NATURAL RESOURCE MAPPING OF KCAET CAMPUS

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NATURAL RESOURCE MAPPING OF KCAET CAMPUS

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PROJECT REPORT

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<u>DECLARATION</u>

We hereby declare that this project entitled **“Natural resource mapping in KCAET campus”** is a bona fide 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 any degree, diploma, associate ship, fellowship or other similar title of any other University or Society.

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Place: Tavanur
Date: 07.02.2017

CERTIFICATE

Certified that this project entitled **“Natural resource mapping in KCAET campus**” is a record of project work done jointly by **Arjun.P** (2013-02-012)**, Arya.S.Anand** (2013-02-028) and **Athira.K** (2013-02-015) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associate ship to them.

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Arjun.P

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DEDICATED TO AGRICULTURAL ENGINEERING PROFESSION

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SYMBOLS AND ABBREVIATIONS

Symbols	Abbreviations
°	Degree
!	Factorial
-	Minus
	Minutes
/	Per
%	Percent
:	Colon
+	Plus
	Second
°C	Degree Celsius
Km^2	Kilometre square
cm	Centimetre
DEM	Digital Elevation Model
DGPS	Differential Global Positioning 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	mega joule
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
SD card	Secure Digital card
LiDAR	Light Detection and Radiation
LS	Length slope
ASTER	Advanced Space borne Thermal - Emission and Reflection Radiometer
2D	Two dimension
3D	Three dimension
TOPODEM	Topographic Digital Elevation Model
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
PC	Personal Computer
ppm	Parts per million
D	Distance
RX	reception
KCAET	Kelappaji College of Agricultural Engineering and Technology

INTRODUCTION

Chapter 1

INTRODUCTION

Soil and water are the two important natural resources and the basic need for agricultural production. During the last century, it is observed that the pressure of increasing population has led to degradation of the natural resources. In other words, increase in agricultural production to feed the increasing population is only possible if there is sufficient fertile land and water available for farming. In India, out of 328 million hectares of total geographical area, about 40 % is severely eroded. That is why soil and water should be given first priority from the conservation point of view and appropriate method should be used to ensure their sustainability and future availability.

Land surveying is the science and art of making all essential measurements to determine the relative position of points or physical and cultural details above, on, or beneath the surface of the earth and to depict them in a usable form, or to establish the position of points or details. These points are usually on the surface of the earth and they are often used to establish land maps and boundaries for ownership or governmental purposes. Furthermore, it is the detailed study or inspection by gathering information through observations, measurements in the field, questionnaires, or research of legal instruments and data analysis for the purpose of planning, designing, and establishing property boundaries. It involves the re-establishment of cadastral survey and land boundaries based on documents of record and historical evidence, as well as certifying surveys (as required by statute or local ordinance) of subdivision plans/maps, registered land surveys, judicial surveys and space delineation. Land surveying can include associated survey such as mapping, related data accumulation, construction layout surveys, precision measurements of length, angle, elevation, area, volume, as well as horizontal and vertical control surveys. It also includes the analysis and utilization of land survey data. The earliest surveys were performed only for the purpose of recording the boundaries of plots of land. Due to advancements in technology, the science of surveying has also attained its due importance.

Topographical maps are maps which are on sufficiently large scale to enable the individual features shown on the map to be identified on the ground by their shapes and positions. Topographic maps, also known as topo maps, are usually drawn on a large scale and are produced on very large sheets of paper. It is a very detailed and accurate representation of the natural and cultural features on the ground. A topo map identifies natural and cultural features, such as roads, rivers, swamps, vegetation and power transmission, among other features. A topographic map of the area is the primary pre-requisite of soil erosion studies. A natural resource map shows the expanse of natural resources found on and in the surface of the Earth. Natural cover of the worlds, world map of natural vegetation and world map of minerals are examples of natural resource maps.

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. A total station is a combination of electronic theodolite and electronic distance measuring device (EDM). EDM is the electronic distance measuring device which measures the distance from the instrument to its target. The EDM sends out a laser or infrared beam which is reflected back to the unit, and the unit uses velocity measurements to calculate the distance traveled by the beam. Electronic theodolites are having facility to mount EDM on the top to measure distance. In electronic theodolite angles are being measured using two scales which are encoded to display the angular measurements in digital display fixed to the instrument. 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. 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.

Advantages of Total Station Surveying:

- Relatively quick collection of information
- Multiple surveys can be performed at one set-up location.
- Easy to perform distance and horizontal measurements with simultaneous calculation of project coordinates (Northing, Easting, and Elevations).
- Layout of construction site quickly and efficiently.
- Digital design data from CAD programs can be uploaded to data collector.
- Daily survey information can also be quickly downloaded into CAD which eliminates data manipulation time required using conventional survey techniques.

Disadvantages of Total Station Surveying:

- Vertical elevation accuracy not as accurate as using conventional survey level and rod technique.
- Horizontal coordinates are calculated on a rectangular grid system. However, the real world should be based on a spheroid and rectangular coordinates must be transformed to geographic coordinates if projects are large scale. Examples: highways, large buildings, etc.

The Global Positioning System (GPS) is a satellite-based navigation system made up of at least 24 satellites. The U.S. Department of Defense (USDOD) originally put the satellites into orbit for military use, but they were made available for civilian use in the 1980s. There are other similar systems to GPS in the world, which are all classified as the Global Navigation Satellite System (GNSS).

Differential Global Positioning System (DGPS) is an enhancement to Global Positioning System that provides improved location accuracy, from the 15-meter nominal GPS accuracy to about 10 cm in case of the best implementations. DGPS refers to using a combination of receivers and satellites to reduce/eliminate common receiver based and satellite based errors reduce orbit errors reduce ionospheric and tropospheric errors, eliminate satellite and receiver clock errors.

In this context, an attempt has been made in this project work to prepare a natural resource map using Total Station with given below specific objectives:

- To study the principle and operations of Total Station.
- To prepare a resource map of KCAET campus using Total Station and DGPS
- To estimate the erosion potential of different slope groups of KCAET campus

REVIEW OF LITERATURE

Chapter 2

REVIEW OF LITERATURE

A critical review of some of the important research work done in the area of total station surveying and DGPS is presented in this chapter.

Colosi *et al*. (2000) conducted a series of topographical surveys in the Salto Valley (Rieti-Lazio) and provided an 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 was 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, which could be used to guide future excavations at this site.

Jeyapalan and Bhagawati (2000) conducted a study on Total Station, Differential Global Positioning System (DGPS), Video logging, 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). Total station can be used in mapping at a scale of 1″=25 ft or less. Data collecting using Total station and DGPS are time consuming in the field where as soft photogrammetry uses more office time. The virtual reality can be used for 3D visualization, fly through and 3D view of proposed modification. The video logging 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. 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.

According to the studies conducted by Jonsson *et al*. (2003), RTK measurement was applied to test accuracy of different GPS instruments (Leica, Topcon and Trimble). A network of nine control points was established using total station. Then, the authors performed RTK measurement on the same network and compared results with different instrument. Results obtained from RTK measurement have shown a horizontal and vertical accuracy of 10 mm and 2 cm respectively. When comparing this result with the result of the thesis, better accuracy was achieved in both horizontal and vertical coordinates.

Lin (2004) addressed in his project: (1) performance comparisons between using RTK and total station system on land use data capture and updating in terms of accuracy, speed, etc., (2) land use change styles analysis on the interested regions, (3) designing an effective land-use change spatial information collecting procedure using GPS based on the land use change styles, and (4) converting collected land use change data to GIS compatible files. The campus of NCCU (National Cheng-Chi University) was selected as a test region to test the performances of RTK and total station system on land use change data collection. The cadastral maps (on different times) of Mu-Za district of Taipei City were analyzed to find the possible land use change styles. Preliminary results indicated that: (1) the horizontal accuracies of RTK and total station system are14 mm+/-4mm and 163mm+/-63mm respectively (the coordinates of check points were determined using static GPS), (2) the time required for one point determination using RTK or total station system are about 15 seconds and 240 seconds respectively, (3) the land use change styles of Mu-Za district can be classified into 3 main types of polygon (each main type may have 2-3 styles), and (4) the field surveying works can be reduced significantly if the designed fielding surveying procedures were followed.

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 reflector less 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 modeling. 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 (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 74cm 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.

Pflipsen (2006) investigated in his thesis about the 3 questions, Laser scanner versus total station: What is more accurate and what is more efficient? Do different software products result in equal outcomes? How far can a point cloud be reduced until there are changes in the result? To answer these questions a pile of sand (size around 400 m^3) were surveyed twice: once with a laser scanner – Leica HDS 3000 – and once with a total station – Leica TPS1200. The data of the measurement were computed with three different software products: Geo, Geograf and Cyclone. Additional to this the point cloud was reduced stepwise and in each case, the volume was calculated. Thus, the effect of the reduction could be observed. Between the different methods, no differences result in the accuracy and in this investigation – hardly in the time for the measurement. The results of the computations showed that there is no difference between the programs Geo and Geograf. Just the result of Cyclone diverged from the other. The point cloud can be reduced without influences on the result with the order "Unify" until a point-to-point distance of 0.30 m.

Valbuena *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 in order 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.

In another study by Fregonese *et al*. (2007) the objective of the study was to access the feasibility of monitoring deformations of large concrete dams using terrestrial laser scanning. For this purpose a test field has been established on the specific dam. First the author established a geodetic network as a reference by Leica TS, and then, using a number of targets on the dam, measurements were taken with a total station and a laser scanner. The reference network was determined with 2 mm horizontal and 3 mm vertical coordinate precision. Targets, mounted on the dam, were measured precisely with a total station, and 3 mm for the horizontal and 4.5 mm for the vertical coordinate accuracy (RMS) has been achieved. On the other hand, using a laser scanner (HDS 300), 4 mm for the horizontal and 8 mm for the vertical coordinate accuracy (RMS) was achieved.

Mottershead *et al*. (2007) surveyed small scale terrains on salt materials with a Total Station and a series of digital elevation models (DEMs) constructed. Two sets of observations were made, eight months apart during which the terrains underwent significant erosion. The difference in elevation shown by the DEMs calculated by subtraction is a measure of surface erosion of the salt terrains. The erosion rate was analyzed 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. Slope profile curvature is also indicated as 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.

Steel *et al*. (2008) prepared a report whose purpose was to look at the accuracy of GPS for maritime archaeological mapping when compared with a total station during survey of the maritime landscape of Indented Head, Port Philip Bay. From the study it was obvious from this study that the Total station data is far more accurate than GPS. For open water plotting and rough maps of an area GPS is quick, simple and efficient, whereas when cm accuracy with both distance and height is necessary the Total station is the best option. The purpose of their study was to map the maritime landscape of Indented Head, this survey also included swim line and circular search, because these methods are not accurate it was not necessary to plot the data found on a Total Station map. The GPS map provided the perfect background of the maritime landscape on which to plot their points of interest.

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. Class V points within the university were used for the measurements. The following plans were executed after the measurements were taken: dimension site plan - 1:500; plot plan - 1:1000; development site plan - 1:10000. The calculations of the geo-topographic support networks were done with the TOTAL 2.0 software. 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, polygon metric networks, triangulation).

Ahmed (2012) tested RTK and total station measurements on an existing network in order to check the compatibility of the RTK method with that of total station method. The objective of the test was to assess the RTK achievable accuracy, to check the repeatability of the results under different satellite configurations and to evaluate RTK performance in urban area. In the test, accuracy and repeatability assessment of the RTK was carried out by comparing the coordinates of points with that of independently precisely determined using a total station. According to the result, the difference between the coordinates of total station and RTK was 2 cm for the horizontal and 3 cm for the vertical coordinates. In comparison with the results of this thesis, the coordinate difference between total station and RTK (coordinates of RTK- coordinates of TS) was 1.8 cm for both horizontal and vertical coordinates.

Mohamed and Nasr (2013) found that there was some rate of distortion in the projected plane coordinates obtained by GPS. The coordinates obtained using terrestrial devices such as Total Station depends on the direct angular observations and distances measurements on the surface of the earth assumed as plane surface. Using different observation systems (terrestrial survey and GPS survey) yields discrepancies in the obtained results for the same location due to the variation of the observation sources and the technology used by each system. The discrepancy that exists in the measured results must be removed to obtain conformity of them by deriving scale factor which was the main objective of this study. This paper covers the procedure of integration between the Electronic Total Station and the Global Positioning System (GPS) and their use in surveying engineering projects. In this paper the author used Total Station and the Global Positioning System (GPS) commonly using observations of common points with the two systems (Total Station and the GPS receivers) to get the horizontal position difference and the scale factor between the Total Station and the GPS coordinates. The results showed that the difference as a distant scale factor for the considered area in Sudan is typical to the published international scale factor.

Lee *et al*. (2013) conducted accuracy and efficiency tests for four different beach-profile surveying methods of: 1) spot measurement using a total station; 2) spot measurement using a RTK-GPS system; 3) continuous walking measurement using a RTK-GPS backpack system; and 4) 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. Test results indicate 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 - 6 cm. In terms of survey efficiency, the RTK-GPS ATV system have advantages in surveying time and operational manpower with a reasonable vertical error of about 3 cm over the other surveying methods. 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 analysis.

Kumar *et al*. (2013) conducted survey 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 is 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 is observed. The maximum error of 0.027m, minimum error of 0.005m and average error 0.007 with standard deviation of 0.01526m is observed in Reduced Level. The variation of average area from DGPS data with reference to Total Station data is 1.058sq.m. The DGPS provides the more reliable and accurate data which can be used for medium to small scale maps.

Khalil (2013) studied 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. This transformation requires real-world coordinates of at least two control points, which can be collected from different sources. This paper also studies the effect of using geodetic GPS, hand-held GPS, Google Earth (GE) and Bing Basemaps as sources for control points on the precision and relative accuracy of total station survey. These effects have been tested by using 111 points covered area of 60,000 m^2 and the results have shown that the CHaMP tool is the best for preserving the relative accuracy of the transformed points. The Georeferencing and spatial adjustment (similarity) tools give the same results and their accuracy are 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 despite their source.

Chekole (2014) made a study to evaluate and compare precision, accuracy and time expenditure of Total station (TS), Global Positioning System (GPS) and terrestrial laser scanner (TLS). To investigate this task, a reference network consisted of 14 control points had been measured five times with Leica 1201 TS and served as a reference value for comparison with RTK and TLS measurements. The reference network points were also measured five times with the GPS RTK method so as to compare accuracy, precision and time expenditure with that of TS. In addition, in order to compare the accuracy, precision and time expense of total station and TLS, the North Eastern façade of the L building at KTH campus in Stockholm, Sweden has been scanned five times with HDS 2500 scanner on six target points. These six target points were also measured five times with TS. Then comparison made to evaluate the quality of the coordinates of the target points determined with both measurements. The data were processed in Cyclone, Geo Professional School and Leica geo office software. According to the result obtained, the reference network points measured with TS were determined with 1 mm precision for both horizontal and vertical coordinates. When using RTK method on the same reference network points, 9 mm in horizontal and 1.5 cm accuracy in vertical coordinates has been achieved. The RTK measurements, which were measured five times, determined with a maximum standard deviation of 8 mm (point I) and 1.5 cm (point A) for horizontal and vertical coordinates respectively.

Ragheb and Fayoumi (2015) dealt with how to facilitate and manage surveying methods to accomplish modernized and cost effective urban survey with best achievable accuracy. This was done by replacing traditional surveying methods with modern methods from both theoretical and practical point of view. At first, a theoretical assessment process on a tradition urban planning project in Saudi Arabia was performed by replacing traditional urban planning techniques previously used with more applicable surveying techniques as total stations regarding different matters such as applicability, cost and accuracy. After approving the main idea of this modernization process, a practical urban planning case study was performed using total station, geodetic GPS receivers and GPS navigators, on a private settlement block consisting of 6 buildings in a crowded neighborhood of Cairo city. The applied surveying techniques showed high efficiency regarding cost and effort, while saving observation time reaching to 60%. Accordingly, the adopted practical application proved to be beneficial for all desired aspects, as well as for more extensive study areas in future.

Arango *et al*. (2015) conducted a study about comparison between multicopter UAV and Total Station for estimating stock pile volumes. Since the UAV (Unmanned Aerial Vehicle) had became an alternative for different engineering applications, especially in surveying, one of these applications was the calculation of volumes of stockpiled material, but there were questions about its accuracy and efficiency, the purpose of this article was to compare traditional surveying methods for estimating total volumes through data obtained by total stations and data obtained by a multicopter UAV. In order to answer these questions they obtained data from the same location and the results and compared the results. After comparing the results it was found that there was a 2.88% difference between the volume calculated with the total station data and the actual volume, and −0,67% difference between the volume calculated with the UAV data and the actual volume, concluding that the estimated volume with UAV data is more accurate.

Archana *et al*. (2016) conducted a 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 northing 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.

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

A Total station consists of a theodolite with a built-in distance meter, and so it can measure angles and distances at the same time. It is also integrated with microprocessor, electronic data collector and storage system. Todays electronic total stations all have an optoelectronic distance meter (EDM) and electronic angle scanning. The coded scales of the horizontal and vertical circles are scanned electronically, and then the angles and distances are displayed digitally. The horizontal distance, the height difference and the coordinates are calculated automatically and all measurements and additional information can be recorded. Total stations are used wherever the positions and heights of points, or merely their positions, need to be determined. 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.

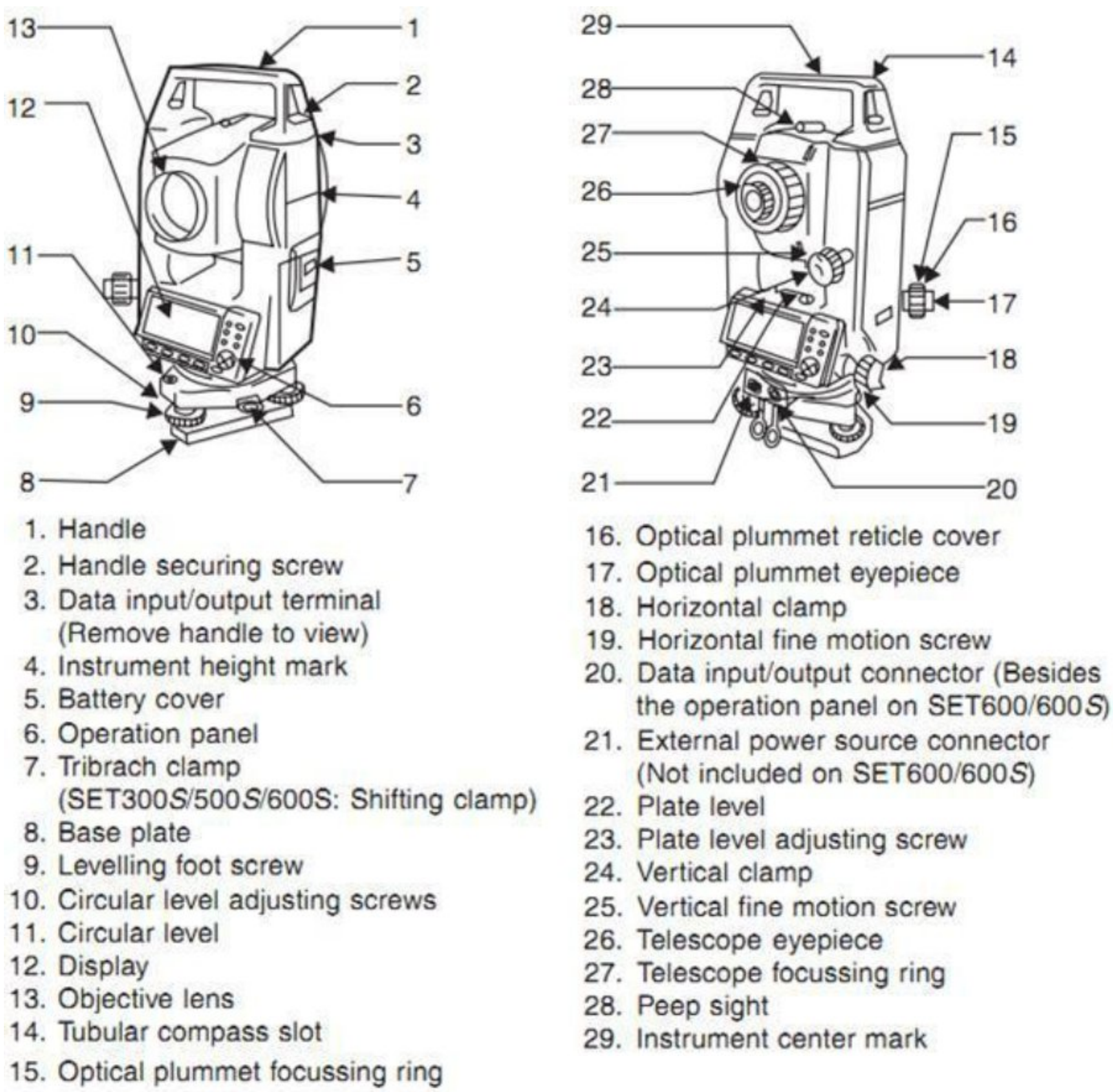

Fig. 3.1 Different parts of a Total Station

3.2.1 Main accessories of total station:

3.2.1.1 Tripod

The most important criterion for a good tripod is its stability, quite explicitly, the torsional rigidity. Other substantial benefits are the height stability under load and the minimal horizontal drift. Also not to be underestimated are advantages such as long life, optimal vibration dampening, water resistance, outstanding behaviour in solar radiation and their weight in relation to load-bearing capacity.

3.2.1.2 Tribrach

Similar to the stability of the tripod, that of the tribrach is a significant factor in measurement accuracy. The torsional rigidity, the most important criterion of a tribrach, is constantly controlled and tested during its production. The precise alignment of the support area to the base plate of the instrument assures extremely accurate forced centering. The optical plummet is so robust that the need for adjustment during the entire lifetime of the tribrach is practically unnecessary. Its construction predestines the tribrach for all applications, including extreme temperatures and high dust and humidity.

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 Important Operations of Total Station

3.2.2.1 Distance Measurement

Electronic distance measuring (EDM) instrument is a major part of total station. Its range varies from 2.8 km to 4.2 km. The accuracy of measurement varies from 5 mm to 10 mm per km measurement. They are used with automatic target recognizer. The distance measured is always sloping distance from instrument to the object. Angle Measurements: The electronic theodolite part of total station is used for measuring vertical and horizontal angle. For measurement of horizontal angles any convenient direction may be taken as reference direction. For vertical angle measurement vertical upward (zenith) direction is taken as reference direction. The accuracy of angle measurement varies from 2 to 6 seconds.

3.2.2.2 Data Processing

This instrument is provided with an inbuilt microprocessor. The microprocessor averages multiple observations. With the help of slope distance and vertical and horizontal angles measured, when height of axis of instrument and targets are supplied, the microprocessor computes the horizontal distance and X, Y, Z coordinates. The processor is capable of applying temperature and pressure corrections to the measurements, if atmospheric temperature and pressures are supplied.

3.2.2.3 Display

Electronic display unit is capable of displaying various values when respective keys are pressed. The system is capable of displaying horizontal distance, vertical distance, horizontal and vertical angles, difference in elevations of two observed points and all the three coordinates of the observed points.

3.2.2.4 Electronic Book

Each point data can be stored in an electronic note book (like compact disc). The capacity of electronic note book varies from 2000 points to 4000 points data. Surveyor can unload the data stored in note book to computer and reuse the note book.

3.2.3 Instrumental setup

Step 1: Tripod Setup

- Tripod legs should be equally spaced.
- Tripod head should be approximately level.
- Head should be directly over survey point.

Step 2: Mount Instrument on Tripod

- Place Instrument on Tripod.
- Secure with centring screw while bracing the instrument with the other hand.
- Insert battery in instrument before levelling.

Step 3: Focus on Survey Point

- Focus the optical plummet on the survey point

Plate 3.1 Working with TS

Step 4: Levelling the Instrument

- Adjust the levelling foot screws to centre the survey point in the optical plummet reticle.
- Centre the bubble in the circular level by adjusting the tripod legs.
- Loosen the horizontal clamp and turn instrument until plate level is parallel to 2 of the levelling foot screws.
- Centre the bubble using the levelling screws- the bubble moves toward the screw that is turned clockwise.
- Rotate the instrument 90 degrees and level using the 3rd levelling screw.

- Observe the survey point in the optical plummet and centre the point by loosening the centring screw and sliding the entire instrument.
- After re-tightening the centring screw check to make sure the plate level bubble is level in several directions.

Step 5: Electronically Verify Levelling

- Turn on the instrument by pressing and holding the “on” button (you should hear an audible beep).
- The opening screen will be the “MEAS” screen. Select the [Tilt] function.
- Adjust the foot level screws to exactly centre the electronic “bubble”.
- Rotate the instrument 90 degrees and repeat.

Step 6: Adjust Image and Reticle Focus

- Release the horizontal & vertical clamps and point telescope to a featureless light background.
- Adjust the reticle (i.e. cross-hair) focus adjustment until reticle image is sharply focused.
- Point telescope to target and adjust the focus ring until target is focused.
- Move your head from side-to-side to test for image shift (i.e. parallax). Repeat the reticle focus step if parallax is significance

Step 7: Measurement using total station

- An operator can measure the Foresight point Coordinates from the “Station point Coordinates and Back sight Coordinates “or the “Station point

Coordinates and Azimuth", and can store the Point name and measured Coordinates in the memory. When the Coordinates of the Station point and Back sight point are already stored in the memory, the new Coordinates input can be omitted by calling or searching from the point name LIST.

- The point name is within 15 characters and the Coordinates are within 8 in integer and 3 in decimal number. There are two Coordinates types of Rectangular and Polar Coordinates in this [MEASURE].
- The Offset at the Target point is possible and the Remote measurement by aiming at any point is possible as well when you select the Rectangular Coordinates.
- An operator can perform the [MEASURE] function only when the Telescope is at the "Face left position".
- Select the Target type before performing the [MEASURE].
- After measuring rectangular coordinates by [MEASURE] function of PowerTopoLite, it is possible to display Angle and Distance by switching the [F3] key.
- When Remote mode is selected, Angle and Distance are also calculated according to the coordinates of the aiming point on real time.
- When Offset mode is selected, Angle and Distance are also calculated according to the coordinates where offset value is added.

Creation of a new Job

- Select 2. CREATE by down arrow key.

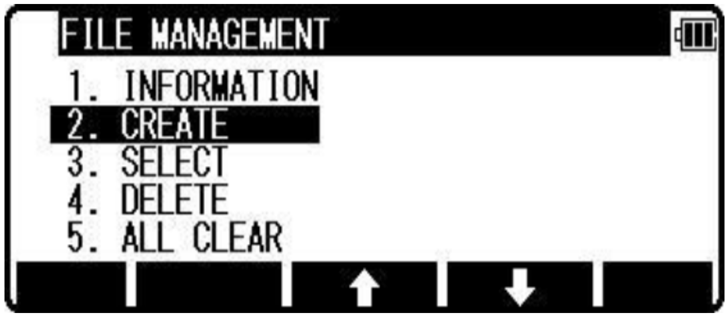

Fig.3.2 Creation of a new job

- Press [ENT] to view the JOB NAME INPUT screen.
- The Job name input method can be selected by the "Input method selection" of the "Preference". This is the "10 KEY SYSTEM" inputs election.

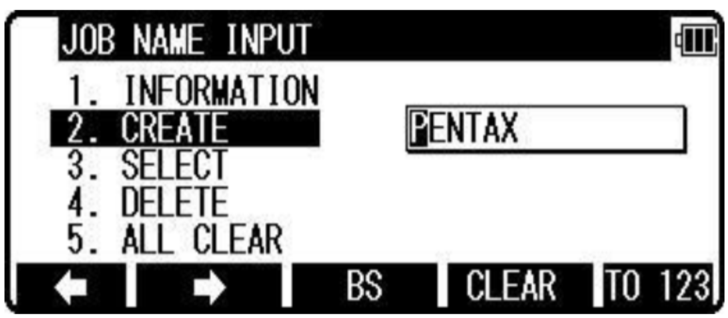

Fig.3.3 Inputting of a new Job name

- If a new Job is created, the new data are stored in this new Job.

Selection of a Job name

- Select 3. SELECT by pressing the down arrow key.

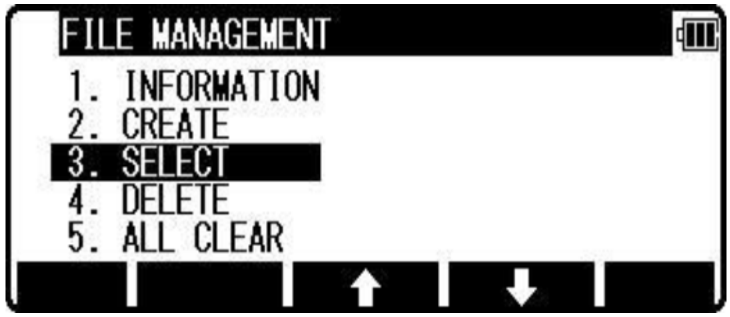

Fig.3.4 Selection of a Job name

- Press [ENT] to view JOB SELECTION screen.

Selection of a Job

- Select 1. JOB LIST SEARCH and press [ENT] to view its screen. JOB LIST is a list of all stored Jobs.

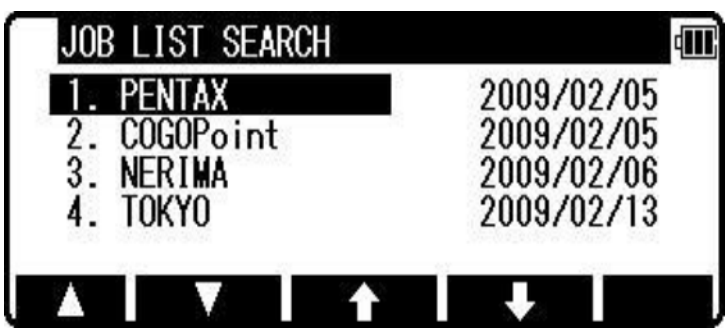

Fig.3.5 Selection of a job

- Select your desired Job name and press [ENT] to select.

Station setup [By Rectangular Coordinates]

- Press [F2][MEAS] of the Power TopoLite screen to view the MEASURE METHOD SELECTION screen

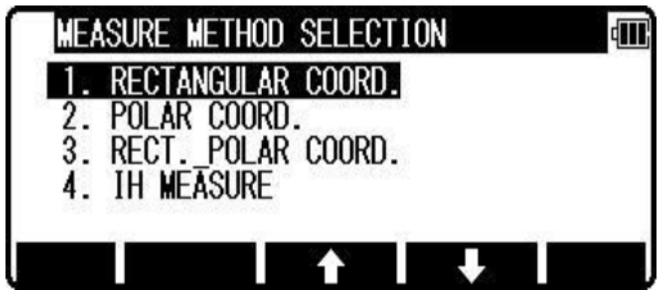

Fig.3.6 Measure method selection

- Select 1. RECTANGULAR COORD. and press [ENT] to view the STATION POINT SETUP screen.

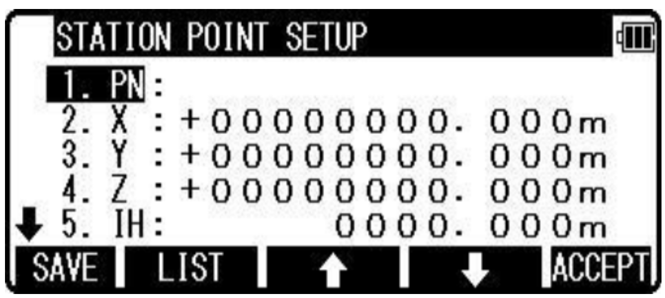

Fig.3.7 Station point setup

- The / mark is used to scroll up / down. 6. PC is viewed by scrolling down.

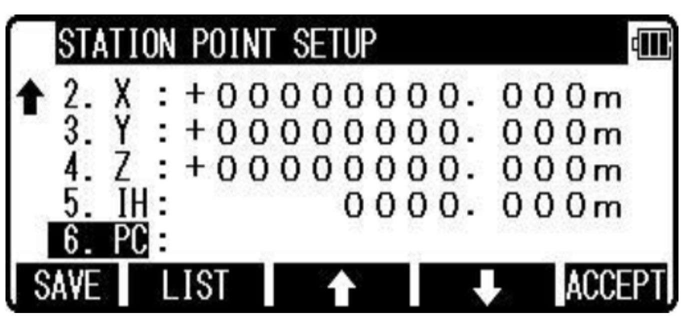

Fig.3.8 Setting point code

Point name, PN, input

- Press [ENT] to view the PN screen.
- The [ENT] is used for both accepting the selected choice and opening the input screen of the Coordinates values etc..
- Input your desired point name by pressing keys, and after all Characters are input, press [ENT].
- Four character selection methods are available.

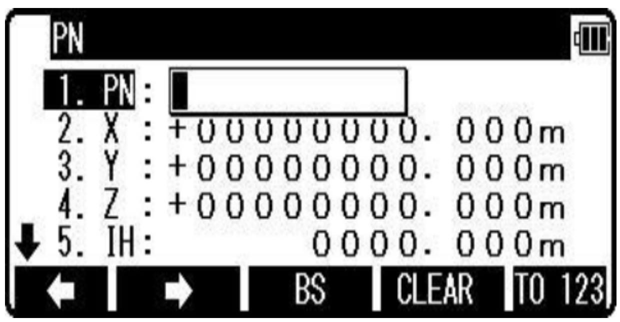

Fig.3.9 Setting point name

Coordinates, X, Y, Z, IH, and PC input

- It goes 2. X coordinate automatically.
- Press [ENT] to view the X coordinate input screen. Input X, Y and Z coordinate Instrument height and PC as follows. Input your desired X coordinate value by pressing each keys. Press [ENT] to view the Z coordinate input screen. Input your desired Z coordinate value by pressing each keys.

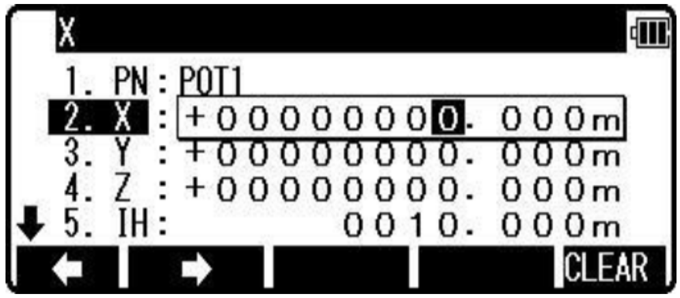

Fig.3.10 X Coordinate input

- Y coordinate: Press [ENT] to view the Y coordinate input screen. Input your desired Y coordinate value by pressing keys.

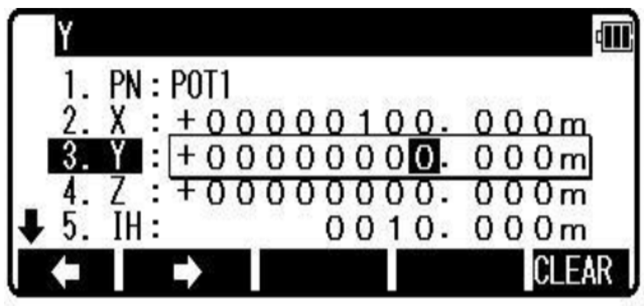

Fig.3.11 Y Coordinate input

- Z coordinate: Press [ENT] to view the Z coordinate input screen. Input your desired Z coordinate value by pressing each keys.

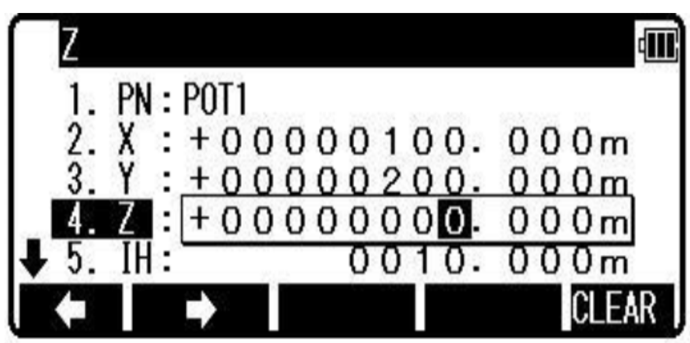

Fig. 3.12 Z Coordinate input

- IH value: Press [ENT] to view the IH, Instrument height, screen. Input your desired IH value by pressing each keys.

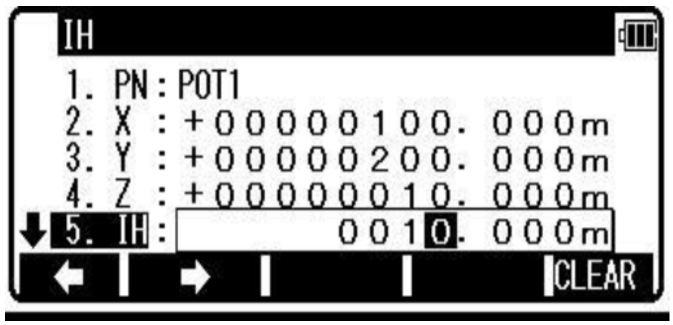

Fig.3.13 IH input

- PC, Point Code: Press [ENT] to view and input the PC, Point code, screen. If Point Code exists, you can easily select them from the list. Then after pressing [ENT], you can edit Point Code data.
- After pressing [ENT], you can edit Point Code data. Input your desired PC name by pressing keys, and press [ENT] to view next screen**.**

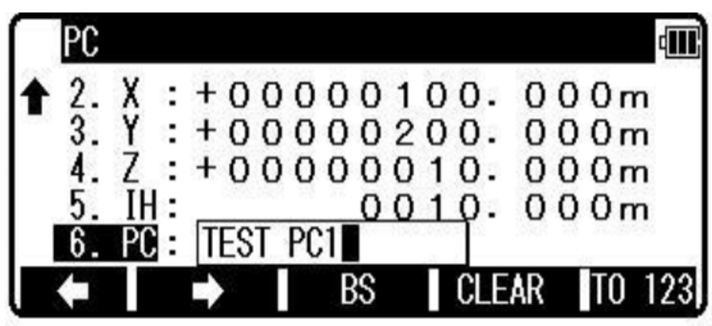

Fig.3.14 PC input

Measuring

- Aim at the reference point and press [ENT] to view the MEASURE screen. Then, aim at the Target point and press the [F1][MEAS] to measure it.
- Press [F3][ME/SAVE] to measure and save the measured data. Press [F2][SAVE] to save the measured data.

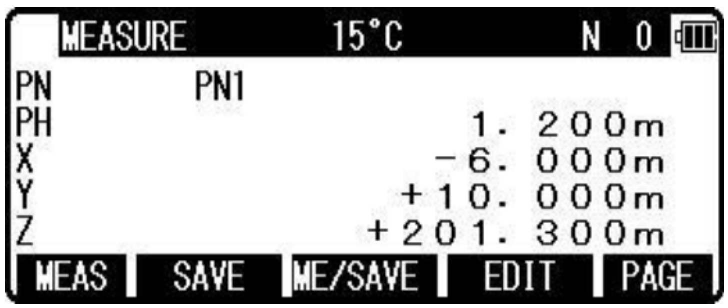

Fig.3.15 Measured data

- Press [F4][EDIT] to edit the PN, Point Name, PH, Prism Height and PC, Point Code. Input your desired Point name, Prism height and Point code. Press [F5][ACCEPT] if the current PN, PH and PC are acceptable. If Point Code exists, you can easily select them from the list or edit one of them after pressing the [ENT].

Step 7: View and Edit

Stored data are displayed graphically, and the edit of the stored data is possible by this Function. The Z Coordinate (the height) of the point is ignored in the graphical display of the point data.

Four menu items are available:

- GRAPHICAL VIEW

- CREATE THE RECT. POINT
- EDIT THE RECT. DATA
- EDIT THE POLAR DATA

Graphical View

- From the PowerTopoLite screen, press [F3][VIEW] to view its screen.

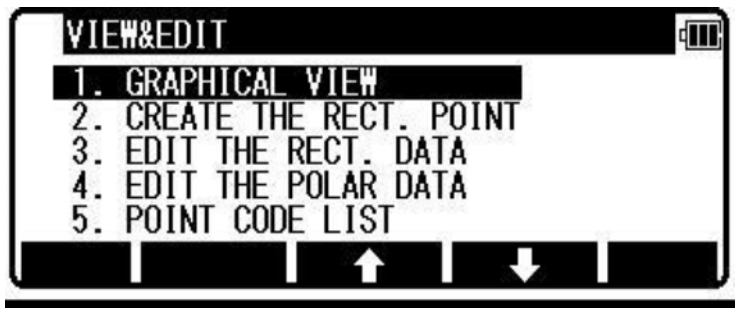

Fig.3.16 View and Edit

- Press [ENT] to view the GRAPHICAL VIEW screen. Points, Point names and their Graphics are displayed. The graphic is moved by pressing the arrow keys. The Graphics are not displayed when points are not stored. Two or more points are needed.

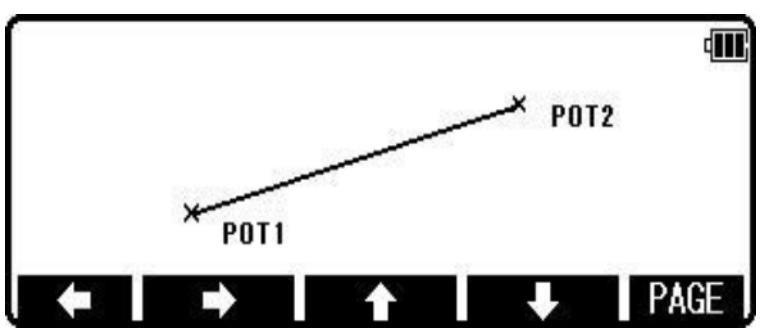

Fig.3.17 First page of Graphical view

- Press the [F5][PAGE] to view another menu.

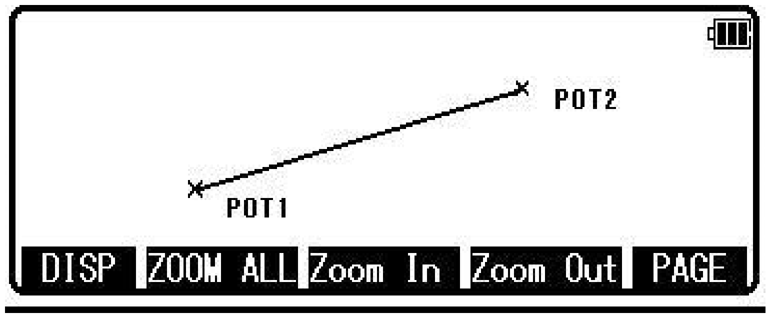

Fig.3.18 Second page of Graphical view

- [DISP]: Each Graphic is displayed as following order by pressing this key.
  Points → Points + Line → Points + Points names → Full
- [ZOOM ALL]: Return to the ordinary Graphics size
- [ZOOM IN]: Enlarge the Graphics size.
- [ZOOM OUT]: Reduce the Graphics size.

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. The data stored in the internal memory is sent to the PC etc.

Fig.3.19 Data Export Window 1

Select the 2. SEND RECT. DATA by pressing the down arrow key, and press [ENT] to view the FORMAT SELECTION screen.

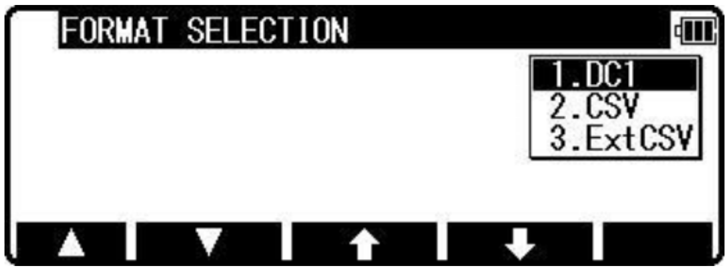

Fig.3.20 Data Export Window 2

Select DC1 format and press [ENT] to view the DATA SEND. CONFIRMATION screen.

(Same procedure is performed at CSV)

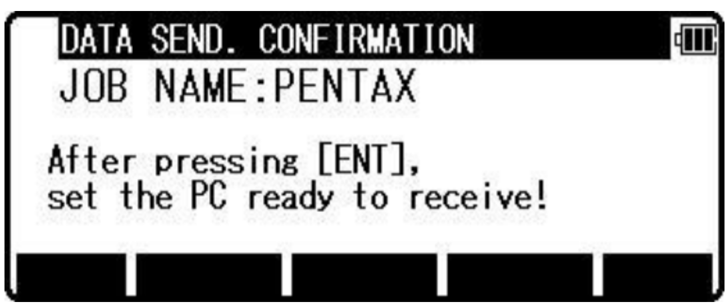

Fig.3.21 Data Export Window 3

Press [ENT], and set the PC to be ready to receive.

3.3 GEOREFERENCING

Georeferencing is the aligning geographic data to a known coordinate system so it can be viewed, queried, and analyzed with other geographic data. For this purpose a hand held GPS was used. Using this, the longitude, latitude, and elevation of a few points were found out. Since this data lacked accuracy, we used DGPS for this purpose.

3.4 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. 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 affect both receivers 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, GALILEO 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. IRNSS is the satellite system set up by India and it has 7 satellites in orbit.

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)

3.4.1 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.

3.4.1.1 Startup procedure of PPK Survey

1. **Base Setup:**

Plate 3.2 Base setup in PPK survey

2. Rover Setup:

The Setup should look like below mentioned setup image.

Plate 3.3 Rover setup in PPK survey

i. Connect the GNSS receiver to Rover → R6XXXXXXX → Accept.
ii. Go to General Survey. You will get six options.
iii. Go to Job → Create New Job.
iv. Give Job Name
v. Select the Coordinate System as per the survey location and zone. Also link your Feature Library if you are using for your survey.
vi. Give approximate project height (MSL) of location.
vii. Accept to save the changes you made in new job
viii. Go to Survey → PPK → Measure Points → Esc

ix. 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.

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

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

xii. Now go to next point.

xiii. Repeat the same procedure for different Topo Points.

3.4.1.2 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.

3.5 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

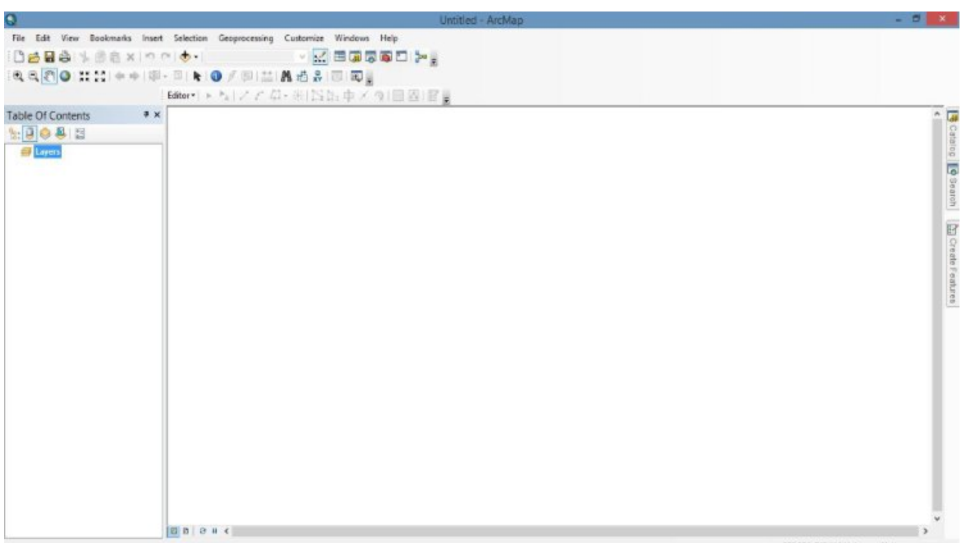

Fig. 3.22. ArcMap window

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 i.e., 1026 points. The co-ordinates of some of the points are tabulated in Table 4.1. and all the points are given in Appendix I.

Table 4.1 Total Station survey data

Point ID	Northing (m)	Easting (m)	Elevation (m)
P1	2000	2000	100
P2	2005.694	2000	100.728
P3	2006.27	2016.265	101.1
P4	2029.303	2016.772	102.121
P5	1999.747	1974.979	99.253
P6	1979.848	1973.761	99.384
P7	1986.575	2015.771	99.814
P8	2028.048	2005.335	102.339
P9	1964.908	2003.054	98.4
P10	1992.11	1975.153	99.396
P11	1992.522	1977.005	99.383
P12	1991.959	1979.986	99.318
P13	2002.348	1976.435	99.714

P14	2003.969	1967.5	99.942
P15	1991.296	1987.656	99.337
P16	1990.967	1991.938	99.541
P17	1990.424	1999.608	99.555
P18	1988.709	2003.484	99.579
P19	1999.53	2003.495	100.265
P20	2001.223	2007.383	100.438
P21	2002.391	2009.913	100.597
P22	2001.104	2047.737	100.479
P23	2002.212	2047.725	100.522
P24	2025.249	2010.746	102.1
P25	2008.983	2009.311	100.929
P26	1995.355	2011.646	100.208
P27	1992.732	2035.092	99.54
P28	1990.779	2047.125	99.62
P29	2004.523	1992.517	101.194
P30	1997.703	1991.579	99.423
P31	1989.4	1975.922	98.534
P32	1988.124	1994.927	98.9
P33	1957.697	1974.78	98.349
P34	2010.022	2003.879	100.986
P35	2012.142	1997.134	101.398
P36	2009.239	2008.947	100.94
P37	2013.228	2012.568	101.271
P38	2027.386	2009.06	102.352
P39	2022.525	2012.838	101.851
P40	1950.655	2006.248	97.438

4.1.2 Map preparation in ArcGIS software

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

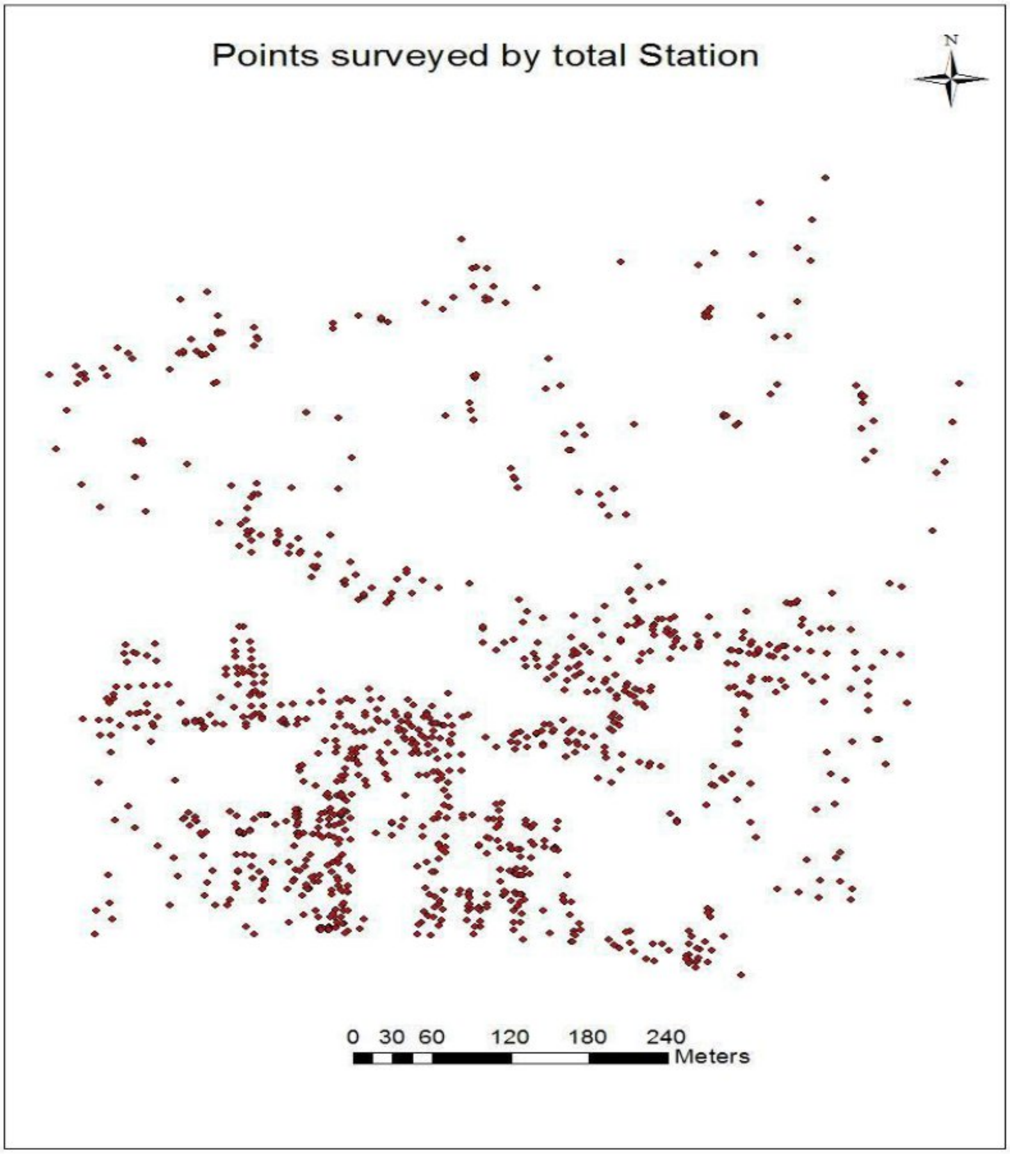

Fig. 4.1 Points surveyed using TS

From the above plot, a boundary plot was drawn using ArcGIS software. In this boundary plot, buildings, roads etc can be plotted using different layers. From this plot, the perimeter and area of the KCAET campus was obtained as:

- Perimeter : 2824.31m
- Area: 385985.67m²

1026 points were surveyed over an area of 40 ha.

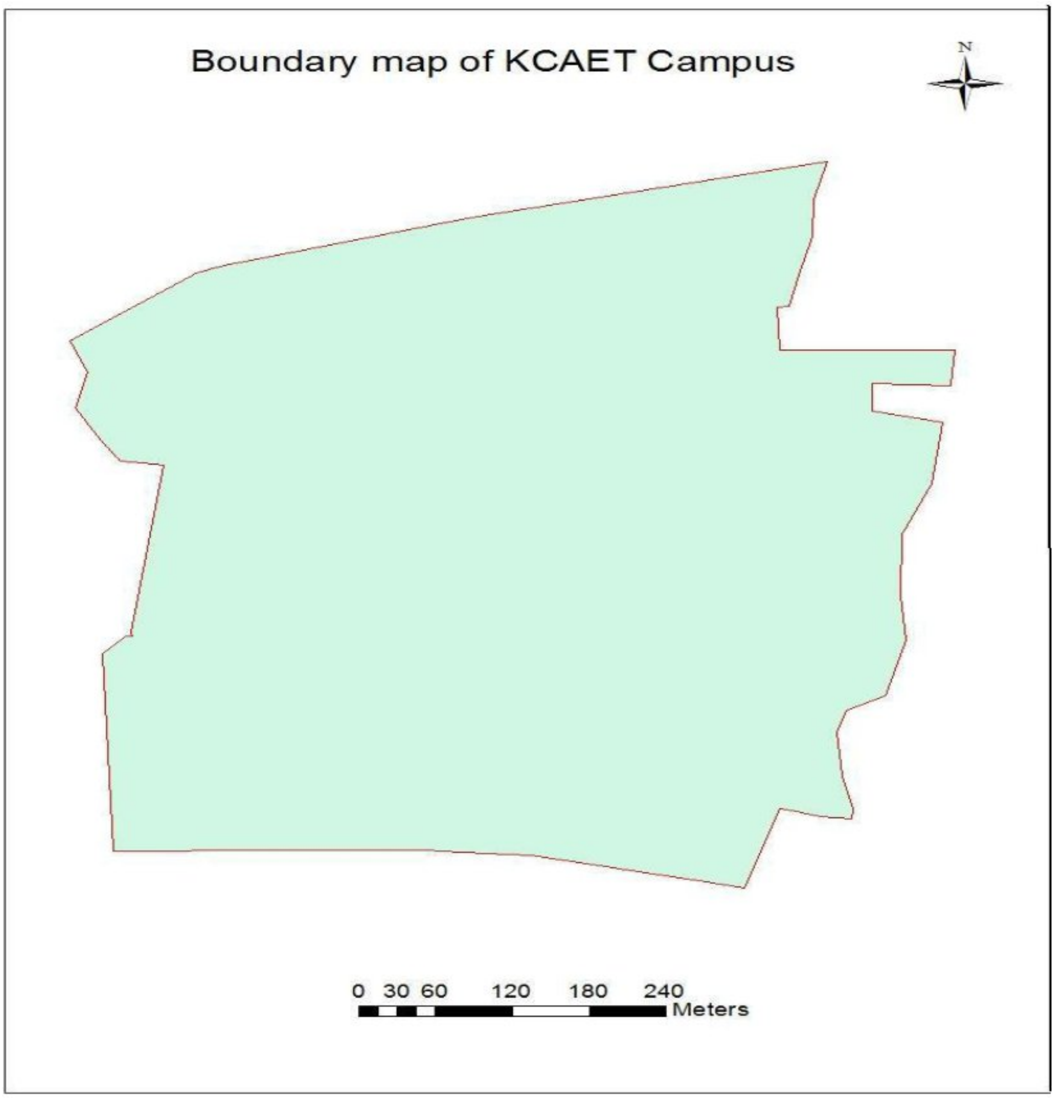

Fig.4.2 Boundary map of KCAET Campus

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 non overlapping triangles. The Fig. 4.2.shows the TIN generated.

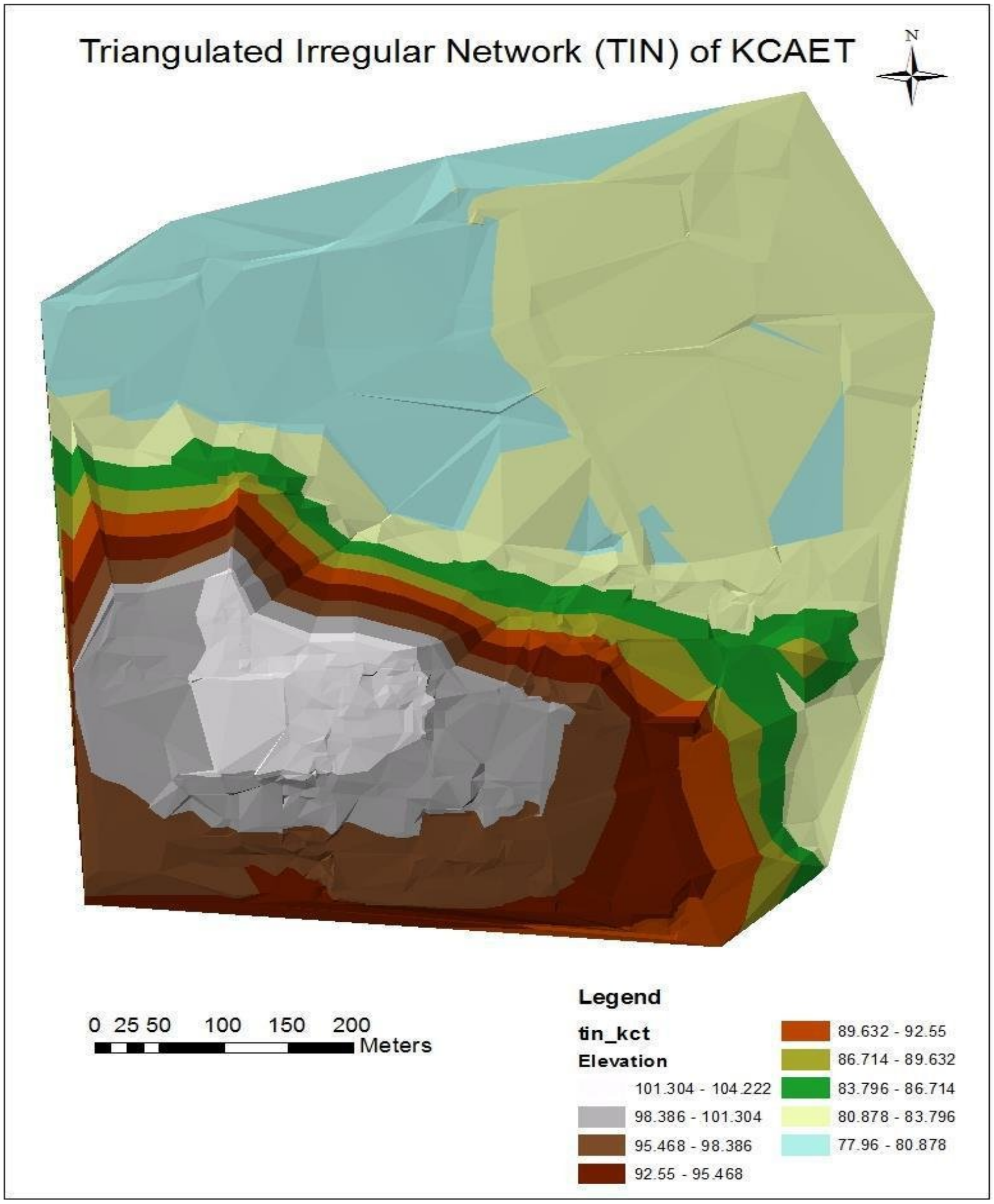

Fig.4.3 TIN of KCAET Campus

From the Figure 4.3, 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 white color in this TIN map. It has an elevation ranging between 101.304m to 104.222m. The lowest elevation points of surveyed area were in between 77.96m and 80.878m. It is shown in blue color in the TIN map.

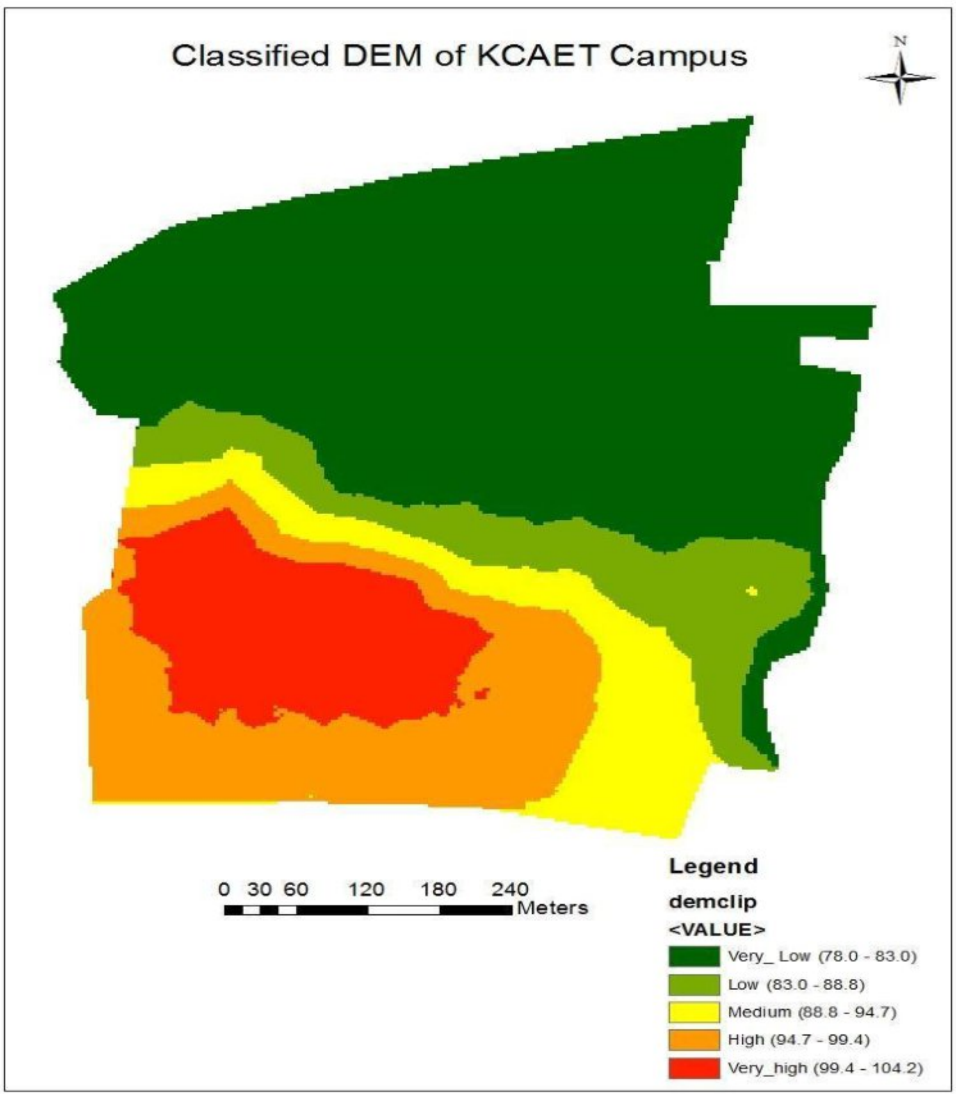

Fig.4.4 DEM of KCAET Campus

A Digital Elevation Model (DEM) is a digital cartographic/geographic dataset of elevations in xyz coordinates. The terrain elevations for ground positions are sampled at regularly spaced horizontal intervals. The maximum elevation of the campus is 99.4 – 104.2m and minimum elevation is 78 – 83m.

A contour map is a topographic map on which the shape of the land surface is shown by contour lines, the relative spacing of the lines indicating the relative slope of the surface.

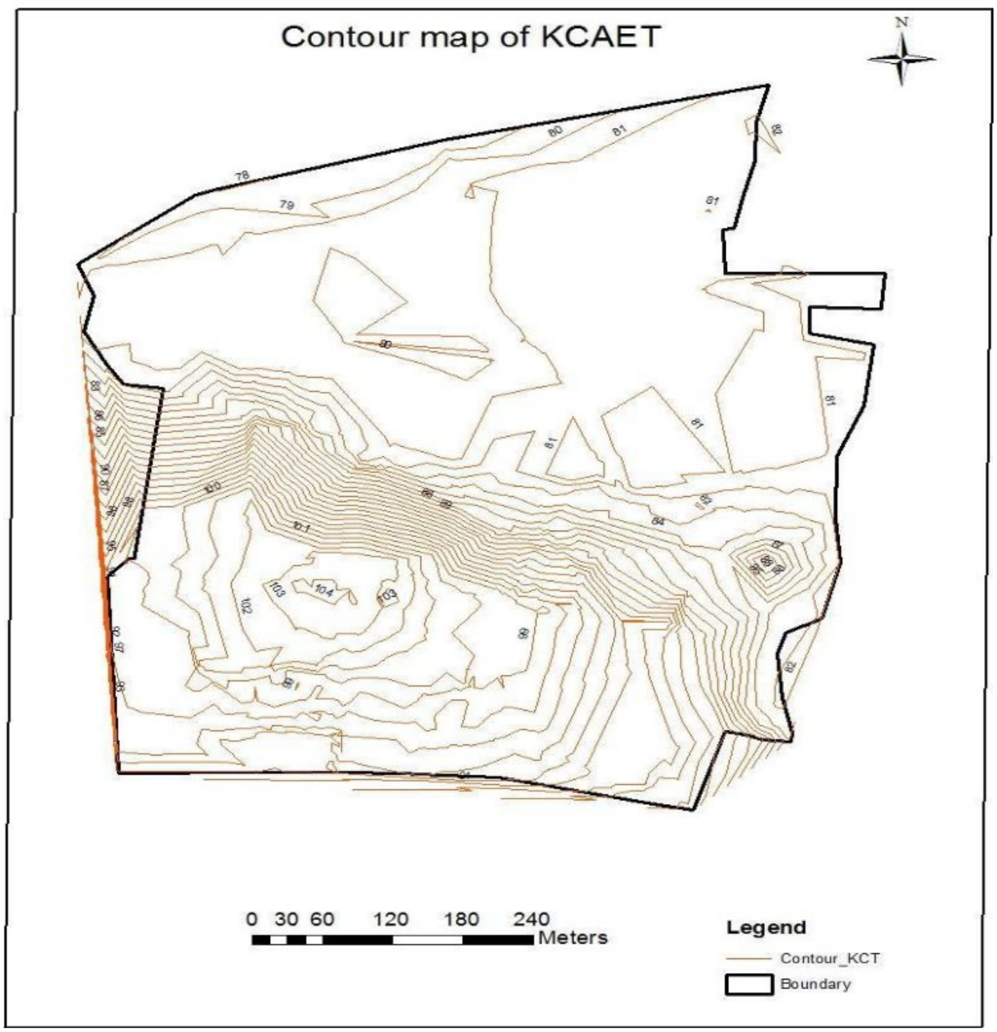

Fig. 4.5 Contour map of KCAET Campus

In a 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 78m is the lowest point.

Slope map was created from the surveyed points and is shown in figure 4.4. This map provides a colorized representation of slope, generated dynamically using a server-side slope function on the Terrain layer followed by the application of a color map.

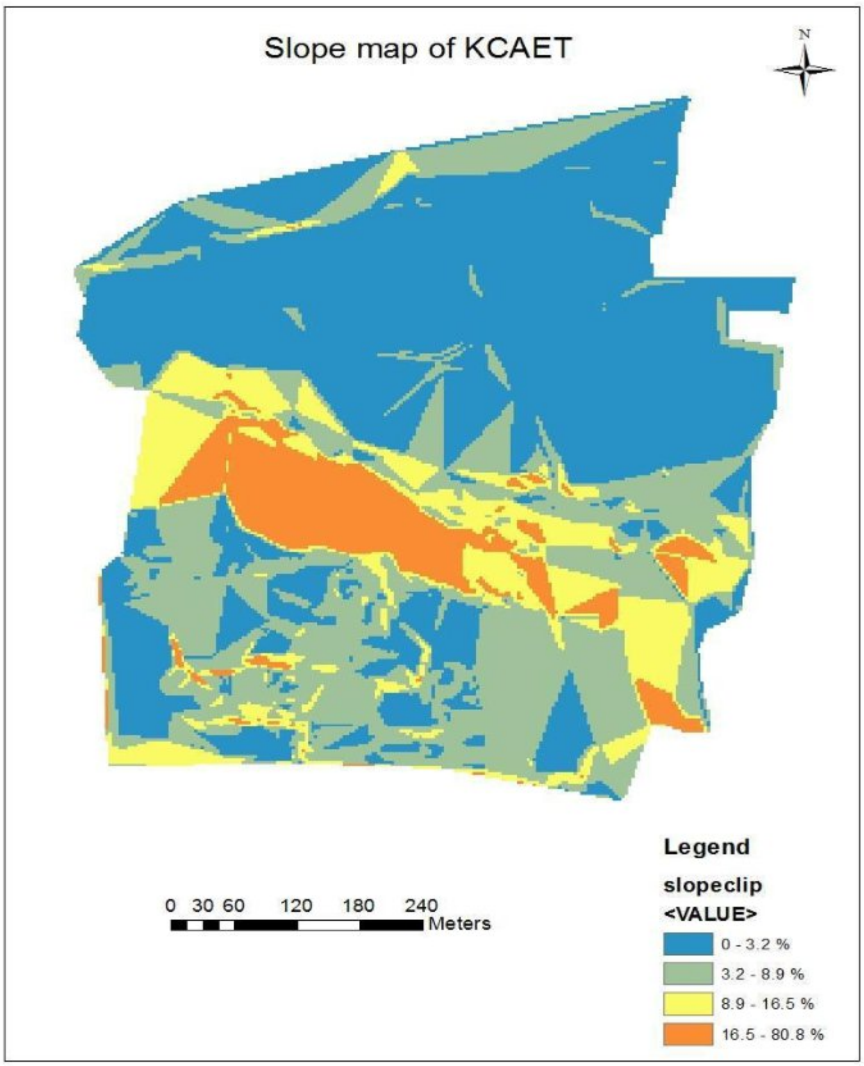

Fig.4.6 Slope map of KCAET campus

The degree of slope is represented by a color map that represents flat surfaces as gray, shallow slopes as light yellow, moderate slopes as light orange and steep slopes as red-brown. . The region with higher slope is represented by orange colored patches which range between 16.5 to 80.8 %, whereas regions with lowest slope are shown by blue colored patches. It ranges between 0 to 3.2 %.

Flow accumulation map was also obtained. FAM is a high resolution map which gives generation of flow lines from a small area.

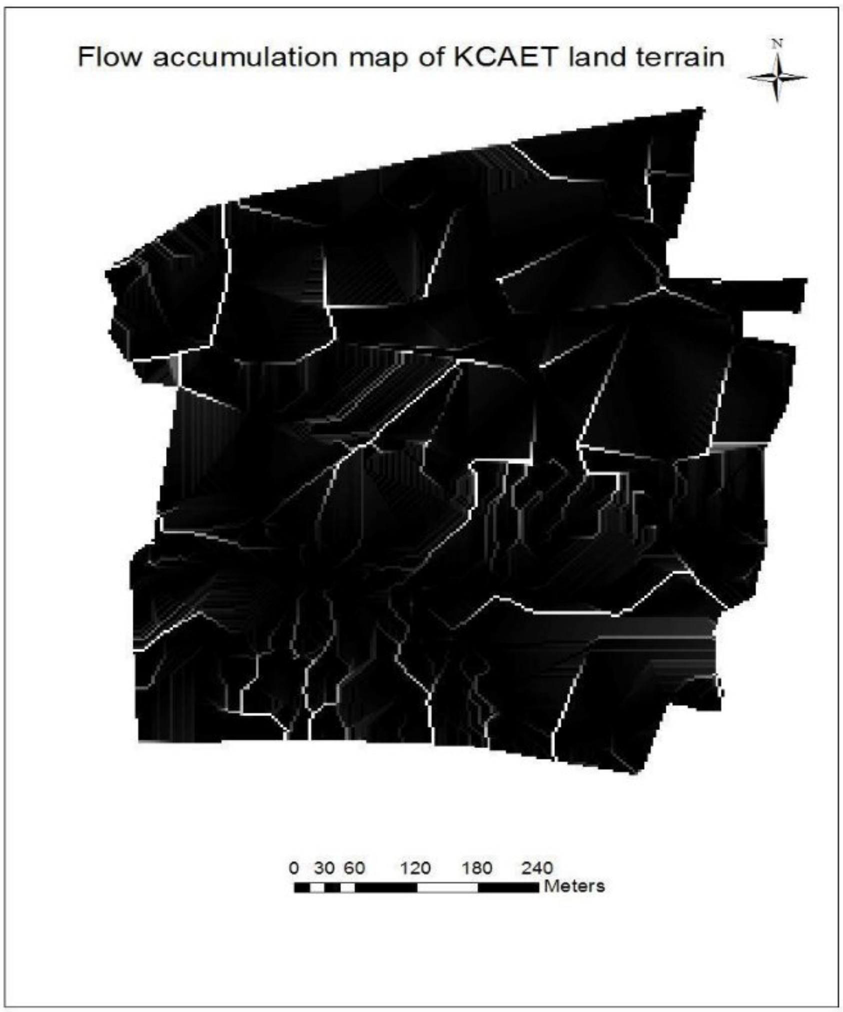

Fig.4.7 Flow accumulation map of KCAET Campus

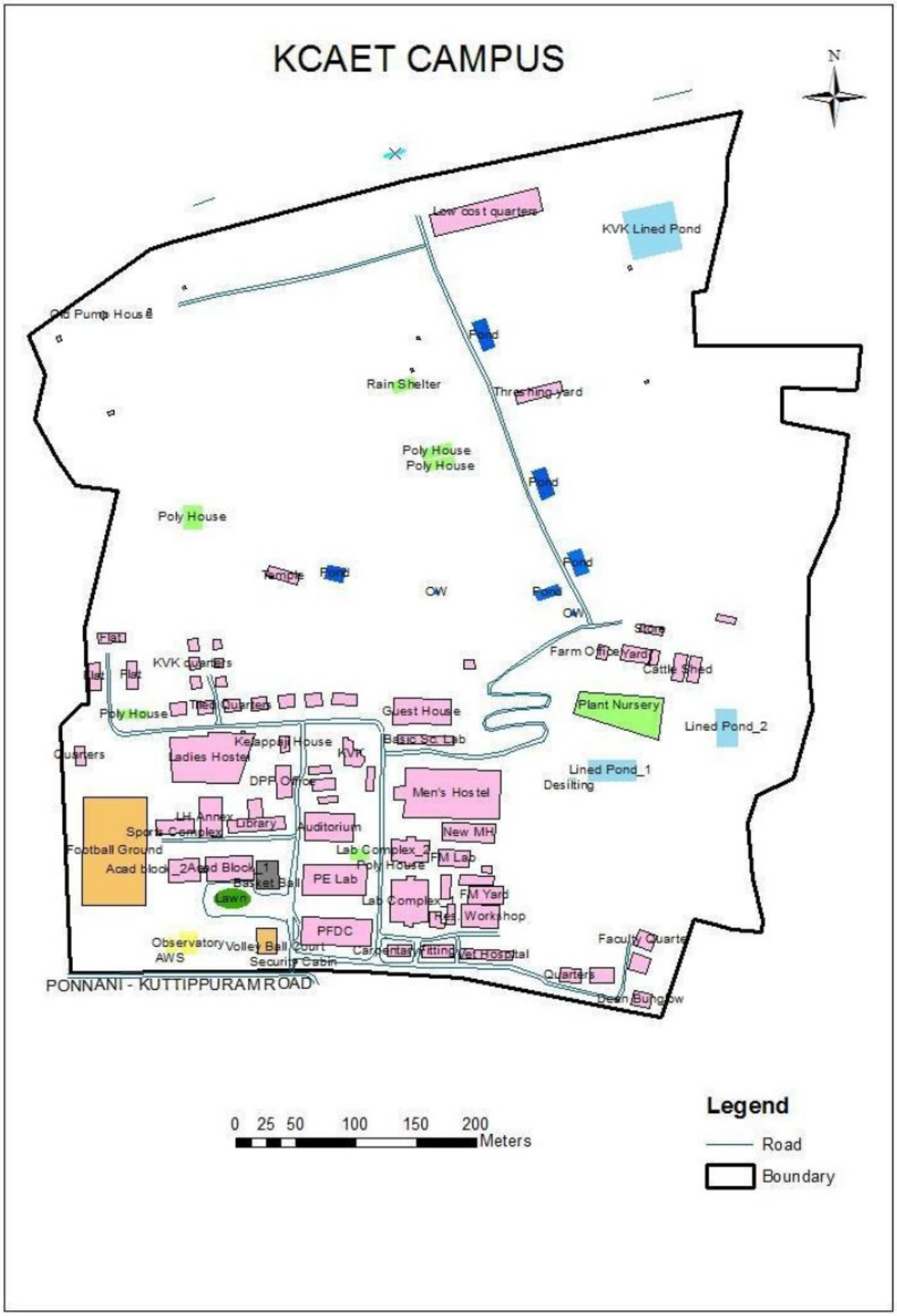

Fig.4.8. Building plot of KCAET Campus

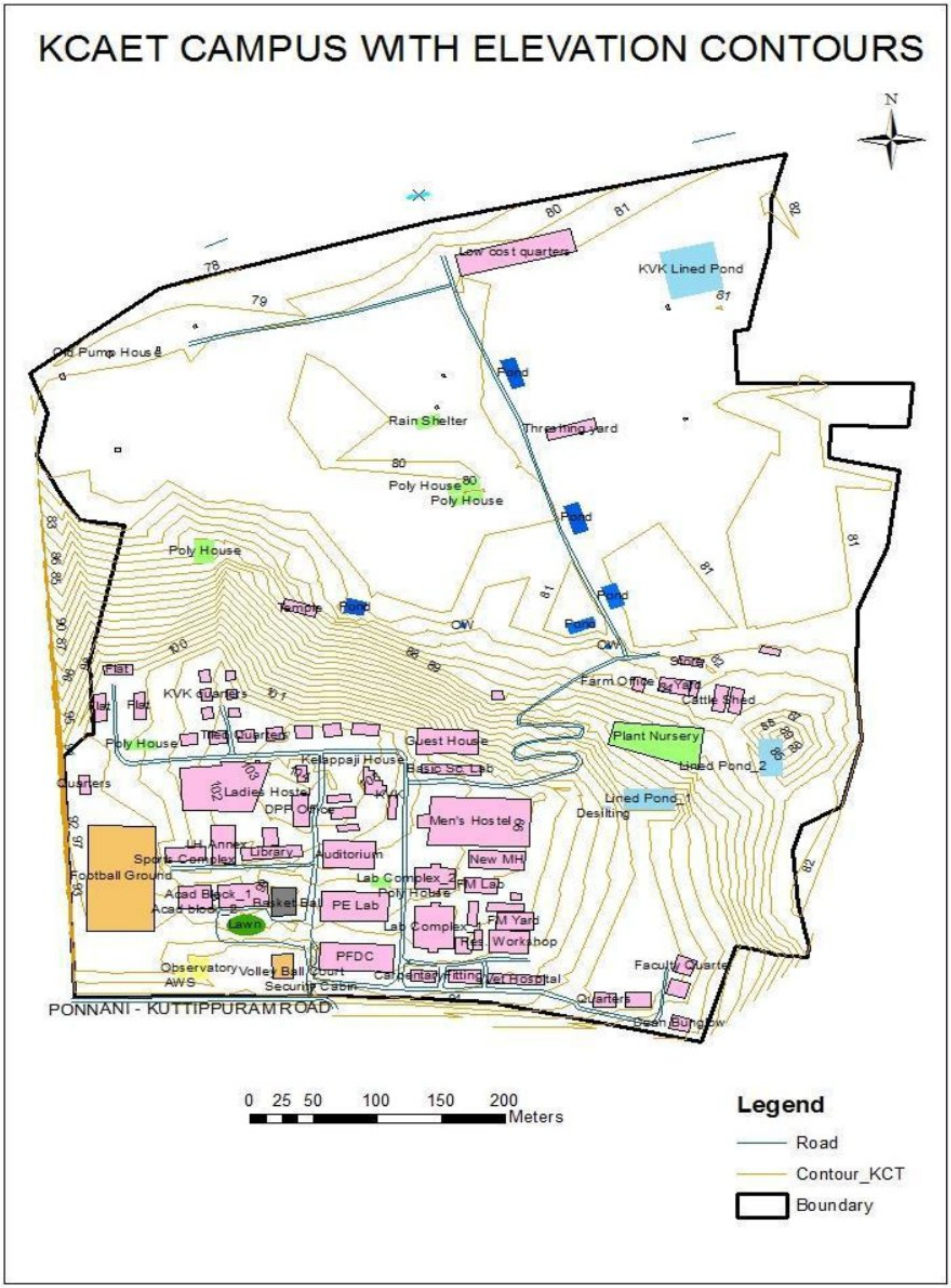

Fig.4.9 Building plot of KCAET Campus with elevation contours

Fig.4.8. shows the building plot of KCAET campus which include all the important buildings, farm ponds, pump houses and main roads which was plotted using ArcGIS software.

Fig.4.9. shows building plot of KCAET campus with elevation contours.

SUMMARY AND CONCLUSION

Chapter 5

SUMMARY AND CONCLUSIONS

The main purpose of this project work is to prepare Natural resource map of KCAET campus. The Natural resource map is important to know about the expanse of natural resources found on and in the surface of the Earth and for soil and water conservation studies. For this purpose, the main equipment used was Total station. As part of this project, the principles and working of Total station was studied. Using Total station, the whole area of KCAET campus was surveyed and the coordinates of 1026 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 of plotting the data using GIS software. So, for georeferencing, we used a hand held GPS to find out latitude and longitude of some of the points. But the values obtained from the hand held GPS was less accurate, and hence a DGPS was employed for the purpose. Using the field collected data, TIN, Digital Elevation Models, contour map, slope map, flow directional map, and flow accumulation map was generated. GNSS was also adopted for surveying some points in the same area. Post process kinematic survey was adopted for this. These points were post processed in PC using Trimble Business Centre Software. 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 is efficient equipment 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. So in order to reduce these limitations, DGPS can be used for georeferencing. In Kerala terrain, working with DGPS alone does not give good results whereas that in combination with TSS give better and satisfactory results and a map with good accuracy and great speed could be generated. DEMs were prepared from these data using ArcGIS. Contour map can be made interactive to accommodate various engineering planning requirements and to provide a 3D view of 2D maps. A slope map was prepared from data collected using TSS. Based on the slope ranges obtained, various conservation measures for the area can be planned and adopted. Flow directional map (FDM) and Flow accumulation map (FAM) was also obtained. FAM helps in planning and design of water conservation structures and also explains surface and subsurface flow. Also the building plot of KCAET campus which include all the important buildings, farm ponds, pump houses and main roads which was plotted using ArcGIS software.

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APPENDICES

APPENDICES

Appendix I

Point list of Total Station survey

Point ID	Northing (m)	Easting (m)	Elevation (m)	Point Name
P1	2000	2000	100	S1
P2	2005.694	2000	100.728	N
P3	2006.27	2016.265	101.1	BC
P4	2029.303	2016.772	102.121	BC
P5	1999.747	1974.979	99.253	BC
P6	1979.848	1973.761	99.384	BC
P7	1986.575	2015.771	99.814	BC
P8	2028.048	2005.335	102.339	RE
P9	1964.908	2003.054	98.4	RE
P10	1992.11	1975.153	99.396	FP
P11	1992.522	1977.005	99.383	FP
P12	1991.959	1979.986	99.318	FP
P13	2002.348	1976.435	99.714	FP
P14	2003.969	1967.5	99.942	FP
P15	1991.296	1987.656	99.337	FP
P16	1990.967	1991.938	99.541	FP
P17	1990.424	1999.608	99.555	FP
P18	1988.709	2003.484	99.579	FP
P19	1999.53	2003.495	100.265	FP
P20	2001.223	2007.383	100.438	FP
P21	2002.391	2009.913	100.597	FP
P22	2001.104	2047.737	100.479	FP
P23	2002.212	2047.725	100.522	FP
P24	2025.249	2010.746	102.1	GP
P25	2008.983	2009.311	100.929	GP
P26	1995.355	2011.646	100.208	GP
P27	1992.732	2035.092	99.54	GP
P28	1990.779	2047.125	99.62	GP
P29	2004.523	1992.517	101.194	GP
P30	1997.703	1991.579	99.423	WP
P31	1989.4	1975.922	98.534	BB

P32	1988.124	1994.927	98.9	BB
P33	1957.697	1974.78	98.349	BB
P34	2010.022	2003.879	100.986	RE
P35	2012.142	1997.134	101.398	RE
P36	2009.239	2008.947	100.94	RE
P37	2013.228	2012.568	101.271	RE
P38	2027.386	2009.06	102.352	RE
P39	2022.525	2012.838	101.851	RE
P40	1950.655	2006.248	97.438	S2
P41	1960.742	2014.885	98.723	S2
P42	1957.21	2016.564	97.757	PH
P43	1942.474	2014.48	97.047	BC
P44	1947.722	2006.722	97.164	RE
P45	1942.568	2007.203	96.963	RE
P46	1937.154	2010.219	96.994	RE
P47	1936.771	2013.808	97.023	RE
P48	1938.868	2001.469	96.664	RE
P49	1955.953	2001.331	97.769	RE
P50	1951.466	1988.317	97.259	RE
P51	1946.136	1988.334	97.104	RE
P52	1952.698	1992.269	98.082	GP
P53	1961.69	1998.38	97.956	GP
P54	1964.022	2006.837	98.418	RE
P55	1968.409	2006.541	98.679	RE
P56	1972.009	2010.294	98.916	RE
P57	1982.07	2006.766	99.329	RE
P58	1986.286	2007.7	99.515	RE
P59	1920.449	2004.528	95.856	RE
P60	1912.888	2004.213	95.466	RE
P61	1924.334	2009.754	96.529	RE
P62	1919.425	2010.665	96.322	RE
P63	1903.754	2000.226	95.146	RE
P64	1912.664	2001.204	95.444	RE
P65	1907.31	2011.029	95.653	S3
P66	1919.613	2013.831	97.022	BC
P67	1906.62	2007.02	95.267	BC
P68	1906.887	2009.62	95.604	BC
P69	1899.887	2013.646	95.537	BWT
P70	1912.718	2008.932	95.639	RE

P71	1910.565	2026.481	96.091	RE
P72	1902.087	2023.261	95.737	GW
P73	1919.375	1989.934	95.436	GW
P74	1907.424	2069.948	96.266	S4
P75	1896.508	2066.877	95.958	BWT
P76	1895.828	2076.689	96.114	BWT
P77	1906.316	2068.065	96.302	RE
P78	1914.254	2075.359	96.551	RE
P79	1912.918	2079.094	96.504	RE
P80	1905.043	2082.858	96.306	RE
P81	1922.225	2080.246	96.955	RE
P82	1925.116	2083.549	97.097	RE
P83	1927.981	2084.714	97.173	RE
P84	1932.718	2079.871	97.359	RE
P85	1917.822	2072.084	96.983	BC
P86	1910.135	2085.425	96.51	BC
P87	1919.652	2085.79	96.775	BC
P88	1909.46	2104.784	96.491	BC
P89	1909.194	2114.468	96.36	BC
P90	1904.087	2114.28	96.208	RE
P91	1904.334	2110.778	96.217	RE
P92	1896.962	2109.314	95.873	GP
P93	1934.092	2076.164	97.495	S100
P94	1900.74	2140.403	95.823	S5
P95	1908.325	2140.174	96.038	BC
P96	1919.344	2140.484	96.296	BC
P97	1916.069	2145.937	96.182	BC
P98	1908.219	2145.659	95.937	BC
P99	1906.808	2189.689	95.358	BC
P100	1901.181	2191.053	94.994	RE
P101	1899.475	2186.396	95.078	RE
P102	1886.169	2216.653	93.681	RE
P103	1891.223	2212.162	94.028	RE
P104	1891.706	2147.182	95.219	BW
P105	1897.404	2167.348	95.201	GP
P106	1896.985	2185.687	95.004	GP
P107	1896.016	2187.014	94.644	GP
P108	1889.439	2184.291	94.936	GP
P109	1889.087	2185.321	94.463	GP

P110	1883.554	2220.6	93.35	S6
P111	1922.861	2143.186	96.561	S200
P112	1888.226	2228.731	93.384	BC
P113	1900.102	2228.77	93.527	BC
P114	1887.579	2246.009	93.342	BC
P115	1887.754	2253.45	93.349	BC
P116	1879.972	2232.081	92.865	RE
P117	1898.99	2225.655	94.124	GP
P118	1873.602	2241.454	92.337	GP
P119	1871.175	2247.041	91.614	GP
P120	1877.013	2273.58	91.469	S7
P121	1871.04	2274.21	91.068	WP
P122	1868.752	2273.509	91.123	WP
P123	1869.775	2278.767	91.193	WP
P124	1871.245	2280.107	91.443	DGP
P125	1874.742	2281.05	91.459	DGP
P126	1870.074	2287.896	91.355	BC
P127	1881.386	2290.522	91.411	BC
P128	1865.011	2278.384	91.546	BW
P129	1858.379	2313.122	90.707	BW
P130	1889.135	2285.444	91.781	BW
P131	1894.851	2300.524	92.172	BC
P132	1912.775	2289.829	93.065	BC
P133	1919.078	2290.302	93.946	BC
P134	1875.954	2271.134	91.514	RE
P135	1873.549	2271.803	91.449	RE
P136	1882.586	2281.892	91.934	RE
P137	1883.765	2279.949	91.969	RE
P138	1921.241	2287.394	93.955	RE
P139	1916.85	2287.697	93.88	S8
P140	1887.444	2273.69	93.184	BC
P141	1900.137	2273.992	93.418	BC
P142	1894.395	2275.261	93.191	GP
P143	1881.589	2258.443	92.279	GP
P144	1915.071	2182.696	96.258	BC
P145	1927.681	2183.713	96.355	BC
P146	1933.577	2177.657	96.402	BC
P147	1934.469	2146.628	97.121	BC
P148	1953.175	2147.248	97.569	BC

P149	1953.331	2141.649	97.831	BC
P150	1936.622	2141.134	97.575	BC
P151	1936.808	2134.551	97.704	BC
P152	1933.357	2131.876	97.708	BC
P153	1934.027	2132.614	97.698	BC
P154	1937.135	2132.736	97.742	BC
P155	1933.905	2119.866	97.742	BC
P156	1937.821	2106.207	97.808	BC
P157	1934.555	2106.074	97.862	BC
P158	1934.773	2098.928	97.89	BC
P159	1919.543	2114.778	96.586	BC
P160	1918.984	2105.16	96.683	BC
P161	1922.479	2114.019	96.696	RE
P162	1920.692	2112.527	96.679	RE
P163	1921.266	2107.797	96.769	RE
P164	1923.05	2106.123	96.918	RE
P165	1925.429	2106.55	96.924	RE
P166	1924.788	2119.822	96.724	RE
P167	1922.516	2120.363	96.702	RE
P168	1928.659	2138.409	96.836	RE
P169	1934.744	2142.498	97.238	RE
P170	1934.588	2145.717	97.092	RE
P171	1929.76	2148.028	96.728	RE
P172	1927.321	2179.245	96.192	RE
P173	1929.683	2177.524	96.197	RE
P174	1927.102	2145.598	96.648	RE
P175	1953.215	2145.475	97.639	RE
P176	1953.161	2143.302	97.633	RE
P177	1958.653	2141.798	98.003	S200
P178	1919.194	2162.219	96.079	GP
P179	1930.868	2106.971	97.24	GP
P180	1957.079	2137.226	98.078	BC
P181	1977.401	2137.858	98.668	BC
P182	1977.141	2145.364	98.594	BC
P183	1969.66	2145.131	98.203	BC
P184	1968.506	2153.27	98.054	BC
P185	1953.711	2152.511	97.765	BC
P186	1953.144	2181.428	97.738	BC
P187	1980.935	2137.666	98.81	S11

P188	1977.375	2139.283	98.604	GA
P189	1977.252	2143.766	98.603	GA
P190	1953.289	2142.328	97.734	GA
P191	1953.145	2146.415	97.664	GA
P192	1958.803	2148.103	97.952	GP
P193	1985.412	2127.554	98.945	BC
P194	1988.049	2119.792	99.962	BC
P195	1977.663	2130.362	98.745	BC
P196	1973.268	2119.492	97.936	BC
P197	1984.533	2153.171	98.996	BC
P198	1979.418	2163.269	98.219	BC
P199	1985.021	2163.454	98.252	BC
P200	1976.306	2174.002	98.472	BC
P201	1979.027	2171.751	98.184	BC
P202	1978.109	2171.054	98.17	CA
P203	1977.331	2171.097	98.153	CA
P204	1980.985	2155.834	98.616	GP
P205	1980.463	2113.318	98.75	CA
P206	1980.992	2113.395	98.644	CA
P207	1987.805	2121.888	99.03	S12
P208	1938.539	2087.135	97.924	BC
P209	1938.053	2099.025	97.885	BC
P210	1973.78	2088.379	98.115	BC
P211	1988.915	2088.463	100.079	BC
P212	1960.684	2067.403	98.819	BC
P213	1982.387	2083.576	99.255	CA
P214	1981.411	2083.546	99.223	CA
P215	2006.179	2081.765	100.176	RE
P216	2005.506	2078.95	100.145	RE
P217	1977.403	2084.832	98.277	GP
P218	1979.314	2088.514	99.111	GP
P219	1968.075	2083.704	98.277	GP
P220	1965.238	2074.543	98.795	GP
P221	1940.568	2072.688	97.335	BC
P222	2011.03	2083.329	100.285	S14
P223	1955.719	2080.494	98.345	RE
P224	1955.678	2077.738	98.303	RE
P225	1998.781	2054.534	100.218	BC
P226	2005.201	2056.767	100.558	BC

P227	2028.312	2057.376	101.249	BC
P228	1998.455	2071.092	100.131	BC
P229	1989.061	2070.852	100.017	BC
P230	2006.867	2089.035	100.305	BC
P231	2006.575	2101.425	100.3	BC
P232	2009.742	2101.555	100.226	BC
P233	2009.484	2108.693	100.309	BC
P234	2016.44	2091.19	100.71	BC
P235	2018.826	2087.314	100.638	BC
P236	2027.41	2090.564	100.832	BC
P237	2032.9	2087.601	100.879	BC
P238	2047.486	2074.198	101.915	BC
P239	2047.759	2067.799	101.89	BC
P240	2042.426	2082.096	101.241	RE
P241	2044.766	2085.033	101.286	RE
P242	2047.027	2085.137	101.304	RE
P243	2050.489	2082.299	101.41	RE
P244	2050.459	2079.483	101.448	RE
P245	2062.314	2082.408	101.577	RE
P246	2070.397	2080.249	101.693	RE
P247	2089.336	2079.286	101.747	S15
P248	2067.644	2068.416	101.921	BC
P249	2067.4	2075.157	101.939	BC
P250	2040.109	2090.755	100.525	BC
P251	2051.141	2091.104	100.205	BC
P252	2051.814	2100.263	100.27	BC
P253	2066.879	2100.732	100.078	BC
P254	2086.454	2093.334	100.412	BC
P255	2094.579	2093.592	100.511	BC
P256	2124.657	2090.441	100.157	BC
P257	2103.139	2090.032	100.348	BC
P258	2102.728	2101.17	99.808	BC
P259	2103.986	2105.552	99.061	BC
P260	2080.976	2062.846	102.859	BC
P261	2089.327	2056.619	102.888	BC
P262	2083.028	2056.483	103.348	BC
P263	2081.121	2058.2	103.341	BC
P264	2089.492	2052.405	102.96	BC
P265	2092.563	2052.488	102.931	BC

P266	2076.692	2062.839	102.994	BC
P267	2076.632	2066.04	102.62	BC
P268	2071.882	2065.93	102.62	BC
P269	2067.615	2062.646	102.334	BC
P270	2083.433	2078.326	101.776	LW
P271	2082.477	2073.316	102.102	LW
P272	2084.612	2070.181	102.43	LW
P273	2090.03	2067.5	102.651	LW
P274	2093.194	2063.245	102.815	LW
P275	2096.89	2059.456	102.986	LW
P276	2102.634	2059.335	103.299	LW
P277	2102.308	2072.238	102.148	LW
P278	2101.557	2075.781	101.95	LW
P279	2096.453	2078.59	101.865	LW
P280	2071.537	2141.579	99.811	S16
P282	2077.099	2092.275	101.066	RE
P283	2080.136	2091.174	101.095	RE
P284	2081.929	2084.383	101.425	RE
P285	2075.946	2075.175	101.866	RE
P286	2096.663	2082.604	101.744	RE
P287	2096.554	2079.985	101.668	RE
P288	2106.927	2074.545	102.077	RE
P289	2103.974	2074.06	101.966	RE
P290	2104.085	2059.8	103.149	RE
P291	2103.871	2050.702	103.424	RE
P292	2107.531	2049.294	103.557	RE
P293	2119.422	2039.175	103.179	BC
P294	2118.815	2060.195	103.101	BC
P295	2113.132	2064.256	102.798	GP
P296	2112.314	2077.871	101.323	GP
P297	2094.56	2086.488	101.513	GP
P298	2094.568	2087.149	100.807	GP
P299	2066.151	2090.28	101.031	GP
P300	2109.745	2036.884	103.779	S17
P301	2118.801	2030.947	103.41	BC
P302	2117.819	2017.447	103.543	BC
P303	2129.18	2030.272	102.757	BC
P304	2068.625	2049.557	102.954	BC
P305	2069.119	2037.98	103.622	BC

P306	2062.827	2038.29	103.375	BC
P307	2058.36	2041.339	103.066	BC
P308	2048.855	2042.069	102.893	BC
P309	2043.431	2044.304	102.697	BC
P310	2073.578	2026.706	104.009	BC
P311	2088.512	2026.067	103.962	BC
P312	2088.251	2020.07	104.012	BC
P313	2079.928	2004.361	104.082	BC
P314	2093.192	2003.837	104.11	BC
P315	2103.874	2027.267	103.86	RE
P316	2106.752	2026.812	103.94	RE
P317	2092.933	2017.054	103.908	RE
P318	2094.106	2013.034	103.946	RE
P319	2102.633	2007.97	103.913	RE
P320	2105.601	2008.154	103.949	RE
P321	2100.3	2036.464	103.892	GP
P322	2098.381	2037.298	103.612	GP
P323	2097.692	2043.214	103.447	GP
P324	2097.554	2043.354	103.081	GP
P325	2077.583	2044.725	103.347	GP
P326	2077.615	2044.817	102.96	GP
P327	2098.416	2055.156	103.323	GP
P328	2098.288	2055.17	102.916	GP
P329	2090.604	2032.683	103.846	GP
P330	2119.567	2012.762	103.445	GP
P331	2073.602	2006.35	104.03	S400
P332	2100.837	1982.725	103.942	S18
P333	2117.132	2008.312	103.258	BC
P334	2116.183	1994.887	103.253	BC
P335	2126.449	1994.075	103.089	BC
P336	2115.565	1985.823	102.884	BC
P337	2114.61	1972.328	102.906	BC
P338	2095.14	1974.98	104.222	BC
P339	2094.8	1966.707	103.728	BC
P340	2097.719	1966.402	103.579	BC
P341	2097.569	1963.592	103.37	BC
P342	2098.707	1963.522	103.11	BC
P343	2102.119	1934.704	102.222	S19
P344	2113.957	1963.304	102.577	BC

P345	2113.029	1949.839	102.341	BC
P346	2123.318	1949.056	102.261	BC
P347	2112.427	1940.901	102.223	BC
P348	2111.49	1927.375	101.983	BC
P349	2096.592	1936.364	102.333	BC
P350	2093.126	1936.554	102.643	BC
P351	2091.612	1904.106	101.41	BC
P352	2121.182	1917.682	101.381	BC
P353	2122.752	1947.017	102.333	S500
P354	2101.94	1940.542	102.343	RE
P355	2105.506	1943.533	102.599	RE
P356	2105.817	1946.573	102.631	RE
P357	2102.52	1949.113	102.552	RE
P358	2100.025	1948.928	102.556	RE
P359	2100.301	1965.591	103.213	RE
P360	2100.004	1976.537	103.759	RE
P361	2097.262	1902.127	101.325	RE
P362	2099.554	1902.245	101.262	RE
P363	2099.131	1897.812	101.13	RE
P364	2096.815	1897.791	101.158	RE
P365	2096.313	1890.942	100.621	RE
P366	2098.508	1890.892	100.583	RE
P367	2095.679	1919.689	102.008	GP
P368	2096.438	1913.251	101.624	GP
P369	2093.193	1904.94	101.708	GP
P370	2104.585	1909.289	101.38	GP
P371	2092.221	1852.931	99.204	S20
P372	2069.207	1834.166	98.705	BC
P373	2085.152	1833.798	98.743	BC
P374	2084.933	1825.152	98.698	BC
P375	2099.779	1833.25	98.674	BC
P376	2099.519	1824.653	98.746	BC
P377	2115.704	1832.957	98.894	BC
P378	2100.828	1812.864	98.684	BW
P379	2119.378	1835.997	99.091	BW
P380	2119.597	1831.136	99.062	BW
P381	2123.411	1835.325	99.122	BW
P382	2114.513	1861.062	99.865	BC
P383	2106.464	1861.185	99.625	BC

P384	2093.551	1865.922	99.714	RE
P385	2096.419	1865.661	99.745	RE
P386	2105.964	1855.814	99.375	RE
P387	2105.376	1853.061	99.324	RE
P388	2104.983	1847.65	98.88	GP
P389	2093.866	1841.053	98.738	GP
P390	2102.313	1869.096	99.7	GP
P391	2079.463	1864.712	99.688	GP
P392	2131.433	1858.375	99.308	S21
P393	2115.273	1887.093	100.416	BC
P394	2131.309	1846.617	99.228	BC
P395	2130.894	1837.825	99.4	BC
P396	2132.169	1868.592	99.559	BC
P397	2132.414	1877.36	99.761	BC
P398	2154.401	1845.695	99.21	BC
P399	2155.219	1867.921	99.485	BC
P400	2170.293	1844.604	99.517	BC
P401	2171.171	1867.651	99.539	BC
P402	2163.032	1851.357	99.383	RE
P403	2162.65	1853.557	99.4	RE
P404	2160.633	1861.397	99.363	GP
P405	2162.108	1843.78	99.053	GP
P406	2133.157	1930.832	101.941	BC
P407	2143.05	1930.056	101.93	BC
P408	2148.921	1929.63	101.953	BC
P409	2158.913	1928.875	101.934	BC
P410	2164.415	1928.421	101.967	BC
P411	2174.405	1927.71	101.888	BC
P412	2134.152	1942.85	102.174	BC
P413	2134.637	1950.248	102.168	BC
P414	2122.741	1940.066	102.23	BC
P415	2126.104	1941.532	102.297	RE
P416	2126.53	1943.909	102.265	RE
P417	2145.291	1938.453	102.052	RE
P418	2144.382	1935.039	101.983	RE
P419	2147.776	1933.095	101.893	SE23
P420	2141.879	1942.283	102.173	BC
P421	2142.542	1951.157	102.2	BC
P422	2149.895	1941.722	102.236	BC

P423	2150.417	1949.066	102.141	BC
P424	2157.627	1941.105	102.171	BC
P425	2148.364	1920.937	101.91	BC
P426	2142.399	1921.362	101.811	BC
P427	2165.586	1940.504	102.08	BC
P428	2173.367	1939.941	102.145	BC
P429	2187.986	1934.63	101.911	RE
P430	2187.891	1931.924	101.951	RE
P431	1998.375	2127.964	99.537	BC
P432	2020.94	2131.268	99.23	BC
P433	2006.063	2130.562	99.274	BC
P434	2005.948	2120.476	100.142	BC
P435	1997.239	2126.701	98.942	GP
P436	2005.157	2124.925	99.905	GP
P437	2019.897	2127.391	100.069	GP
P438	2013.381	2129.51	99.067	GP
P439	1947.037	2129.847	98.042	BC
P440	1957.422	2129.623	98.243	BC
P441	2000.39	2128.671	99.467	S24
P442	2004.098	2174.172	98.962	BC
P443	1995.994	2173.323	98.799	GP
P444	1997.417	2153.837	98.917	BC
P445	2000.197	2155.048	99.041	PR
P446	2000.375	2149.397	99.039	PR
P447	2005.133	2149.566	99.409	BC
P448	2073.257	2020.739	103.993	BC
P449	2068.189	2019.674	103.822	BC
P450	2061.925	2020.016	103.804	BC
P451	2057.457	2022.106	103.499	BC
P452	2047.676	2022.569	103.269	BC
P453	2042.437	2027.493	103.075	BC
P454	2037.109	2027.785	102.762	BC
P455	2041.761	2006.079	103.474	BC
P456	2068.796	2004.835	103.505	BC
P457	2068.268	1991.994	103.556	BC
P458	2079.659	1996.264	104.071	BC
P459	2067.921	2017	103.793	RE
P460	2071.988	2017.177	103.87	RE
P461	2053.561	2012.027	103.407	RE

P462	2047.015	2011.601	103.21	RE
P463	2062.573	2016.537	103.652	RE
P464	2063.16	2013.627	103.643	RE
P465	2046.122	2008.556	103.517	GP
P466	2041.969	2009.466	102.965	GP
P467	2013.464	2011.386	101.385	S26
P468	2015.884	2000.395	101.794	BC
P469	2025.975	1999.813	102.381	BC
P470	2040.91	1980.51	102.667	BC
P471	2051.212	1977.328	103.1	BW
P472	2028.554	1997.728	102.432	FP
P473	2030.464	1998.888	102.418	FP
P474	2037.204	1989.519	102.733	FP
P475	2056.003	1977.173	103.396	FP
P476	2056.737	1979.356	103.263	FP
P477	2030.048	2009.221	102.381	RE
P478	2027.564	2009.467	102.301	RE
P479	2006.035	1943.1	100.918	S27
P480	2014.935	1976.159	102.239	BC
P481	2014.83	1974.067	102.217	BC
P482	2012.132	2009.059	101.678	GP
P483	2011.937	2009.093	101.331	GP
P484	2011.553	2000.375	101.878	GP
P485	2011.43	2000.341	101.578	GP
P486	2011.256	1993.134	102.17	GP
P487	2011.236	1993.141	101.74	GP
P488	2010.322	1976.284	101.394	GP
P489	2010.26	1974.257	101.329	GP
P490	2009.745	1953.024	102.125	GP
P491	2009.675	1952.363	101.08	GP
P492	2009.628	1951.151	101.091	GP
P493	2009.475	1947.807	101.032	BC
P494	2008.716	1929.689	101.077	BC
P495	1991.096	1934.406	99.305	BC
P496	1992.015	1934.348	99.311	BC
P497	1991.985	1931.855	99.333	BC
P498	1990.786	1903.133	98.855	BC
P499	1993.775	1905.627	100.606	GP
P500	1992.716	1901.746	99.573	GP

P501	1994.439	1931.161	100.592	GP
P502	1993.872	1931.137	99.118	GP
P503	1995.399	1939.624	100.2	GP
P504	1994.533	1939.676	99.044	GP
P505	2000.811	1958.557	100.495	GP
P506	2007.319	1976.568	101.252	FP
P507	2007.199	1974.525	101.136	FP
P508	2003.545	1898.453	100.949	S28
P509	2012.72	1924.423	101.514	BC
P510	2011.471	1893.244	101.283	BC
P511	2006.974	1890.144	100.417	GP
P512	2006.011	1888.416	98.868	GP
P513	1999.049	1893.503	99.856	GP
P514	2007.359	1897.431	101.149	RE
P515	2004.717	1897.763	101.022	RE
P516	1926.465	1832.371	97.597	S29
P517	2041.997	1882.331	98.893	GB
P518	2039.794	1824.219	98.611	GB
P519	1952.687	1831.551	97.883	GB
P520	1952.053	1884.624	97.957	GB
P521	1969.19	1881.889	98.234	GP
P522	1980.587	1869.306	98.307	GP
P523	1997.04	1851.859	98.343	GP
P524	2004.471	1836.343	98.369	GP
P525	2017.651	1846.544	98.552	GP
P526	1919.457	1822.623	97.023	S30
P527	1956.345	1911.555	97.746	S31
P528	1924.03	1879.015	97.677	GP
P529	1896.218	1821.433	94.585	BWC
P530	1911.206	1835.051	96.448	GP
P531	1970.835	1903.703	98.028	BC
P532	1971.919	1929.387	99.114	BC
P533	1972.097	1935.189	99.049	BC
P534	1929.415	1923.969	95.858	BC
P535	1924.472	1913.41	95.979	BC
P536	1923.757	1922.626	95.862	BC
P537	1940.015	1928.981	96.524	GP
P538	1944.871	1928.224	97.121	GP
P539	1955.48	1930.271	97.914	GP

P540	1957.132	1930.484	97.7	GP
P541	1945.593	1907.343	97.367	GP
P542	1933.793	1904.625	96.057	GP
P543	1949.258	1941.754	97.722	S32
P544	1907.506	1969.276	95.247	S33
P545	1903.876	1936.945	95.804	BC
P546	1897.137	1942.664	94.738	BW
P547	1915.029	1980.594	95.365	VBC
P548	1916.187	2002.987	95.385	VBC
P549	1934.227	2002.022	95.527	VBC
P550	1933.045	1979.698	95.495	VBC
P551	1940.252	1982.881	96.11	GP
P552	1940.281	1984.787	96.243	GP
P553	1939.074	1984.806	95.934	GP
P554	1939.021	1982.99	95.95	GP
P556	1897.443	2012	94.994	BWT
P557	1902.997	2005.283	94.42	WHP
P558	1908.291	2005.489	94.536	WHP
P559	1902.823	1999.692	95.366	WHP
P560	1902.627	1998.372	95.339	WHP
P561	1900.845	1998.417	95.351	WHP
P562	1900.785	1999.841	95.345	WHP
P563	1902.466	1994.197	95.346	WHP
P564	1902.516	1992.604	95.27	WHP
P565	1900.706	1992.476	95.294	WHP
P566	1900.394	1993.917	95.337	WHP
P567	1913.372	1991.258	95.371	GP
P568	1926.566	2010.822	95.616	GP
P569	1937.321	2013.053	96.455	GP
P570	1938.258	2008.488	95.845	GP
P571	1939.562	1968.606	95.784	GP
P572	1939.947	1948.999	95.722	GP
P573	1928.746	1949.114	95.397	GP
P574	1948.338	1951.245	97.29	LP
P575	1948.144	1972.929	97.172	LP
P576	1957.143	1976.957	97.886	LP
P577	1964.484	1969.027	98.706	LP
P578	1965.206	1957.008	98.936	LP
P579	1956.23	1946.319	98.034	LP

P580	1947.01	1950.558	97.236	RE
P581	1943.337	1950.528	97.202	RE
P582	1946.795	1972.666	97.122	RE
P583	1943.104	1982.662	97.05	RE
P584	1946.947	1991.241	97.155	RE
P585	1950.893	1986.892	97.332	RE
P586	1960.972	1981.44	98.016	RE
P587	1966.798	1982.647	98.627	RE
P588	1972.287	1985.74	98.883	RE
P589	1960.621	1941.167	98.474	RE
P590	1970.735	1941.238	98.897	RE
P591	2074.286	2127.423	100.141	S34
P592	2085.363	2140.331	99.746	BC
P593	2078.481	2137.863	99.756	RE
P594	2078.249	2142.968	99.729	RE
P595	2088.461	2145.555	99.212	RE
P596	2086.808	2142.29	99.39	RE
P597	2076.904	2162.508	99.035	RE
P598	2074.532	2162.487	99.038	RE
P599	2077.482	2181.597	98.087	RE
P600	2080.126	2180.849	98.008	RE
P601	2082.605	2119.219	100.176	RE
P602	2074.058	2150.567	99.491	RE
P603	2078.855	2188.548	97.797	S35
P604	2064.547	2179.656	99.102	BC
P605	2091.662	2213.911	95.337	RE
P606	2089.25	2215.712	95.596	RE
P607	2093.838	2220.524	95.098	RE
P608	2096.973	2216.871	94.497	RE
P609	2101.092	2221.132	94.515	S36
P610	2063.22	2210.143	97.788	S37
P611	2074.141	2195.448	98.094	GP
P612	2086.807	2181.702	97.391	GP
P613	2059.289	2235.68	95.913	WHP
P614	2058.18	2243.991	95.478	WHP
P615	2055.979	2243.194	95.509	WHP
P616	2055.63	2252.068	94.096	WHP
P617	2055.231	2292.335	94.02	WHP
P618	2044.695	2204.32	97.665	GP

P619	2039.928	2214.254	97.065	GP
P620	2052.204	2221.368	96.967	GP
P621	2066.806	2222.631	96.639	GP
P622	2068.486	2209.627	97.413	GP
P623	2073.749	2209.443	98.149	GP
P624	2105.459	2216.286	94.122	RE
P625	2102.25	2214.517	94.084	RE
P626	2087.999	2169.752	96.506	RE
P627	2090.602	2171.246	96.362	RE
P628	2094.877	2163.785	96.335	RE
P629	2095.336	2167.813	95.804	RE
P630	2075.526	2189.182	98.064	GP
P631	2068.28	2186.748	99.298	GP
P632	2083.707	2201.184	96.478	GP
P633	2087.145	2192.652	96.059	GP
P634	2089.692	2185.511	95.953	GP
P635	2089.504	2161.679	97.85	GP
P636	2086.572	2157.226	98.863	GP
P637	2083.474	2149.91	99.195	GP
P638	2086.802	2157.093	98.319	GP
P639	2099.287	2177.975	95.05	S38
P640	2128.733	2233.112	89.59	S39
P641	2122.443	2218.852	90.553	RE
P642	2119.432	2218.543	90.587	RE
P643	2121.543	2231.459	90.046	RE
P644	2124.206	2228.566	89.608	RE
P645	2134.125	2226.618	89.368	RE
P646	2130.984	2225.771	89.37	RE
P647	2135.189	2209.321	88.819	RE
P648	2138.4	2210.155	88.633	RE
P649	2127.025	2203.31	91.072	RE
P650	2125.332	2196.675	91.25	RE
P651	2127.591	2213.621	90.447	GP
P652	2126.876	2224.289	90.223	GP
P653	2127.212	2237.275	89.026	GP
P654	2130.57	2245.267	88.523	BC
P655	2126.424	2243.81	88.531	BC
P656	2115.5	2233.515	90.552	GP
P657	2114.435	2238.445	89.495	GP

P658	2111.88	2240.335	89.413	BC
P659	2148.275	2182.387	87.553	S40
P660	2138.419	2199.415	88.227	GP
P661	2142.579	2217.757	88.63	GP
P662	2141.347	2187.31	88.965	GP
P663	2136.67	2180.456	89.459	GP
P664	2128.076	2178.491	92.103	RE
P665	2144.17	2190.922	88.641	GP
P666	2141.871	2170.916	88.648	GP
P667	2137.959	2165.536	89.824	GP
P668	2149.185	2167.559	87.419	GP
P669	2153.687	2171.623	86.742	GP
P670	2156.985	2157.794	86.784	BC
P671	2149.756	2158.089	86.957	BC
P672	2150.236	2148.917	87.081	BC
P673	2159.224	2173.04	85.808	GP
P674	2160.808	2184.586	85.724	RE
P675	2165.728	2186.538	85.381	RE
P676	2152.126	2190.089	86.712	RE
P677	2150.102	2187.59	86.899	RE
P678	2162.56	2186.051	85.735	RE
P679	2162.046	2189.192	85.553	RE
P680	2168.117	2194.147	85.131	RE
P681	2170.04	2193.172	84.52	GP
P682	2163.9	2198.422	86.031	GP
P683	2157.489	2211.112	86.099	GP
P684	2177.998	2183.733	83.637	GP
P685	2198.217	2185.648	82.798	GP
P686	2193.867	2202.923	82.462	GP
P687	2179.608	2207.701	83.608	GP
P688	2189.505	2247.038	82.698	S41
P689	2172.944	2158.945	85.074	S42
P690	2173.149	2221.882	83.651	RE
P691	2175.877	2221.91	83.582	RE
P692	2185.26	2246.504	82.856	RE
P693	2187.674	2246.133	82.818	RE
P694	2194.746	2250.126	82.185	RE
P695	2195.465	2252.984	82.13	RE
P696	2186.199	2257.461	82.719	RE

P697	2183.199	2255.894	82.85	RE
P698	2179.991	2259.847	82.974	RE
P699	2183.071	2262.164	82.897	RE
P700	2177.167	2263.999	83.035	RE
P701	2173.662	2263.82	83.079	RE
P702	2192.118	2236.845	82.935	BC
P703	2196.103	2234.27	82.979	BC
P704	2190.074	2233.705	83.162	BC
P705	2188.696	2232.888	83.287	BC
P706	2188.592	2227.181	83.751	BC
P707	2168.793	2261.057	83.592	BC
P708	2157.506	2259.215	84.024	BC
P709	2225.501	2242.622	81.46	BC
P710	2229.521	2253.483	80.834	BC
P711	2245.23	2234.624	81.322	BC
P712	2220.111	2227.844	80.661	BC
P713	2212.235	2230.642	80.161	BC
P714	2179.468	2247.618	83.365	GP
P715	2194.656	2259.316	81.223	GP
P716	2196.684	2262.357	80.681	GP
P717	2196.769	2289.192	80.882	GP
P718	2201.852	2316.952	81.041	GP
P719	2209.936	2348.053	81.011	GP
P720	2209.553	2350.842	81.452	RE
P721	2209.834	2354.913	81.504	RE
P722	2210.046	2354.426	81.499	S43
P723	2169.005	2280.88	82.876	BC
P724	2165.211	2304.96	82.64	BC
P725	2153	2303.026	83.119	BC
P726	2180.037	2279.606	82.772	GP
P727	2164.787	2312.355	82.717	S44
P728	2302.584	2207.209	81.361	S45
P729	2164.33	2243.655	83.878	GP
P730	2162.046	2238.275	84.592	GP
P731	2155.331	2236.11	85.477	GP
P732	2222.335	2228.813	80.819	GP
P733	2167.502	2269.201	83.519	BC
P734	2180.114	2294.962	82.278	BC
P735	2176.927	2313.875	82.223	BC

P736	2182.868	2314.945	82.229	BC
P737	2165.036	2305.967	82.706	BC
P738	2164.12	2311.51	82.761	BC
P739	2151.971	2309.519	83.267	BC
P740	2140.11	2321.463	83.647	BC
P741	2162.033	2325.132	83.203	BC
P742	2160.376	2335.039	83.437	BC
P743	2159.883	2337.701	83.671	BC
P744	2158.43	2346.969	83.542	BC
P745	2169.104	2347.391	83.194	RE
P746	2169.99	2344.695	83.292	RE
P747	2167.674	2341.42	83.203	RE
P748	2165.159	2340.936	83.299	RE
P749	2164.109	2326.522	83.003	RE
P750	2166.901	2326.643	83.046	RE
P751	2173.315	2281.852	82.748	RE
P752	2170.45	2281.191	82.757	RE
P753	2170.309	2320.109	82.635	GP
P754	2173.578	2321.226	81.671	GP
P755	2166.502	2355.614	83.124	GP
P756	2170.549	2335.047	83.145	GP
P757	2162.879	2319.646	83.036	RE
P758	2136.142	2320.665	83.783	S46
P759	2161.554	2323.77	83.318	RE
P760	2164.341	2366.435	83.309	S47
P761	2125.285	2315.556	84.721	BC
P762	2090.315	2310.92	86.375	BC
P763	2108.493	2315.024	85.687	RE
P764	2103.941	2316.485	85.864	RE
P765	2130.448	2308.298	84.175	GP
P766	2129.531	2303.656	85.537	GP
P767	2123.982	2311.64	85.655	GP
P768	2138.422	2331.445	83.411	BC
P769	2138.46	2334.499	83.647	BC
P770	2137.131	2343.464	84.019	BC
P771	2131.078	2346.472	84.26	GP
P772	2125.427	2340.256	84.259	GP
P773	2121.475	2319.156	85.167	GP
P774	2076.722	2311.682	87.299	RE

P775	2077.133	2309.411	87.262	RE
P776	2048.77	2306.691	90.422	S48
P777	2185.64	2374.187	82.393	BC
P778	2189.297	2359.007	82.2	BC
P779	2181.919	2365.072	82.568	GP
P780	2162.099	2378.941	83.446	GP
P781	2163.077	2400.19	83.297	GP
P782	2161.658	2434.952	81.955	BW
P783	2163.031	2422.533	82.473	GP
P784	2185.676	2381.466	82.427	GP
P785	2184.41	2396.524	82.186	GP
P786	2142.028	2362.241	84.138	GP
P787	2135.694	2367.197	85.381	GP
P788	2157.353	2148.542	86.737	BC
P789	2162.688	2155.844	85.907	GP
P790	2192.433	2147.332	83.505	GP
P791	2196.354	2162.681	83.003	GP
P792	2175.732	2140.517	85.408	GP
P793	2172.512	2133.538	86.36	GP
P794	2165.093	2127.015	86.691	GP
P795	2185.974	2116.528	84.761	RE
P796	2188.101	2116.907	84.791	RE
P797	2172.514	2117.084	86.75	GP
P798	2201.938	2150.676	82.766	GP
P799	2213.654	2144.408	82.706	GP
P800	2214.155	2047.064	83.479	S49
P801	2219.411	2062.459	81.615	GP
P802	2224.41	2083.392	81.665	GP
P803	2231.718	2070.508	81.625	GP
P804	2238.329	2058.357	81.608	GP
P805	2241.576	2059.13	80.675	GP
P806	2232.443	2051.193	81.294	BC
P807	2219.384	2047.798	82.881	BC
P808	2224.075	2032.271	81.554	BC
P809	2215.984	2026.344	83.774	GP
P810	2218.647	2026.631	83.637	GP
P811	2212.884	2022.024	85.37	GP
P812	2209.835	2043.389	85.243	GP
P813	2227.66	2012.264	83.986	BC

P814	2230.715	2010.499	83.815	RE
P815	2232.089	2012.102	83.654	RE
P816	2242.451	1989.673	85.854	RE
P817	2244.622	1990.317	85.699	RE
P818	2236.407	2020.544	82.629	GP
P819	2244.83	1987.563	85.971	S50
P820	2234.939	1986.857	86.914	BC
P821	2249.48	2015.535	82.923	GP
P822	2256.209	1991.907	83.458	GP
P823	2274.365	2000.273	83.352	GP
P824	2259.64	1977.928	86.128	RE
P825	2257.211	1977.144	86.155	RE
P826	2271.784	1976.737	84.868	GP
P827	2264.416	1970.459	86.014	S51
P828	2268.716	1959.614	86.507	RE
P829	2266.185	1959.648	86.522	RE
P830	2274.052	1961.756	86.292	GP
P831	2278.309	1960.831	85.61	GP
P832	2257.541	1969.142	88.296	GP
P833	2274.546	1938.104	87.124	S52
P834	2278.587	1940.592	86.26	RE
P835	2278.453	1937.602	86.463	RE
P836	2313.257	1942.567	81.467	RE
P837	2313.352	1945.497	81.486	RE
P838	2310.452	1940.832	82.23	GP
P839	2299.434	1937.948	83.677	GP
P840	2288.915	1936.316	85.548	GP
P841	2257.935	1940.243	91.038	GP
P842	2269.009	1940.766	88.041	GP
P843	2274.905	1947.624	87.119	GP
P844	2264.432	1931.357	87.274	BC
P845	2322.883	1944.261	80.652	S53
P846	2284.566	1932.242	86.024	BC
P847	2285.778	1916.372	86.03	BC
P848	2321.651	1925.464	80.479	GP
P849	2341.517	1892.208	80.476	GP
P850	2319.435	1970.944	80.379	GP
P851	2318.267	2007.12	80.297	GP
P852	2347.682	2017.108	79.979	GP

P853	2385.705	2007.261	79.544	GP
P854	2390.326	1982.293	80.183	GP
P855	2418.071	1912.13	80.357	RE
P856	2418.542	1914.206	80.371	RE
P857	2444.507	1903.245	80.129	S54
P858	2328.931	1852.394	80.697	S55
P859	2297.128	1860.389	81.519	BW
P860	2300.996	1826.1	82	BW
P861	2322.643	1811.479	81.384	BW
P862	2356.243	1792.023	80.539	BW
P863	2393.025	1800.586	80.525	BW
P864	2446.006	1888.317	79.718	BC
P865	2448.696	1888.309	79.731	BC
P866	2446.05	1885.749	79.705	BC
P867	2432.337	1827.741	79.406	S55
P868	2430.91	1878.389	80.285	GP
P869	2448.823	1898.986	79.689	GP
P870	2459.737	1895.294	79.597	GP
P871	2497.423	1887.213	78.476	BW
P872	2504.151	1907.566	77.96	BW
P873	2482.548	1915.498	79.121	GP
P874	2467.321	1915.119	79.575	BC
P875	2465.207	1915.723	79.529	BC
P876	2465.773	1917.87	79.596	BC
P877	2470.918	1943.085	79.666	GP
P878	2454.027	1942.503	80.338	GP
P879	2461.908	1945.046	79.782	RE
P880	2459.46	1945.533	79.943	RE
P881	2450.554	1911.628	79.721	RE
P882	2453.031	1910.443	79.606	RE
P883	2445.632	1902.996	80.103	RE
P884	2445.538	1906.174	80.109	RE
P885	2475.295	2002.356	78.989	S56
P886	2440.949	1850.08	79.402	BC
P887	2446.13	1847.34	79.37	BC
P888	2451.457	1838.839	79.08	GP
P889	2424.969	1830.584	80.219	GP
P890	2426.678	1813.093	79.848	BC
P891	2426.074	1810.048	79.89	BC

P892	2422.074	1814.068	80.365	BC
P893	2417.812	1808.698	80.338	GP
P894	2426.2	1786.945	79.488	BW
P895	2434.169	1807.497	78.936	GP
P896	2360.657	1858.155	80.676	BC
P897	2363.935	1857.615	80.704	BC
P898	2363.158	1853.009	80.651	BC
P899	2478.127	2039.85	80.284	RE
P900	2480.227	2039.449	80.162	RE
P901	2475.876	2044.896	80.439	GP
P902	2469.634	2002.676	80.203	GP
P903	2482.597	2022.383	79.45	GP
P904	2488.246	2086.37	80.633	S57
P905	2499.247	2119.001	80.911	RE
P906	2495.897	2119.237	80.902	RE
P907	2392.818	2107.333	80.226	BC
P908	2383.115	2109.809	80.276	BC
P909	2387.856	2087.866	80.131	BC
P910	2399.537	2106.58	80.105	BC
P911	2423.353	2110.233	80.244	BC
P912	2425.547	2109.84	80.251	BC
P913	2426.039	2112.024	80.245	BC
P914	2498.957	2093.976	80.364	GP
P915	2494.609	2073.188	80.339	GP
P916	2194.95	2360.212	82.043	BC
P917	2212.247	2356.43	80.827	GP
P918	2219.254	2382.416	80.804	GP
P919	2228.953	2426.273	80.939	GP
P920	2225.59	2435.569	81.275	BW
P921	2278.536	2459.142	81.426	BW
P922	2343.872	2468.426	81.534	BW
P923	2333.341	2461.521	80.946	GP
P924	2354.363	2413.946	81.408	BW
P925	2345.602	2407.709	80.874	GP
P926	2375.2	2405.063	80.884	GP
P927	2399.953	2406.464	81.123	S58
P928	2382.44	2414.2	81.581	BW
P929	2381.079	2474.258	81.374	BW
P930	2417.673	2479.276	81.457	BW

P931	2416.838	2340.6	81.365	BW
P932	2407.44	2336.051	80.847	GP
P933	2415.791	2400.641	80.916	GP
P934	2408.058	2404.776	81.179	BC
P935	2405.758	2405.266	81.214	BC
P936	2406.245	2407.107	81.105	BC
P937	2369.494	2193.738	81.436	BC
P938	2378.735	2191.287	81.144	BC
P939	2379.815	2232.309	81.253	BC
P940	2386.89	2300.166	81.498	BC
P941	2388.71	2299.764	81.251	BC
P942	2387.352	2302.502	81.342	BC
P943	2379.98	2311.615	81.242	RE
P944	2378.506	2309.07	81.185	RE
P945	2318.045	2216.448	81.067	BC
P946	2293.883	2225.546	81.101	BC
P947	2292.361	2212.765	81.312	BC
P948	2313.526	2205.697	81.333	BC
P949	2228.876	2106.715	80.39	GP
P951	2327.412	2140.977	79.959	BC
P952	2337.095	2138.061	79.945	BC
P953	2370.218	2178.616	81.438	S59
P954	2206.893	2209.037	80.223	BC
P955	2315.432	2189.964	80.652	GP
P956	2319.509	2142.807	80.305	BC
P957	2329.402	2140.466	80.314	BC
P958	2355.161	2184.341	81.384	RE
P959	2354.624	2181.981	81.349	RE
P960	2529.666	2280.34	81.202	BC
P961	2540.141	2322.51	81.258	BC
P962	2489.622	2289.412	81.123	BC
P963	2484.033	2285.367	81.471	BC
P964	2480.797	2286.289	81.54	BC
P965	2481.494	2289.108	81.429	BC
P966	2441.032	2166.598	81.691	BC
P967	2416.393	2175.52	81.127	BC
P968	2412.829	2164.465	81.555	BC
P969	2497.089	2121.564	81.194	S60
P970	2509.392	2124.637	81.016	BC

P971	2526.556	2119.386	80.751	BC
P972	2554.76	2100.148	78.133	BW
P973	2527.221	2108.911	80.958	RE
P974	2527.842	2111.37	80.867	RE
P975	2509.771	2109.799	80.676	GP
P976	2508.281	2157.395	81.213	GP
P977	2494.034	2134.211	80.719	GP
P978	2532.647	2221.878	81.155	BC
P979	2540.878	2293.008	81.676	S61
P980	2485.879	2288.249	81.497	BC
P981	2461.496	2338.569	81.535	BW
P982	2462.483	2348.656	81.366	BW
P983	2481.635	2328.877	80.987	GP
P984	2495.168	2355.757	81.681	BW
P985	2534.087	2365.76	81.549	BW
P986	2573.183	2367.081	82.133	BW
P987	2612.112	2377.914	81.558	BW
P988	2589.437	2327.963	81.445	GP
P989	2546.154	2356.387	81.817	GP
P990	2039.599	2320.136	89.553	GP
P991	2024.469	2309.927	90.592	GP
P992	2002.562	2320.711	89.904	GP
P993	1988.516	2324.852	89.758	GP
P994	2044.28	2299.487	91.034	RE
P995	2042.028	2300.979	91.074	RE
P996	2038.473	2291.361	91.91	RE
P997	2036.862	2293.137	91.823	RE
P998	2004.507	2264.321	93.751	RE
P999	2002.553	2264.768	93.829	RE
P1000	2011.133	2259.429	93.92	GP
P1001	2018.764	2286.622	92.12	GP
P1002	2140.431	2377.866	85.011	S62
P1003	2116.833	2376.077	89.545	WHP
P1004	2135.627	2409.858	83.944	S63
P1005	2115.271	2439.321	81.983	BW
P1006	2122.517	2410.159	84.108	GP
P1007	2149.6	2413.511	84.324	GP
P1008	2148.499	2400.954	84.271	GP
P1009	2128.59	2397.141	85.387	GP

P1010	2108.792	2409.682	84.72	S64
P1011	2057.908	2423.038	81.91	BW
P1012	2080.772	2417.947	81.854	GP
P1013	2081.176	2415.755	82.17	S65
P1014	2078.807	2397.858	82.803	GP
P1015	2068.349	2378.542	83.125	GP
P1016	2048.166	2381.356	82.615	S66
P1018	2042.515	2392.914	82.349	BW
P1019	2019.85	2384.781	82.224	BW
P1020	2015.299	2370.166	82.799	GP
P1021	1967.029	2363.191	83.324	S67
P1022	1939.958	2340.577	90.314	BW
P1023	1936.429	2357.225	88.496	BW
P1024	1931.798	2372.647	87.253	BW
P1025	1939.154	2398.189	82.773	BW
P1026	1929.776	2396.497	83.127	BW
P1027	1946.925	2388.875	82.573	GP
P1028	1947.855	2373.159	83.741	GP
P1029	1969.455	2385.436	81.89	GP
P1030	1974.545	2389.157	81.723	BW

Appendix II

Point list of GPS

Point ID	Latitude	Longitude	Elevation
P6	10°51.153'	75°59.169'	46m
P69	10°51.111'	75°59.196'	25m
P129	10°51.107'	75°59.361'	21m
P247	10°51.219'	75°59.219'	43m
P371	10°51.215'	75°59.094'	43m
P529	10°51.109'	75°59.079'	40m
P545	10°51.115'	75°59.142'	42m
P603	10°51.220'	75°59.280'	38m
P659	10°51.257'	75°59.273'	29m
P760	10°51.276'	75°59.372'	17m
P845	10°51.339'	75°59.130'	23m
P859	10°51.317'	75°59.087'	24m
P865	10°51.401'	75°59.094'	20m
P928	10°51.396'	75°59.384'	16m
P938	10°51.381'	75°59.263'	15m
P970	10°51.447'	75°59.220'	21m
P1026	10°51.147'	75°59.403'	16m

Appendix III

Point list of DGPS

Point ID	Northing	Easting
P1	1199872.018	607810.122
P549	1199807.772	607803.872
P550	1199964.712	607653.95
P247	1199968.318	607879.295
P74	1199786.577	607890.565

NATURAL RESOURCE MAPPING OF KCAET CAMPUS

By

ARJUN.P

ARYA.S.ANAND

ATHIRA.K

ABSTRACT

Submitted in partial fulfillment of the requirement for the degree

Bachelor of Technology

In

Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Land and Water Resources & Conservation Engineering

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2017

ABSTRACT

Topographic map is of great importance for the professional activities of an Agricultural Engineer. Natural resource map is a type of topo map.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 natural resource map of KCAET, Tavanur using modern surveying equipments such as Total Station (Pentax_R200) and DGPS (Trimble). Using the field collected data from Total Station, a topographic map was plotted using ArcGIS10.3 software. TIN, DEM, contour map, slope map and flow accumulation 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 northing 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.