Development of Deformation Monitoring System of an Engineering Structure using Reflectorless Total Station

by

Mohd Shahril bin Hasim

A project dissertation report submitted in partial fulfillment of

the requirements for the

Bachelor of Engineering (Hons)

(Civil Engineering)

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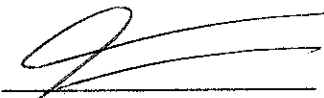Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

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(Dr. Abdul Nasir Matori)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2006

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons

MOHD SHAHRIL BIN HASIM

ABSTRACT

The rationale of Final Year Project (FYP) is to develop student's ability in the process of learning and applying knowledge in the area of interest with minimum guidance and supervision. This FYP entitled *Development of Deformation Monitoring System of an Engineering Structure using Reflectorless Total Station* is basically preparing appropriate system from hardware and software aspect for deformation of engineering structure with the aid of reflectorless total station. Deformation of engineering structure is measured to ensure that the structure is exhibiting safe deformation behaviour. The engineering structure selected to assess the workability of the system was the UTP Academic Complex Canopy. The deformation data collected will be processed and analysed by developed computer system. The results will demonstrate if movement occurred on selected structure and give warning when the movement is critical. At the end if the project is realistic and reasonable, the developed system can be used for monitoring deformation work of other engineering structures.

ACKNOWLEDGEMENT

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CHAPTER 1

INTRODUCTION

1.1   BACKGROUND OF STUDY

Engineering structures such as dams, bridges, high-rise structures and oil platforms are subject to natural causes and to human interaction that may lead to collapse or structural failure. These structures can undergo deformation due to landslide, tectonic movement, differences in underground water level tidal phenomena and many other factors. On the latter circumstance, the development of an appropriate methodology for the remote structure monitoring is important for safety reasons [4].

Hence, engineering surveying play an important role in determining the magnitude of movements occurred on structures for the purpose of safety and maintenance. The measurements techniques can be grouped mainly into two; geodetic and non-geodetic techniques. The selection of most appropriate technique or combination of techniques for any particular application will depend upon cost, the accuracy required, and the scale of the survey involves [8].

In this project, an appropriate deformation monitoring system of an engineering structure will be developed in order to detect and quantify the deformation if occurred. The system will consist both software and hardware preparation. The reflectorless total station chose to measure the coordinates of identified point because it can be used without reflector. Therefore this instrument can be used for deformation monitoring of inaccessible structure.

The data from the reflectorless total station will be transferred to computer facilities. By using relevant software, the computer will automatically interpret if structural movement detected. Moreover the computer will evaluate whether the movement is

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still safe or not. When the movement is exceeding its allowable movement, the alarm will be automatically triggered as a warning system.

In order to simulate the system developed, an engineering structure which is UTP Academic Complex Canopy will be monitored to obtain the fieldwork data. The structure is selected as it is inaccessible structure because it is difficult to put geodetic target such as prism or GPS receiver due to high constraints. Therefore reflectorless total station can provide the best option for the monitoring work. During the project, the reflectorless total station is located at a permanent location to observe the movement of identified reference points on the canopy within certain duration of time.

1.2 PROBLEM STATEMENT

1.2.1 Problem Identification

The main tasks in deformation monitoring of engineering structure is to study the magnitude and direction of movement due to factors such as changes of ground water level, tidal phenomena, tectonic phenomena, and others. The magnitude of deformation in most common cases is usually small and could not be detected with naked eyes unless until at the very late stage.

Beside, some structures such as high-rise buildings are allowed to have temporary movement due to environmental effect like wind and storm. But at the end the structure will go back to its original position. The structure should be allowed to move in the range of its allowable movement. For safety purposes, the deformation monitoring can be used to investigate whether the structure movement is within its permissible movement. The critical condition occurred when the movement detected was exceeding its allowable movement.

Mostly the available methods of deformation are costly and time consuming. Hence, normally involved parties neglect to plan the deformation monitoring work to avoid cost of implementation. These people assumed that their structures will be stable and save throughout their design life. But in reality, there are structures that already

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collapsed due to deformation failure even tough the structures still in their design life.

Hence the usage of reflectorless total station in deformation monitoring work can be applied as it can save time and economical. But the performance of the total station might become an obstacle to be used for deformation work. The reflectorless total station may lack the range their counter part with reflector has.

Besides, there were cases of death during structure collapse as people were not warned or being warned late. There should be a system that can analyze the data from deformation work and distinguish whether the structure still safe or not.

1.2.2 Significance of the Project

The deformation monitoring is necessary to evaluate the condition of structure. An appropriate method and high accuracy equipments should be used in order to detect the deformation at the early phase so that repair work can be done at low cost.

The developments of a system that can provide warning to people are necessary to save human life. People can get enough time to evacuate the building safely before the structure collapsing. The system should be able calculating the deformation and give the output in a short time.

Latest development technology in total station has resulted them could be operated without reflector (reflectorless total station). Hence its practicality in deformation monitoring has significantly improved. This is due to the fact that now it could be used in any structure that was before inaccessible because of reflector placement difficulty.

1.3 OBJECTIVES AND SCOPE OF STUDY

1.3.1 The Relevancy of the Project

As the author had identified the current problem, the author was thinking of developing the application that can overcome these problems. The desired product would be deformation monitoring system of engineering structure with the aid of reflectorless total station. Basically, there are two objectives for this project which are:

a) *To develop a system that warns the users when the deformation of selected engineering structure is critical.*

The main objective of this project is to develop a system that can analyze the data obtained from reflectorless total station. The system will quantify the magnitude of deformation and give output; if the deformation is critical, an alarm will be triggered automatically. The system also will store the data inserted for future reference. The real data are taken in order to test the system.

b) *To assess the performance of reflectorless total station for deformation monitoring inaccessible structure.*

Currently the conventional total station was using for most of surveying work including deformation monitoring of structure. As technology advances, reflectorless total station had been designed. This equipment can measure object without using reflector. However the real performance of the equipment is uncertain. It is important to evaluate its performance during monitoring work of selected engineering structure.

1.3.2 Feasibility of the Project within the Scope and Time Frame

The feasibility of this project is to develop deformation monitoring system with the aid of reflectorless total station. The analysis is done by developing a system that can detect deformation on selected structure. It took about two semesters to accomplish the project. In the first semesters, the author just concentrated on literature review and research towards the implementation of application. Then for the second semester, the author is applying the theories gained and develops a system using Microsoft Visual Basic 6.0. The data obtained from observing UTP Academic Complex Canopy with the using of reflectorless total station is used to test the functionality of developed system.

CHAPTER 2
THEORY

2.1 DEFORMATION OF ENGINEERING STRUCTURES

In engineering mechanics, deformation is a change in shape of an object because of an applied force. This can be a result of tensile forces, compressive forces, shear, bending or torsion. In Figure 2.1 below, it can be seen that the cylinder had exhibited deformation due to compressive loading (indicated by the arrow). The sides bulge because the material, although strong enough to not crack or otherwise fail, is not strong enough to support the load without change, thus the material is forced out laterally. [7]
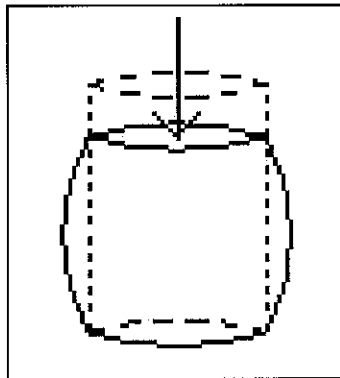
Figure 2.1: Deformation of cylinder

Engineering structures are subject to deformation due to factors such as changes of ground water level, tidal phenomena, tectonic phenomena, and others. Engineering structures are designed and constructed to meet the requirements of a particular project. These structures differ in size, shape, and intended function between projects. As a result, the magnitude of differential settlement and movement that can be tolerated must be established for each structure. Specifications for the allowable magnitudes of differential deformation that can be tolerated are determined by structural and geotechnical engineers. The magnitude of allowable differential

movement should be sufficiently low to prevent the development of shear and tensile stresses within the structure in excess of tolerable limits.

The collapse of Highland Tower building, the Sultan Abdul Halim ferry terminal bridge collapse, Hotel New World disaster, Sampoong Department Store collapse, were the structural failure disasters that occurred due to deformation problems. In order to evade such incidents from happening over again, the need to determine the suitable technique and instrument that applicable to detect and monitor deformation is very important. Deformation measurement techniques generally can be divided into geodetic and non-geodetic methods.

Each main measurement technique has its own advantages and limitations. Geodetic techniques by angle or distance measurements provide an adequate redundancy of observations for the statistical evaluation of their quality and for a detection of errors. They give global information on the behavior of the deformable structure while the non-geodetic techniques give localized and locally disturbed information without any further check. Besides, the instruments used in non-geodetic measurements, are easier to be used for automatic and continuous monitoring than conventional instruments of geodetic measurements. Geodetic techniques have traditionally been used for determining the absolute displacements of selected points on the surface of the object with respect to some reference points that are assumed to be stable. Non-geodetic techniques have mainly been used for relative deformation measurements within the deformable object and its surroundings. [6]

2.2   THE GEODETIC METHODS

The geodetic methods that normally can be used are Global Positioning System (GPS), close range photogrammetry and conventional terrestrial survey.

GPS offers advantages over conventional global methods. Intervisibility between stations is not strictly necessary, allowing greater flexibility in the selection of station locations. Measurements can be carried out during night or day, under varying weather conditions. The limitation using GPS is the location of the GPS

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receiver should be at open space and clear sky in order to have better and clear signal.

Close range photogrammetry defines as if an object is photographed from two or more survey points of known relative positions with a known relative orientation of the cameras. Thus, relative positions of any identifiable object points can be determined from the geometrical relationship between the intersecting optical rays which connect the image and object points.

Conventional terrestrial survey normally interested in determining precise levelling measurements, angle and distance measurements. The use of level, theodolite, and total station are needed during conducting this method. The use of prism (geodetic target) is needed as reflector in order to obtain the measurements. This method is considered as more economical but the placement of reflectors normally consuming time.

Magnitude of deformation in geodetic methods can be calculated by finding the difference of original coordinates and current coordinates.

$$(\Delta x, \Delta y, \Delta z) = |(x,y,z) - (x',y',z')|$$

The total displacement of the structures can be obtained from root mean square equation.

$$\text{Total displacement, } d = \sqrt{(\Delta x^2, \Delta y^2, \Delta z^2)}$$

The structure is considered in critical when the total displacement calculated higher than the structure's allowable tolerance.

2.3   INSTRUMENT UTILIZED

2.3.1   Reflectorless Total Station

Some recently introduced total station can measure deformation without using reflector which the measuring surface itself is used as a reflector. Some manufacturers employ a timed-pulse infrared signal, transmitted by a laser diode. This reflectorless total station permits direct acquisition of distances from target. It can be used promisingly at the places where the problem to locate prism arise due to steep slope, hazardous area and inaccessible building. The reflectorless total station has been used in improving speed and accuracy along with low maintenance and less cost as compared to more conventional survey methods. Besides, it can be handled by saving workforce.

When the first short-range EDMs (Electronic Distance Measuring) were introduced in the late '60s, it changed forever the way distances are measured [6]. Reflectorless total station is used with an attached EDM beam which helps to identify the feature being measured; that is, the visible beam is set on the desired feature so that the correct surface is being measured and not some feature just beside it or just behind it. Since the measurement is so fast, care must be taken not to mistakenly measure to some object that may temporarily intersect the measuring signal.

The problem that always arises with reflectorless total station is coming from its large EDM beam spot that result the reflectorless total station is not capable to measure small objects. The other problem is the reflectorless total station does not give the accurate distance during measurement. Sometimes actual measurable distance drops down into very short only. The reflectorless total station performance is influenced by colour, shape and surface of the measured object.

Thus, in order to improve the problem faced while using reflectorless total station, some manufacturer like Topcon Corporation has come out with its reflectorless total station which is reliable because it will only provide the accurate result. The reflectorless total station will not give value at situation which is difficult to measure (such as building corner and chainlink fence). The total station also provided with

precise pulse-laser system which can rectify the problem while measured small objects. In addition, the reflectorless total station provides the longest reflectorless range (up to 250 m) that only uses safety class 1 laser which is not harmful to human health.

The Topcon's reflectorless total station also equipped with dual laser optics system. One narrow beam can be used for non-prism mode and a broader beam when prism mode is chosen. This stabilizes the beam over long distances by providing accurate measurement even in adverse atmospheric conditions such as heat shimmer [3]. The reflectorless total station used for this project is GPT3005LN (or for international level known as GPT3005LW). The product specification is attached in Appendix A.
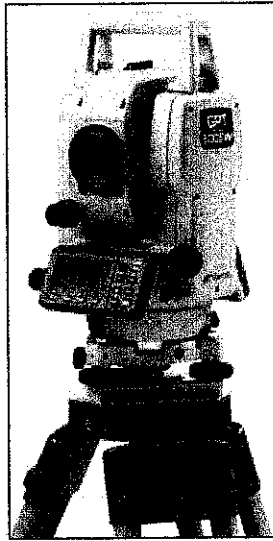
Figure 2.2: Topcon's reflectorless total station

2.4 SOFTWARE UTILIZED

2.4.1 Microsoft Visual Basic 6.0

The *Visual* part refers to the method used to create the graphical user interface (GUI). Rather than writing numerous lines of code to describe the appearance and location of interface elements, prebuilt objects can be added into place on screen.

The *Basic* part refers to the BASIC (Beginners All-Purpose Symbolic Instruction Code) language, a language used by more programmers than any other language in

the history of computing. The new users can create useful applications by learning just a few of the keywords whereas the power of the language allows professionals to accomplish anything that can be accomplished using other programming languages.

The features that Visual Basic has:

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- Data access features allow user to create databases, front-end applications, and scalable server-side components for most popular database formats.
- ActiveX technologies allow user to use the functionality provided by other applications, such as Microsoft Word processor, Microsoft Excel spreadsheet, and other Windows applications.
- User's finished application is a true .exe file that uses a Visual Basic Virtual Machine that user can freely distribute.
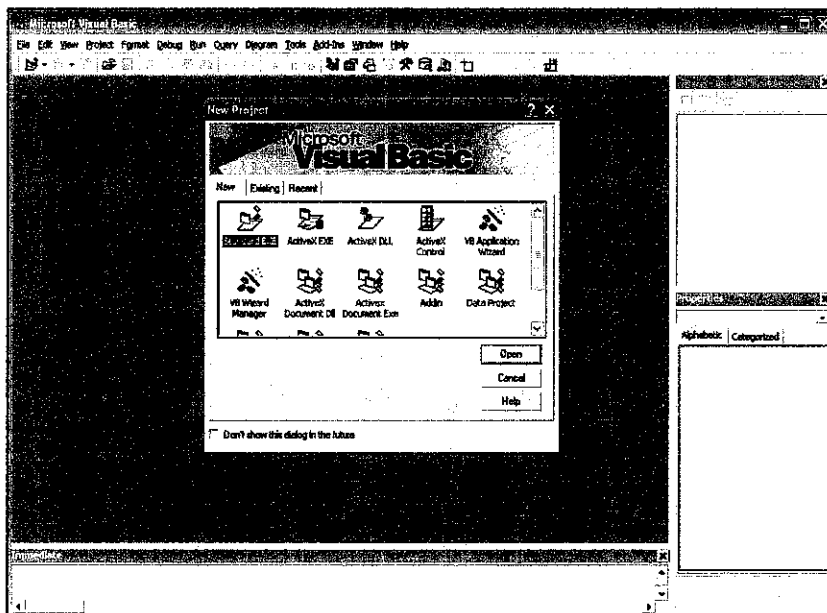
Figure 2.3: Microsoft Visual Basic 6.0 interface

2.4.2   Microsoft Access

Microsoft Access is a popular program used to create and manage databases. It is provided with built in features to assist in developing and viewing information.

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It is important to understand how Microsoft Access breaks down a database. Some terms involved in this process are: *Database File, Table, Record, Field, and Data-type*. Below is the Hierarchy that Microsoft Access uses in breaking down a database.
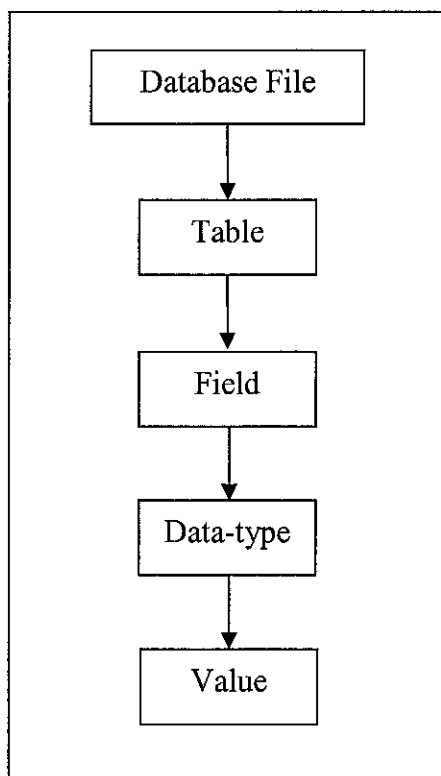
Figure 2.4: Hierarchy of databases' break down in Microsoft Access

Database File is the main file that included the entire database and that is saved to computer storage. A *table* is the collection of data about a particular topic. *Fields* are the different groups within a table. Table commonly encloses several fields. *Data-types* are the properties of each field. A field must only have one data-type.

2.4.3 Topcon Link

Topcon Link developed by Topcon Company is a computer program that transfers files from and to any Topcon data collector, Topcon total station and Topcon GPS system to a PC. The software can view, edit and convert coordinate and raw data files and distinguishes many standard formats.

The use of the software can help to save time used when transferring data taken. Besides it can reduce human errors during importing and exporting files.

Figure 2.5: Topcon Link interface

The data transferred to PC will be saved as text file. The format of data in the text file showed as Figure 2.6 below.

<Point number>,<Northing>,<Easting>,<Elevation>,<Data label>

Figure 2.6: Coordinate data format in text file

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CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1   PROCEDURE IDENTIFICATION

For this part the basic experimental set up and instrumentation will be explained. Basically after research work was done, the next project progress is divided into three phases which is as in Figure 3.1 below. The first phase is began with site and equipment preparation and followed by second phase which is system development phase. The final phase is experimental works.

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┌─────────────────────────────────────────────────┐
│   ┌─────────────────────────────────────┐        │
│   │            Phase 1                   │        │
│   │   Site Selection and Equipments      │        │
│   │           Preparation                │        │
│   └─────────────────────────────────────┘        │
│                     │                             │
│                     ▼                             │
│   ┌─────────────────────────────────────┐        │
│   │            Phase 2                   │        │
│   │       System Development             │        │
│   └─────────────────────────────────────┘        │
│                     │                             │
│                     ▼                             │
│   ┌─────────────────────────────────────┐        │
│   │            Phase 3                   │        │
│   │          Experiments                 │        │
│   └─────────────────────────────────────┘        │
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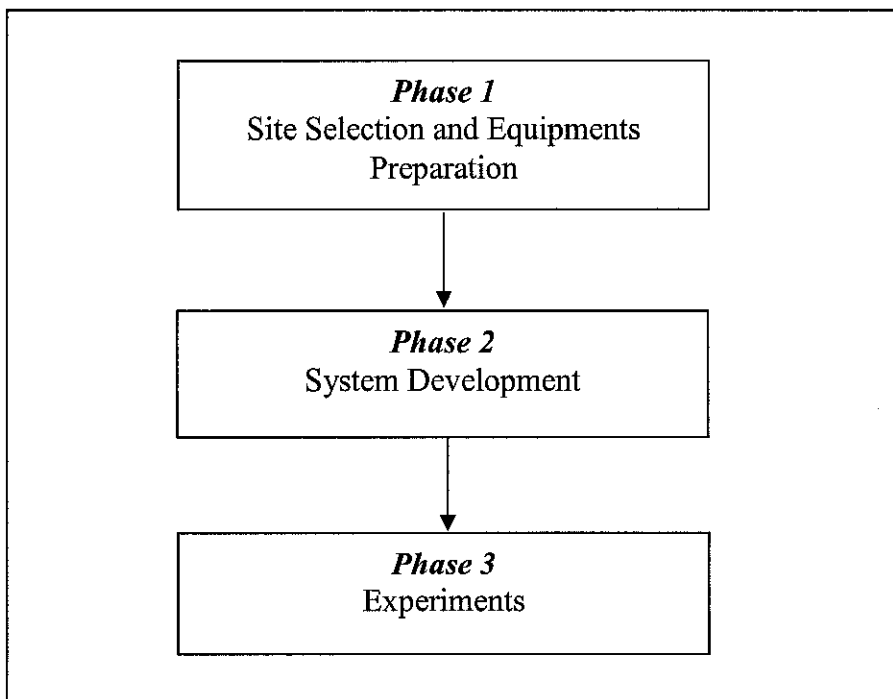
Figure 3.1: The project's phases

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3.1.1 Phase 1: Site Selection and Equipments Preparation

3.1.1.1 Identify and determine possible control point locations

Control point acts as the fixed point whereby the monitoring data are collected from time to time. One control point identified as observation point is located on engineering structure which is on the top of building 14 and will be the place to put the reflectorless total station.

The reason why the author chooses to locate the mounting pod on this structure is because it is the best location with minimum distraction. The location is not the place where peoples always access. Thus, the risk that the mounting pod had been removed and disturbed is small. Besides, the place is not imposed to environment change like rain. Therefore even during bad weather, the data collection work still can be conducted.
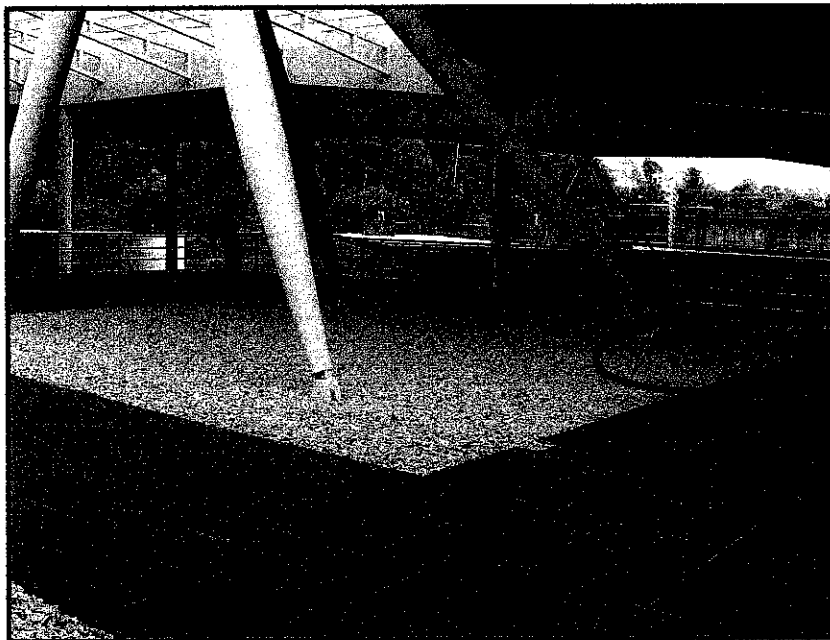
Figure 3.2: Observation point

Reference point is used as reference to other control points. The reference point acts as the point of calibration to eliminate the error during monitoring observation points. Both observation point and reference point needed to be

rigid and not exhibit any deformation so that no error detected during fieldwork.

Figure 3.3: Reference point

Selection of Control Points for Deformation Monitoring System

During the fieldwork, the deformation of two observed points namely Observed Point 1 and Observed Point 2 located on UTP Academic Building Canopy around Civil Engineering Buildings (Block 13 and Block 14) were observed. These two points will be observed daily for certain duration of time to obtain continuous data.

Figure 3.4: Observed Point 1

Figure 3.5: Observed Point 2

The important features that taken into considerations while choosing the location of the control points are:

- The control points located on the canopy should be assessable from the observation point.
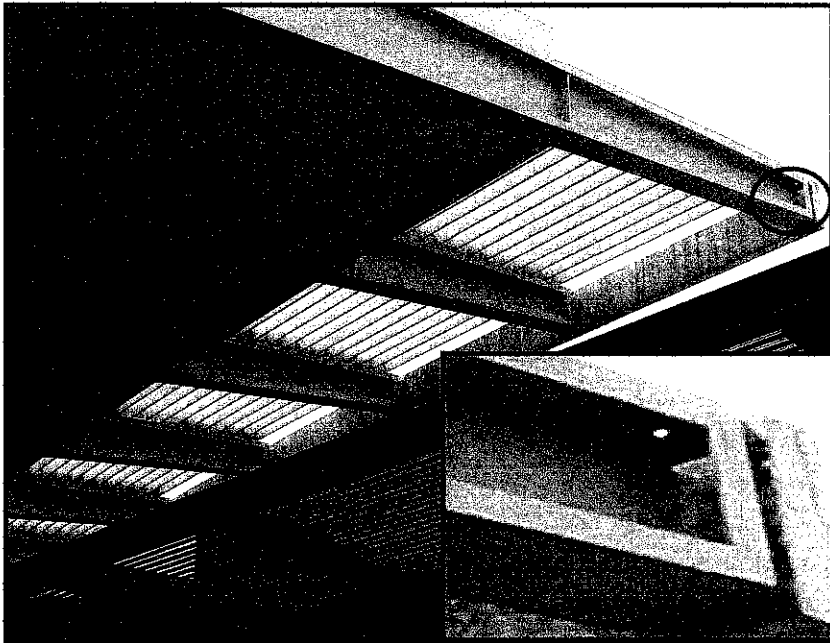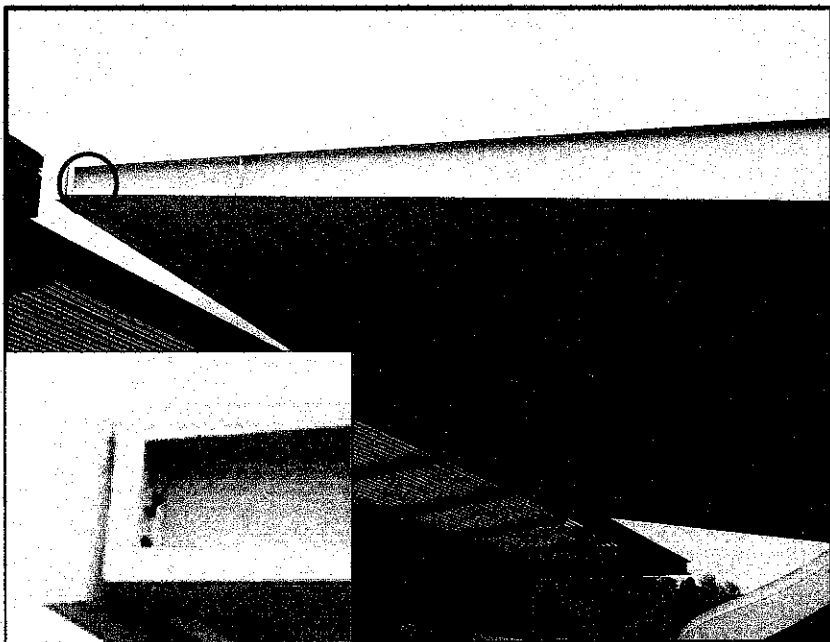- The observation points and the reference point should not exhibit any deformation.

- The location of these control points does not obstruct the continual activities around them.

In order to asses the reflectorless total station performance four groups of point are selected namely Points A, Points B, Points C and Points D. These points located at different location and distance. Each set of these points consist of two individual points which both located vertically to each other (refer to Appendix B). The vertical distance of these two individual points are same throughout the four groups of point. The reflectorless total station will measure the upper point and then measure the bottom point. The vertical difference will be obtained by subtracting the upper point elevation with lower point elevation. Supposedly the vertical difference of the four groups of point should be the same. Thus, from the experiment the performance of reflectorless total station when measuring variation of distance can be evaluated.
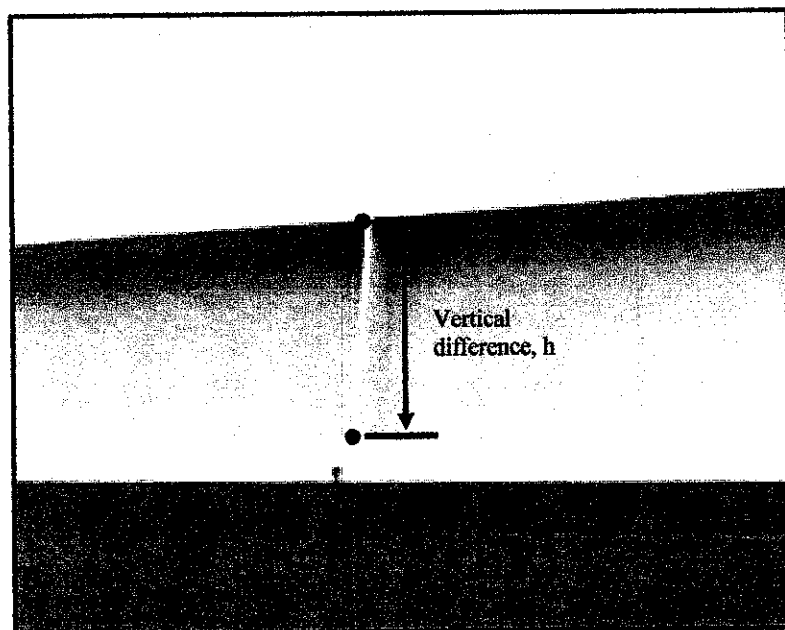
Figure 3.6: How vertical difference obtained

3.1.1.2 Design of Reflectorless Total Station Mounting Pod

In order to make sure the observation point does not change during data collection the author is required to design a mounting pod for the reflectorless total station. The mounting pod will be located at the observation point throughout the project so that the inaccuracy because of human contact is minimized.
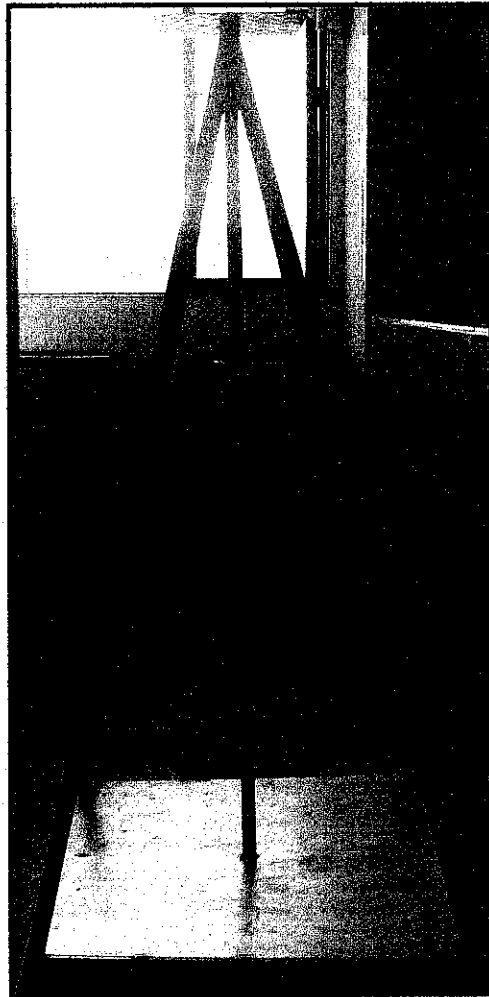
Figure 3.7: Reflectorless total station's mounting pod
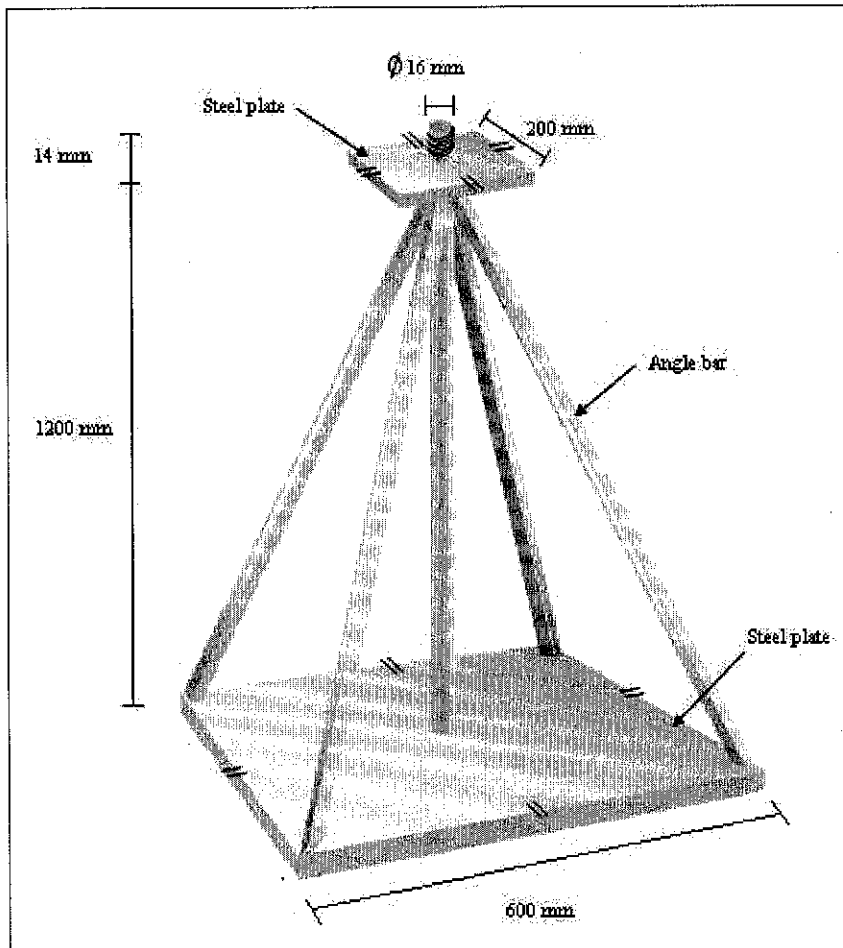
Figure 3.8: Reflectorless total station's mounting pod dimension

The design of mounting pod is as Figure 3.8 above. The mounting pod is made of steel so that it can be constructed in short time. Beside, the heavy weight of the steel itself can forbid the mounting pod from easily moved. The total height of the mounting pod is 1214 mm. The area of basement plate is 600 mm x 600 mm while the top plate area is 200 mm x 200 mm. the screw with diameter of 16 mm is installed on centre of top plate in order to hold the reflectorless total station from moving.

3.1.2 Phase 2: System Development
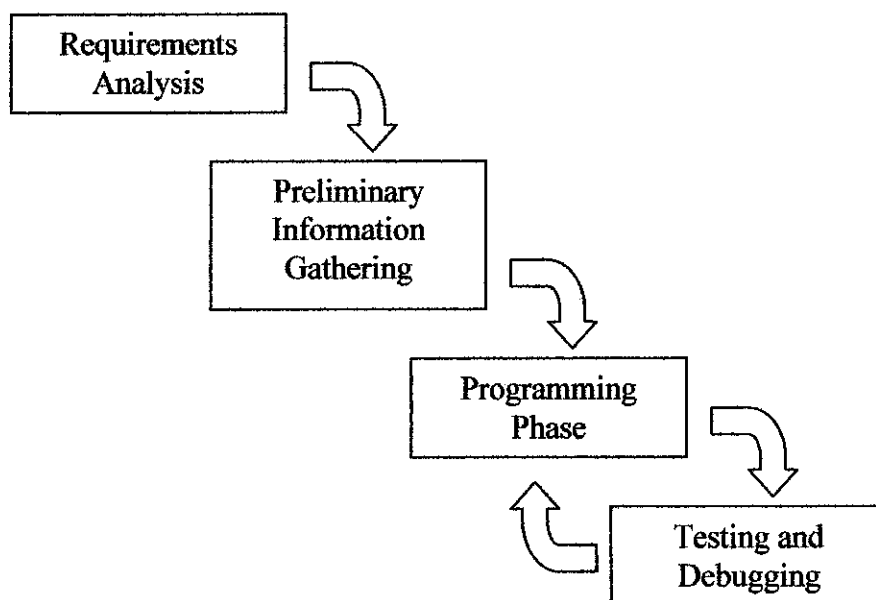
Figure 3.9: Sub-phases in system development

3.1.2.1 Requirements Analysis

At this initial phase, various issues are being discussed hence determining the objectives of the project. Understanding the objectives of the project is very significant as to guide the author to the correct path and to accomplish the project within the predefined scope. Discussion with supervisor is helpful to clearly define the objectives and scope of the project. Although requirements might be changed from time to time, analysis for each requirement can determine whether the requirements are feasible or not. If it is not feasible, the requirement can be ignored and the author can proceed with feasible requirement only to save the time. Requirements analysis are important such that to make sure no requirement is being left out or neglected at the end of the project. At the end of this phase, the author already has clear and distinct requirements of the project.

In this phase, the author has made decision on the software to be used in development phase. The system will be developed by using Visual Basic 6.0. As it name implies, Visual Basic is more visually oriented than most of other programming languages. In fact, Visual Basic represents a new way to write

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computer programs. Within the last ten years, Visual Basic has become one of the most popular languages for developing industry and enterprise applications. In large part, the success of Visual Basic is due to its ability to hide technical complexity and allow developers to focus on the big picture.

3.1.2.2 Preliminary Information Gathering

Then, the development work starts with preliminary information gathering whereby a lot of researches have to be done by collecting materials from library and Internet. The research is very important so that the author can have better understanding about the implementation of the system. As the author does not have much understanding towards the programming language to be used (Visual Basic 6.0), the author needs to study that language in detail before the programming phase. As such, the result would be a benchmark towards the development of the application later on.

3.1.2.3 Programming Phase

This is the main phase in System Development phase. During programming phase, the main task is to develop deformation monitoring system which can evaluate and store data that had been transferred. The system can notify user when critical deformation is detected. The warning system work is illustrated as in Figure 3.10 next page.

HOW THE DEFORMATION MONITORING SYSTEM WORK

Insert the original coordinates (x,y,z) and allowable movement (d)

Obtain current coordinates from text files (x^1,y^1,z^1)

Determine the individual movement $(\Delta x, \Delta y, \Delta z) = (x,y,z) - (x',y',z')$

Determine the total movement, d'
$$d' = \sqrt{(\Delta x^2, \Delta y^2, \Delta z^2)}$$

Check $d' \leq d$

No → The structure is in danger and the alarm will be triggered
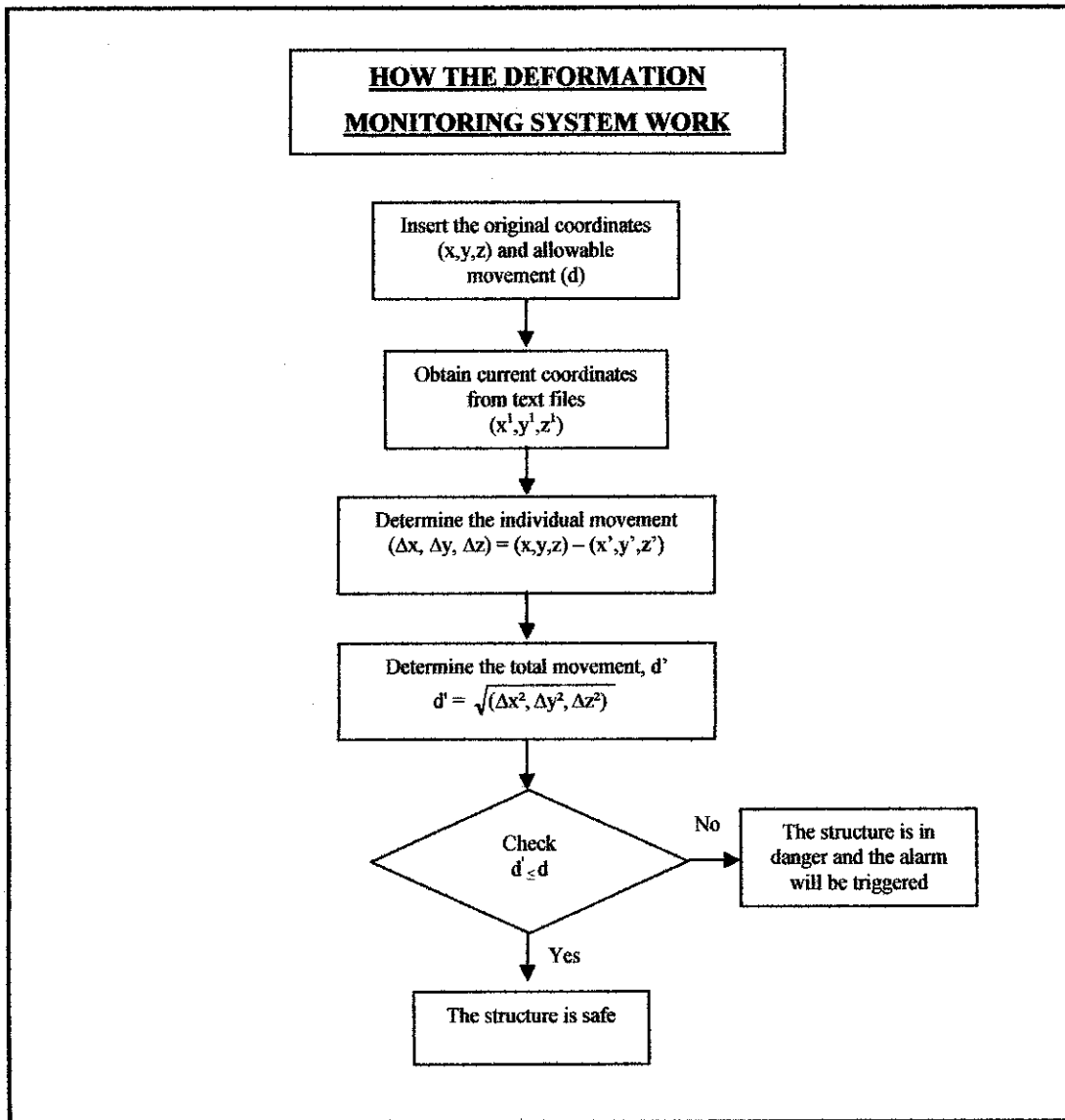
Yes → The structure is safe

Figure 3.10: Flowchart of deformation monitoring system

First, the system is designed to ask the user to insert the original coordinates (x,y,z) of point and its allowable movement (d). Then the system is developed to obtain the current coordinates (x',y',z') from text files. The system will determine the individual movement (Δx, Δy, Δz) by finding the difference between latest coordinate with original coordinate. From the indivual movement, the system will determine the total movement (d') by using root mean square equation. The system will check if the observed movement (d') is exceeding the allowable movement (d) or not. If the movement is lower than its allowable movement, the structure is considered in safe condition. But if the movement is higher than its allowable

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movement, the structure is in danger state and the alarm will be triggered so that people can evacuate immediately from the structure.

3.1.3 Phase 3: Experiments

The arrangement of the experimental set up is summarized in Figure 3.10 below.
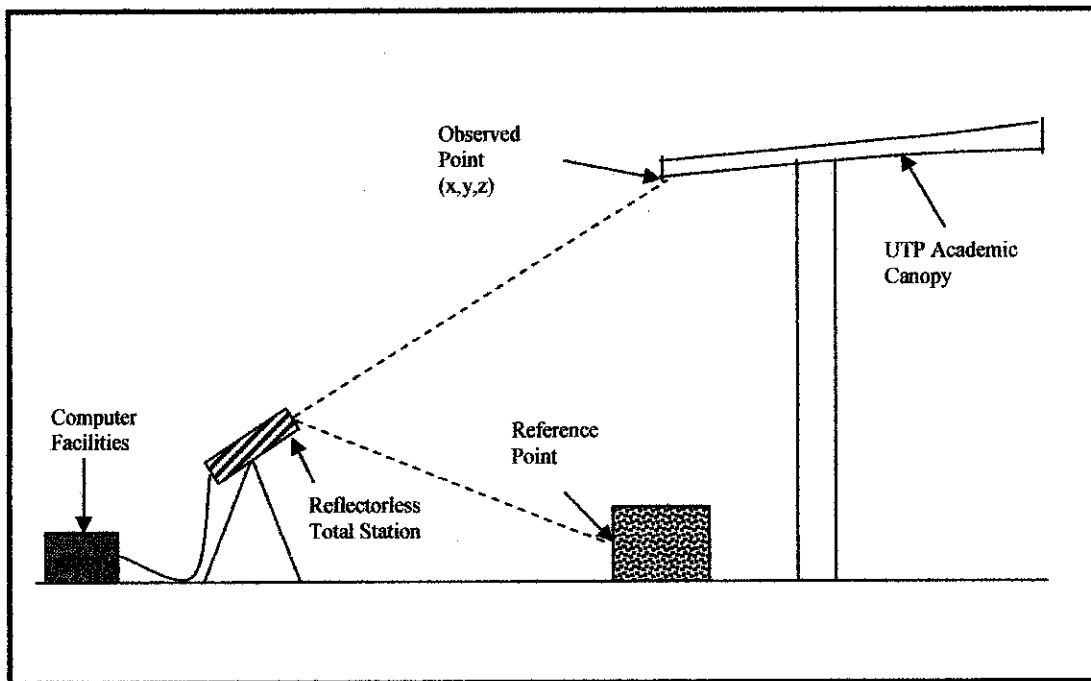
Figure 3.11: Data collection layout

The reflectorless total station will be mounted on the mounting pod which is located at observation point. The reflectorless total station need to be set up accordingly to reduce error (The procedure to setup the total station and preparing data collector are attached in Appendix C).

Firstly the reference point will be assessed and identified. Then the observed points will be monitored to obtain their coordinates (x,y,z) based on their length from established reference point.

The data collected will be transferred to computer facilities via direct connection using transfer cable. A program namely Topcon Link used to

enable the transfer process to be established. The procedure to use Topcon Link is attached in Appendix D. A text file which is *file1.txt* will be generated in computer storage once the transferring process finish.

The data inside the *file1.txt* will be uploaded automatically by Computer Deformation Monitoring System developed using Visual Basic 6.0. The system then will analyze the data to distinguish whether the structure is still safe or not.

In order to store the data in proper way, Microsoft Access program is linked with the deformation monitoring system. Beside Microsoft Access can be used to develop graph in order to study the trend of deformation.

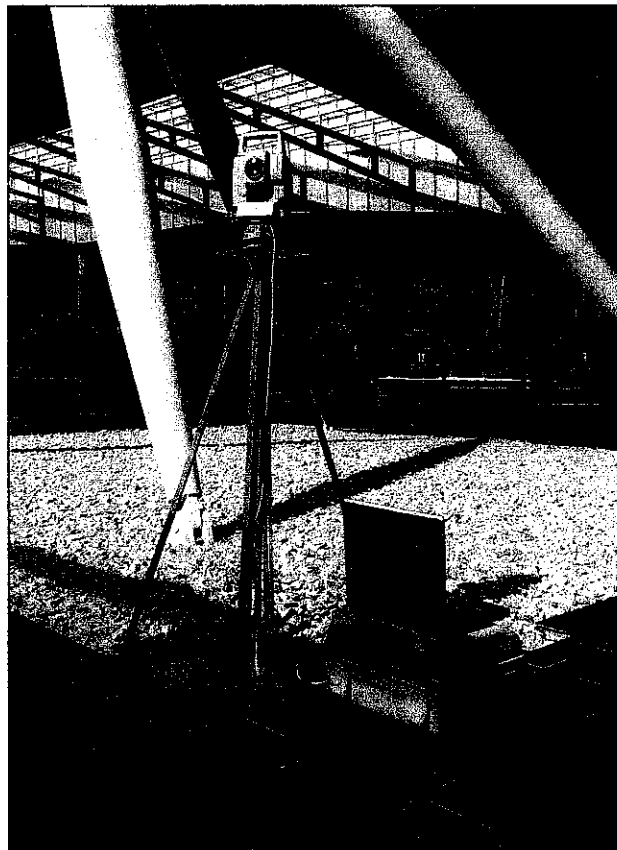## 3.2   TOOLS OR EQUIPMENTS REQUIRED

Figure 3.12: Equipments set up

To ensure the expected application to be run smoothly, the author needs several related equipments (hardware and software). Below is the list of related tools or equipment required:

3.2.1 Hardware

a. *Reflectorless total station with transfer cable*

The reflectoless total station used to quantify the magnitude of deformation during monitoring work. The transfer cable needed to connect the reflectorless total station with computer facilities. This equipment is borrowed from supplier.

b. *Reflectorless total station mounting pod*

The mounting pod is the equipment to cater a place for reflectorless total station to be located. This equipment is located at permanent location to reduce the error because of equipment movement.

c. *Computer facilities*

In order to evaluate the deformation work, the computer facilities needed to run the application.

3.2.2 Software

a. *Microsoft Visual Basic 6.0*

To develop the deformation monitoring system, the author chose to develop it using this software as it is powerful and user friendly application.

b. *Topcon Link*

This software used to transfer files from reflectorless total station to PC. The data file which will be in text file will be used by the deformation monitoring system to be analyzed.

c. Microsoft Access

This program used to create and manage databases. The program will be linked with Visual Basic application in order to store the data from deformation work.

CHAPTER 4

RESULTS AND DISCUSSION

4.1.   RESULT

4.1.1   System Interface

Figure 4.1: The system interface

4.1.2 Deformation Monitoring Experiment

Table 4.1: Coordinates of observed points in Microsoft Excel

Date	Observed Point 1 (m)			Observed Point 2 (m)		
	x	y	z	X	y	z
*23-Feb	21.217	5.917	9.008	-3.993	20.878	7.414
24-Feb	21.215	5.918	9.006	-3.991	20.881	7.414
25-Feb	21.216	5.920	9.004	-3.992	20.881	7.415
26-Feb	21.214	5.920	9.006	-3.994	20.882	7.421
27-Feb	21.215	5.918	9.011	-3.992	20.881	7.419
28-Feb	21.215	5.920	9.008	-3.998	20.879	7.420
1-Mar	21.231	5.859	9.009	-3.935	20.895	7.413
2-Mar	21.221	5.917	8.991	-3.993	20.880	7.420
3-Mar	21.222	5.916	8.989	-3.992	20.875	7.442
4-Mar	21.221	5.917	8.996	-3.990	20.884	7.414
5-Mar	21.220	5.911	9.004	-3.989	20.883	7.409

* The coordinate obtained on 23 February is assumed as initial coordinates and the coordinates obtained in text file format attached in Appendix E. The allowable movement is assumed to be 0.03m

	fld_date	fld_x	fld_y	fld_z	fld_diffx	fld_diffy	fld_diffz	fld_distance	fld_result
	2/24/2006	21.215	5.918	9.006	0.002	0.001	0.002	0.003	OK
	2/25/2006	21.216	5.92	9.004	0.001	0.003	0.004	0.005	OK
	2/26/2006	21.214	5.92	9.006	0.003	0.003	0.002	0.005	OK
	2/27/2006	21.215	5.918	9.011	0.002	0.001	0.003	0.004	OK
	2/28/2006	21.215	5.92	9.008	0.002	0.003	0	0.004	OK
	3/1/2006	21.231	5.859	9.009	0.014	0.058	0.001	0.06	DANGER!
/	3/2/2006	21.221	5.917	8.991	0.004	0	0.017	0.017	OK
	3/3/2006	21.222	5.916	8.989	0.005	0.001	0.019	0.02	OK
	3/4/2006	21.221	5.917	8.996	0.004	0	0.012	0.013	OK
	3/5/2006	21.22	5.911	9.004	0.003	0.006	0.004	0.008	OK

Record: 7 of 10

Figure 4.2: The deformation result for Observed Point 1

fld_date	fld_x	fld_y	fld_z	fld_diffx	fld_diffy	fld_diffz	fld_distance	fld_result
2/24/2006	-3.991	20.881	7.414	0.002	0.003	0	0.004	OK
2/25/2006	-3.992	20.881	7.415	0.001	0.003	0.001	0.003	OK
2/26/2006	-3.994	20.882	7.421	0.001	0.004	0.007	0.008	OK
2/27/2006	-3.992	20.881	7.419	0.001	0.003	0.005	0.006	OK
2/28/2006	-3.998	20.879	7.42	0.005	0.001	0.006	0.008	OK
3/1/2006	-3.935	20.895	7.413	0.058	0.017	0.001	0.06	DANGER!
3/2/2006	-3.993	20.88	7.42	0	0.002	0.006	0.006	OK
3/3/2006	-3.992	20.875	7.442	0.001	0.003	0.028	0.028	OK
3/4/2006	-3.99	20.884	7.414	0.003	0.006	0	0.007	OK
3/5/2006	-3.989	20.883	7.409	0.004	0.005	0.005	0.008	OK

Record: |◄| |◄| 11 |►| |►| of 11

Figure 4.3: The deformation result for Observed Point 2

4.1.3 Reflectorless Total Station Performance Experiment

Table 4.2: Different in vertical depths between four points

	Average Horizontal Distance (m)	Different in Vertical Depth (m)
Points A	18.745	0.497
Points B	23.957	0.493
Points C	166.131	0.511
Points D	223.810	0.516

4.2   DISCUSSION

4.2.1   System Interface

The objective of the system is to run the analysis for deformation monitoring of academic complex canopy. The program will acquire the required data to be keyed-in into the system to perform the analysis. Generally, the screenshots of the system are as follow:
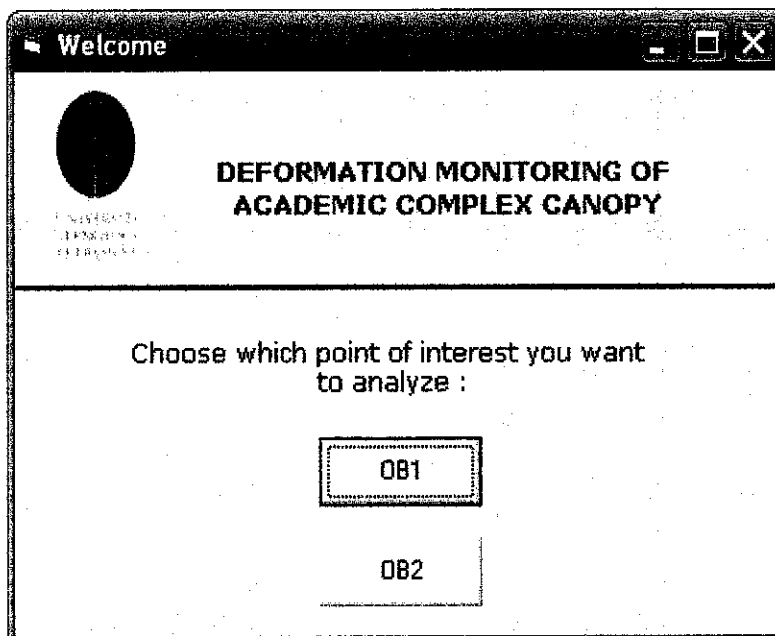

Figure 4.4: Main page of the system

First of all, the main page of the system will be displayed as shown in the above figure. The user needs to choose which observation point to analyze; either OB1 or OB2.
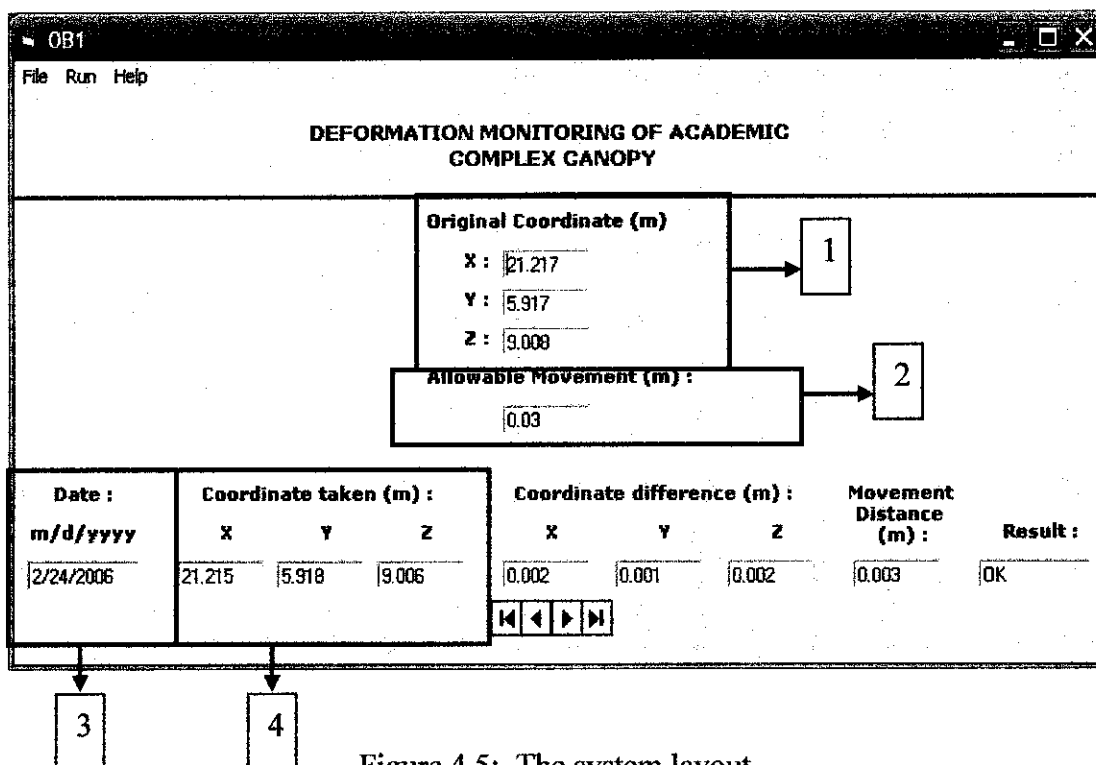
Figure 4.5: The system layout

In this system, the user needs to fill in several parts which are (as indicated in the above figure):

1) Reference coordinate for x, y, and z (in meter, m)

2) Allowable movement (in meter, m)

For item no 1 and 2, the default value is displayed as shown in the screenshot above. However, the user can change the value as and when needed. To add new data, the user needs to click on File > New (as shown below).
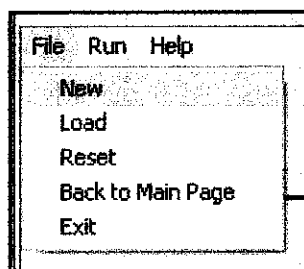

Figure 4.6: File > New menu

For item no 3, the date will be automatically appear based on current date. Then, the user need to load coordinate taken from the text file by clicking File > Load (as shown next page).
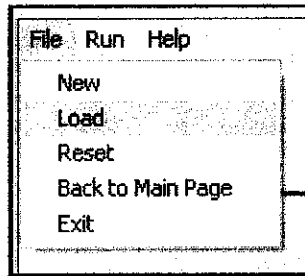
Figure 4.7: File > Load menu

The "Load" function will load coordinate taken for x, y and z in item no 4 from the text file and based on the observation point that has been chosen. The text file will be generated from the Topcon Link software which is obtained from reflectorless total station. After that, the user needs to run the analysis by clicking on Run > Analyze.

Figure 4.8: Run > Analyze menu

The analysis will be performed based on the pseudocode below:

1) Finding the difference between the coordinate taken and the reference coordinate for x, y, and z. The result will be put in the textbox of coordinate difference for x, y and z.

2) Finding the total movement distance by using root mean square method.

3) Comparing the total movement and allowable movement. The message box will appear to notify the result of the analysis. The result will be put in the textbox for Result.

4) Produce sound as an alert if maximum different is greater than allowable movement (DANGER!!).

If the user wants to add data for other observed point, the user needs to click on File > Back to Main Page. The main page will appear as Figure 4.4 in previous page.
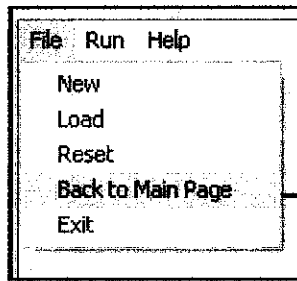
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Figure 4.9: File > Back to Main Page menu

The other functionality of this system is that it will store all the data in the database (.mdb files in Microsoft Access) after the analysis is performed. Thus, the data can be reviewed for future reference. The user needs to click on the Adodc control in the system to view the available data (as shown in the figure below).

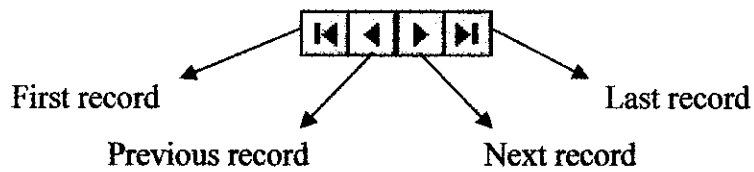First record   Previous record   Next record   Last record

Figure 4.10: The Adodc control

After performing the analysis, the result will be shown in the message box as follows (an alarm will be triggered on the same time if the result is danger):
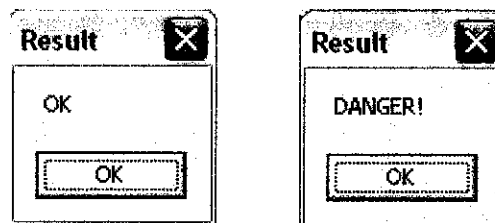

Figure 4.11: Result's message box

As in the File menu of the system, there are five submenus which are 'New', 'Load', 'Reset', 'Back to Main Page', and 'Exit'. The 'Reset' submenu will clear the textbox whereas the 'Exit' submenu is to quit from the system. If the user clicks on the 'Exit' button, the message box will appear asking confirmation from the user if they really want to quit from the system.
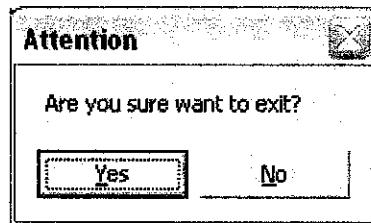
Figure 4.12: Exit submenu's message box

The coding of the system is attached in Appendix F. The system developed can be used to other computer without needing to install Visual Basic 6.0. This can increase the usefulness of the program to other deformation monitoring work.

4.2.2 Deformation Monitoring System Experiment

A fieldwork was done to obtain two points of interest (POI) coordinate with time varied in order to test the deformation monitoring system. The data taken was in daily basis (from 23 February 2006 to 5 March 2006). The coordinate obtained on day first was assumed to be the initial coordinate while the data taken for the next 10 days were assumed as current coordinates.

The allowable movement was assumed to be 0.03m as the actual allowable movement is unknown. The system performed well when the analysis done; alarm was triggered when the movement higher than actual movement. The status of deformation of these observed points can be obtained in the column 9 in Figure 4.2 and Figure 4.3 which each figure show only one danger result (1 March 2006). The individual deformation can be obtained in column 5 until column 7 and movement in three axes direction can be obtained in column 8.

The graphs of the movement in single axis versus time and the graph of the three axes movement versus time for each observed point are plotted to investigate the result.

Figure 4.13 show the movement in single axis versus time for Observed Point 1 (OB1). It can be noticed that during 1 March 2006 the fluctuation occurred in y-axis

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which about 0.058m. Other data were still stable and not showing much different with each other.
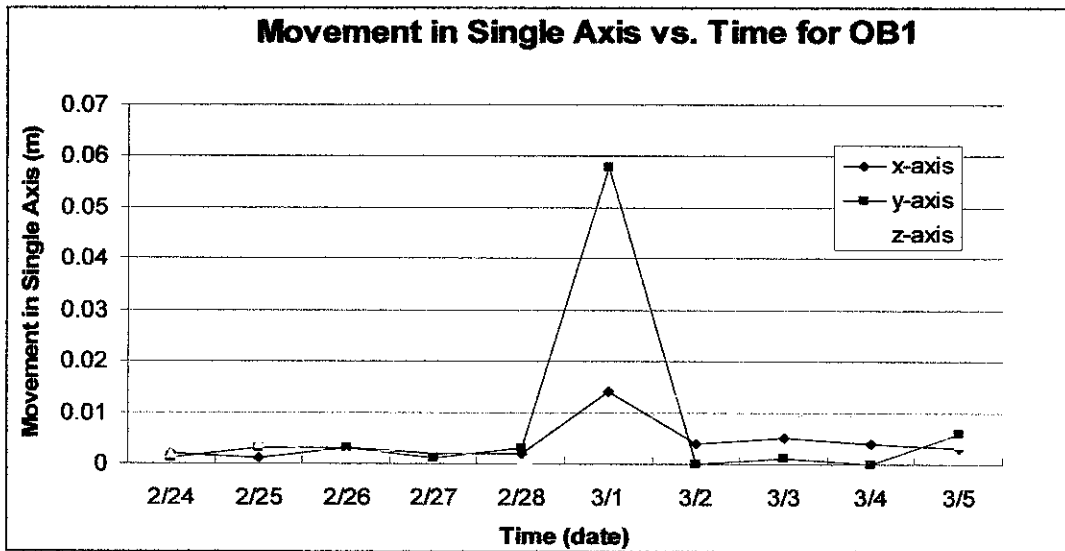

Figure 4.13: Movement in single axis against time for OB1

From Figure 4.14 show that movement of Observed Point 1 in three axes direction. It shows that the fluctuation still occurred on 1 March 2006. This because the data had been influenced by the measurement obtains from y-axis movement.
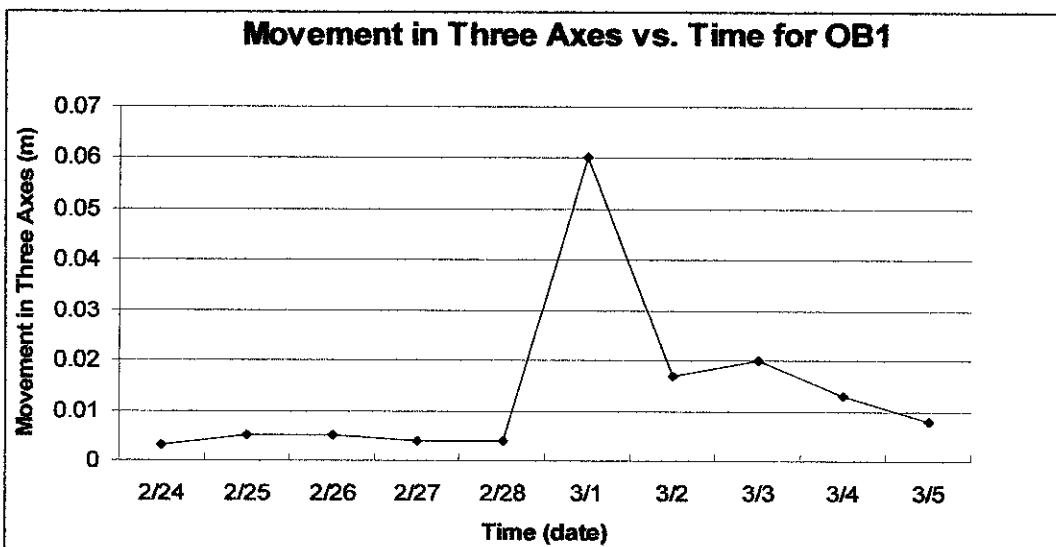

Figure 4.14: Movement in three axes against time for OB1

Meanwhile Figure 4.15 shows the movement in single axis versus time for Observed Point 2. From the plotted graph, it shows that on 1 March 2006 the maximum

measurement detected. The reading comes from x-axis value which was 0.058m. Others value were quite stabile with the magnitude below 0.028m.
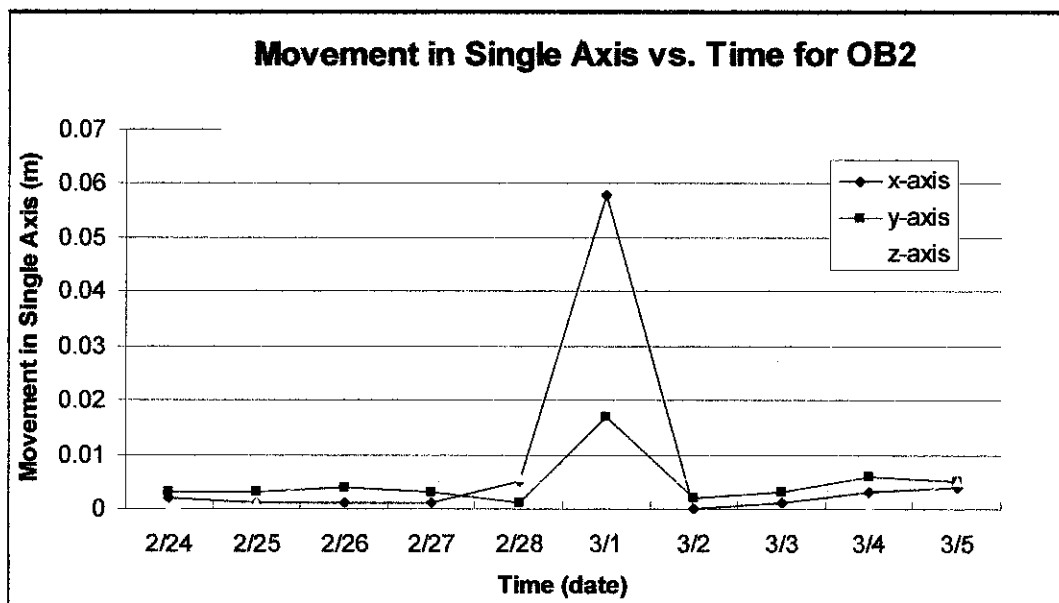

Figure 4.15: Movement in single axis against time for OB2

As the result of maximum value of x-axis on 1 March 2006, the movement on that day was also the highest one. From Figure 4.16 the maximum movement in three axes direction is 0.06m.
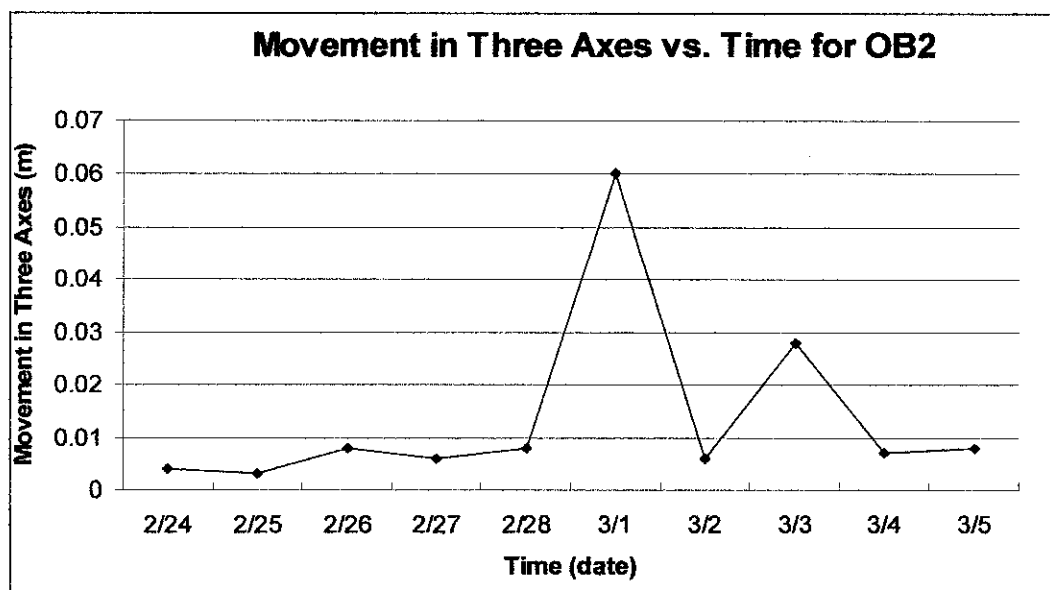

Figure 4.16: Movement in three axes against time for OB2

The coordinates values obtained are quite acceptable for these two observed points which can simulate the best deformation scenario of the selected points except for value obtained on 1 March 2006. It is not reasonable that the movement can be as big like that even tough high rise structure had been permitted to have certain tolerable movement due to environmental factors. Thus, some errors had been occurred while observation works were done.

The error occurred mainly because the observed points are not small to be observed as the both of points actually are bolts located on UTP Academic Complex Canopy. The reason the author choose the bolts as observed point because they are the only components that can be identified located on the canopy as the monitoring work would be done on daily basis. Thus it is reasonable to choose the bolts because they are easily to be recognized.
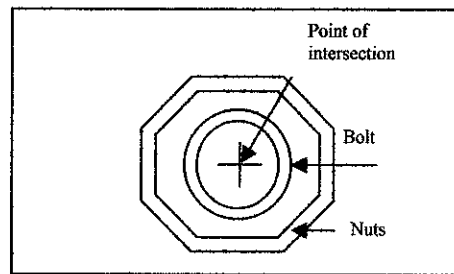

Figure 4.17: The expected intersection point on bolt

Suppose the author need to observe the centre of bolt during obtaining the measurement. The author might be not measuring the centre of bolt during the error measurement taken. This type of error can occur often as the intersection point in the reflectorless total station is very small and precise and the observed point is quite big.

Besides, it is hard to get the right angle during observing the point through the total station. The point of intersection inside the total station was hard to locate so that it is aligned with the point of interest when reading it from wrong angle. The third constraint is total station's point of intersection is hard to be traced when the point of interest is directly exposed to sunshine. The author needs to observe carefully the

location of intersection point in the reflectorless total station as the intersection point will become smudge during this condition.

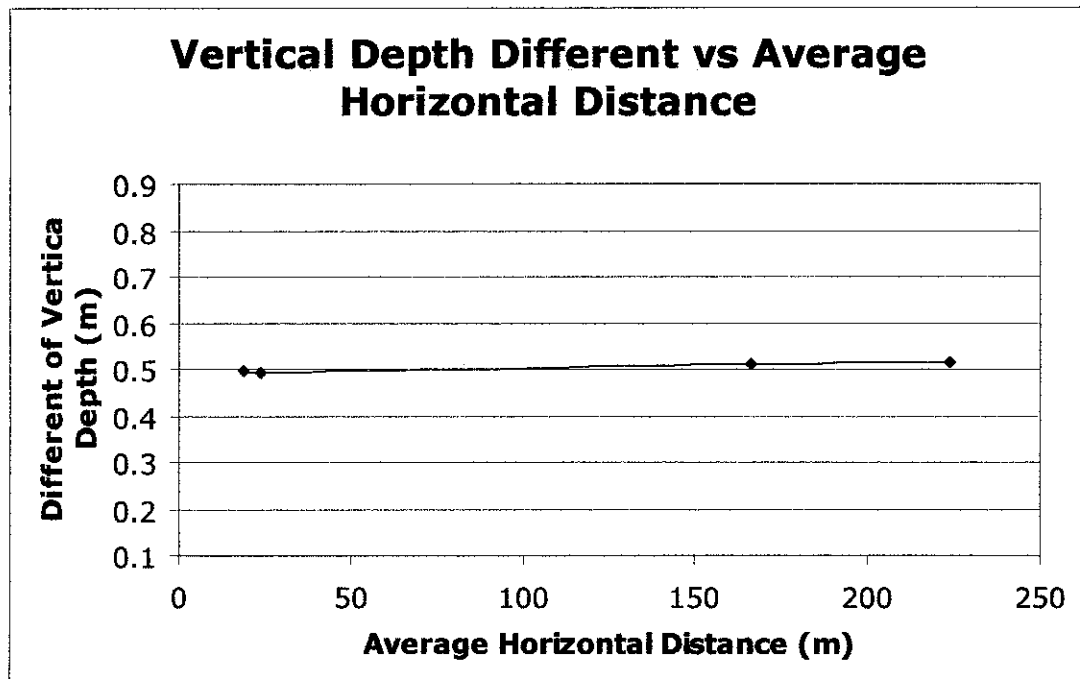### 4.2.3 Reflectorless Total Station Performance Experiment

Figure 4.18: Vertical depths different against average horizontal distance

This experiment was conducted after the deformation monitoring work was done. The vertical depth difference obtained by subtracting two points that different in height but located at the same horizontal distance. Supposedly this experiment should be conducted at initial phase in order to evaluate the performance of reflectorless total station before fieldwork start. But as refer to the graph above, the measurement of these four points are consistent which show the reflectorless total station still performs when the distance of object increased. It is verifying the claim by manufacturer that the total station can give precise measurement up to 250m.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 RELEVANCY TO THE OBJECTIVES

The whole project is intended to develop a system during deformation monitoring work. The development of a warning system will enhance the deformation monitoring work to be more effective. People can be warn immediately when the structures is no longer safe. This system can help saving humans life if installed at each structure. The system performed well during tested with actual fieldwork data. The magnitude of deformation of selected structure which is UTP Academic Complex Canopy is considered in safe behavior. Suppose the movement occurred are not permanent deformation but only the temporary deformation which any high structure should have. Besides, the error which came from the author while using reflectorless total station was influencing the result. The reflectorless total station is powerful tool to be used in monitoring work but certain precautions should be considered if this instrument is going to be used.

5.2 FUTURE WORK

There is plenty of room in this project for upcoming work. The development of system which can provide a real time monitoring work needed. The author initially actually tried to develop a system which can connect with reflectorless total station so that the data from the reflectorless total station can be automatically transferred from reflectorless total station into the system to be analyze immediately. But the author unable to further more due to certain circumstance such as limited information on how reflectorless total station functioning during data transferring. Besides, the complicated programming language and installation of additional electronic instruments might be needed to realism this work. Thus, collaboration with IT expert may become worth.

It is encouraged if the reflectorless total station can measured the point by its own. The total station is set up to take reading in certain duration. Thus the usage of human power can be reduced. The errors that also come from human also can be minimal as the total station can measure the point automatically. Unfortunately the current total station is not enabled to do this type of job. The usage of highly Artificial Intelligent total station which called robotic total station is known can automatically take the measurement without involvement from human being.

Plans for future work also include how accurately the position of observed points can be defined. As the reflectorless total station can measure all the objects and give the output, thus the users need to evaluate the points which can be measured precisely. Several precautions need to be developed during monitoring points so that the point measured is the correct point and not the adjacent location.

Besides certain experiments need to be conducted in order to evaluate the performance of reflectorless total station. It can be done by comparing the measurement of an object taken by reflectorless total station and conventional total station. If both the measurements are the same, the reflectorless total station ability is experimental approved and should be use for other monitoring works. Unfortunately during the project, the author was unable to conduct the experiment because lack of times and more concentrating on development of computer system rather than evaluating the reflectorless total station cautiously.

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4. www.fig.net

5. www.gsdidocs.org

6. www.isprs.org/istanbul2004/comm7/papers/123.pdf.

7. www.en.wikipedia.org/wiki/Deformation

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APPENDICES

- Appendix A: The Reflectorless Total Station Specifications
- Appendix B: The Control Points to Assess Reflectorless Total Station
- Appendix C: Setting up the Reflectorless Total Station
- Appendix D: How to Transfer Data using Topcon Link
- Appendix E: The Coordinates of Observed Points in Text File Format
- Appendix F: The Coding of Computer System

LONGEST REFLECTORLESS RANGE

Topcon's unique pulse laser technology allows the GPT-3000 series to measure up to 250m in the standard reflectorless mode, and now up to an astonishing 1200m in the new Long Range mode! Topcon has developed this advanced technology to give you the best reflectorless performance with complete safety and confidence. The Class 1 laser is safe to use around populated areas or heavy traffic.

The new Topcon 3000LW series measures nearly four times farther than any other competitive total station, once again demonstrating the technology advantages that Topcon offers.

DUAL LASER OPTICS

Topcon's GPT-3000 uses a dual laser optics system, one narrow beam for non-prism functions, and a broader beam when using a prism. This stabilizes the beam over long distances providing accurate measurement, even in adverse atmospheric conditions such as heat shimmer.

BLUETOOTH WIRELESS COMMUNICATION

Topcon is the first manufacturer to offer Bluetooth wireless technology for electronic total stations. This unique technology eliminates the hassles of broken data collector cables, and struggling with office cable connections.

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Topcon also offers two different field controller options – our new FC-100 for a compact system, and the new FC-2000 for a full keyboard option. Both systems offer a fast 400MHz Intel processor and a bright full-color touchscreen running the popular Windows CE® platform.

TOPCON
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Livermore, CA 94551
Phone: (925) 245-8300

MODELS	3002LW	3003LW	3005LW	3007LW
Angle Accuracy	2"	3"	5"	7"
Angle Reading	1"/5"	1"/5"	1"/5"	5"/10"
Method	Absolute Reading			
Compensation	Dual	Dual	Dual	Single

Length	150mm
Objective Diameter	45mm (EDM 50mm)
Magnification	30x
Image	Erect
Field of View	1deg 30min
Min. Focus Distance	1.3m (4.29 ft)

STANDARD:

|		
Measurement Range (1 prism)		3,000m (9,000ft)
Measurement Accuracy		3mm+2ppm
Measurement Time	Fine	Approx 1.2 Sec (Init 3 sec.)
	Coarse	Approx 0.5 Sec (Init 2.5 sec.)
	Tracking	Approx 0.3 Sec (Init 2.5 sec.)

REFLECTORLESS:

Measurement Range (Kodak White)		
Long Mode:		1,200m (3,900ft)
Normal Mode:		250m (820ft)
Measurement Accuracy <25m		+10mm
Measurement Accuracy 25-1200m		+5mm
Measurement Time	Fine	Approx 1.2 Sec (Init 3 sec.)
	Coarse	Approx 0.5 Sec (Init 2.5 sec.)
	Tracking	Approx 0.3 Sec (Init 2.5 sec.)

Screen Type	Graphics LCD 160x64 Dots with backlight			
Display Unit	Dual	Dual	Dual	Single

OPERATING TIME – SINGLE BATTERY

Including EDM measurement	3.2 Hours
Angle measurement only	45 hours
Recharge Time	1.8 Hours
Battery Type	NiMH

Wireless Connection	YES, Bluetooth
Point Guide	YES
Laser Plummet	YES
Laser Pointer	YES
Weight (w/battery)	11.4 lbs.
Waterproof Protection	IP66
Temperature Range	-4 to +122 F
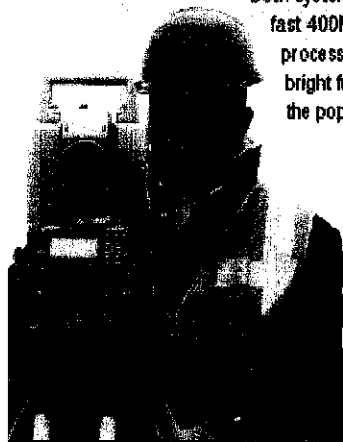
GPT-7000i
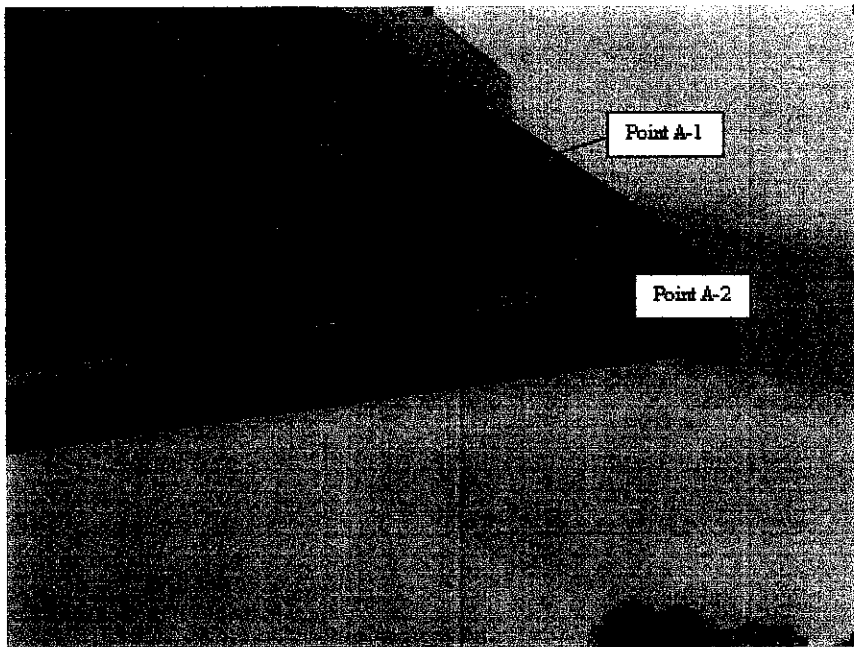Total Station with
Imaging technology
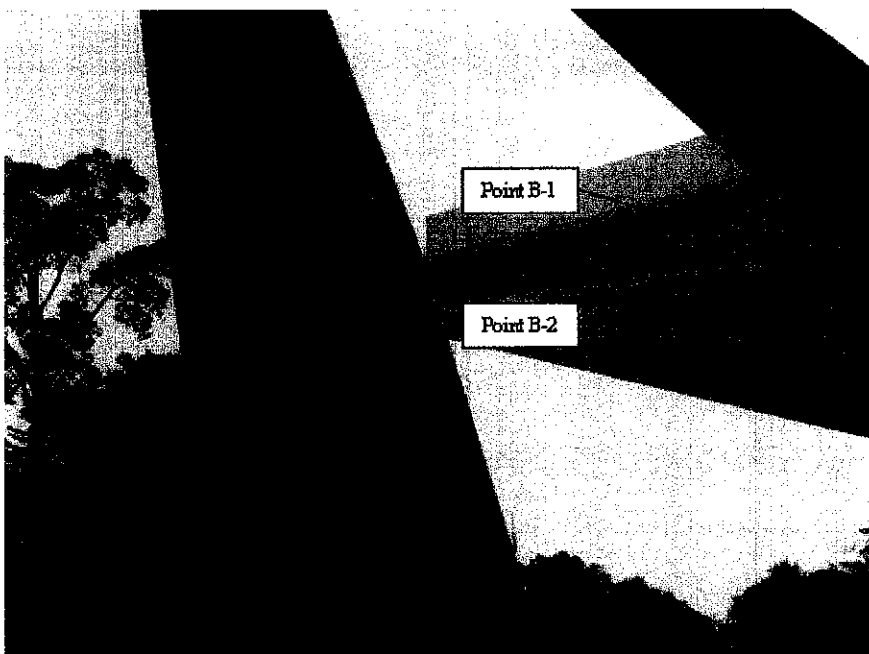
FC-100
Rugged Windows CE®
Field Computer

HiPer Lite+
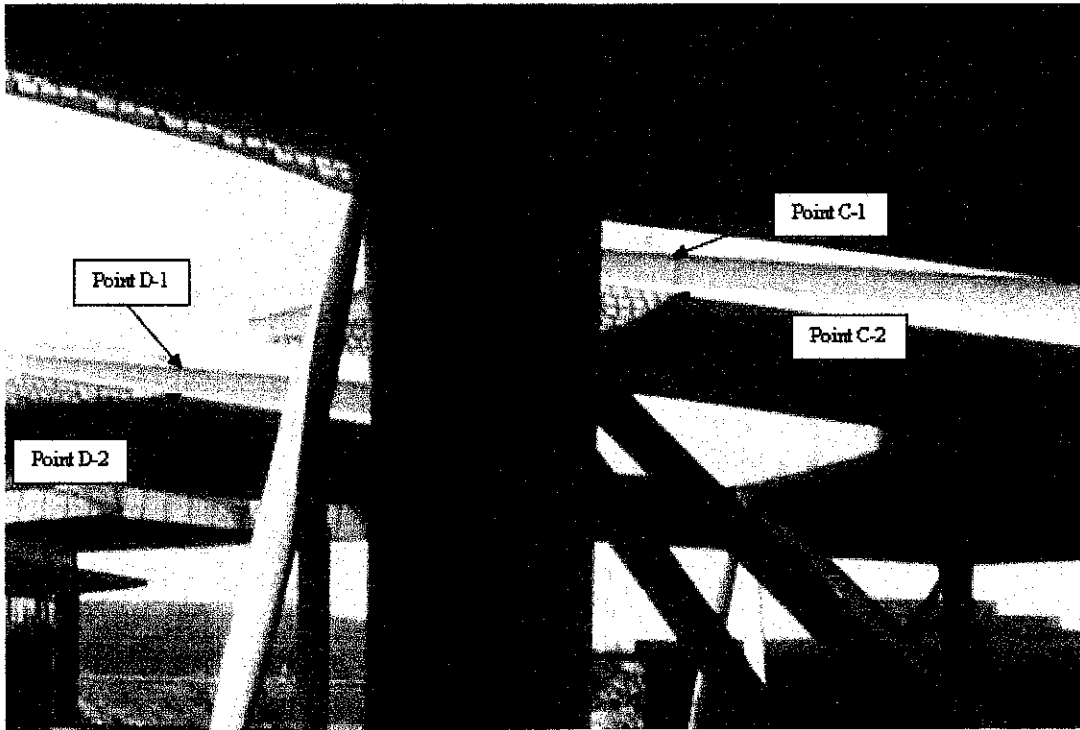Cable-free GPS+
RTK system

Appendix B: Control Points to Assess Reflectorless Total Station


Points A Location

Points B Location

Points C and Points D Location

Appendix C: Setting up the Reflectorless Total Station

Levelling the Instrument

- Place the reflectorless total station on the mounting pod.
- Center the bull's eye level using the three knuckle screws for finer adjustment. After centering bull's eye, the user need to center line level by first using two knuckles screws concurrently. Then turn the reflectorless total station 90 degrees, and use third knuckles screw to finally center the line level.
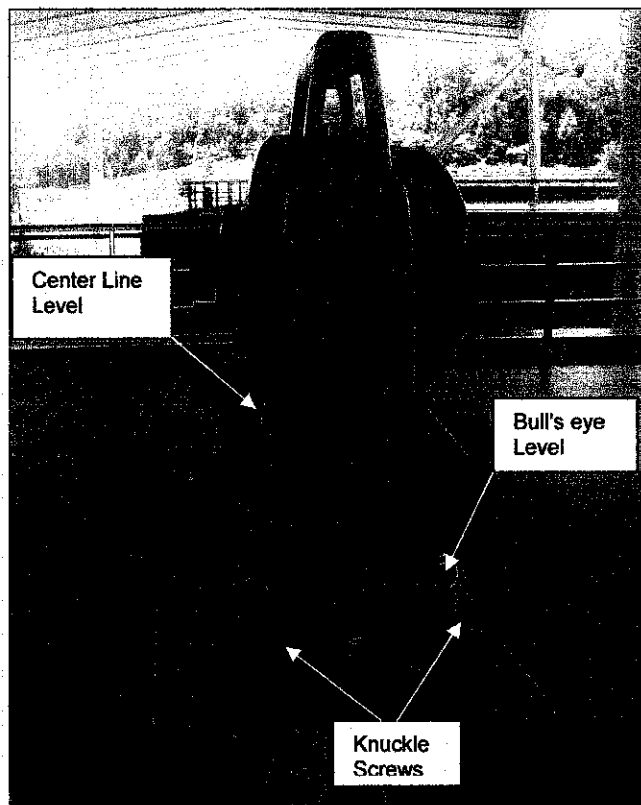
Preparing Data Collector

Creating new data file

- Press MENU button followed by "Collect Data"
- Press "Job File" and type in Job File Name followed by ENTER button.

Idding to Data File

- Press MENU and "Collect data"
- Press "Job File". Use arrows to select file. Press ENTER.

Obtaining Back Sight for Total Station (in this project used for Reference Point)

- Enter OCC. PT# (Occupied point, normally numbered as 1)
- Enter OCC. ID (Occupied point ID, descriptive label for marker point)
- Enter INST HT, (Instrument Height) in meters. (For this project INST.HT = 1.415m)
- Press 0CNEZ to accept default coordinate (0, 0, 0)
- Press ENTER
- Enter BS PT# (back Sight point)
- Enter BS ID (Back sight ID)
- Press 0 Set
- Aim total station at back sighting point and press MEAS

Obtaining Fore Sight for Ttotal Station (in this project used to measure Observed Points)

- Enter Point# (Point number)
- Enter Point ID (target point description; in analysis let the Point ID to be OB1)
- Enter Target Height (set to 0)
- Press MEAS.
- Redo Step above with different Point# and Point ID (Let Point ID to be OB2 and so on)

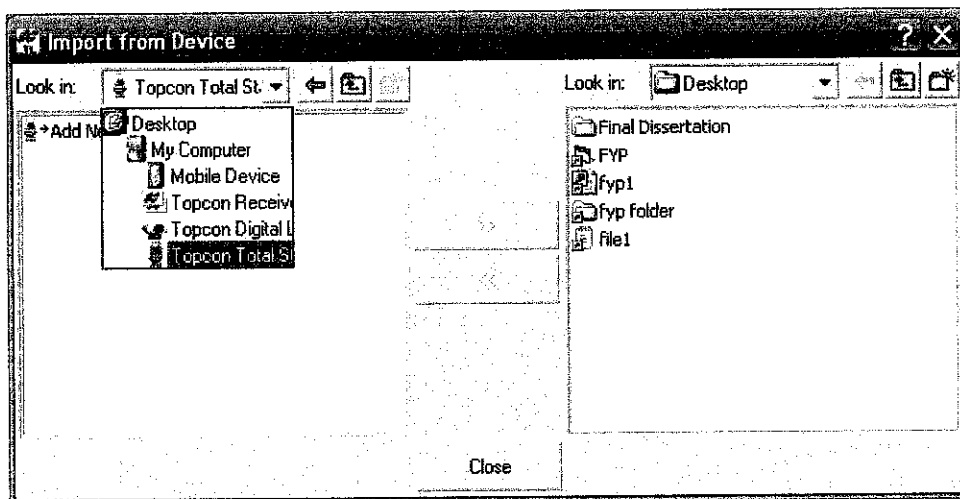# Appendix D: How to Transfer Data using Topcon Link

:tting on Topcon Link

In order to create new device properties the user need to click File > Import from
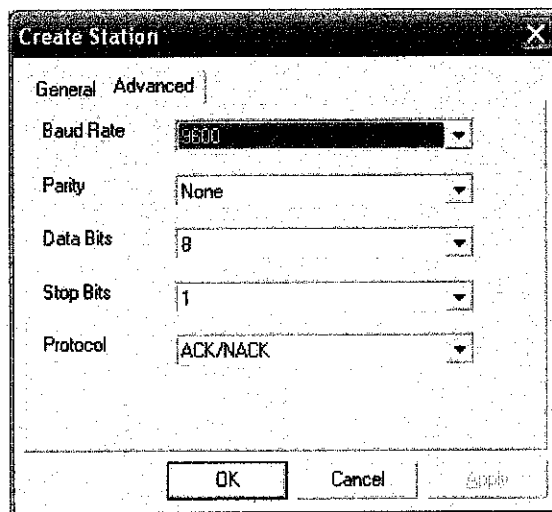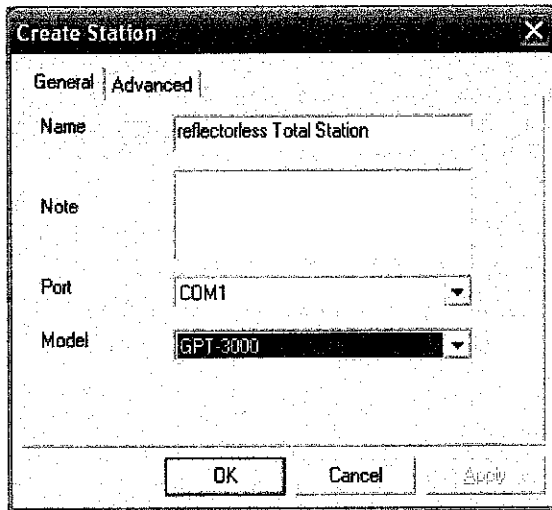Devices (as shown below).
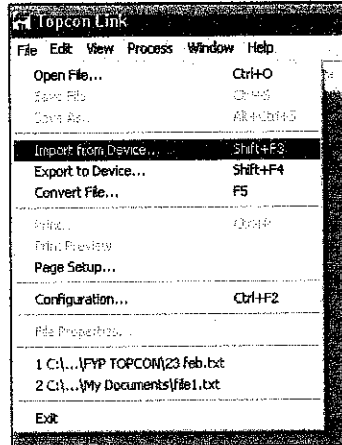
Click on Look in > Topcon Total Station menu at the box left side (as figure below).
Click on Add New Station.

Create Station Menu will be appeared. The menu consists of two main parts which is
General and Advance Sub-menu. Fill in the properties as figures next page. Click OK
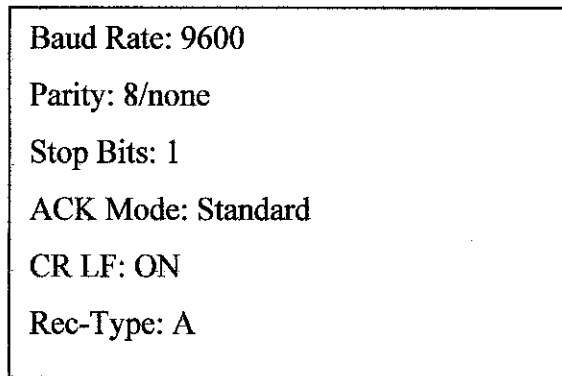button once done.

Click on newly added total station (Reflectorless Total Station), then the file1.txt file will be shown. Then in right box choose the folder "C\fyp" as destination where the file will be stored.
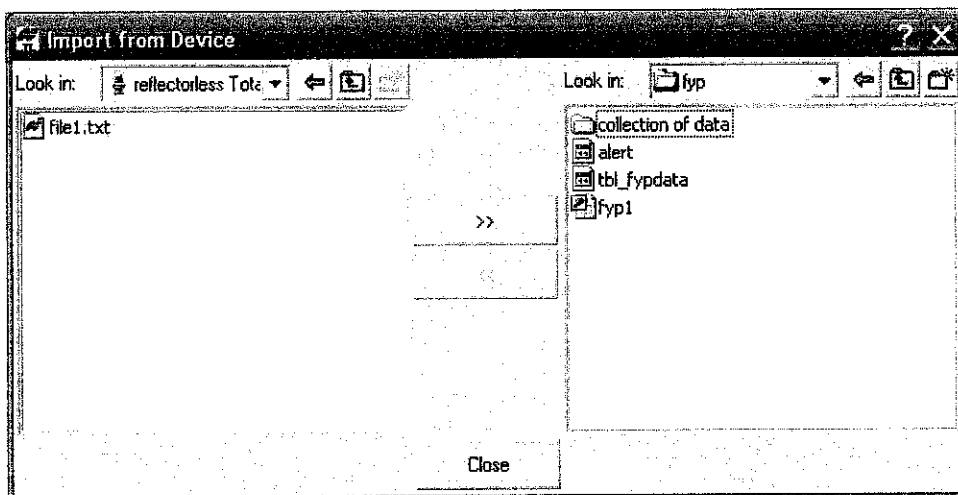
etting on Reflectorless Total Station

ie reflectorless total station also needed to be set up in order to establish a connection with PC r data transferring. The instrument needs to be switched on first. The next procedure is as llow:

Press Menu > Parameters > RS-232 button and set the parameters as below:

Baud Rate: 9600

Parity: 8/none

Stop Bits: 1

ACK Mode: Standard

CR LF: ON

Rec-Type: A

After finished, press Menu > Memory Manager > Data Transfer > SSS
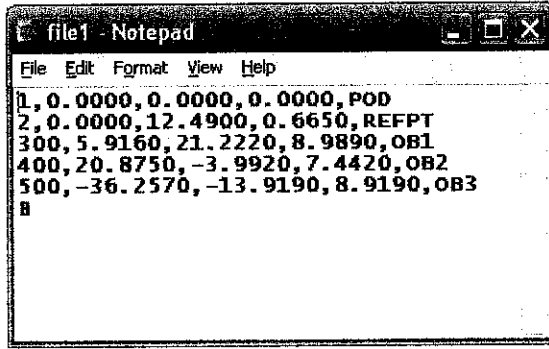
Press Menu > Comm Parameters > Check all (check whether the parameters same as figure above. Change it if not similar)

Press Send data > Coordinate Data > File Name (Choose the file that need to be transferred)

Meanwhile click >> button in Topcon Link Menu as shown in figure below and followed by pressing YES button on total station for completing the process. Click close button to exit.
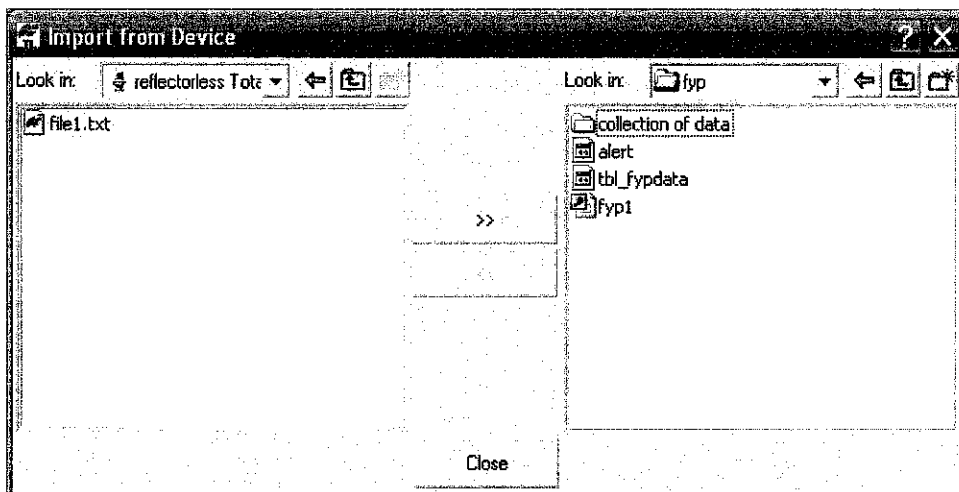
ιe example of file.1 txt data is shown as figure below.

```
file1 - Notepad
File  Edit  Format  View  Help
1,0.0000,0.0000,0.0000,POD
2,0.0000,12.4900,0.6650,REFPT
300,5.9160,21.2220,8.9890,OB1
400,20.8750,-3.9920,7.4420,OB2
500,-36.2570,-13.9190,8.9190,OB3
B
```

Appendix E: The Coordinates of Observed Points in Text File Format

Date: 23 February 2006

```
300,5.9170,21.2170,9.0080,OB1
400,20.8780,-3.9930,7.4140,OB2
```

Date: 24 February 2006

```
300,5.9180,21.2150,9.0060,OB1
400,20.8810,-3.9910,7.4140,OB2
```

Date: 25 February 2006

```
300,5.9200,21.2160,9.0040,OB1
400,20.8810,-3.9920,7.4150,OB2
```

Date: 26 February 2006

```
300,5.9200,21.2140,9.0060,OB1
400,20.8820,-3.9940,7.4210,OB2
```

Date: 27 February 2006

```
300,5.9180,21.2150,9.0110,OB1
400,20.8810,-3.9920,7.4190,OB2
```

Date: 28 February 2006

```
300,5.9200,21.2150,9.0080,OB1
400,20.8790,-3.9980,7.4200,OB2
```

Date: 1 March 2006

```
300,5.8590,21.2310,9.0090,OB1
400,20.8950,-3.9350,7.4130,OB2
```

Date: 2 March 2006

```
300,5.9170,21.2210,8.9910,OB1
400,20.8800,-3.9930,7.4200,OB2
```

Date: 3 March 2006

```
300,5.9160,21.2220,8.9890,OB1
400,20.8750,-3.9920,7.4420,OB2
```

Date: 4 March 2006

```
300,5.9170,21.2210,8.9960,OB1
400,20.8840,-3.9900,7.4140,OB2
```

)ate: 5 March 2006

```
:00,5.9110,21.2200,9.0040,OB1
·00,20.8830,-3.9890,7.4090,OB2
```

' The date will not appear in the text file. It is shown to differentiate each data.

Appendix F: The Coding of System

ı) Main Page

```
Private Sub Command1_Click()

    main.Hide
    POI1.Show

End Sub

Private Sub Command2_Click()

    main.Hide
    POI2.Show

End Sub
```

ı) System Interface for OB1

```
Private Sub mnuAbout_Click()
About.Show

End Sub

Private Sub mnuAnalyze_Click()
Dim X1 As Double
Dim Y1 As Double
Dim Z1 As Double
Dim mov_dist As Double
Dim sResult1 As String
Dim sResult2 As String
Dim sSound As String

'finding the difference between the coordinate taken and the reference coordinate
txtDiffx1.Text = Round(Abs(Val(txtRefx.Text) - Val(txtCoordx1.Text)), 3)
txtDiffy1.Text = Round(Abs(Val(txtRefy.Text) - Val(txtCoordy1.Text)), 3)
txtDiffz1.Text = Round(Abs(Val(txtRefz.Text) - Val(txtCoordz1.Text)), 3)


'to verify the date is keyed in
If txtDate1 = "" Then
    MsgBox "Please enter the date", vbOKOnly, "Attention"
Else

    'finding the movement distance
    'movement distance = square root of [(X1 * X1) + (Y1 * Y1) + (Z1 * Z1)]
    X1 = txtDiffx1
    Y1 = txtDiffy1
    Z1 = txtDiffz1

    mov_dist = Sqr((X1 * X1) + (Y1 * Y1) + (Z1 * Z1))
    txtMaxDiff1.Text = Round(mov_dist, 3)


    sResult1 = "OK"
    sResult2 = "DANGER!"

    'Path of sound's file. Located in "C:\fyp\alert.wav"
    sSound = "C:\fyp\alert.wav"

    'to evaluate whether the result is "OK" or "DANGER"
    If (Val(txtMaxDiff1.Text) < Val(txtAllowable.Text)) Then
        'for "OK" result
        MsgBox sResult1, vbOKOnly, "Result"
        txtResult1.Text = sResult1

    Else
        'for "DANGER" result
        'produce sound
        ActiveMovieControl.RunVideoContent sSound
```

```
        MsgBox sResult2, vbOKOnly, "Result"
        txtResult1.Text = sResult2

    End If
End If

Adodc1.Recordset.Save
mnuNew.Enabled = True


End Sub

Private Sub mnuBack_Click()
POI1.Hide
main.Show

End Sub

Private Sub mnuExit_Click()
Dim reply As Integer

reply = MsgBox("Are you sure want to exit?", vbYesNo, "Attention")
If reply = vbYes Then
    End
ElseIf reply = vbNo Then
    POI1.Show

End If

to exit from the application
End

End Sub

Private Sub mnuLoad_Click()

Adodc1.Recordset.AddNew

Dim intNULL As Integer, dblX As Double, dblY As Double, dblZ As Double, strPoint As String, intcount As Integer

Open "c:\fyp\file1.txt" For Input As #1
Do While Not EOF(1)
intcount = 0
Do While intcount < 5
Input #1, intNULL, dblY, dblX, dblZ, strPoint
If strPoint = "OB1" Then

txtCoordx1.Text = dblX
txtCoordy1.Text = dblY
txtCoordz1.Text = dblZ

End If
intcount = intcount + 1
Loop

Close #1

Adodc1.Recordset.Save

End Sub

Private Sub mnuNew_Click()

Adodc1.Recordset.AddNew
mnuNew.Enabled = False

'to display date automatically (without key in)
'txtDate1.Text = Date$
End Sub

Private Sub mnuReset_Click()
txtDate1 = ""
txtCoordx1 = ""
txtCoordy1 = ""
txtCoordz1 = ""
txtDiffx1 = ""
txtDiffy1 = ""
```

```
xtDiffz1 = ""
xtMaxDiff1 = ""
xtResult1 = ""

End Sub

Private Sub mnuView_Click()

POI1.Hide
lb_POI1.Show

End Sub
```

:) System Interface for OB2

```
Private Sub mnuAbout_Click()
About.Show

End Sub

Private Sub mnuAnalyze_Click()
Dim X1 As Double
Dim Y1 As Double
Dim Z1 As Double
Dim mov_dist As Double
Dim sResult1 As String
Dim sResult2 As String
Dim sSound As String

'finding the difference between the coordinate taken and the reference coordinate
xtDiffx1.Text = Round(Abs(Val(txtRefx.Text) - Val(txtCoordx1.Text)), 3)
xtDiffy1.Text = Round(Abs(Val(txtRefy.Text) - Val(txtCoordy1.Text)), 3)
xtDiffz1.Text = Round(Abs(Val(txtRefz.Text) - Val(txtCoordz1.Text)), 3)


'o verify the date is keyed in
' txtDate1 = "" Then
    MsgBox "Please enter the date", vbOKOnly, "Attention"
Else

    'finding the movement distance
    'movement distance = square root of [(X1 * X1) + (Y1 * Y1) + (Z1 * Z1)]
    X1 = txtDiffx1
    Y1 = txtDiffy1
    Z1 = txtDiffz1

    mov_dist = Sqr((X1 * X1) + (Y1 * Y1) + (Z1 * Z1))
    txtMaxDiff1.Text = Round(mov_dist, 3)

    sResult1 = "OK"
    sResult2 = "DANGER!"

    'Path of sound's file. Located in "C:\fyp\alert.wav"
    sSound = "C:\fyp\alert.wav"

    'to evaluate whether the result is "OK" or "DANGER"
    If (Val(txtMaxDiff1.Text) < Val(txtAllowable.Text)) Then
        'for "OK" result
        MsgBox sResult1, vbOKOnly, "Result"
        txtResult1.Text = sResult1

    Else
        'for "DANGER" result
        'produce sound
        ActiveMovieControl.RunVideoContent sSound
        MsgBox sResult2, vbOKOnly, "Result"
        txtResult1.Text = sResult2

    End If

End If

dodc1.Recordset.Save
mnuNew.Enabled = True
```

```vb
End Sub

Private Sub mnuBack_Click()
POI2.Hide
main.Show

End Sub

Private Sub mnuExit_Click()
Dim reply As Integer

reply = MsgBox("Are you sure want to exit?", vbYesNo, "Attention")
If reply = vbYes Then
    End
ElseIf reply = vbNo Then
    POI2.Show

End If

 to exit from the application
End

End Sub

Private Sub mnuLoad_Click()

Adodc1.Recordset.AddNew

Dim intNULL As Integer, dblX As Double, dblY As Double, dblZ As Double, strPoint As String, intcount As Integer

Open "c:\fyp\file1.txt" For Input As #1
Do While Not EOF(1)
ntcount = 0
Do While intcount < 5
nput #1, intNULL, dblY, dblX, dblZ, strPoint
f strPoint = "OB2" Then

xtCoordx1.Text = dblX
xtCoordy1.Text = dblY
xtCoordz1.Text = dblZ

End If
ntcount = intcount + 1
Loop

Close #1

End Sub

Private Sub mnuNew_Click()
    Adodc1.Recordset.AddNew

    mnuNew.Enabled = False
    'to display date automatically (without key in)
    'txtDate1.Text = Date$

End Sub

Private Sub mnuReset_Click()
txtDate1 = ""
txtCoordx1 = ""
txtCoordy1 = ""
txtCoordz1 = ""
txtDiffx1 = ""
txtDiffy1 = ""
txtDiffz1 = ""
txtMaxDiff1 = ""
txtResult1 = ""

End Sub

Private Sub mnuView_Click()

POI2.Hide
db_POI2.Show
```

End Sub

---

1) To Provide Sound when Critical Condition

```vb
Option Explicit
Option Base 0
Option Compare Text

Private m_dblRate As Double            'Rate in Frames Per Second
Private m_bstrFileName As String       'Loaded Filename
Private m_dblRunLength As Double         'Duration in seconds
Private m_dblStartPosition As Double     'Start position in seconds
Public m_boolVideoRunning As Boolean       'Flag used to trigger clock
Private dblPosition As Double            ' Current Play position
Private m_objBasicAudio  As IBasicAudio    'Basic Audio Object
Private m_objBasicVideo As IBasicVideo     'Basic Video Object
Private m_objMediaEvent As IMediaEvent      'MediaEvent Object
Private m_objVideoWindow As IVideoWindow    'VideoWindow Object
Private m_objMediaControl As IMediaControl  'MediaControl Object
Private m_objMediaPosition As IMediaPosition 'MediaPosition Object


    'Main Video/Audio Loading codes
    'method to load video/audio file
    Sub RunVideoContent(ByVal path As String, Optional ByVal DontMaintainRatio As Boolean, Optional ByVal FullScreen As
Boolean)

    Dim nCount As Long
    Dim sScale As Double
    Dim topMod As Long
    On Local Error GoTo ErrLine

    'clean up memory (in case a file was previously opened)
    UnloadActiveMovieControl

    'Setting file to object
    m_bstrFileName = path

    'Instantiate a filter graph for the requested file format.
    Set m_objMediaControl = New FilgraphManager
    Call m_objMediaControl.RenderFile(m_bstrFileName)

    'Setup the IBasicAudio object (this is equivalent to calling QueryInterface()
    'on IFilterGraphManager).
    'Initialize the volume to the maximum value.

    'Some filter graphs don't render audio
    'In this sample, skip setting volume property
    Set m_objBasicAudio = m_objMediaControl
    m_objBasicAudio.Volume = 0
    m_objBasicAudio.Balance = 0

    'Setup the IMediaEvent object (PLAY video/audio).
    Set m_objMediaEvent = m_objMediaControl

    'set the playback rate given the desired optional
    m_objMediaPosition.Rate = 1 ' Normal play rate
    ' NOTE: you can set values like 1.5 for 150% speed, pretty nice

    'Use user-established playback rate
    m_dblRate = m_objMediaPosition.Rate

    'Reset start position to 0
    m_dblStartPosition = 0

    'Play the file
    PlayActiveMovie

    Exit Sub

ErrLine:
    Err.Clear
    Resume Next
End Sub
```

```
' *********************************************
' ****    Unloading Control from memory   ****
' *********************************************

Sub UnloadActiveMovieControl()
On Local Error GoTo ErrLine

'stop playback
m_boolVideoRunning = False
DoEvents

'cleanup media control
If Not m_objMediaControl Is Nothing Then
    m_objMediaControl.Stop
End If

'clean-up & dereference
If Not m_objBasicAudio Is Nothing Then Set m_objBasicAudio = Nothing
If Not m_objBasicVideo Is Nothing Then Set m_objBasicVideo = Nothing
If Not m_objMediaControl Is Nothing Then Set m_objMediaControl = Nothing
If Not m_objVideoWindow Is Nothing Then Set m_objVideoWindow = Nothing
If Not m_objMediaPosition Is Nothing Then Set m_objMediaPosition = Nothing
Exit Sub

ErrLine:
    Err.Clear
End Sub


' ************************************
' ****    Control Methods  (PLAY)   ****
' ************************************

Sub PlayActiveMovie()
On Local Error GoTo errHandle

'Assign specified starting position dependent on state
If CLng(m_objMediaPosition.CurrentPosition) < CLng(m_dblStartPosition) Then
    m_objMediaPosition.CurrentPosition = m_dblStartPosition
ElseIf CLng(m_objMediaPosition.CurrentPosition) = CLng(m_dblRunLength) Then
    m_objMediaPosition.CurrentPosition = m_dblStartPosition
End If

m_boolVideoRunning = True
Call m_objMediaControl.Run


    Exit Sub
errHandle:
    Err.Clear

    Resume Next
    'logerror
End Sub
```