Nile Higher Institute for
Engineering & Technology

Department of Civil
Engineering

”Survey Engineering Project”

"مشروع الهندسة المساحية"

Cadastral Survey for Nile Higher Institute for Engineering and Technology El-Mansoura - Egypt

Supervisors

Dr. Ahmed Abu Bakr

“Teacher at Civil Department, Nile Higher Institute for Engineering and Technology, Mansoura "

Department Head	Dean
Dr. Amr El-Baghdadi	**Prof. Dr. Ahmed Saleh**

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Acknowledgments

First and foremost, praise and thanks for God. we would like to express our deepest gratitude and appreciation to our supervisors **Dr. Ahmed Abu Bakr , and Dr. Amr El-Baghdadi** for their kind supervision, support, guidance planning, generous support, helpful advice, encouragement, useful suggestions since the start of the work and their continues revision of this project.

The experimental part of this study was carried out at the laboratory of materials, Faculty of Engineering at Nile institute for engineering and technology. Special thanks to all technicians of the laboratory for their assistance during the conduct of this research work.

ABSTRACT

This project tends to clear the exploited spaces to the owner of Nile Higher Institute for engineering and technology, Mansoura. Where the owner constructed some building in the institute area and they need to know the area and shape of the unused spaces, so the cadastral survey for the building and all details in the institute area "As built" must be drawn using surveying devices and techniques. This task was carried out in four steps. The first step was distributing many fixed points around the institute buildings using surveying closed traverse and observed with accurate devices, Step two was correcting the observations of the closed traverse according to regulations of "Egyptian General Survey Authority", Step three using the traverse points "fixed points" with total station SOKKIA "cx105" to observe all buildings and details in the institute area, Final step drawing the institute using all observation data by AutoCAD Software.

This study was carried out according to the **Egyptian General Survey Authority.**

Chapter 1 Initial Report

1.1 Project Definition

Surveyors perform different types of work such as measuring land, air space, and water areas. They describe where a certain area of land is. They compute, portray and explain what it looks like, and how much is there. They put these facts in deeds, leases, and other legal documents.

The research work is divided into the following activities in order to resolve the given issues: The Nile institute raising was to make mare a polygon and distribute the cadastral points.

1.2 The Problem

There aren't many cadastral points The institute has many details. Good planning to the real area of the institute and making a survey on the actual area and how to expedite it .

1.3 Study Objectives

In this research, the concentration was on:

- ✓ Plan and Coordinate our Work
- ✓ Study land properties
- ✓ Use Total Station
- ✓ Observing and recording of information

1.4 Existing Solutions

. Using the total station device to spot the institute to identify the actual area and how to make use of the empty space.

1.5 Design Constraints

The primary constrains faced during our research work are classified into these categories:

1.5.1 Economic

The Survey analyses the trends in agricultural and industrial production, infrastructure, employment, money supply, prices, imports, exports, foreign exchange reserves and other relevant economic factors that have a bearing on the Budget.

1.5.2 Environmental

Environmental surveyors use surveying techniques to understand the potential impact of environmental factors on real estate and construction developments, and conversely the impact that real estate and construction developments will have on the environment.

1.5.3 Sustainability

We have a strong focus on sustainability. Among the products and services we offer to promote this effort is environmental surveying. Environmental surveyors use general surveying techniques to investigate and identify the potential impact of environmental factors on construction and real estate developments, and vice versa. In other words, environmental surveying seeks to understand the symbiotic relationship that exists between the environment and architectural development**.**

1.5.4 Ethical

Survey respondents should be informed of risks and must voluntarily consent to participating. For example, ensuring respondent privacy and confidentiality can help build trust with your respondents. Informed consent can also entail what data is being collected, stored, and used.

1.5.5 Health and Safety

Legal responsibilities for health and safety may arise for a surveyor providing health and safety advice and who is considered to be in control of a building or workplace. This will include advice given to landlords and tenant/occupiers. The nature of advice a surveyor may provide to a landlord is likely to reflect such things as the type, condition and age of the building and the purpose for which the building is to be put.

1.5.6 Social and Political

The establishment of a number of seminars and meetings involving students and professors, which pose academic and administrative problems and everyone, is working to provide appropriate solutions, which increase the bond between students and their teachers.

1.5.7 Development:

Good planning to the real area of the institute and making a survey on the actual area and how to expedite it.

1.6 CUSTOMER NEEDS:

Spotting the Nile institute to know the actual area and surveying on the empty space and how to make the best use of it to construct other buildings.

1.7 GENERATED CONCEPTS:

. Calculate the information of an in access point through choosing a helping point through which we can see the points which the device can't detect due to an obstacle

. Orientation process and measuring the triple coordinates of the point:

The purpose of this step is to input the static coordinates and the sight back if it was known by deviation from the magnetic north. This step is considered the most important work that should be applied during the process of detection either detailed or topography and also when signing.

1.8 FINAL CONCEPT:

The final selection protocol to carried out the cadastral survey for the "Nile Higher Institute for Engineering and Technology" was consider an accurate protocol, where the distributing of the fixed points using closed surveying traverse decrease the equal in coordinates of fixed point ,also many fixed points in area decrease the temporary points finally using the totalstion sokkia ((cx l05)) increase the accuracy because it is accuracy equal S" and T 2mm

Chapter 2 Introduction to the Surveying

2.1 Introduction:

The subject of engineering surveying continues to develop at a rapid pace and this has been reflected in the many and substantial changes that have been made in updating and revising the previous edition. The authors have taken the opportunity to examine in detail all the previous material making both minor and major changes throughout. As always, decisions have to be made as to what should be retained that is still current and relevant and to identify the material that needs to be cut to make way for new text to describe the emerging technologies.

The subject of survey control is now treated in much greater depth. The chapter on traditional methods still in current practice is followed by a whole new chapter on rigorous methods of control, that is, the application of the technique of least squares in the determination of coordinates and their quality. This topic was dropped from the fifth edition of this book but now reappears in a completely rewritten chapter which reflects modern software applications of a technique that underlies much of satellite positioning and inertial navigation as well as rigorous survey control.

Satellite positioning brings up to date the many advances that have been made in the development of GPS and its applications, as well as looking to the changes now taking place with GLONASS and the European GALILEO systems.

The chapter on underground surveying includes an enlarged section on gyrotheodolites which reflects new techniques that have been developed and the application of automation in modern instrumentation. The final chapter on mass data methods brings together substantial sections on simple applications of photogrammetry with the revolutionary new technology of laser scanning by aerial and terrestrial means.

Inertial technology, once seen as an emerging standalone surveying technology, now reappears in a com-pletely new guise as part of aircraft positioning and orientation systems used to aid the control of aerial photogrammetry and laser scanners.

In spite of all this new material the authors have been able to keep the same level of worked examples and examination questions that have been so popular in previous editions. We are confident that this new edition will find favor with students and practitioners alike in the areas of engineering and construction surveying, civil engineering, mining and in many local authority applications. This book will prove valuable for undergraduate study and professional development alike.

2.2 Basic concepts of surveying:

The aim of this chapter is to introduce the reader to the basic concepts of surveying. It is therefore the most important chapter and worthy of careful study and consideration.

2.3 DEFINITION:

Surveying may be defined as the science of determining the position, in three dimensions, of natural and man-made features on or beneath the surface of the Earth. These features may be represented in analogue form as a contoured map, plan or chart, or in digital form such as a digital ground model (DGM). In engineering surveying, either or both of the above formats may be used for planning, design and construction of works, both on the surface and underground. At a later stage, surveying techniques are used for dimensional control or setting out of designed constructional elements and also for monitoring deformation movements.

In the first instance, surveying requires management and decision making in deciding the appropriate methods and instrumentation required to complete the task satisfactorily to the specified accuracy and within the time limits available. This initial process can only be properly executed after very careful and detailed reconnaissance of the area to be surveyed.

When the above logistics are complete, the field work – involving the capture and storage of field data – is carried out using instruments and techniques appropriate to the task in hand.

Processing the data is the next step in the operation. The majority, if not all, of the computation will be carried out with computing aids ranging from pocket calculator to personal computer. The methods adopted will depend upon the size and precision of the survey and the manner of its recording; whether in a field book or a data logger. Data representation in analogue or digital form may now be carried out by conventional cartographic plotting or through a totally automated computer-based system leading to a paper- or screen-based plot. In engineering, the plan or DGM is used when planning and designing a construction project. The project may be a railway, highway, dam, bridge, or even a new town complex.

No matter what the work is, or how complicated, it must be set out on the ground in its correct place and to its correct dimensions, within the tolerances specified. To this end, surveying procedures and instrumentation of varying precision and complexity are used depending on the project in hand.

Surveying is indispensable to the engineer when planning, designing and constructing a project, so all engineers should have a thorough understanding of the limits of accuracy possible in the construction and manufacturing processes. This knowledge, combined with an equal understanding of the limits and capabilities of surveying instrumentation and techniques, will enable the engineer to complete the project successfully in the most economical manner and in the shortest possible time

2.4 PRINCIPLES:

Every profession must be founded upon sound practice and in this engineering surveying is no different. Practice in turn must be based upon proven principles. This section is concerned with examining the principles of survey, describing their interrelationship and showing how they may be applied in practice. Most of the principles below have an application at all stages of a survey and it is an unwise and unprofessional surveyor who does not take them into consideration when planning, executing, computing and presenting the results of the survey work. The principles described here have application across the whole spectrum of survey activity, from field work to photogrammetry, mining surveying to metrology, hydrography to cartography, and cadastral to construction surveying.

2.5 Control:

A control network is the framework of survey stations whose coordinates have been precisely determined and are often considered definitive. The stations are the reference monuments, to which other survey work of a lesser quality is related. By its nature, a control survey needs to be precise, complete and reliable and it must be possible to show that these qualities have been achieved. This is done by using equipment of proven precision, with methods that satisfy the principles and data processing that not only computes the correct values but gives numerical measures of their precision and reliability.

Since care needs to be taken over the provision of control, then it must be planned to ensure that it achieves the numerically stated objectives of precision and reliability. It must also be complete as it will be needed for all related and dependent survey work. Other survey works that may use the control will usually be less precise but of greater quantity. Examples are setting out for earthworks on a construction site, detail surveys of a greenfield site or of an as-built development and monitoring many points on a structure suspected of undergoing deformation.

The practice of using a control framework as a basis for further survey operations is often called ‘working from the whole to the part’. If it becomes necessary to work outside the control framework then it must be extended to cover the increased area of operations. Failure to do so will degrade the accuracy of later survey work even if the quality of survey observations is maintained.

For operations other than setting out, it is not strictly necessary to observe the control before other survey work. The observations may be concurrent or even consecutive. However, the control survey must be fully computed before any other work is made to depend upon it.

2.6 Economy of accuracy:

Surveys are only ever undertaken for a specific purpose and so should be as accurate as they need to be, but not more accurate. In spite of modern equipment, automated systems, and statistical data processing the business of survey is still a manpower intensive one and needs to be kept to an economic minimum. Once the requirement for a survey or some setting out exists, then part of the specification for the work must include a statement of the relative and absolute accuracies to be achieved. From this, a specification for the control survey may be derived and once this specification has been achieved, there is no requirement for further work.

Whereas control involves working from ‘the whole to the part’ the specification for all survey products is achieved by working from ‘the part to the whole’. The specification for the control may be derived from estimation based upon experience using knowledge of survey methods to be applied, the instruments to be used and the capabilities of the personnel involved. Such a specification defines the expected quality of the output by defining the quality of the work that goes into the survey. Alternatively a statistical analysis of the proposed control network may be used and this is the preferable approach. In practice a good specification will involve a combination of both methods, statistics tempered by experience. The accuracy of any survey work will never be better than the control upon which it is based. You cannot set out steelwork to 5 mm if the control is only good to 2 cm.

2.7 Consistency:

Any ‘product’ is only as good as the most poorly executed part of it. It matters not whether that ‘product’ is a washing machine or open heart surgery, a weakness or inconsistency in the endeavour could cause a catastrophic failure. The same may apply in survey, especially with control. For example, say the majority of control on a construction site is established to a certain designed precision. Later one or two further control points are less well established, but all the control is assumed to be of the same quality. When holding-down bolts for a steelwork fabrication are set out from the erroneous control it may require a good nudge from a JCB to make the later stages of the steelwork fit.

Such is the traditional view of consistency. Modern methods of survey network adjustment allow for some flexibility in the application of the principle and it is not always necessary for all of a particular stage of a survey to be of the same quality. If error statistics for the computed control are not to be made available, then quality can only be assured by consistency in observational technique and method. Such a quality assurance is therefore only second hand. With positional error statistics the quality of the control may be assessed point by point. Only least squares adjustments can ensure consistency and then only if reliability is also assured. Consistency and economy of accuracy usually go hand in hand in the production of control.

2.8 The Independent check:

The independent check is a technique of quality assurance. It is a means of guarding against a blunder or gross error and the principle must be applied at all stages of a survey. Failure to do so will lead to the risk, if not probability, of ‘catastrophic failure’ of the survey work. If observations are made with optical or mechanical instruments, then the observations will need to be written down. A standard format should be used, with sufficient arithmetic checks upon the booking sheet to ensure that there are no computational errors. The observations should be repeated, or better, made in a different manner to ensure that they are in sympathy with each other. For example, if a rectangular building is to be set out, then once the four corners have been set out, opposite sides should be the same length and so should the diagonals. The sides and diagonals should also be related through

Pythagoras' theorem. Such checks and many others will be familiar to the practising surveyor.

Checks should be applied to ensure that stations have been properly occupied and the observations between them properly made. This may be achieved by taking extra and different measurements beyond the strict minimum required to solve the survey problem. An adjustment of these observations, especially by least squares, leads to misclosure or error statistics, which in themselves are a manifestation of the independent check.

Data abstraction, preliminary computations, data preparation and data entry are all areas where transcription errors are likely to lead to apparent blunders. Ideally all these activities should be carried out by more than one person so as to duplicate the work and with frequent cross-reference to detect errors. In short, wherever there is a human interaction with data or data collection there is scope for error.

Every human activity needs to be duplicated if it is not self-checking. Wherever there is an opportunity for an error there must be a system for checking that no error exists. If an error exists, there must be a means of finding it.

Safeguarding:

Since survey can be an expensive process, every sensible precaution should be taken to ensure that the work is not compromised. Safeguarding is concerned with the protection of work. Observations which are written down in the field must be in a permanent, legible, unambiguous and easily understood form so that others may make good sense of the work. Observations and other data should be duplicated at the earliest possible stage, so that if something happens to the original work the information is not lost. This may be by photocopying field sheets, or making backup copies of computer files. Whenever the data is in a unique form or where all forms of the data are held in the same place, then that data is vulnerable to accidental destruction.

In the case of a control survey, the protection of survey monuments is most important since the precise coordinates of a point which no longer exists or cannot be found are useless.

2.9 BASIC MEASUREMENTS:

Surveying is concerned with the fixing of position whether it be control points or points of topographic detail and, as such, requires some form of reference system.

The physical surface of the Earth, on which the actual survey measurements are carried out, is not mathematically definable. It cannot therefore be used as a reference datum on which to compute position.

Alternatively, consider a level surface at all points normal to the direction of gravity. Such a surface would be closed and could be formed to fit the mean position of the oceans, assuming them to be free from all external forces, such as tides, currents, winds, etc. This surface is called the geoid and is defined as the equipotential surface that most closely approximates to mean sea level in the open oceans. An equipotential surface is one from which it would require the same amount of work to move a given mass to infinity no matter from which point on the surface one started. Equipotential surfaces are surfaces of equal potential; they are not surfaces of equal gravity. The most significant aspect of an equipotential surface going through an observer is that survey instruments are set up relative to it. That is, their vertical axes are in the direction of the force of gravity at that point. A level or equipotential surface through a point is normal, i.e. at right angles, to the direction of gravity. Indeed, the points surveyed on the physical surface of the Earth are frequently reduced, initially, to their equivalent position on the geoid by projection along their gravity vectors.

The reduced level or elevation of a point is its height above or below the geoid as measured in the direction of its gravity vector, or plumb line, and is most commonly referred to as its height above or below mean sea level (MSL). This assumes that the geoid passes through local MSL, which is acceptable for most practical purposes. However, due to variations in the mass distribution within the Earth, the geoid, which although very smooth is still an irregular surface and so cannot be used to locate position mathematically.

The simplest mathematically definable figure which fits the shape of the geoid best is an ellipsoid formed by rotating an ellipse about its minor axis. Where this shape is used by a country as the surface for its mapping system, it is termed the reference ellipsoid. Figure 1.1 illustrates the relationship between these surfaces.

The majority of engineering surveys are carried out in areas of limited extent, in which case the reference surface may be taken as a tangent plane to the geoid and the principles of plane surveying applied. In other words, the curvature of the Earth is ignored and all points on the physical surface are orthogonally projected onto a flat plane as illustrated in Figure 1.2. For areas less than 10 km square the assumption of a flat Earth is perfectly acceptable when one considers that in a triangle of approximately 200 km2, the difference between the sum of the spherical angles and the plane angles would be 1 second of arc, or that the difference in length of an arc of approximately 20 km on the Earth's surface and its equivalent chord length is a mere 8 mm.

The above assumptions of a flat Earth, while acceptable for some positional applications, are not acceptable for finding elevations, as the geoid deviates from the tangent plane by about 80 mm at 1 km or 8 m at 10 km from the point of contact. Elevations are therefore referred to the geoid, at least theoretically, but usually to MSL practically.

2.10 Basic concepts of surveying

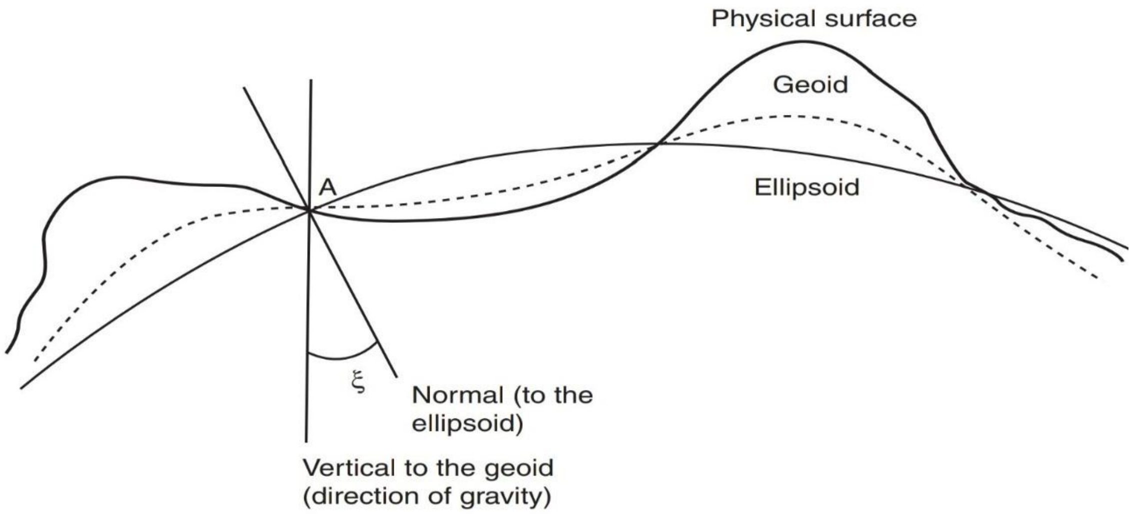


Fig. 2.1 Geoid, ellipsoid and physical surface

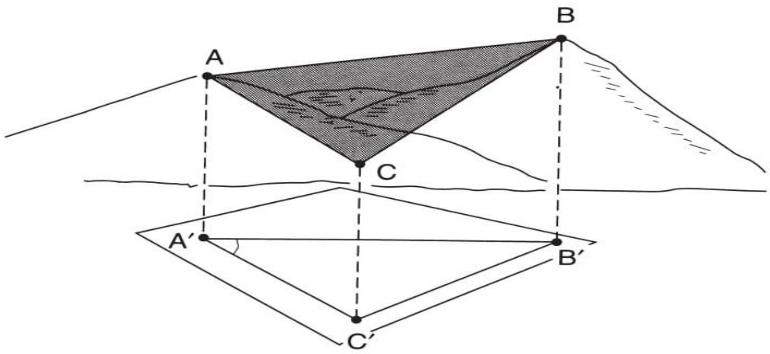


Fig. 2.2 Projection onto a plane surface

An examination of Figure 2.2 clearly shows the basic surveying measurements needed to locate points A, B and C and plot them orthogonally as A , B and C . Assuming the direction of B from A is known then the measured slope distance AB and the vertical angle to B from A will be needed to fix the position of B relative to A. The vertical angle to B from A is needed to reduce the slope distance AB to its equivalent horizontal distance A B for the purposes of plotting. Whilst similar measurements will fix C relative to A, it also requires the horizontal angle at A measured from B to C (B A C) to fix C relative to B. The vertical distances defining the relative elevation of the three points may also be obtained from the slope distance and vertical angle or by direct levelling (Chapter 3) relative to a specific reference datum. The five measurements mentioned above comprise the basis of plane surveying and are illustrated in Figure 2.3, i.e. AB is the slope distance, AA the horizontal distance, A B the vertical distance, BAA the vertical angle (α) and A AC the horizontal angle (θ).

It can be seen from the above that the only measurements needed in plane surveying are angle and distance. Nevertheless, the full impact of modern technology has been brought to bear in the acquisition and processing of this simple data. Angles may now be resolved with single-second accuracy using optical and electronic theodolites; electromagnetic distance measuring (EDM) equipment can obtain distances up.

5.1.10 Engineering Surveying

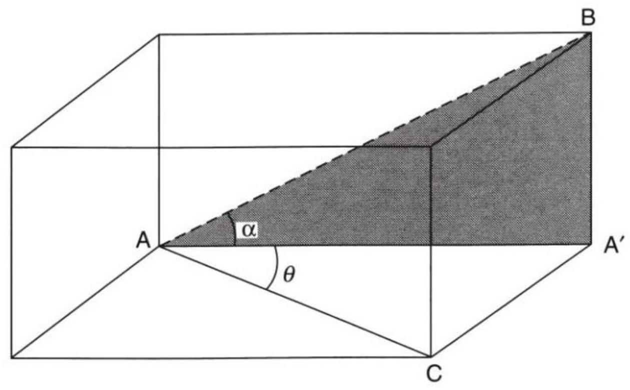


Fig. 2.3 Basic measurements

To several kilometres with millimetre precision, depending on the distance measured; lasers and northseeking gyroscopes are virtually standard equipment for tunnel surveys; orbiting satellites are being used for position fixing offshore as well as on; continued improvement in aerial and terrestrial photogrammetric and scanning equipment makes mass data capture technology an invaluable surveying tool; finally, data loggers and computers enable the most sophisticated procedures to be adopted in the processing and automatic plotting of field data

Chapter 3 Control Traverse

3.1 Introduction

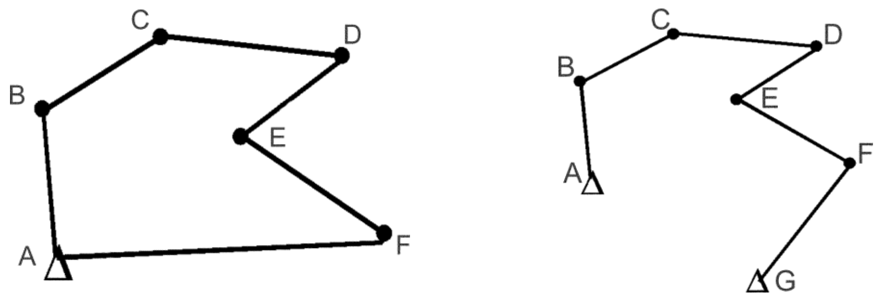
A traverse is a series of related points or stations which, when connected together with angular and linear values, form a framework.

3.2 Types of Traverse:

Traverses are classified as either closed or open.

3.2.1 The Closed Traverse:

If a traverse proceeds from one coordinated (fixed) point to another, it is known as a closed traverse. Note that a closed traverse may either close back to its starting point or to any other coordinated point. It is, therefore, able to be checked and adjusted to fit accurately between these known points.



□ **Known Station** □ **New Station**

Fig 3.1 Examples of closed traverses

3.2.2 The Open Traverse:

An open traverse does not close on to a known point. The end of the traverse, point F, is left 'swinging' with no accurate means of checking angular or linear errors that may have occurred between A and F. The only check would be to repeat the whole traverse, or resurvey in the opposite direction.

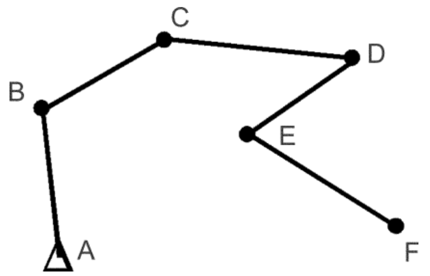


Fig 3.2 Examples of an open traverse

3.2.3 A Control Traverse:

Traversing is employed to extend coordinates from one point to another. This is achieved by starting the observations at a control point of known coordinates and with a known bearing, measured from another control point, carry forward the coordinated along a traverse by measuring a series of angles and distances or a series of bearings and distances and then closing onto a final control point.

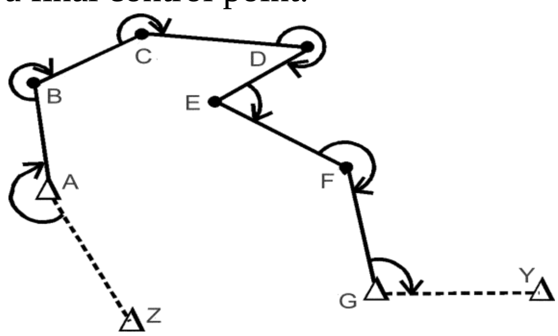


Fig 3.3 A control traverse

The normal practice in surveying is to measure the clockwise angles along a traverse using a theodolite, or total station. With a known initial bearing and a series of clockwise angles, the bearings between each of the points can be calculated.

By closing onto a known bearing (in Figure 13.3, the line GY) it is possible to adjust for any errors in observing the angles or bearings.

Distances can be measured by either the traditional method with a steel tape or with an Electronic Distance Measuring device.

From the bearings and distances, the differences in coordinates can be calculated and from them, the coordinates of each of the points along the traverse can be calculated.

3.3 The Purpose of Traversing:

Traversing may be employed in the following:

1. Control establishing a system of horizontal control for setting out and surveying detail of engineering or mining projects.
2. Setting out the position of design features such as roads, buildings, sewerage and drainage lines.
3. Surveying detail pick-up of natural and artificial features in relation to control.
4. Cadastral establishment of original boundaries and subdivision into parcels of land.
5. Geodetic traversing to provide major control for mapping large areas.

3.4 Traverse Accuracy:

The accuracy of a traverse is dependent on the type of equipment used and the measuring technique employed, which in turn is dependent on the purpose of the survey. It is also dependent on the accuracy of the original control that is used as the basis of the traverse.

For general engineering and site work the range of accuracy could vary between 1:5 000 to 1:20 000 depending on the individual specifications for the job, with, perhaps, 1:10 000 being a fairly common traverse accuracy.

3.5 Field Work Procedures:

The initial part of all survey traverses is the reconnaissance. In its simplest form, the reconnaissance may only be a 'walk around' the job; or it may become involved to the stage where aerial photography of the area is studied in conjunction with associated maps.

Essentially the site is examined to determine the most suitable position to place traverse stations in the form of posts, pegs, concrete blocks, iron spikes or rock marks.

This examination should consider the following factors.

3.6 Application:

Survey traverses are run for many reasons. For example:

- . Topographical engineering
- . cadastral and
- . geodetic surveys.

During the reconnaissance we must look for any existing survey marks so that the traverse connects to these marks.
Existing surveys should also provide start and finish bearings.

3.7 General Survey Requirements:

3.7.1 Line length:

Lines should be sufficiently long to minimise sighting (random) errors in the angular work.

3.7.2 Lines of Sight:

There should be clear visibility between stations. Because of the effects of refraction, causing shimmer, traverse lines should be well above ground level, and clear of buildings and large trees (0.5 - 1 metre clearance).

3.8 Durability of Station Positions:

Traverse stations should be located in positions of good accessibility but also where they are least likely to be disturbed.

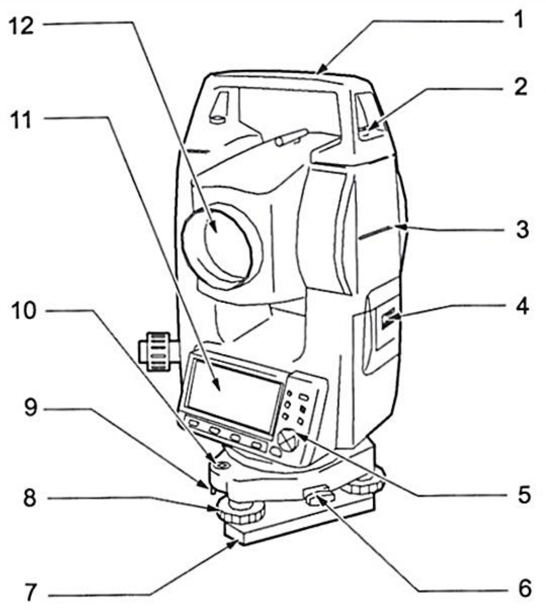
3.9 Equipment Requirements:

Even though a theodolite and EDM, or a total station, would normally be used, the normal tapes and accessories would be required for short measurements and referencing of marks. Additional tribrachs may be required for use in forced centring. Two-way radios may also be needed for communication between stations.

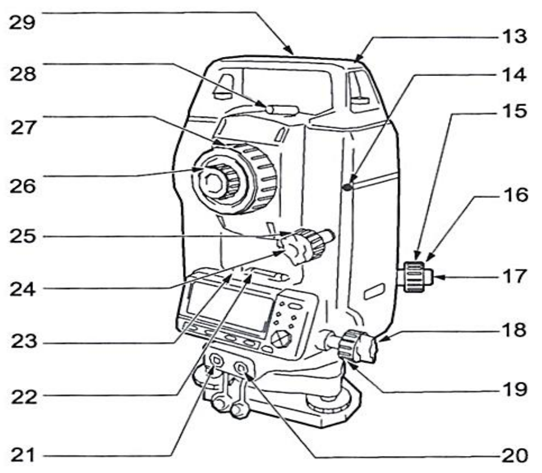
Chapter 4 TOTAL STATION

4.1 Introduction

4.1.1 Parts of the SET Total Station:



1 Handle
2 Handle securing screw
3 Instrument height mark
4 Battery cover
5 Operation panel
6 Tribrach clamp (SET310S/510S/610S: Shifting clamp)
7 Base plate
8 Levelling foot screw
9 Circular level adjusting screws
10 Circular level
11 Display
12 Objective lens



13 Tubular compass slot
14 Beam detector for wireless keyboard (Not included on SET610/610S)
15 Optical plummet focussing ring
16 Optical plummet reticle cover
17 Optical plummet eyepiece
18 Horizontal clamp
19 Horizontal fine motion screw
20 Data input/output connector (Beside the operation panel on SET610/610S)
21 External power source connector (Not included on SET610/610S)
22 Plate level
23 Plate level adjusting screw
24 Vertical clamp
25 Vertical fine motion screw
26 Telescope eyepiece
27 Telescope focussing ring
28 Peep sight
29 Instrument center mark

Fig 4.1 Total station components

4.1.2 PRECAUTIONS:

4.1.2.1 Charging Battery:

Be sure to charge the battery within the charging temperature range. Charging temperature range: 0 to 40°C

As for warranty policy for Battery, it is an expendable item. The decline in retained capacity depending on the repeated charging/discharging cycle is out of warranty.

The lithium battery is used to maintain the CX Calendar & Clock function. It can back up data for approximately 5 years of normal use and storage (Temperature = 20°, humidity = about 50%), but its lifetime may be shorter depending on circumstances.

4.1.2.2 Bluetooth Wireless Technology

Bluetooth function may not be built in depending on telecommunications regulations of the country or the area where the instrument is purchased. Contact your local dealer for the details.

4.1.2.3 Tribrach Clamp:

When the instrument is shipped, the tribrach clamp is held firmly in place with a locking screw to prevent the instrument from shifting on the tribrachs. Before using the instrument the first time, loosen this screw with a screwdriver. And before transporting it, tighten the locking screw to fasten the tribrach clamp in place so that it will not shift on the tribrachs.

Always fully release the vertical/horizontal clamps when rotating the instrument or telescope. Rotating with clamp(s) partially applied may adversely affect accuracy.

4.1.2.4 Precautions concerning water and dust resistance:

CX conforms to IP66 specifications for waterproofing and dust resistance when the battery cover and external interface hatch are closed and connector caps are attached correctly.

To retain the waterproof property, it is recommended that you replace the rubber packing once every two years. To replace the packing, contact your local dealer.

Be sure to close the battery cover and external interface hatch, and correctly attach the connector caps to protect the CX from moisture and dust particles.

Make sure that moisture or dust particles do not come in contact with the inside of the battery cover, terminal or connectors. Contact with these parts may cause damage to the instrument.

Make sure that the inside of the carrying case and the instrument are dry before closing the case. If moisture is trapped inside the case, it may cause the instrument to rust.

4.1.2.5 General

- ✓ Do not press the speaker hole using something with a pointed tip. Doing so will damage an internal waterproof sheet, resulting in a degraded waterproof property.
- ✓ If there is a crack or deformation in the rubber packing for the battery cover or external interface hatch, stop using and replace the packing.
- ✓ Data should be backed up (transfered to an external device etc.) on a regular basis to prevent data loss.
- ✓ Close the external interface hatch before starting measurement. Otherwise, ambient light entering the USB port may adversely affect measurement results.

- ✓ If the CX is moved from a warm place to an extremely cold place, internal parts may contract and make the keys difficult to operate. This is caused by cold air trapped inside the hermetically sealed casing.
- ✓ If the keys do not depress, open the battery cover to resume normal functionality. To prevent the keys from becoming stiff, remove the connector caps before moving the CX to a cold place.
- ✓ Never place the CX directly on the ground. Sand or dust may cause damage to the screw holes or the centering screw on the base plate. ï Do not aim the telescope directly at the sun.
- ✓ Also, attach the lens cap to the telescope when not in use. Use the Solar filter to avoid causing internal damage to the instrument when observing the sun.
- ✓ Protect the CX from heavy shocks or vibration.
- ✓ Never carry the CX on the tripod to another site.
- ✓ Turn the power off before removing the battery.
- ✓ When placing the CX in its case, first remove its battery and place it in the case in accordance with the layout plan.
- ✓ Consult your local dealer before using the instrument under special conditions such as long periods of continuous use or high levels of humidity. In general, special conditions are treated as being outside the scope of the product warranty.

4.1.3 Maintenance:

- ✓ Always clean the instrument before returning it to the case. The lens requires special care. First, dust it off with the lens brush to remove tiny particles. Then, after providing a little condensation by breathing on the lens, wipe it with the wiping cloth.

- ✓ If the display unit is dirty, carefully wipe it with a soft, dry cloth. To clean other parts of the instrument or the carrying case, lightly moisten a soft cloth in a mild detergent solution. Wring out excess water until the cloth is slightly damp, then carefully wipe the surface of the unit. Do not use any alkaline cleaning solutions, alcohol, or any other organic solvents, on the instrument or display unit
- ✓ Store the CX in a dry room where the temperature remains fairly constant.
- ✓ Check the tripod for loose fit and loose screws.
- ✓ If any trouble is found on the rotatable portion, screws or optical parts (e.g. lens), contact your local dealer.
- ✓ When the instrument is not used for a long time, check it at least once every 3 months.
- ✓ When removing the CX from the carrying case, never pull it out by force. The empty carrying case should be closed to protect it from moisture.
- ✓ Check the CX for proper adjustment periodically to maintain the instrument accuracy.

4.2 Sighting collimator

Use sighting collimator to aim the CX in the direction of the measurement point. Turn the instrument until the triangle in the sighting collimator is aligned with the target.

4.2.1 Instrument height mark

The height of the CX is as follows:

192.5mm (from tribrach mounting surface to this mark)

236mm (from tribrach dish (TR-102) to this mark) "Instrument height" is input when setting instrument station data and is the height from the measuring point (where CX is mounted) to this mark.

4.2.2 Trigger Key

Press the trigger key when the CX is in the OBS mode or when [MEAS]/ [STOP] is indicated on the display unit. You can start/stop measurement. In the screen displaying [AUTO], press trigger key to perform automatic operation from distance measurement to recording.

4.2.3 Laser-pointer Function

A target can be sighted with a red laser beam in dark locations without the use of the telescope.

4.3 Operation panel:

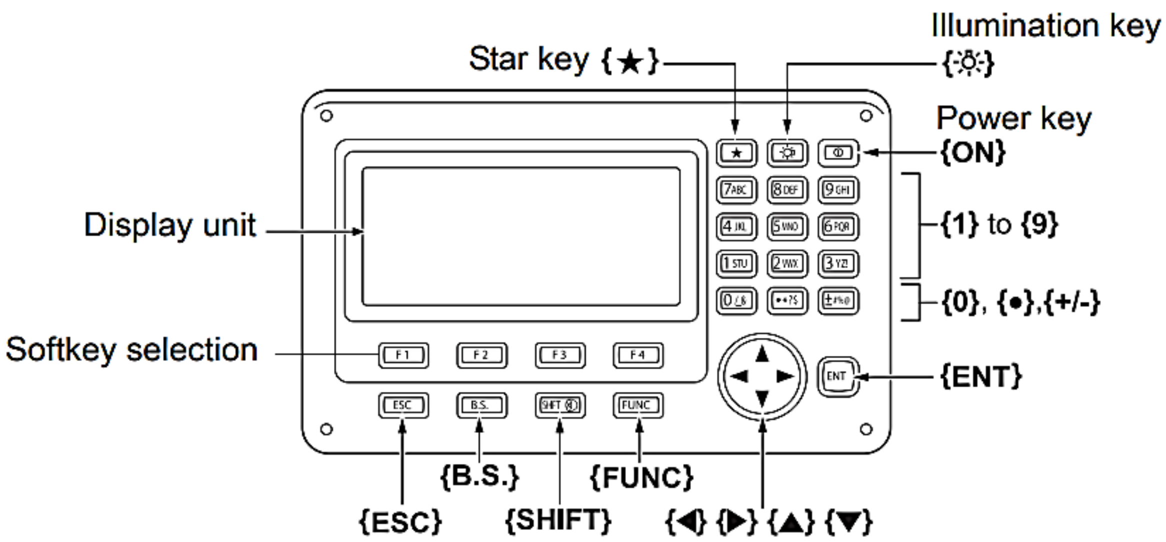


Figure 4.2. Shows the control panel

4.4 Point guide:

Fast and simple to use, the Point Guide feature is useful when doing setting-out work. The Point Guide System on the instrument telescope assist the poleman to get on-line. When using with the Point Guide System, the operating time of internal power source will become short.

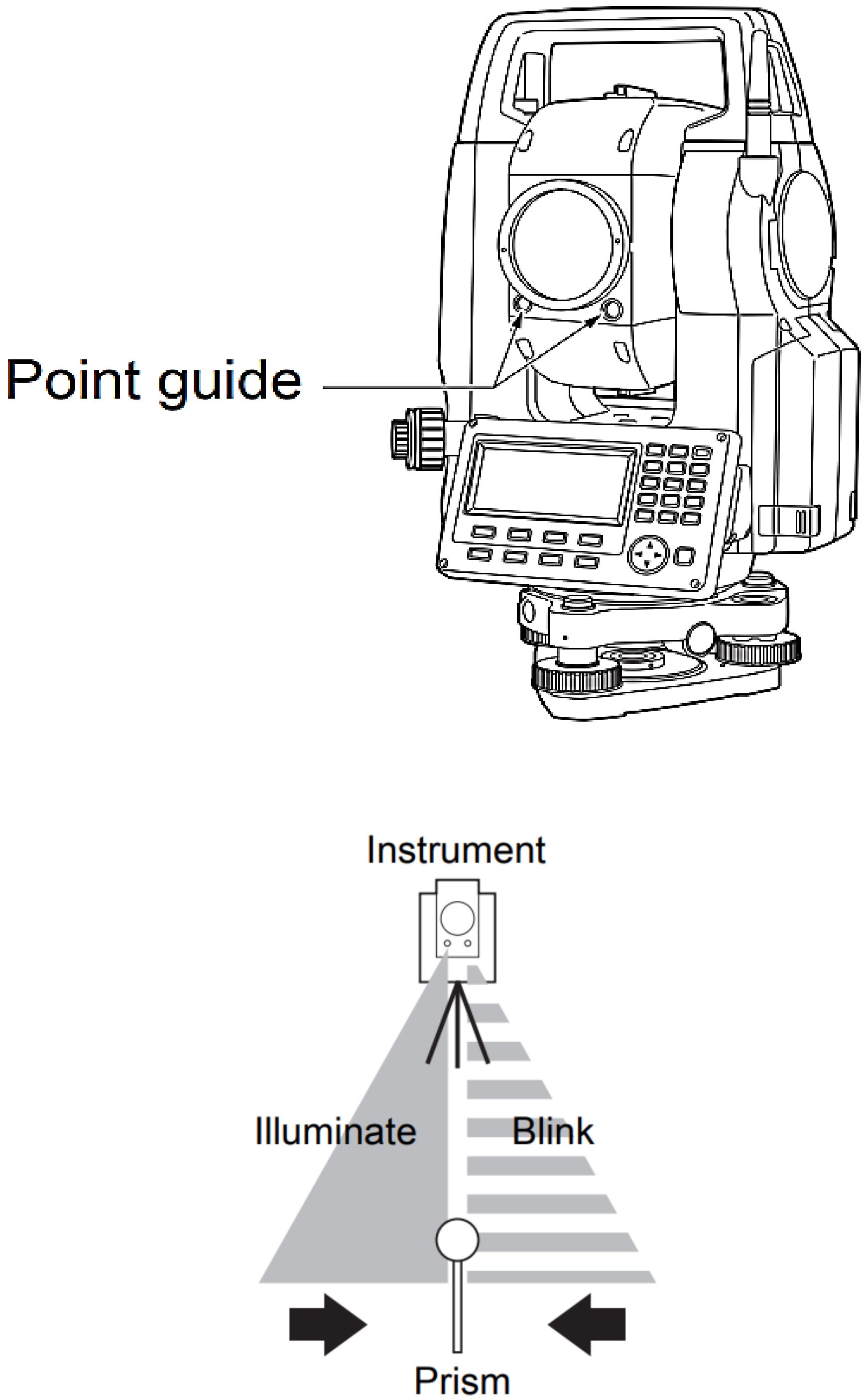


Figure 4.3. Shows the point guide in TS

Looking at the objective lens of the telescope, the right LED will blink and the left LED will stay lit.

The Point Guide should be used within a distance of 100m (328 feet). The quality of its results will depend on the weather conditions and the user's eyesight.

The goal of the poleman is to look at both LED's on the instrument and move the prism on-line until both LED's are equally bright.

If the solid LED is brighter, move right. If the blinking LED is brighter, move left.

Once you have determined that both of the LED's are equally bright, you are on-line with the instrument.

4.5 Centering:

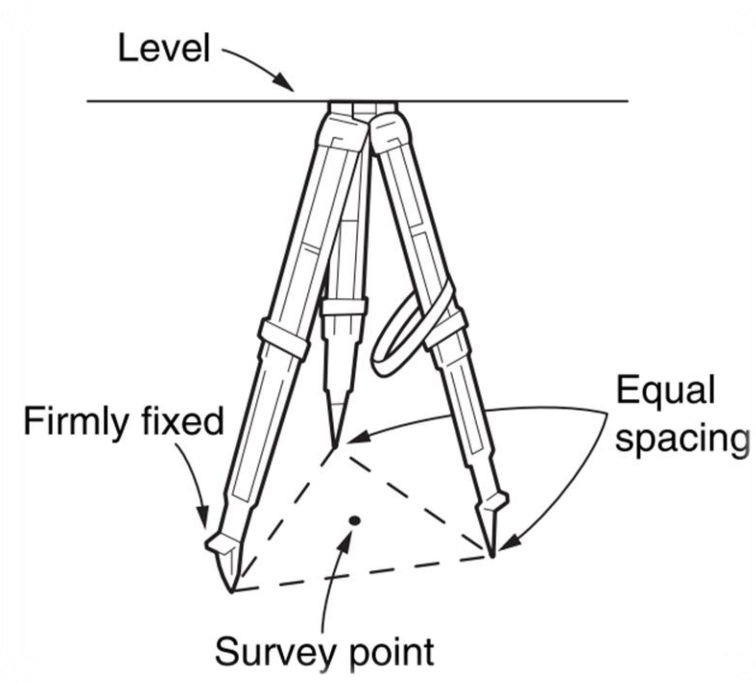


Figure 4.4 Centering with the optical plummet eyepiece

Make sure the legs are spaced at equal intervals and the head is approximately level. Set the tripod so that the head is positioned over the survey point. Make sure the tripod shoes are firmly fixed in the ground.

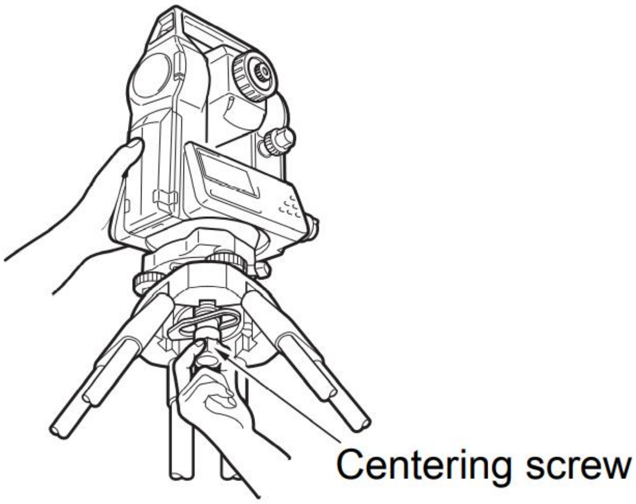


Figure 4.5. Shows the centering screws

Place the instrument on the tripod head. Supporting it with one hand, tighten the centering screw on the bottom of the unit to make sure it is secured to the tripod.

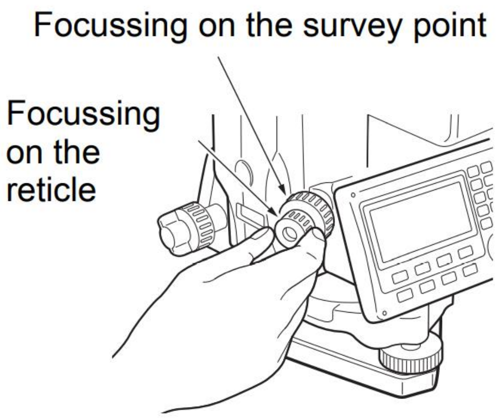


Figure 4.6. Shows the focusing secrews

Looking through the optical plummet eyepiece, turn the optical plummet eyepiece to focus on the reticle. Turn the optical plummet focussing ring to focus on the survey point.

4.6 Setting Up the Instrument:

PROCEDURE: Centering with the laser plummet

- ✓ Adjust the levelling foot screws to center the survey
- ✓ point in the optical plummet reticle.
- ✓ Continue to the levelling procedure.
- ✓ Set up the tripod and affix the instrument on the tripod head.

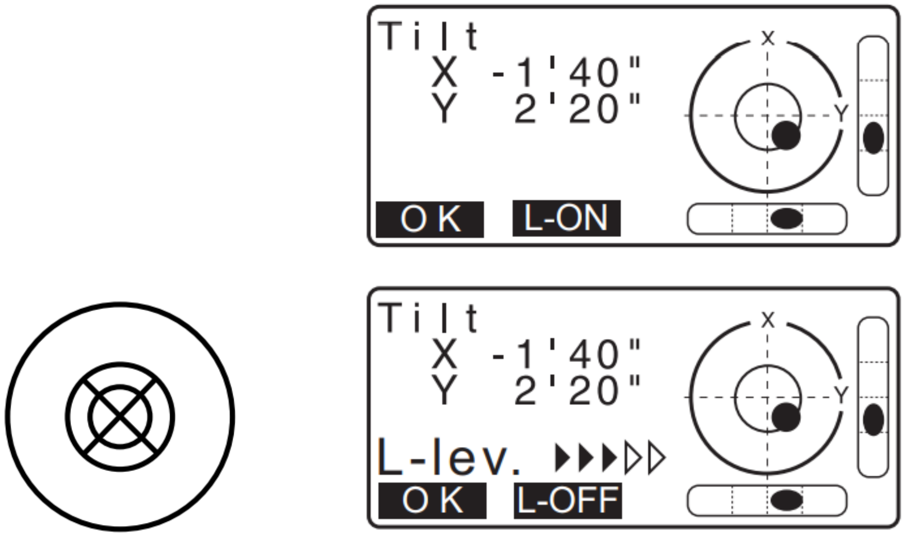


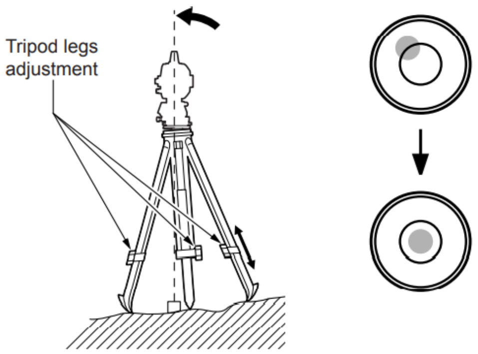
Figure 4.7. Shows centering with the laser plummet

- ✓ Press {ON} to power on The circular level is displayed on the screen.
- ✓ Press [L-ON]. The laser plummet beam will be emitted from the bottom of the instrument.
- ✓ Use to adjust the brightness of the laser.

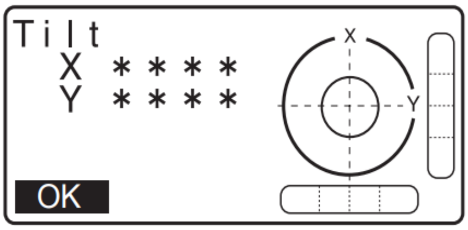
- ✓ Adjust the levelling foot screws to align the laser beam with the center the survey point.
- ✓ Press [L-OFF] to turn the laser plummet off. Alternatively,
- ✓ press {ESC} to return to the previous screen.
- ✓ The laser plummet will switch off automatically.
- ✓ Continue to the levelling procedure.

4.7 PROCEDURE:

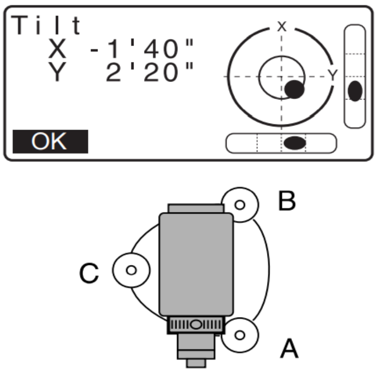
- ✓ . Perform the centering procedure.
- ✓ Center the bubble in the circular level by either shortening the tripod leg closest to



- ✓ the offcenter direction of the bubble or by lengthening the tripod leg farthest from
- ✓ the offcenter direction of the bubble.
- ✓ Adjust one more tripod leg to center the bubble.
- ✓ Turn the levelling foot screws while checking the circular level until the bubble is centered in the center circle.



- ✓ SETTING UP THE INSTRUMENT
- ✓ Press {ON} to power on
- ✓ The circular level is displayed on the screen.
- ✓ indicates bubble in circular level. The range of the inside circle is ±4' and the range of the outside circle is ±6'.
- ✓ Tilt angle values X and Y are also displayed on the screen.
- ✓ If it is not displayed when the tilt of the instrument exceeds the detection range of the tilt sensor. Level the instrument while checking the air bubbles in the circular level until is displayed on the screen.



- ✓ When executing the measurement program, if measurement starts with the instrument tilted, the circular level is displayed on the screen.
- ✓ Center in the circular level α steps 1 to 2
- ✓ If the bubble is centered, move to step 9.
- ✓ Turn the instrument until the telescope is parallel to a line between levelling foot screws A and B, then tighten the horizontal clamp.
- ✓ Set the tilt angle to 0° using foot screws A and B for the X direction and levelling screw C for the Y direction.
- ✓ Loosen the centering screw slightly. Looking through the optical plummet eyepiece, slide the instrument over the tripod head until the

survey point is exactly centered in the reticle. Retighten the centering screw securely.

- ✓ When the instrument was centered using the laser plummet, emit the plummet beam again to check position over the survey point.
- ✓ Centering with the laser plummet.
- ✓ Confirm that the bubble is positioned at the center of the circular level on the screen. If not, repeat the procedure starting from step 6.
- ✓ When levelling is completed, press [OK] to enter into the OBS mode.

4.8 BASIC OPERATION:

Learn basic key operations here before you read each measurement procedure.

- **Power ON / OFF**

{ON}	Power On
{ON} (Press and hold: About 1 second)	Power Off

- **Lighting up the display unit and key**

{□}	Switch the screen/key backlight and Reticle illumination On / Off

- ***Switching target type***

Target type can be switched only on the screen where the target symbol (ex.) is displayed.

{SHIFT}	Switches between target types (Prism/ N-Prism (reflectorless)/LN-Prism (long range reflectorless))

□Target symbol displayed:

Switching between target types in the Star Key mode:

Switching the target type in Config mode":

- ***Switching the Laser-pointer/Point guide ON/OFF***

{□} (Press and hold)	To turn the laser-pointer/point guide ON/OFF, press and hold until a beep sounds.

□Selecting laser-pointer/point guide:

After turning ON the laser-pointer/point guide, the laser beam is emitted for 5 minutes, and then automatically switches OFF. But in the Status screen and when target symbol (ex.) is not displayed in the OBS mode, the laser beamis not automatically turned off.

.Softkey operation

Softkeys are displayed on the bottom line of the screen.

{F1} to {F4}	Select the function matching the softkeys
{FUNC}	Toggle between OBS mode screen pages (when more than 4 softkeys are allocated)

● **Inputting letters/figures**

{SHIFT}	Switch between numeric and alphabetic characters.
{0} to {9}	During numeric input, input number of the key. During alphabetic input, input the characters displayed above the key in the order they are listed.
{.}/{±}	Input a decimal point/plus or minus sign during numeric input. During alphabetic input, input the characters displayed above the key in the order they are listed.
{□}/{□}	Right and left cursor/Select other option.
{ESC}	Cancel the input data.
{B.S.}	Delete a character on the left.
{ENT}	Select/accept input word/value.

● **Switching modes**

[★]	From OBS mode (Observation Mode) to Star Key Mode
[CNFG]	From Status mode to Config Mode (Configuration Mode)
[OBS]	From Status mode to OBS mode (Observation Mode)
[USB]	From Status mode to USB Mode
[DATA]	From Status mode to Data Mode

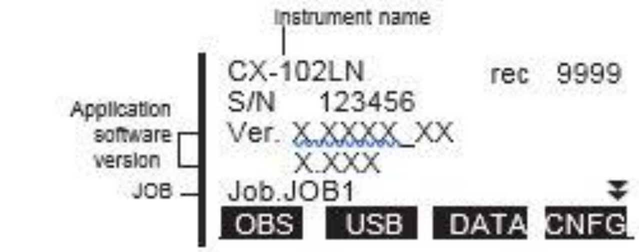
{ESC}	Return to the Status mode from each Mode

- **Other operation**

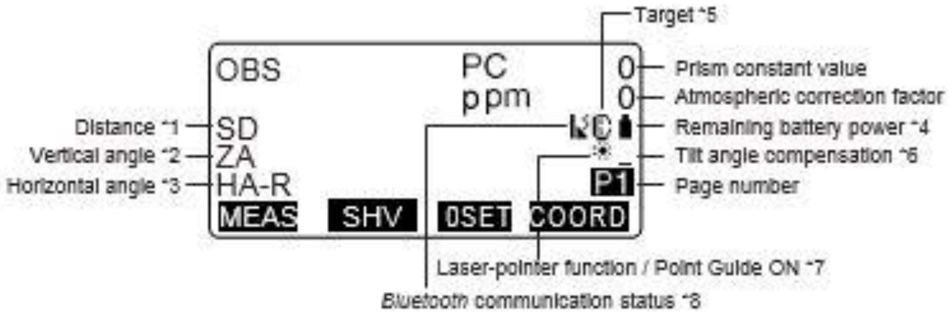
{ESC}	Return to the previous screen

4.9 Display Functions:

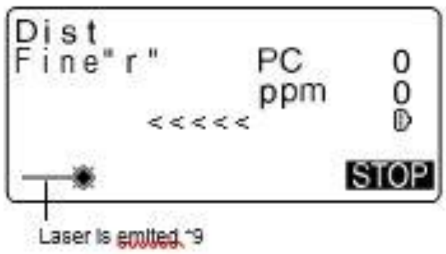
Status screen



OBS mode screen



Measuring screen



Input screen

4.10 ANGLE MEASUREMENT:

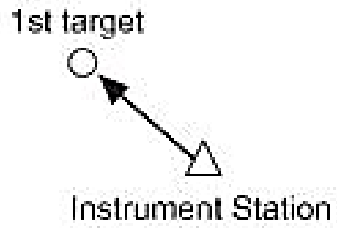
This section explains the procedures for basic angle measurement.

Use the "0SET" function to measure the included angle between two points.

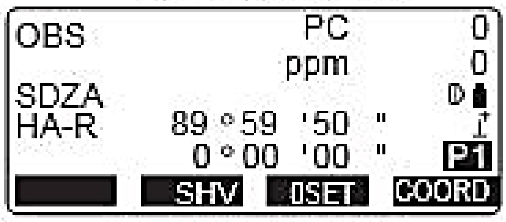
The horizontal angle can be set to 0 at any direction.

PROCEDURE:

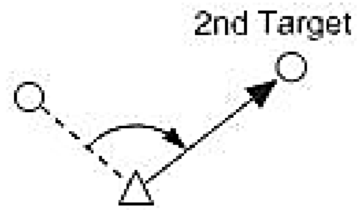
1. Sight the first target as at right.



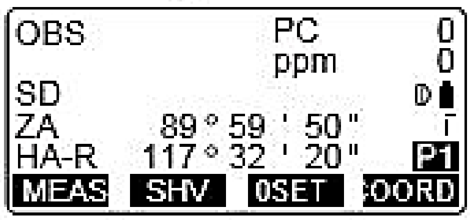
2. In the first page of the OBS mode screen, press **[0SET]**.
   [0SET] will flash, so press **[0SET]** again.
   The horizontal angle at the first target becomes 0°.



3. Sight the second target.



   The displayed horizontal angle (HA-R) is the included angle between two points.



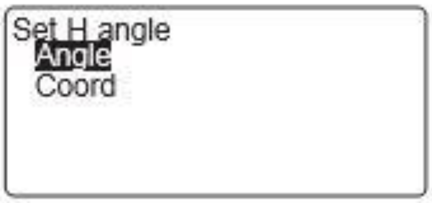
Setting the Horizontal Angle to a Required Value (Horizontal Angle Hold):

You can reset the horizontal angle to a required value and use this value to find the horizontal angle of a new target.

PROCEDURE: Entering the horizontal angle

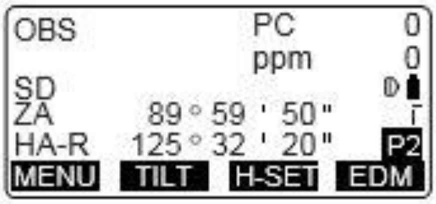
1. Sight the first target.

2. Press **[H-SET]** on the second page of the OBS mode and select "Angle."



3. Enter the angle you wish to set, then press **[OK]**.
   The value that is input as the horizontal angle is displayed.

   - Press **[REC]** to set and record the horizontal angle.
     ☐"28.2 Recording Backsight Point"



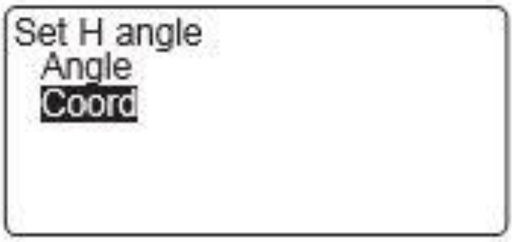
4. Sight the second target.
   The horizontal angle from the second target to the value set as the horizontal angle is displayed.

☐

- Pressing **[HOLD]** performs the same function as above.
- Press **[HOLD]** to set the displayed horizontal angle. Then, set the angle that is in hold status to the direction you require.
  ☐Allocating **[HOLD]**: "33.3 Allocating Key Functions"

PROCEDURE: Entering the coordinate:

1. Press **[H-SET]** on the second page of the OBS mode and select "Coord."

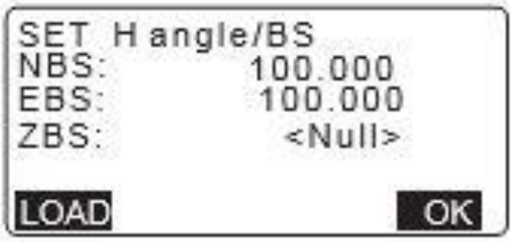


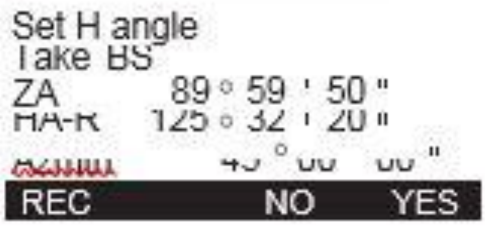
2. Set the known point coordinate. Enter the coordinate for the first point, and press **[OK]**.

   Press **[YES]** to set the horizontal angle.

   - Press **[REC]** to set and record the horizontal angle.

     Point"





3. Sight the second target. The horizontal angle from the set coordinate is displayed.

4.11 . Angle Measurement and Outputting the Data:

The following explains angle measurement and the features used to output measurement data to a computer or peripheral equipment.

□Bluetooth communication: "10. CONNECTING TO EXTERNAL DEVICES"

Communication cables: "36.2 Optional accessories"

Output format and command operations: "Communication manual"

PROCEDURE

1. Connect CX and host computer.

2. Allocate the [HVOUT-T] or [HVOUT-S] softkey to the OBS mode screen.

3 Allocating Key Functions"• Pressing the softkey outputs data in the following format. [HVOUT-T] : GTS format [HVOUT-S] : SET format

3. Sight the target point.

4. Press [HVOUT-T] or [HVOUT-S]. Output measurement data to peripheral equipment.

4.12 DISTANCE MEASUREMENT:

Perform the following settings as preparation for distance measurement.

• Distance measurement mode

• Target type

• Prism constant correction value

• Atmospheric correction factor

□"33.1 Configuration -Config Mode-"/"33.2 EDM Settings"

□ CAUTION

When using the Laser-pointer function, be sure to turn OFF the output laser after distance measurement is completed. Even if distance measurement is canceled, the Laser-pointer function is still operating and the laser beam continues to be emitted. (After turning ON the Laser-pointer, the laser beam is emitted for 5 minutes, and then automatically switches OFF. But in the Status screen and when target symbol (ex.) is not displayed in the OBS mode, the laser beam is not automatically turned off.)

• Make sure that the target setting on the instrument matches the type of target used. CX automatically adjusts the intensity of the laser beam and switches the distance measurement display range to match the type of target used. If the target does not correspond to the target settings, accurate measurement results cannot be obtained.

• Accurate measurement results cannot be obtained if the objective lens is dirty. Dust it off with the lens brush first, to remove minute particles. Then, after providing a little condensation by breathing on the lens, wipe it off with the wiping cloth.

• During reflectorless measurement, if an object obstructs the light beam used for measurement or an object is positioned with a high reflective factor (metal or white surface) behind the target, accurate measurement results may not be received.

• Scintillation may affect the accuracy of distance measurement results. Should this occur, repeat measurement several times and use the averaged value of the obtained results.

Precautions for use of Long range reflectorless measurement

CX made reflectorless measurement possible to reach the distance that had never been achieved before.

In the Long range reflectorless measurement, the following attentions need to be paid because the farther the target object be, the weaker the reflection from the target and the larger the beam diameter become.

Measurement Time:

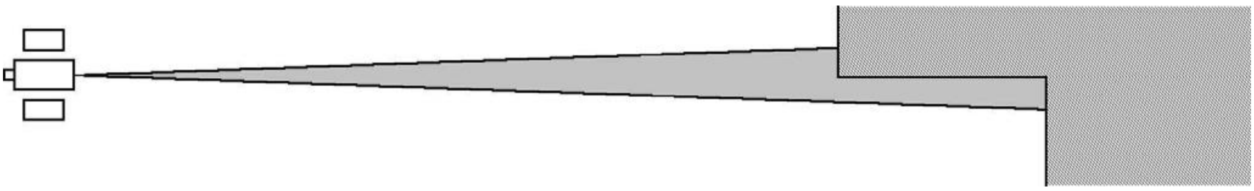
In the LN-Prism mode, the measuring time largely depends on a distance to the target object and the color (or reflectance) of the object. Especially when the measurement distance is far, or when the reflectance of the measured surface is low, measuring time will become longer.

Beam Diameter:

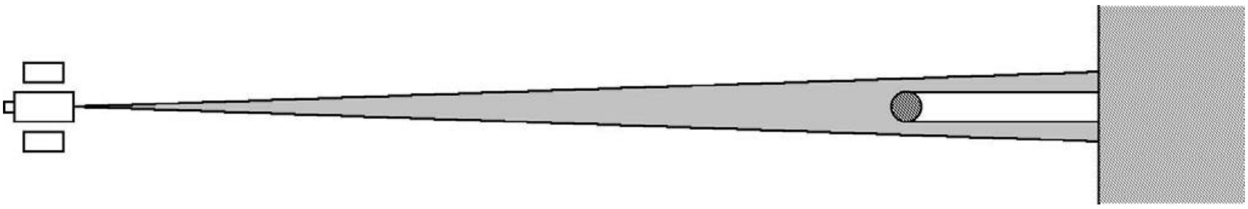
Beam diameter becomes large in the long distance. Try to bring as much beam as possible to the measured surface.

If the beam is not lased rightly as in the cases below, may cause incorrect measurement.

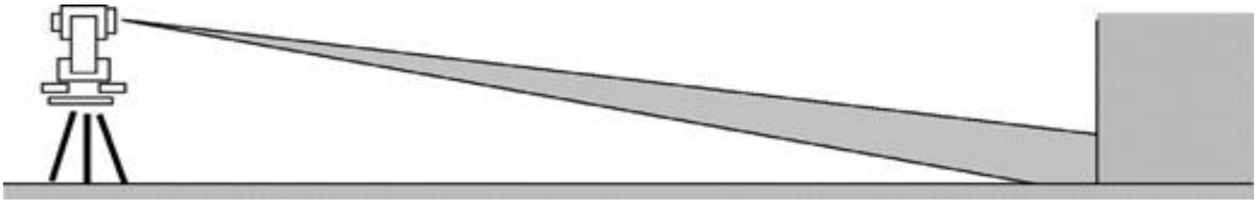
In such cases, collimate the position where the beam is not fallen besides the measured surface, set measurement distance range (□ "33.2 EDM Settings □LNP range"), or operate the plane offset measurement (□20.4 Plane Offset Measurement).



(e.g.1) the beam also reaches the wall either before or behind the object



(e.g.2) the beam reaches the wall behind due to the size of the object



(e.g.3) the beam is thrown on the ground before the object

4.13 Cutoff during Measurement:

While in the LN-Prism mode, you had better use the instrument in the place where the light path may not be cut off by cars or people. You may not be able to collect accurate figures if it is often cut off.

Re-measuring

When the reflectance of the measured surface drastically changes as in the case of looking quickly from the white object to the black object, or when the distance to the object changes a lot, you may face a temporary suspension. If you cannot measure even after a while, press [MEAS] to restart measurement.

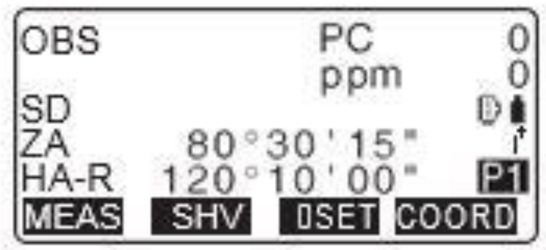
4.14 Distance and Angle Measurement:

An angle can be measured at the same time as the distance.

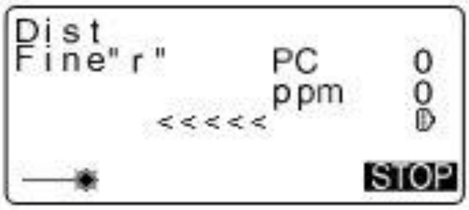
PROCEDURE

1.Sight the target.

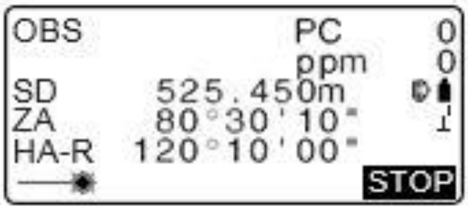
2. In the first page of Obs Mode, press [MEAS] to start distance measurement



When measurement starts, EDM information (distance mode, prism constant correction value, atmospheric correction factor) is represented by a flashing light.

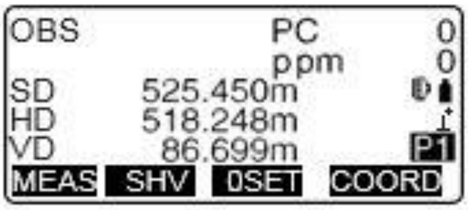


A short beep sounds, and the measured distance data (SD), vertical angle (ZA), and horizontal angle (HA-R) are displayed.



3. Press **[STOP]** to quit distance measurement.

- Each time **[SHV]** is pressed, SD (Slope distance), HD (Horizontal distance) and VD (Height difference) are displayed alternately.



- If the single measurement mode is selected, measurement automatically stops after a single measurement.
- During fine average measurement, the distance data is displayed as S-1, S-2, ... to S-9. When the designated number of measurements has been completed, the average value of the distance is displayed in the [S-A] line.
- The distance and angle that are most recently measured remain stored in the memory until the power is off and can be displayed at any time.
  "12.3 Recalling the Measured Data"
- If the tracking measurement is conducted with the target type "reflectorless", the measured data for a distance exceeding 250m is not displayed.

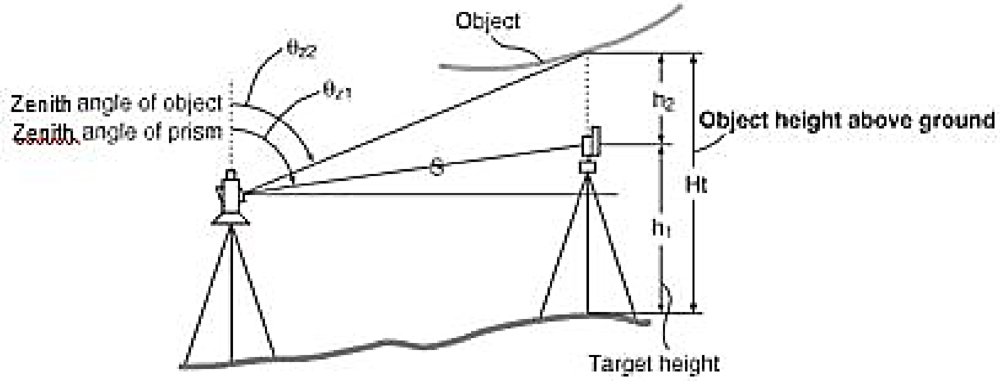
4.15 REM Measurement:

An REM measurement is a function used to measure the height to a point where a target cannot be directly installed such as power lines, overhead cables and bridges, etc.

The height of the target is calculated using the following formula.

$Ht = h1 + h2$

$h2 = S \sin \theta z1 \times \cot \theta z2 - S \cos \theta z1$

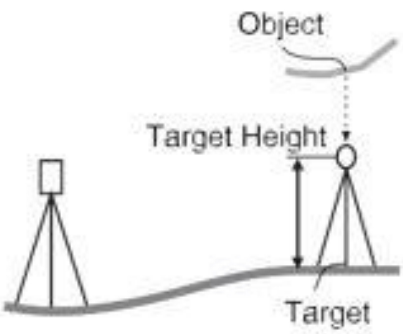


□

- The items displayed as <Null> in the coordinate data are excluded from the calculation (Null is different from 0).

PROCEDURE

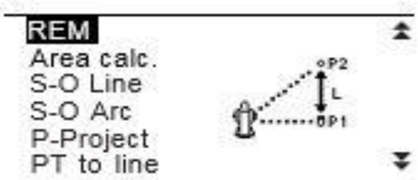
1. Set the target directly under or directly over the object and measure the target height with a tape measure etc.



2. After inputting the target height, accurately sight the target.
   □ " □ "
   Press **[MEAS]** in page 1 of Obs Mode to carry out measurement.

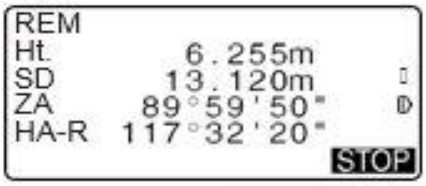
The measured distance data (SD), vertical angle (ZA), and horizontal angle (HA-R) are displayed.
Press **[STOP]** to stop the measurement.

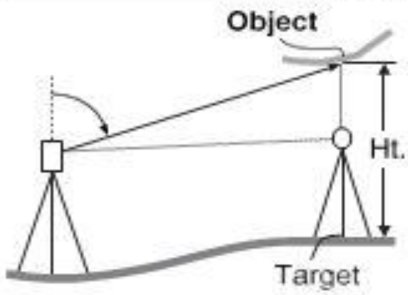
3. In the second page of OBS mode screen, press **[MENU]**, then select "REM".



4. Enter into the REM menu. Select "REM."

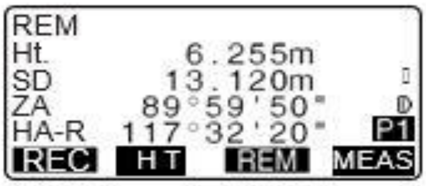
5. Sight the target.
Pressing **[REM]** starts REM measurement.
The height from the ground to the object is displayed in "Ht.".





6. Press **[STOP]** to terminate the measurement operation.

- To re-observe the target, sight the target, then press **[MEAS]**.



- Press **[HT]** to enter an instrument height (HI) and a target height (HR).

- When **[REC]** is pressed, REM data is saved.
  ☐"28. RECORDING DATA - TOPO MENU -"

- Press **[HT/Z]** on the second page of the REM measurement to display the Z coordinate for the height from the ground to the target. Pressing **[HT/Z]** again returns to the height display.

7. Press **{ESC}** to finish measurement and return to the OBS mode screen.

☐

- It is also possible to perform REM measurement by pressing **[REM]** when allocated to the OBS mode screen.
  ☐"33.3 Allocating Key Functions"
- Inputting instrument and target height: Press **[HT]** to set instrument and target height. It can be set also in "Occ. Orientation" of coordinate measurement.
  ☐"13.1 Entering Instrument Station Data and Azimuth Angle"

4.16 SETTING INSTRUMENT STATION:

It is possible to set from the instrument station data to the backsight angle in a series of procedures

• Key input:

- ✓ Entering Instrument Station Data and Azimuth Angle" Step 3
    - Reading the registered coordinate:
- ✓ Entering Instrument Station Data and Azimuth Angle" PROCEDURE Reading in Registered Coordinate Data
    - Calculating data by resection measurement:
- ✓ Setting Instrument Station Coordinate with resection measurement"
    - Inputting the backsight angle:
- ✓ Entering Instrument Station Data and Azimuth Angle" Step 3
    - Calculating from the backsight coordinate:
- ✓ Entering Instrument Station Data and Azimuth Angle" Step 3
- ✓ Calculating the direction angle by assuming the known point (first point) at the time of resection measurement as the backsight point.
- ✓ Setting Instrument Station Coordinate with resection measurement" Step 9

- When performing measurement in which the reduced data is output, be sure to record the instrument station data before the measurement. If a correct instrument station data is not recorded, it may cause output of an unintended measurement result.

4.17 TRAVERSE ADJUSTMENT:

Measurement of a traverse begins with observation of the backsight station and foresight station. The instrument station is then moved to the foresight station and the previous instrument station becomes the backsight station. Observation is performed again at the new position. This process is repeated for the length of the route.

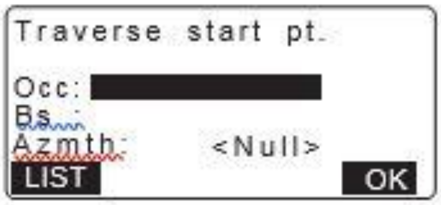
This adjustment function is used to calculate the coordinates of such a sequence of consecutively-observed points (traverse points and points observed from traverse points (see P3-1 to P3-3 below)). When calculation is complete, the CX displays the precision of the traverse and, when necessary, traverse adjustment can be performed.

PROCEDURE

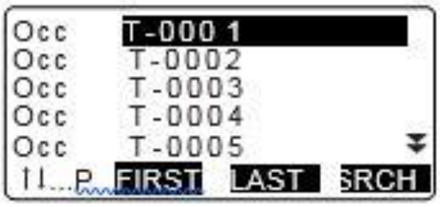
Before starting traverse calculation, observe the sequence of traverse points and record the results.

"28.4 Recording Distance
Measurement Data"/
"28.6 Recording Distance and Coordinate Data"

1. Enter the start point name and press **{ENT}**.

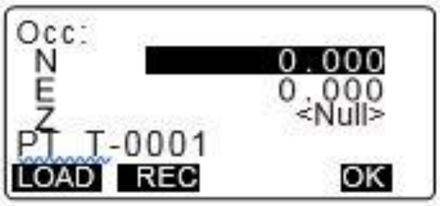


- When **[LIST]** is pressed, a list of instrument stations saved in the current JOB is displayed. A point from this list can be recalled and used.

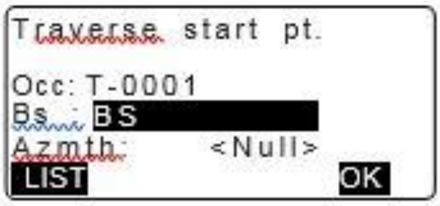


☐For using softkeys in this screen, see "13.1 Entering Instrument Station Data and Azimuth Angle PROCEDURE Reading in Registered Coordinate Data"

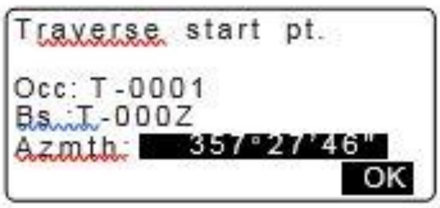
- Enter values manually when there are no coordinates saved for the specified instrument station.
  Press **[OK]** to proceed to step 4.



2. Enter the point name of the backsight station for the start point and press **{ENT}**.



When there are saved coordinates for the backsight station, the calculated azimuth angle is displayed.



- Enter values manually when there are no coordinates saved for the specified start point backsight station.
  Press **[OK]** to display the calculated azimuth angle.

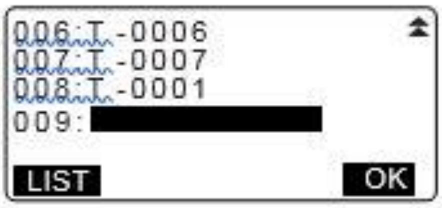
- To enter azimuth angle without entering backsight station coordinates, press {□} to move the cursor down to "Azmth" then enter an angle value.

3. When **[OK]** is pressed in the screen in step 4, the CX will search for a traverse route. The points from step 1 will be displayed in the order in which they were observed.

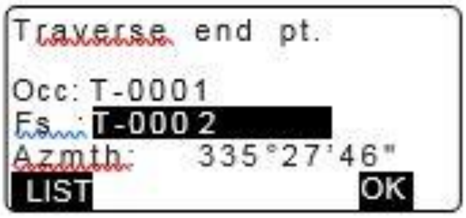
- This search can be stopped by pressing **{ESC}**. If **{ESC}** is pressed, a route can be computed using only the points found prior to the search being stopped.

- When a traverse point with recorded known point coordinates is found, or there are multiple foresight stations for a point, the automatic route search will stop. Press **[LIST]** and select which foresight station to use as the next point.
  □"□ Automatic route search"

4. Press **[OK]** to confirm the traverse route.

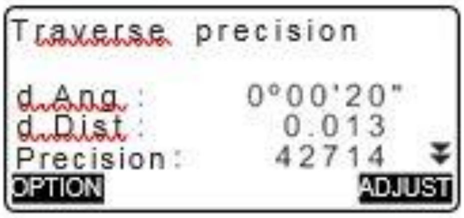


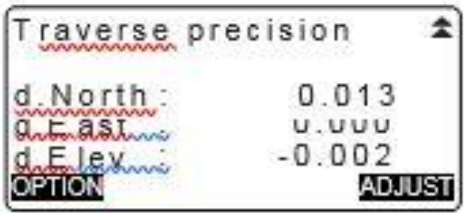
5. Enter the point name of the backsight station for the end point and press **{ENT}**.
The calculated azimuth angle is displayed.



Enter the azimuth angle when there are no recorded coordinates for the end point backsight station.

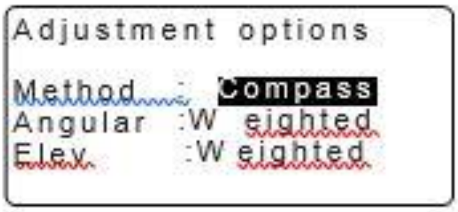
6. When **[OK]** is pressed in the screen in step 7, the CX will display the precision of the traverse.





d.Ang:	Angular closure error
d.Dist:	Horizontal closure distance
Precision:	Precision of the traverse as a ratio of the total horizontal distance traversed to the closure distance
d.North:	Closure distance in Northing coordinates
d.East:	Closure distance in Easting coordinates
d.Elev:	Closure distance in elevation

- Press **[OPTION]** to change the method by which the traverse adjustments are distributed.



(*:Factory setting)

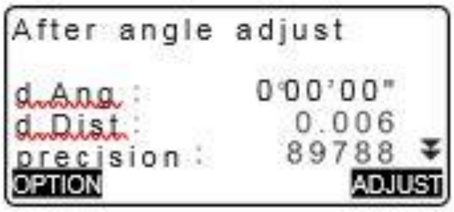
(1) Method (coordinate adjustment):
Compass*, Transit

(2) Angular:
Weighted*, Linear, None

(3) Elev (Elevation):
Weighted*, Linear, None

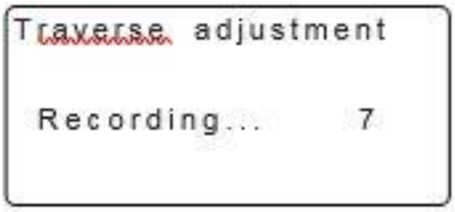
☐ For all options, see "☐ Adjustment methods"

7. Angular adjustment will be performed first. Press **[ADJUST]** to start adjustment using the method selected in "(2) Angular" in step 8.



- When "None" is selected in "(2) Angular" in step 8, only coordinate and elevation adjustment will be performed.

8. After confirming the results, press **[ADJUST]** again to start coordinate and elevation adjustment using the methods selected in "(1) Method" and "(3) Elev" respectively. All adjusted instrument data will be in saved in the currently selected JOB and traverse adjustment will be finished.



• It is also possible to perform traverse adjustment by pressing [TRAV] when allocated to the OBS mode screen.

 Allocating [TRAV]: "33.3 Allocating Key Functions"

• Traverse adjustment results of traverse points, points observed from traverse points and traverse adjustment data will be saved in the currently selected JOB as Notes data. Data including the distributed closure error will also be saved in the currently selected JOB as ordinary coordinate data.

Traverse line record:

1. point names of start and end points
2. backsight station name and azimuth to said backsight station
3. foresight station name and azimuth to said foresight

Adjustment setting record:

The selected method for distributing closure error.

Closure error record (2x2):

1. precision and closure error for angle/distance
2. coordinate closure error

Coordinate adjustment record

(No. of included points between start and end points):

Coordinates

 Types of traverse

CX can calculate closed-loop and closed traverses. In both cases, the azimuth for the start point (and for the end point in the case of a closed traverse) must be set.

 Automatic route search

This function searches for consecutively-observed traverse points already stored on the CX and presents them as potential traverse routes.

This function is activated when the following conditions are met. When a point has been observed more than once, the most recent data will be used for the search.

•At least one backsight station and one foresight station are observed from an instrument station.

•The foresight station becomes the instrument station for the subsequent measurement.

•The instrument station becomes the backsight station for the subsequent measurement.

If one of the following conditions is met, the automatic route search will terminate. The same search can be resumed by specifying the name of the next point in the route.

•There is more than one potential foresight station for an instrument station. (Route search terminates as a juncture appears in the route.)

•The foresight station for the previous measurement was the Start pt. (Route search terminates as this measurement is judged to have closed a closed-loop traverse.)

•The most recently measured point has the same point name as a recorded known point. (Route search terminates as this point is judged to be the End pt.)

The automatic route search function cannot be used in the following case.

•The final measurement is to a traverse point on the traverse route other than the Start pt.

 Adjustment methods:

Adjustment is applied to results for traverse points and points observed from traverse points.

Adjustment methods and distribution options selected in step 8 are described below.

4.18 USING USB MEMORY DEVICE:

It is possible to read in/output data from/to a USB memory device.

•When using a USB memory device, data is stored in the root directory. You cannot read/write data from/to subdirectories.

•When using the CX, an MS-DOS-compatible text file can be input/output.

•When "S type" is selected, only files with an extension of "SDR" can be input/output. The CX cannot display files with an extension other than "SDR" stored in a USB memory device. Also, an output code data file can be displayed only when "T type" is selected. (The same will apply to a case for saving a code while "S type" is selected.)

•You can neither save a file under the same name as a read-only file, nor change/delete the name of a read-only file. (However, this varies depending on the model or software you are using.)

•For "Communication Manual" that describes details on the communication formats used for inputting/outputting data to/from a USB memory device, please consult with your local dealer.

•When using the CX, you can use a USB memory device with the capacity of up to 8GB.

Inserting the USB Memory Device:

•Do not remove the USB memory device during data read/write. Doing so will

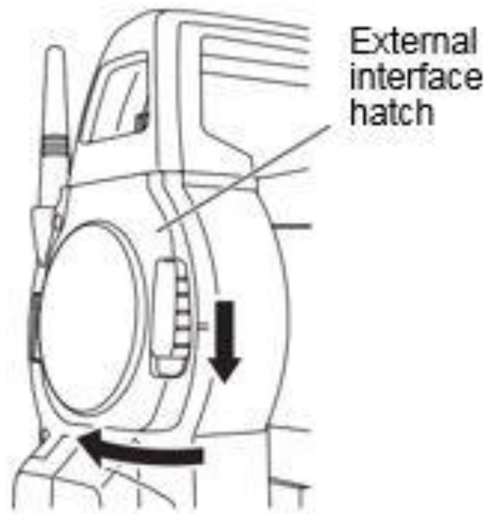
cause data stored in the USB memory device or the CX to be lost.

•Do not remove the battery or turn off the power during data read/write. Doing so will cause data stored in the USB memory device or the CX to be lost.

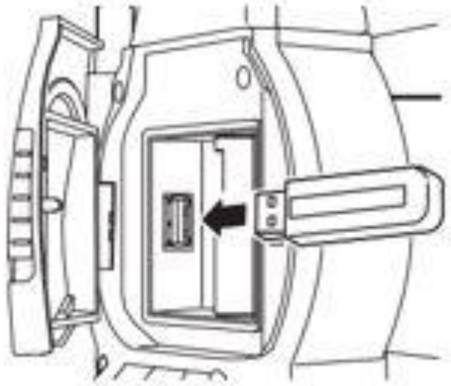
•Waterproofing property for this instrument is not secured unless the battery cover and external interface hatch are closed, and the connector caps are correctly attached. Do not use it with these open or loose, under the condition where water or other liquid spills over the instrument.

PROCEDURE:

1. Slide the catch on the external interface hatch cover down to open.



2. Insert the USB memory device in the respective slot.



☐

- When using a USB memory with 4 metal terminals on the surface, insert it with the terminal facing backwards to avoid damaging the USB port.

3. Close the cover.
   Listen for the click to ensure that the cover is properly closed.

Selecting T type/S type:

1. Press **[USB]** on the status screen.

2. Select "T type" or "S type".
   Press **[ENT]** after selection.

- Select either "T type" or "S type" according to the communication format used.

☐"33.1 Configuration -Config Mode-" Communication Setup

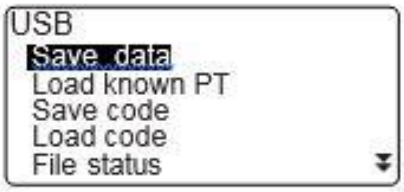
Storing JOB Data to USB Memory device

The measurement data (distance, angle, coordinate), known point data input on the CX, station point data and note stored in a JOB of the CX can be saved to the USB memory device. Also, if multiple JOBs are selected, they can be saved to one file.

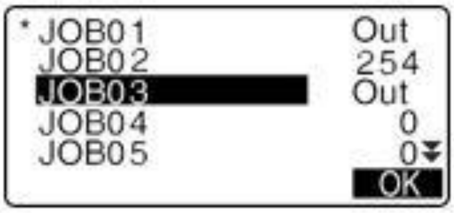
- When selecting S type, the data is saved as a file with an extension corresponding to the output communication format.
- When selecting T type, a file extension is automatically set corresponding to the output communication format, but it can be deleted or changed to any other extension.

PROCEDURE Data saving

1. Select "Save data" in USB mode.

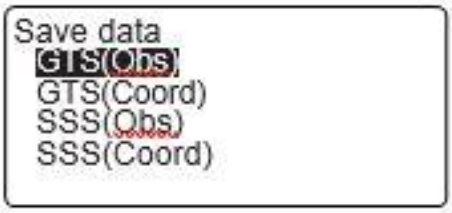


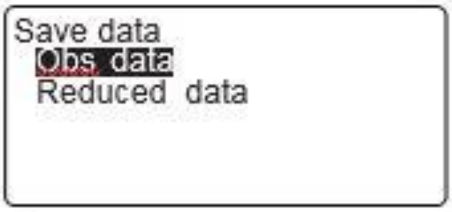
2. In the list of JOBs, select the JOB to be recorded and press **{ENT}**. "Out" is displayed to the right of the selected JOB. Multiple JOBs can be selected.



3. After selecting the JOB(s), press **[OK]**.

4. Select output format. (When T type is selected.)





5. Enter the file name. Press **{ENT}** to set the data.

 • File extension name can be entered when T type is selected. After entering file name, press **{ENT}**/**{▫}** to move the cursor to the extension name.

6. Select output format. (When S type is selected) Align the cursor with "Format" to select the output format.

 • Selecting "Yes" for "Send RED data" on the second page outputs the horizontal distance data converted from the slope distance.

7. Press **[OK]** to save the JOB to the external memory media. After saving a JOB, the screen returns to the JOB list.

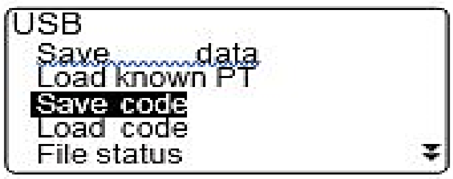
   If **{ESC}** is pressed while data is being recorded, data recording is canceled.

- Maximum size of file name: 8 characters (alphanumeric) excluding the file extension.
- Characters used to make File name: Alphabet (capital letters only), special characters (-)
- Output format
  T type: GTS (Obs), GTS (Coord), SSS (Obs), SSS (Coord)
  S type: SDR33, SDR2x
- Maximum size of extension name: 3 characters (only when T type is selected)
- When a file is overwritten, the overwritten file is deleted.

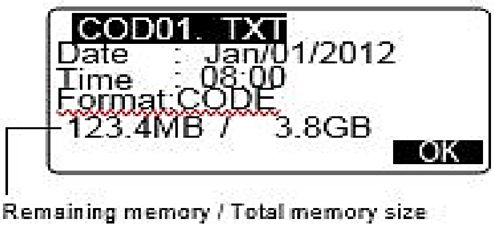
PROCEDURE Code saving

- When saving the code, it is necessary to select "T type" in the communication setting. ☐"33.1 Configuration -Config Mode-" Communication Setup

1. Select "Save code" on the first page of the USB mode.



2. Specify a file name and press **{ENT}**.
   ☐Entering extension name:
   " PROCEDURE Data saving step5"



3. Pressing [OK] starts saving the code. When saving is completed, the screen returns to the list of JOBs.

Pressing {ESC} stops saving.

Chapter 5 EXPERIMENTAL WORK

5.1 Introduction

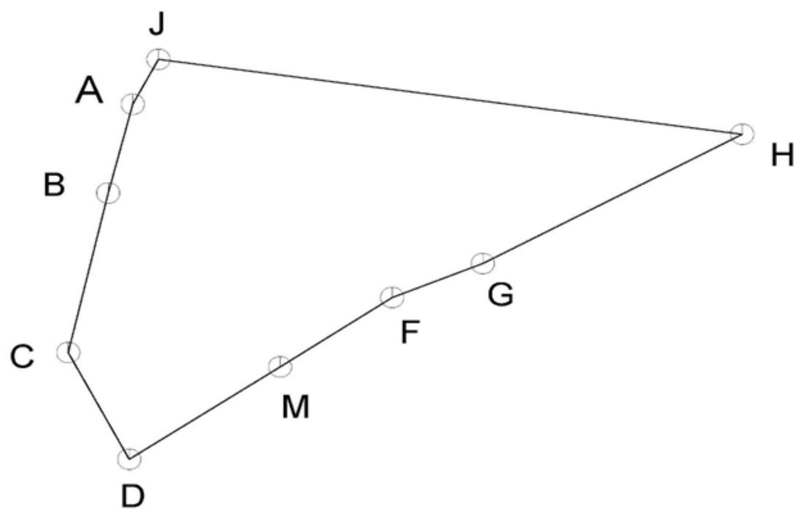


Figure 5-1 points of survey

The final points and data taken from the total station for the given space can be shown in figure (5-1) and table (5-1)

Table5-1 points of survey

Point	**side**	**x**	**y**	**Δx**	**Δy**
A	**AB**	**2.297**	**-5.402**	**-4.649**	**-18.942**
B	**BC**	**-2.3252**	**-24.344**	**-7.6**	**-34.016**
C	**CD**	**-9.952**	**-58.36**	**11.581**	**-22.752**
D	**DE**	**1.629**	**-81.112**	**28.634**	**19.69**
E	**EF**	**30.263**	**-61.422**	**21.28**	**14.796**

F	**FG**	**51.543**	**-46.626**	**17.179**	**7.245**
G	**GH**	**68.722**	**-39.381**	**49.23**	**27.551**
H	**HJ**	**117.952**	**-11.83**	**-110.78**	**15.989**
J	**JA**	**7.172**	**4.159**	**-4.875**	**-9.561**
				0	**0**

5.2 As built for Nile Higher Institute for engineering and technology, Mansoura.

Some of the actual points and data taken from the total station for the given space can be shown in table (5-2), the rest of the table can be found in Appendix A

Table5-1 points of survey

Point coordinates	**x**	**y**	**z**
8	**-4.973**	**38.539**	**1.588**
9	**18.473**	**23.349**	**1.52**
10	**16.442**	**20.248**	**1.578**
11	**26.003**	**7.028**	**1.545**
12	**28.082**	**4.044**	**1.474**
13	**27.109**	**5.289**	**1.543**
14	**8.555**	**-8.375**	**1.702**
15	**10.814**	**-8.744**	**1.653**
16	**-16.073**	**-3.297**	**2.42**
17	**-16.161**	**-4.071**	**2.506**
18	**-16.525**	**-5.277**	**2.509**
19	**-16.745**	**-6.078**	**1.472**

20	**-17.608**	**-10.225**	**2.342**
21	**-17.738**	**-11.007**	**2.278**
22	**-17.898**	**-12.281**	**2.726**
23	**-18.018**	**-12.982**	**2.979**
24	**-18.022**	**-12.956**	**2.978**
25	**-12.685**	**-14.344**	**2.891**
26	**-12.469**	**-13.631**	**2.887**
27	**-11.933**	**-12.399**	**2.445**
28	**-5.702**	**-14.208**	**2.209**
29	**-5.265**	**-13.211**	**2.434**
30	**-4.836**	**-12.075**	**2.411**
31	**32.303**	**-24.533**	**2.048**
32	**32.972**	**-23.038**	**2.044**
33	**35.151**	**-19.83**	**1.338**
34	**35.001**	**-20.484**	**1.42**
35	**34.72**	**-21.95**	**1.372**
36	**45.561**	**-22.189**	**1.333**
37	**45.906**	**-21.158**	**1.194**
38	**51.346**	**-22.52**	**1.253**
39	**51.166**	**-23.51**	**0.856**
40	**46.875**	**-14.37**	**1.346**
41	**32.622**	**. 728**	**1.491**
42	**32.521**	**8.76**	**1.707**
43	**32.002**	**9.45**	**1.714**
44	**28.179**	**6.762**	**1.655**
45	**25.494**	**10.498**	**1.687**

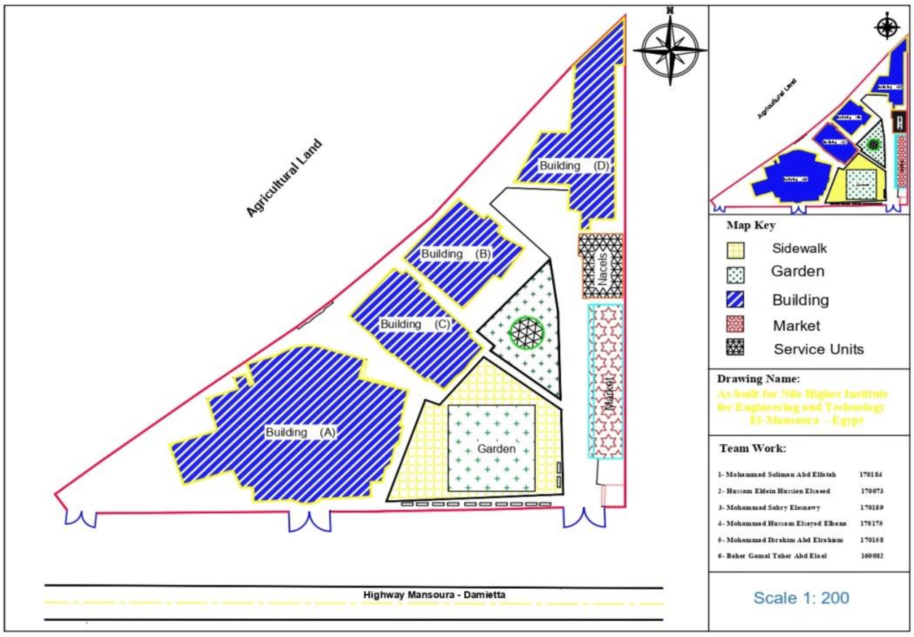


Figure 5-2 shows the layout of the location

5.3 Field investigation

Figure 5-3 Field investigation

Figure 5-4 Field investigation

Figure 5-5 Field investigation

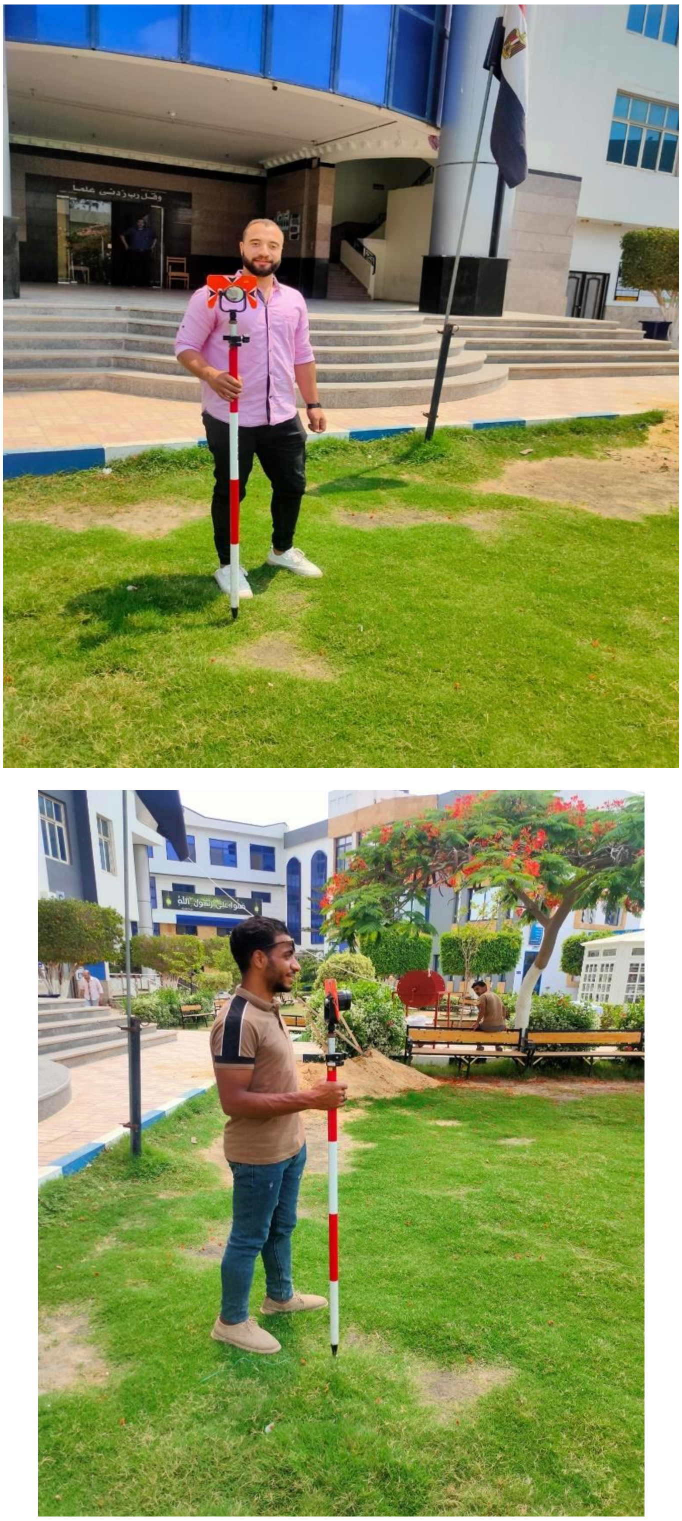


Figure 5-6 Field investigation

Figure 5-7 Field investigation

5.4 FINAL REPORT:

5.4.1 Prototype:

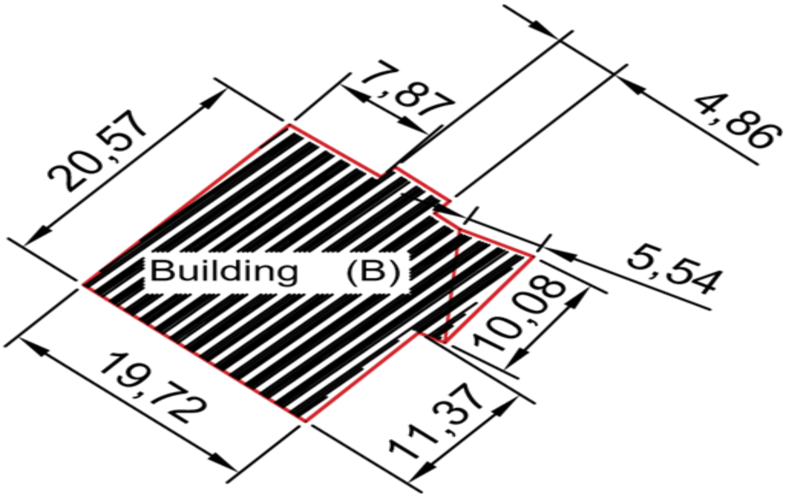


Figure 5-7 Dimension of building B

-4.973	38.539	1.588
18.473	23.349	1.52
16.442	20.248	1.578
26.003	7.028	1.545
28.082	4.044	1.474
27.109	5.289	1.543
8.555	-8.375	1.702
10.814	-8.744	1.653
-16.073	-3.297	2.42
-16.161	-4.071	2.506
-16.525	-5.277	2.509
-16.745	-6.078	1.472
-17.608	-10.225	2.342

-17.738	-11.007	2.278
-17.898	-12.281	2.726
-18.018	-12.982	2.979

5.5 Conclusion:

The accurate cadastral survey for the Nile higher institute for engineering and technology, Mansoura, “asbult” was carried out in for steps. The first step was distributing many fixed points around the institute buildings using surveying closed traverse and observed with accurate devices, Step two was correcting the observations of the closed traverse according to regulations of "Egyptian General Survey Authority", Step three using the traverse points "fixed points" with total station SOKKIA "cx105" to observe all buildings and details in the institute area, Final step drawing the institute using all observation data by AutoCAD Software. At the compulsion between the dimension of the resulted cad drawing and the dimensions of the buildings of institute in nature the accuracy was about ± 2mm which it equal to the accuracy of the used total station. So the observations are accurate.

5.6 Recommendations

Based on our study and result, we recommend the following:

- Always first test the instrument when accurate reflectorless observations are required.
- If possible, it is good to avoid higher angle of incidence of targets for reflectorless measurement.
- To calibrate your instrument one can use KTH-TSC software by measuring slope distance, horizontal and vertical angles towards targets.

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APPENDIX A

TABLE (5-2) points of survey

Point coordinates	x	y	z
46	22.653	14.662	1.686
47	20.033	18.327	1.865
48	23.601	21.234	1.795
49	23.121	21.902	1.794
50	21.703	26.761	1.835
51	31.473	34.745	2.574
52	29.777	35.582	1.958
53	13.339	30.662	1.818
54	12.98	30.082	1.804
55	8.614	32.124	1.806
56	8.785	32.824	1.809
57	7.716	33.4	1.81
58	5.634	34.363	1.8
59	4.126	35.026	1.802
60	3.384	36.593	1.798
61	0.105	38.19	1.785
62	-2.993	41.667	1.809
63	-12.421	-0.79	1.79
64	-12.841	-3.958	2.024
65	-12.257	14.941	2.014
66	-7.015	39.814	1.872

67	**-4.794**	**50.101**	**1.812**
68	**-4.18**	**52.231**	**2.568**
69	**-3.84**	**54.127**	**2.575**
70	**-3.642**	**54.842**	**2.974**
71	**53.099**	**-14.237**	**1.222**
72	**52.938**	**. 728**	**1.853**
73	**54.367**	**-30.164**	**3.003**
74	**51.639**	**-25.799**	**3.319**
75	**52.267**	**-25.459**	**2.944**
76	**56.685**	**-22.903**	**2.797**
77	**58.023**	**-24.11**	**2.79**
78	**64.086**	**-21.281**	**2.817**
79	**67.723**	**-22.931**	**3.006**
80	**44.512**	**-10.07**	**3.024**
81	**50.862**	**-1.488**	**3.019**
82	**54.354**	**-8.66**	**3.187**
83	**56.44**	**-4.694**	**3.358**
84	**57.37**	**-3.261**	**3.034**
85	**60.959**	**-4.468**	**3.035**
86	**66.47**	**-1.958**	**2.884**
87	**63.699**	**3.966**	**3.184**
88	**66.839**	**-3.21**	**2.822**
89	**62.821**	**-8.06**	**2.832**
90	**68.558**	**-22.66**	**2.819**
91	**39.235**	**3.908**	**3.2**

92	**33.063**	**9.198**	**3.017**
93	**73.337**	**-13.245**	**2.73**
94	**52.938**	**-7.686**	**3.142**
95	**53.099**	**-14.237**	**1.222**
96	**75.029**	**-15.572**	**4.666**
97	**78.94**	**-19.422**	**4.652**
98	**88.385**	**-29.714**	**4.785**
99	**93.153**	**-31.058**	**4.791**
100	**93.39**	**-30.354**	**3.982**
101	**53.099**	**-14.237**	**1.222**
102	**53.099**	**-14.237**	**1.222**
103	**56.732**	**21.605**	**5.095**
104	**73.337**	**-7.686**	**3.142**
105	**67.12**	**6.076**	**6.506**
106	**63.614**	**11.224**	**6.511**
107	**54.877**	**20.362**	**6.639**
108	**52.725**	**23.186**	**6.667**
109	**50.852**	**21.481**	**6.275**
110	**51.49**	**20.546**	**6.259**
111	**47.203**	**17.534**	**6.228**
112	**46.407**	**18.541**	**7.242**
113	**40.658**	**14.305**	**6.387**
114	**53.558**	**29.427**	**6.657**
115	**49.366**	**37.173**	**6.671**
116	**43.345**	**36.337**	**6.642**

117	**48.079**	**39.776**	**6.659**
118	**47.601**	**39.527**	**6.676**
119	**46.556**	**41.818**	**6.678**
120	**45.588**	**43.327**	**6.646**
121	**44.646**	**45.382**	**6.641**
122	**43.917**	**47.197**	**7.789**
123	**42.9**	**49.174**	**7.793**
124	**43.36**	**49.63**	**7.779**
125	**45.272**	**40.822**	**6.645**
126	**56.732**	**21.605**	**5.095**
127	**42.95**	**40.983**	**8.14**
128	**40.224**	**39.125**	**9.281**
129	**36.819**	**36.297**	**9.262**
130	**35.196**	**34.881**	**8.271**
131	**30.713**	**31.573**	**8.501**
132	**23.789**	**29.713**	**9.205**
133	**23.968**	**29.921**	**8.731**
134	**23.304**	**29.821**	**8.906**
135	**24.919**	**32.032**	**8.243**
136	**31.848**	**35.269**	**10.478**
137	**36.219**	**43.149**	**7.826**
138	**38.593**	**49.238**	**8.146**
139	**37.767**	**55.621**	**8.164**
140	**40.473**	**56.591**	**8.155**
141	**37.089**	**63.448**	**8.164**

142	**37.714**	**63.63**	**8.225**
143	**36.994**	**31.801**	**8.098**
144	**30.94**	**27.91**	**8.005**
145	**36.821**	**64.726**	**8.107**
146	**45.272**	**40.822**	**6.645**
147	**34.336**	**67.445**	**9.641**
148	**31.446**	**67.107**	**10.857**
149	**31.634**	**63.954**	**10.135**
150	**34.701**	**64.234**	**10.094**
151	**30.584**	**74.961**	**9.763**
152	**32.728**	**75.292**	**9.873**
153	**26.13**	**90.454**	**9.786**
154	**15.739**	**108.981**	**10.372**
155	**36.821**	**64.726**	**8.107**
156	**22.147**	**74.385**	**14.637**
157	**21.172**	**86.489**	**12.93**
158	**10.207**	**85.401**	**12.936**
159	**11.093**	**72.995**	**14.432**
160	**6.417**	**72.048**	**12.63**
161	**2.175**	**69.974**	**12.642**
162	**-1.936**	**61.989**	**13.319**
163	**-1.809**	**63.029**	**12.642**
164	**-2.56**	**59.199**	**13.323**
165	**-2.663**	**58.532**	**13.303**
166	**-0.34**	**69.747**	**12.646**

167	**1.992**	**80.146**	**12.762**
168	**4.288**	**90.728**	**13.099**
169	**8.029**	**107.575**	**12.347**
170	**8.346**	**108.442**	**12.343**
171	**8.623**	**109.178**	**12.356**
172	**9.979**	**112.785**	**12.364**
173	**10.359**	**113.359**	**12.341**
174	**10.592**	**114.387**	**12.344**
175	**12.935**	**115.386**	**12.066**
176	**15.59**	**114.564**	**12.136**
177	**20.999**	**102.514**	**11.85**
178	**36.821**	**64.726**	**8.107**
179	**-18.93**	**116.134**	**12.522**
180	**-18.315**	**116.021**	**12.536**
181	**15.739**	**108.981**	**10.372**
182	**7.432**	**107.007**	**14.025**
183	**6.228**	**107.385**	**13.95**
184	**-3.903**	**109.571**	**14.076**
185	**-14.845**	**64.644**	**14.074**
186	**-3.485**	**63.987**	**16.598**
187	**-2.783**	**62.507**	**16.625**
188	**-5.15**	**51.775**	**16.999**
189	**-7.53**	**52.004**	**16.711**
190	**-18.753**	**53.826**	**13.883**
191	**-31.155**	**1.097**	**16.493**

192	**-17.825**	**-2.51**	**15.058**
193	**-15.911**	**-3.401**	**16.157**
194	**-35.959**	**2.145**	**14.198**
195	**-36.109**	**2.117**	**15.341**
196	**-22.854**	**58.118**	**15.149**
197	**-12.831**	**99.936**	**14.099**
198	**-19.098**	**111.093**	**14.054**
199	**-28.872**	**68.927**	**14.168**
200	**-43.648**	**4.687**	

Engineering standards

- All the surveying investigation work starting from planning stage, followed by field work to production stage is conducted according to Egyptian General Survey Authority (ESA). Moreover, All Egyptian standards in the field are nearly harmonized with the international, European, or foreign standards.

- ESA can be regarded as the backbone for supplying data to the Egyptian society. In fact, it is currently the only governmental organization responsible for the coverage of Egypt with base topographic maps of several scales. It also has the responsibility of supporting national cadastre and land registration, in cooperation with the Real Estate Office in the Ministry of Justice. Moreover, ESA is a solid candidate in the Egyptian Geography Network (EGN), Egyptts National Geospatial Infrastructure (NSDI). In accordance, with its national role comes the establishment of ESAAs Geographic Information Management System (ESA GIM). This paper will provide a summary of the main business requirements and challenges that can be overcome with the aid of ESA GIM. It also gives a detailed description of the system established including the concept of the system, the system architecture, the data model and the different modules from which the system comprises. The proposed system architecture is based on building ESA GIM Data Warehouse, which is the data repository populated from three main data sources: the topographic department, the ECIM (Egyptian Cadastral

Information Management) project and the cadastre project in Cairo province. Hence, the solution provides ESA with a tool to convert data coming in from multiple sources.