.341	32.097
rov223	607836.108	1199876.783	40.439
rov224	607836.871	1199876.577	41.039
rov225	607836.886	1199872.054	39.797
rov226	607817.499	1199861.900	30.567
rov227	607818.189	1199844.660	28.775
rov228	607819.864	1199818.833	22.741
rov229	607822.067	1199804.405	26.283
rov230	607823.667	1199787.036	25.384
rov231	607814.022	1199774.265	27.433
rov232	607801.292	1199772.168	27.576
rov233	607787.888	1199771.359	20.748
rov234	607756.934	1199773.309	25.636
rov235	607746.640	1199771.661	24.846
rov236	607743.402	1199785.666	20.876
rov237	607743.416	1199789.302	20.980
rov238	607739.126	1199802.088	21.572
rov239	607713.604	1199797.163	21.406
rov240	607703.875	1199794.824	21.425
rov241	607703.284	1199811.626	22.244
rov242	607703.000	1199824.486	26.851
rov243	607704.140	1199840.669	27.022

rov244	607713.290	1199825.269	23.222
rov245	607715.791	1199816.628	27.639
rov246	607706.158	1199786.545	25.399
rov247	607713.016	1199788.449	25.212
rov248	607733.048	1199816.846	24.358
rov249	607734.633	1199813.371	23.671
rov250	607736.210	1199807.431	21.579

PREPARATION OF TOPOGRAPHIC MAP USING TOTAL STATION AND GNSS

By

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ABSTRACT

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In

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ABSTRACT

Topographic map is of great importance for the professional activities of an Agricultural Engineer. This map is an important prerequisite for soil and water conservation planning, design and planning of irrigation and drainage networks, farm infrastructure and other developments in agricultural field. This project work mainly focused on the preparation of topographic map of upland regions of KCAET, Tavanur using modern surveying equipments such as Total Station (LeicaTS06) and DGPS (Trimble). Using the field collected data from Total Station, a topographic map was plotted using ArcGIS10.3 software. TIN, contour map, and slope map were generated from this topographic map. In GNSS survey, post-process kinematic survey method was adopted. Post- processing of field collected data was done in Trimble Business Center software. The base line report obtained by exporting the data from the software provides the longitude, latitude, elevation, easting and northings etc. of the field point. It was found that,in Kerala terrain (with dense canopy) working with DGPS alone does not give good result whereas, in combination with TSS gives better and more satisfactory results. A contour map and slope map with good accuracy and great speed were generated and they can be used to accommodate various engineering planning requirements.