Real Time Kinematic GPS for Mass Haul Simulation.

By

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13578

Dissertation submitted in partial fulfillment of
the requirements for the
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CERTIFICATION OF APPROVAL

REAL TIME KINEMATIC GPS FOR MASS HAUL SIMULATION

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A project dissertation submitted to the civil engineering program,

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in partial fulfillment of the requirement for the

BACHELOR OF ENGINEERING (HONS) CIVIL.

Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
September 2014.

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.

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MOHD FARIS AIMAN BIN SHAHROM

ABSTRACT

The survey work for determining the mass haul that needs to be performed to a site is done by using Real Time Kinematic GPS (RTK GPS), instead of total stations. This is due to the features of RTK GPS that require less manpower and does not need mutual visibility between the rover and the base of the GPS devices. However, there are conditions that have to be met in order to perform the survey using RTK GPS such as clear skies and the site that is clear from static and dynamic obstructions.

From the data of the survey, Digital Terrain Model (DTM) is produced that highlighted the topography level of the site in three dimensional views. Based on the model, the mass haul that is needed to be performed to the site is analyzed, providing the site will be proceeded to be developed. The three dimensional data will ease up the analyzing process of the mass haul and reduce the probability of the error that may be done during the analysis. Developer needs the analysis that is as precise as possible, as errors done during the analysis may cost more money and unnecessary expenditure for them.

Keywords; RTK GPS, total stations, rover, base, DTM, three dimensional model. model analysis

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Mass haul is one of the main aspects of every construction and development project that is proposed to be done. The basic idea of the mass haul is to determine the embankment and excavation of the soils that needs to be done in order to gain a flat surface ground for the construction to be commenced, whether it is for the housing development, road development or even for the runways of the airport. Excavation is defined as the amount of soils that need to be removed from the grade, while embankment is the amount of soil that needs to be added onto the grade in order to make it a flat and even surface [1].

There are various ways of conducting the site investigation or land survey for earthwork process such as by the application of total station and Light Detecting and Ranging (LIDAR) survey methods. Most of the surveyors applied the conventional method in their surveying process, which is by using the total station. However, this method is seen to be lacked in practicality, as it required a large number of manpower to be done, the mutual visibility between the total station and its receivers and takes a lot of time. These conditions are very hard to be met if the development site is very large in area and consists of various geographical features. While LIDAR survey applies the concept of recording the levels of topography by laser reflection, it is not very suitable for the low to medium scale development project as the survey needs to be done by airplanes, which is very costly and the tedious works of processing the differences between the surface and terrain that needs to be done. Hence, the application of Real Time Kinematic (RTK GPS) is seen as the best alternative for the land survey work to be done.

The topographical data gained from the survey via RTK GPS can be translated into three- dimensional view with the use of Digital Terrain Model (DTM). According to Olsen, DTM has the ability to provide the dynamic addition or removal of points, no intersections and maximization of triangles' internal angle [2]. These features will help the engineers to understand better regarding the topographical condition of the site and detailed estimation for the earthwork can be accurately done.

Hence, this paper is written to demonstrate the ability and suitability of RTK GPS in land survey works for simulating the mass haul that needs to be done providing the site is set to be developed. These data will then be interpreted in three –dimensional modeling via DTM so accurate estimation for mass haul that should be done, thus benefitting the developer ultimately in terms of costs and project management. It also may minimalize the damage that needs to be done to the environment for the sake of developing the area.

Keyword: RTK GPS, DTM, earthwork, excavation, embankment, LIDAR, land survey

1.2 PROBLEM STATEMENT

The current land survey method that is usually being practiced, which is the application of total station has many disadvantages and limitations. Both of the total station and its receiver must be visible to each other in order to record the differences in topography. This feature will cause difficulties for the surveyors if the site area consists of the terrain and woody area.

Relative to the size of the site area, the manpower needed in order for the survey to be done via total station will be higher and the surveying process is very tedious and slow. All these processes may cause the delay to the project to be commenced.

Total station will produce a two- dimensional topographical data and may increase the probability of misinterpreting the earthwork that needs to be done to the site. The error in the earthwork estimation will cause time- delay and extra- expenditure to the developer. The extra excavation job that needs to be done due to the data misinterpretation may add up the cost that needed to bear by the developer.

This paper is written for the purpose of proposing a method of land survey which is more efficient in many aspects namely the efficiency of the survey process, the reliability of the data obtained and the efficiency of the data analyzing. These advantages will benefit the developer in terms of the construction project management as a whole.

Keywords: total station, difficulties, manpower, data misinterpretation, costs, land survey, project management

1.3 OBJECTIVES

The objectives of this project are;

1. Demonstrating the application Real Time Kinematic GPS for land surveying process for the purpose of earthwork.

2. Perform the mass haul simulation by using Digital Terrain Model (DTM) from the topographical data that has been obtained from objective (1).

1.4 SCOPE OF STUDY

Among the scope of studies that are related to this project are;

1. The land survey activity by applying the RTK GPS method.
2. The data processing from the survey activity to produce Digital Terrain Model (DTM).
3. The study of the DTM data produced, and thus producing the earthwork simulation.
4. The proposal of further steps and actions regarding the earthwork that needs to be done based on the simulated earthwork

CHAPTER 2

LITERATURE REVIEW

Earthwork

Earthwork is defined as the processes whereby the surface of the earth is excavated and transported to and compacted at another location, with the aim of flatten out the site area. It is carried out during the early stage of the construction project [7].

Earthwork process consists of four types, namely bulk excavation, under water rock excavation, dumpling work of support and embankment. It plays a pivotal role to the completion of the project, as it is highly depends on the completion of the earthwork process within the scheduled time. The success of the earthwork process is also depends on the site investigation that must be done adequately, along with the practical and satisfactory earthwork designs that have been planned [7].

Mass Haul

Mass haul is part of the earthwork activity, which is the action of removing the volume of soils from the designated site. The volume of the soils that needs to be hauled is actually estimated by geotechnical engineers via mass haul diagram.

Mass haul diagram is actually a cumulative volume of soil against the designated distance of the site, or often called the chainage. It is closely related to the activity of cut and fill, which the cut indicated by negative (-) while fill is by positive (+) signs.

The accumulated volume of earthwork at horizontal axis (y= 0) is 0. Accumulated volumes at the points are said to be equal when the horizontal line intercepts those axis along the chainage. At the end of the chainage, negative volume produced by the curve indicates that borrow is required in order to complete the fill activity while if the positive volume is produced, it indicates that waste operation of the soils needs to be done for the land to be flattened.

The most ideal volume that should be produced by the curve is 0, which indicates that the soil that needs to be borrowed or excavated is all balance out with the existed soil at the site. Thus, the soil transportation costs and time can be saved.

Real Time Kinematic GPS (RTK GPS)

GPS is the navigation, timing and positioning system developed by the U.S, which consists of three main parts: satellites, ground tracking monitoring station and customer station. GPS satellites made up of a network of 24 satellites placed into orbit, circle the earth in a precise orbit and transmit signal information. The theory of triangulation is applied in order to calculate the user's exact location. Essentially, the GPS receiver compares the time signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is and when the same concept is applied to some other satellites in the orbit, the location of the receiver is then determined [3].

Nowadays, Global Positioning System (GPS) have been widely used in the process of land survey, whether it is for resource management, urban planning, landscape management and so on. Real Time Kinematic GPS (RTK GPS), which is developed from GPS is applied due to its advantages, namely the higher positioning accuracy, shorter observation time, unnecessary intervisible and direct result of coordinate in the field [3].

Primarily, Real Time Kinematic GPS has chosen due to its ability to provide the real-time corrections, providing up to centimeter-level accuracy. A set of GPS-RTK positioning system generally consists of reference station, mobile station and communication system In the measure, GPS-RTK system receives the satellite signal simultaneously with at least two GPS receivers. One of them is located at the known coordinate as reference station while the other ones undertake the measure of unknown point coordinate, as mobile station which can be rest in mobile or static state. Operatively, the work mechanism of GPS RTK begins with the reference station receives from the satellite GPS signal, and sends its observations and coordinate information of observation station to the mobile station through the data chain. Then, the mobile station carries on the match, calculates each satellite the difference correction value, and modulates the radio signal. The mobile station not only collects data from reference station through the data chain, but also gathers the GPS observation data, and composes the differential observations in system to perform real-time processing. Reference station computes the modified value of satellite distance according to its precise coordinate. The modified value is sent to mobile station to correct the position result, which can greatly improve the position precision [3].

However, there are some circumstances that may cause errors during the survey by using RTK GPS. The shadowing and multipath that caused by static obstacles such as flyovers bridges and buildings; and mobile obstacles such as vehicles may disrupt the signals between the component of RTK GPS and thus, may affect the precision of the data produced [4].

Digital Terrain Model (DTM)

Digital Terrain Model (DTM) plays a pivotal role in mapping processes after the land survey is done. The data used for the modeling are collected either by using Global Positioning System (GPS), non- imaging airborne technique or photogrammetric technique. The model is developed based on the sets of X- axis (easting), Y-axis (northing) and Z-axis (heights), which will then be generated into contour maps, surface modeling and volume generated [5]. All these features that can be produced by the DTM will help the engineers to further investigate the site area in various aspects. The triangulation concept (the X,Y,Z axis) that is extensively applied in DTM have many advantages, namely promoting rapid construction, no intersection, dynamic removal or points additions, and the maximization of the triangles' internal angles [2].

CHAPTER 3

METHODOLOGY

Throughout the semester, the author has run the project based on the designated methodology that has been planned throughout the timeline. The project's scopes of works are limited to three elements, namely the **site**, the **instruments application**, and **software application**. In other words, the project only focuses on the data gathering and analysis of the earthwork required at the designated site, without actually doing the earthwork.

3.1 PRE-PROJECT

This is the phase where the author done researches regarding the subjects that are related to the chosen topic which is "The Real Time GPS for Mass Haul Simulation". After all related materials have been gathered, a paper is written for the purpose of extended proposal to the supervisor. The author needs to present the topic and defense the necessities and relevancy of why the project should be proceed during the defense proposal presentation in front of fellow students, the supervisor, and one internal examiner.

3.2 PROJECT METHODOLOGY

Project Location

After the topic proposal has been accepted, the project activities may started to commence. For this project, it is kick started with the selection of the location of the project to be done. The location that is chosen must have these characteristics, namely;

- Suitable topography; the site must have a suitable topography, which in this case shows a clear difference between the topographical level around the site. This is very important in order to highlight the topographical differences in DTM analysis later in the project.
- Open spaces; The site chosen must be in open spaces and if possible, with no static and dynamic obstruction such as buildings and vehicles as all these features may disrupt the signal of the GPS and thus, affect the data produced.

The writer has decided to choose the extreme motorcross arena that is located at Parit to be the site for this project. The location is chosen due to its various topography levels that will highlight the ability of the RTK GPS to record the difference of the topography up to centimeter accuracy. The site also does not have neighboring buildings that may interrupt the signal of the GPS.

Figure 1; the plan view of the site

Figure 4; site surrounding area

Figure 2; site surrounding area

Figure 3; site surrounding area

Instruments and software

For this project, there are instruments that will be used in order to gain the data during the survey activity, as well as the software that will be used to process the data gained into desired form, such as three dimensional models.

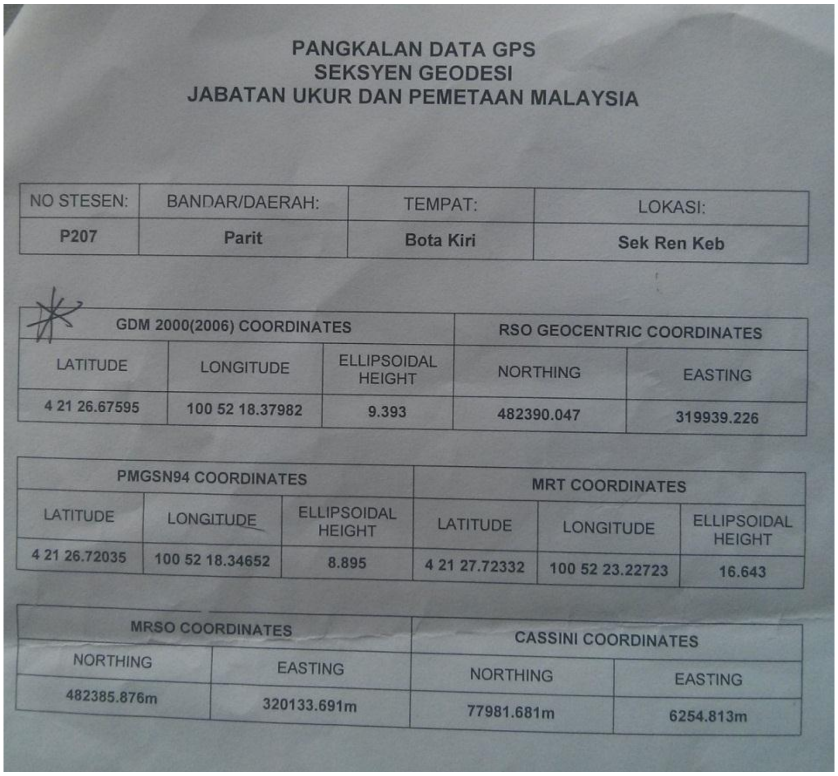
For the instruments, the author will extensively use the tripod, bipod, meter tape, HiperII devices, which are the main instrument for RTK GPS survey.

Spatial analysis software will be used in order to process the data gained from the survey into three dimensional model, before analysis is done. For this purpose, ArcGIS software or Topcon 3D Tools may be applied.

Obtaining coordinate of GPS monument

Every survey work must be done based on a reference point that can be assumed or by using the points that haven been set by Jabatan Ukur dan Pemetaan (JUPEM). The reference point by JUPEM is called GPS monument, and every district in Malaysia will have at least one GPS monument within the district area. In order to ensure the precision of the results gained from the survey, the reference point issued by JUPEM will be used rather than just assuming the point. In other words, the coordinate of the GPS monument will be the point (0, 0, 0) for the survey work that will be carried out.

The coordinate must be obtained from JUPEM office with 15 ringgit processing fees. The data obtained consists of the station details and the coordinates of the location in various formats such as GDM 2000, RSO geocentric, PMGSN94, MRT, MRSO and Cassini. For every format, the latitude, longitude and its ellipsoidal height is also given.



PANGKALAN DATA GPS
SEKSYEN GEODESI
JABATAN UKUR DAN PEMETAAN MALAYSIA

NO STESEN:	BANDAR/DAERAH:	TEMPAT:	LOKASI:
P207	Parit	Bota Kiri	Sek Ren Keb

GDM 2000(2006) COORDINATES			RSO GEOCENTRIC COORDINATES	
LATITUDE	LONGITUDE	ELLIPSOIDAL HEIGHT	NORTHING	EASTING
4 21 26.67595	100 52 18.37982	9.393	482390.047	319939.226

PMGSN94 COORDINATES			MRT COORDINATES		
LATITUDE	LONGITUDE	ELLIPSOIDAL HEIGHT	LATITUDE	LONGITUDE	ELLIPSOIDAL HEIGHT
4 21 26.72035	100 52 18.34652	8.895	4 21 27.72332	100 52 23.22723	16.643

MRSO COORDINATES		CASSINI COORDINATES	
NORTHING	EASTING	NORTHING	EASTING
482385.876m	320133.691m	77981.681m	6254.813m

Figure 5; GPS monument coordinate

Site work activity

After the coordinates of the GPS monument for Parit district successfully been obtained from JUPEM main office, a series of discussion has been made between the technologists and the author, before it has come to a conclusion that static GPS activity needs to be done beforehand before proceeding with the site work (RTK GPS).

This is due to the location of the GPS monument that is considered as too far from the chosen site. The distance between both of the location is approximately 12.2 kilometers, and it is too far for the base and the rover of HiperII devices to work together to produce the necessary data. Hence, static GPS activity is done in order to create a new base point which is within the working range of the devices.

Site work (static GPS)

Three sets of HiperII devices are used in this activity. The first set of the device is set at the GPS monument that has been provided by JUPEM, which is in the compound of SMK Bota Kiri, while the other two sets are being set up both at the site and in the compound of Universiti Teknologi Petronas (UTP) respectively. The set at the GPS monument is being activated first before both of the other sets to be done the same thing, after 15 minutes time.

The elevations of the devices from the ground are all measured by using the meter tape. There are left for at least 2 hours in order to gain an accurate new base point. The accuracy of the result is also largely depends on the transmission between the devices and the satellites and hence, this activity is done on a sunny, clear sky day in order to reduce the interruption of the transmission by the clouds.

The concept of the activity is actually to create a triangulation between the devices that has been set up at the respective places before applying it to create a new base point which is much nearer to the site for the ease of the next activity, which is the site survey.

After the designated hours have passed, the devices were brought back to the Geomatics lab for the extraction of the data gained from the GPS static activity. With the assistance from Mrs. Suhaila (technologist), the coordinate for the new base point can be determined from the data extraction from the devices and the elevations that have been recorded, by using Topcon Office Tools software. The new base point will have the coordinate details as follows;

N 484383.405, E 328935.639, Z 36.150 with projection Asia- Malaysia RSO and datum Kertau.

Figure 6; Triangulation of UTP, survey site and GPS monument

Figure 8; The GPS monument

Figure 7; HiperII device set up at new base

Survey activity (RTK GPS)

After the new base point has been obtained, the progress of the project is continued with the survey activity by using RTK GPS. Similar with the static GPS, this activity must also be done under the clear skies in order to ensure accurate data can be obtained.

At the site, the base of the RTK GPS and the rover is set up on top of the tripod and bipod respectively. Then, the Bluetooth connection between the base and the controller is set up and the new work file in the controller is set. For this project, the author has chosen the codename “FARISSS” to mark his undergoing project. After the base has been established, the same controller is used to establish the Bluetooth connection, this time for the rover of the GPS.

When the devices have been successfully established, the survey work can be kicked off right away. The rover must be made sure to be perpendicular to the sky before the coordinate location is saved. It took approximately 1 second for the rover to detect, and record its current position coordinate, with the assistance of the controller.

The rover is being marched to a desired location, before the location is locked and recorded by using the controller. The controller will produce a ‘beep’ sound, which indicates that the coordinate for that particular location has been successfully recorded. The LCD indicator of the controller will show the current number of points that already been recorded.

RTK GPS works with the sole concept of “the higher the number of points taken, the better”. It is indeed very true as all these points will later on be used to render a three dimensional model and higher number of points recorded means the more detail the rendered model will be produced. The author has applied the same principle during approaching the survey activity, as the points taken for the location with the topographical differences are much more frequent than the points taken on the flatlands. The interval between the points taken for locations with topography differences is less than one meter while the interval will be higher at the flatlands. Overall, the number of points that have been successfully recorded are 299 and considered as sufficient for the model to be rendered.

Figure 11; The hiperII controller

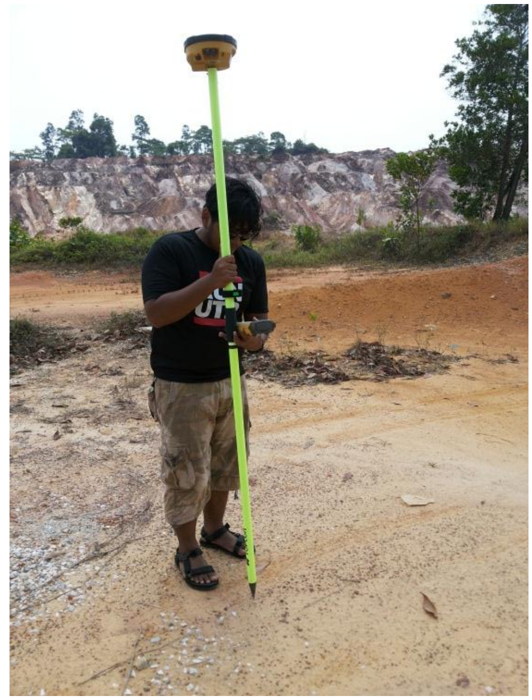


Figure 10; The author is handling the rover

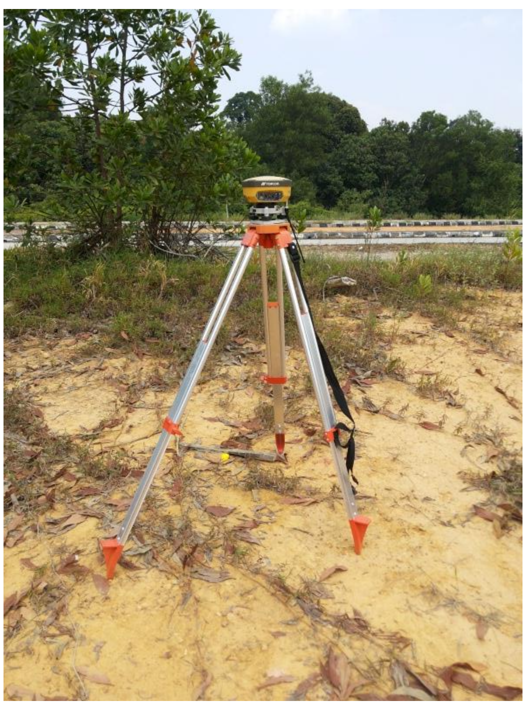


Figure 9; The base of RTK GPS

Data extraction

After the survey work at the site has been completed, HiperII devices are brought back to the geomatics facility laboratory in UTP for the data to be extracted. During the survey work, all the data gained are being stored in the memory card in both of the devices. With the assistance of the lab technologist, the data managed to be transferred into laboratory computer via the software that comes with the devices, which is Topcon Office Tools.

The data are produced in various formats such as csv, jff and mtt. After this step, the data is ready to be processed and being rendered into three dimensional models.

Model rendering

The data which is kept in csv file will be opened in ArcGIS software in order to begin the modeling phase of the project. The steps of how the modeling process is done are as follows;

[1] ArcMap software is loaded, and a new job is created. The csv file data will be uploaded under the new job. Hence, a basic layer is created.

[2] The data uploaded will be defined its coordinate/ xy display. For this job, the x, y, z is set to be the north, east and height respectively.

[3] A new layer for data output export is created from the uploaded data.

[4] Under the data output layer, a new TIN layer is created. TIN stands for triangulated irregular network, a digital data that is vector- based and made up of irregular x, y and z coordinates. Each point that has been recorded during the site survey is considered as a set of TIN data, and the combination of numerous TIN data will produce the digital elevation model.

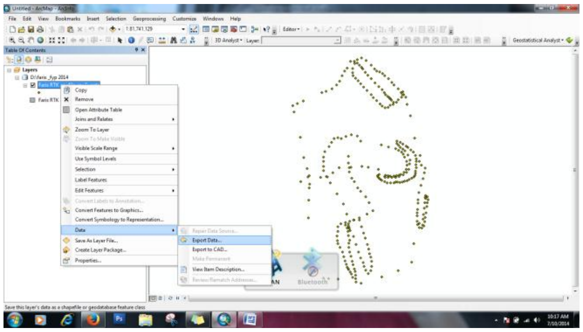


Figure 12; Points recorded

[5] A new layer is created, which converts the TIN layer that have been generated to raster images. It is done to ensure that the image can be viewed perfectly, with all the desired and necessary details.

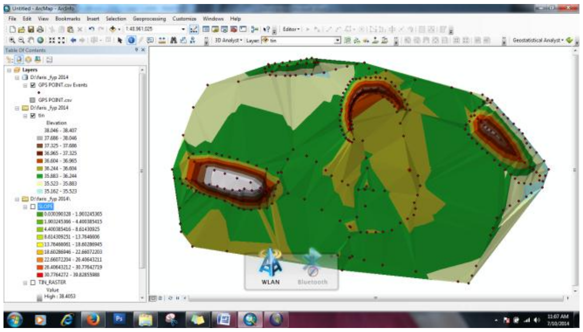


Figure 13; DEM produced

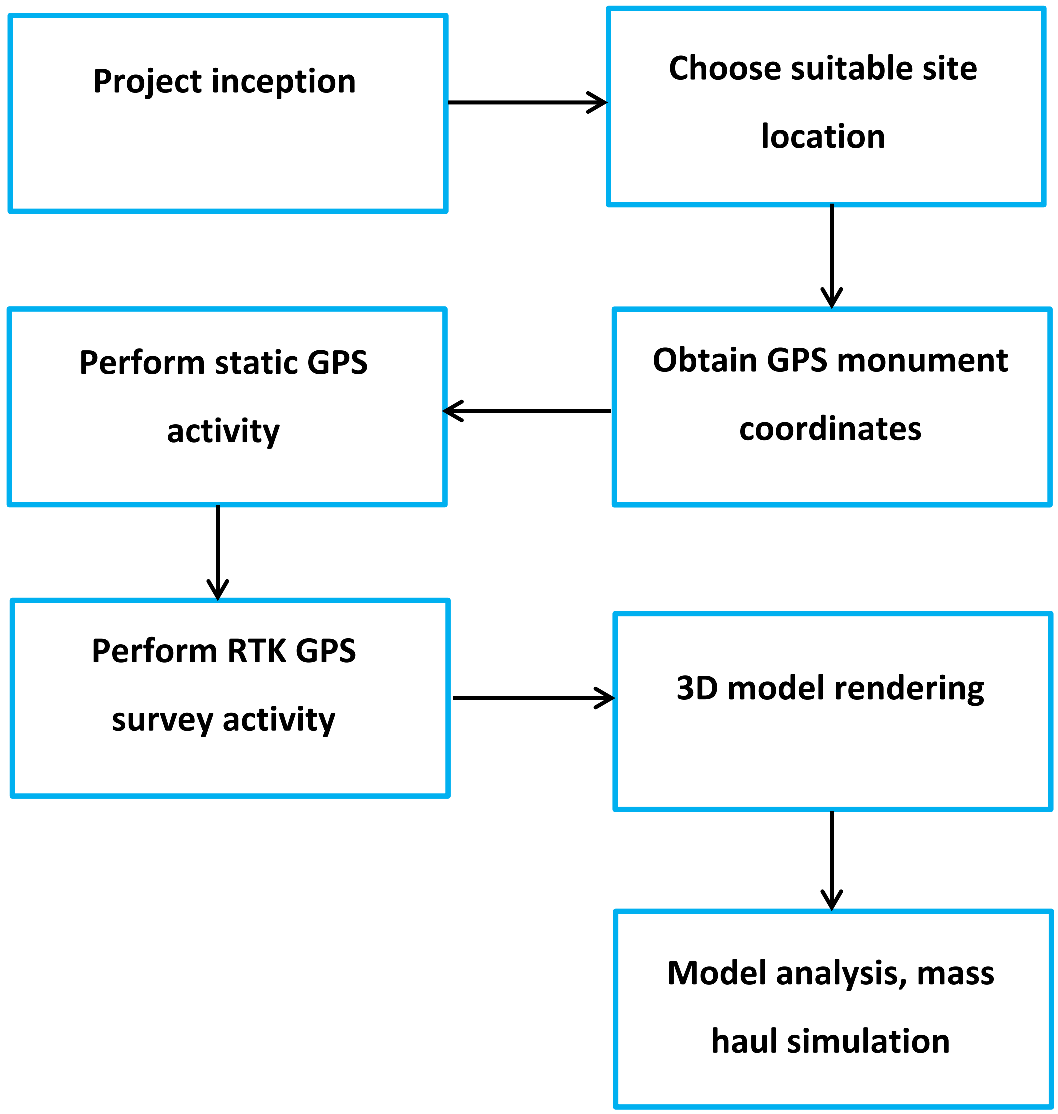
Thus, digital elevation model managed to be rendered from the gained data. The difference in slope and elevation is portrayed by the difference of colour in every layer of the slope. Each colour represents its particular level of slope and elevation and these differences can be easily spotted in the generated elevation model.

Model analysis and mass haul simulation

Based on the model that has been rendered, the analysis for the simulation of the mass haul that should be done to the site is performed.

The volume of the soil that should be excavated, added, or should be left untouched are determined based on the model analysis. The location for the necessary mass haul simulation can also be reviewed from the model.

The methodology of the project is simplified by this following flowchart;



3.3 GANNT CHART & KEY MILESTONES

From the inception of the project, key milestones and gannt chart have been created in order to manage and plan the work progress that have and will be completed. Both of these items governed the flow of the project and most of all, ensuring that the author is in the right direction and pace of completing the project.

Although the nature of this project is very dependable on external factors, such as availability of the devices and the weather, the author tried his best to keep up the progress according to the planned timeline in the charts. This is to ensure that everything is successfully completed by the end of the semester of the study.

Subject	Week	Status
Project title selection	1	Completed
Theoretical research	2	Completed
Extended proposal	6	Completed
Proposal defense	12	Completed

Table 1; FYP1 key milestones

Subject	Week	Status
Site investigation	2	Completed
Project work	6	Completed
Progress report	7	Completed
Pre- sedex	10	Completed
Oral presentation	13	Completed
Final submission	14	Completed

Table 2; FYP2 key milestones

No	Activities	Week																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	SEMESTER BREAK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Research topic confirmation - RTK GPS in mass haul simulation																													
2	Preliminary research and proposal draft																													
3	Extended Proposal																													
4	Familiarization with equipments and softwares.																													
5	Proposal Defense																													
8	Data collection trial run																													
9	End of FYP 1 - Interim Report																													
10	Enhanced Literature Review																													
11	Site work for data collection																													
13	Data conversion, DTM modelling																													
14	Progress report																													
15	Presentation of analysis results																													
16	Review data for errors																													
17	Pre-SEDEX and oral presentation																													
18	End of FYP 2 - Final report, technical report																													

Table 3; Gantt chart of the project

CHAPTER 4

RESULTS & DISCUSSIONS

4.1 SITE SURVEY ACTIVITY

After the site survey has been completed, HiperII devices have been brought back to the geomatics lab of UTP for the data recorded to be extracted. The data is saved in the memory card that is slotted in both of the rover and the base and it is extracted by using the Topcon Office Tools, which is the software that comes with the devices from the developer, which is Topcon.

Although the data is in various formats, it is preferable to keep it csv format, since it is compatible with the modeling software that will be used. Spatial analysis software, such as ArcGIS can interpret data that is kept in csv format and thus, save the author from hassle of incompatibility issues.

There are 299 points that have been recorded altogether, with each coordinate point is interpreted by northing, easting and height. The three dimensional model will be rendered based on these recorded points.

The table shows some of the raw data that have been gained from the site survey activity;

Table 4; Raw data of the survey activity

North	East	Height
484379.2	329129.9	36.15
484383.1	329132.7	36.088
484383.3	329128.7	36.274
484383.1	329127	36.15
484382.8	329121.3	36.172
484382.6	329113.3	36.296
484384.5	329098.1	36.283
484385.7	329088.5	36.357
484389.8	329085.4	36.267
484392.1	329085.2	36.118
484396.4	329085.1	36.065
484403.1	329085.7	36.084
484402.6	329087.3	36.278
484402	329088.3	36.238
484401.2	329089.5	36.28
484401.2	329089.6	36.222
484400.6	329090.5	36.19
484400.2	329091.7	36.185
484399.6	329093.3	36.219
484399.1	329095.2	36.211
484398.4	329097.5	36.218
484397.2	329099.6	36.154
484396.3	329101.4	36.135
484396	329102.7	36.113
484395.9	329104.8	36.126
484396.2	329107	36.283
484396.4	329109.2	36.172
484397.7	329110.5	36.271
484399.9	329111.1	36.37
484403.7	329112.3	36.348
484406.2	329112.2	36.132
484407.1	329109	36.134
484408.2	329106.2	36.12
484409	329103.9	36.096
484409.9	329101	36.048
484410.4	329098.8	36.002
484410.9	329096.7	35.992
484411.4	329095.1	35.965
484411.8	329093.1	35.985
484411.8	329090.8	35.941
484411.4	329088.8	36.071
484410.3	329087.5	36.542
484409.2	329089.1	36.899
484408.3	329090.9	37.3
484408.4	329090.9	37.286
484407.9	329092.5	37.69
484406.8	329094.6	38.142
484405.8	329097.5	38.256
484404.7	329100.9	38.387
484403.5	329104.6	38.407
484402	329107.3	38.211
484401.6	329108.2	37.647
484401.5	329109	37.238
484401.2	329109.5	36.972
484401.1	329110.5	36.601
484399.7	329109.9	36.592
484400.5	329108.5	37.263

4.2 MODEL RENDERING

Based on the data that have been obtained from the site survey, the three dimensional model is rendered by using spatial analysis software, namely ArcGIS. The model rendered consists of various layers that can be opened both individually and collectively, which each of them represents different aspects of the site such as the topographical elevation and the slope.

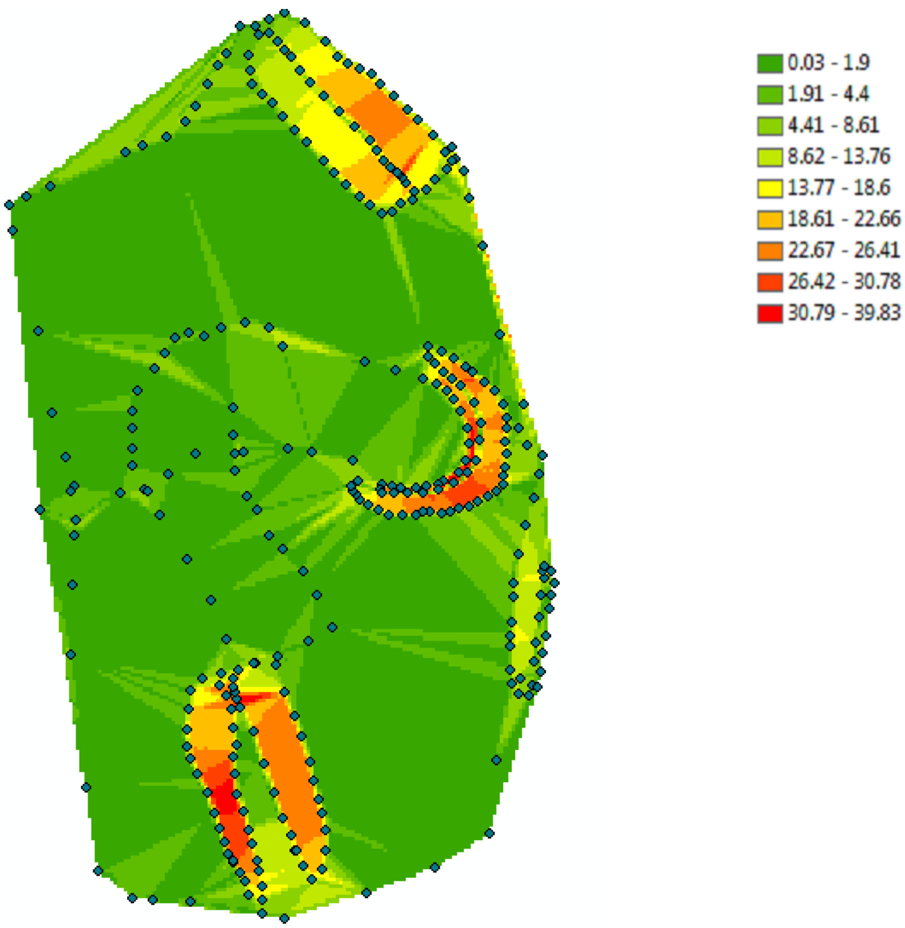


Figure 14; DTM (slope layer)

The dotted points at the picture represent the locations of the point that have been recorded during the survey activity. Altogether, there are 299 points recorded throughout the site. The frequency of the recorded points at the hilly area of the site is more in order to ensure that the topographical features of the site can be well presented during the rendering process.

The legend represents the degree of the slopes available at the site. Differentiated by the colour, the slopes have the range from 1 degree up until 40 degrees, with the colour ranges from green to red.

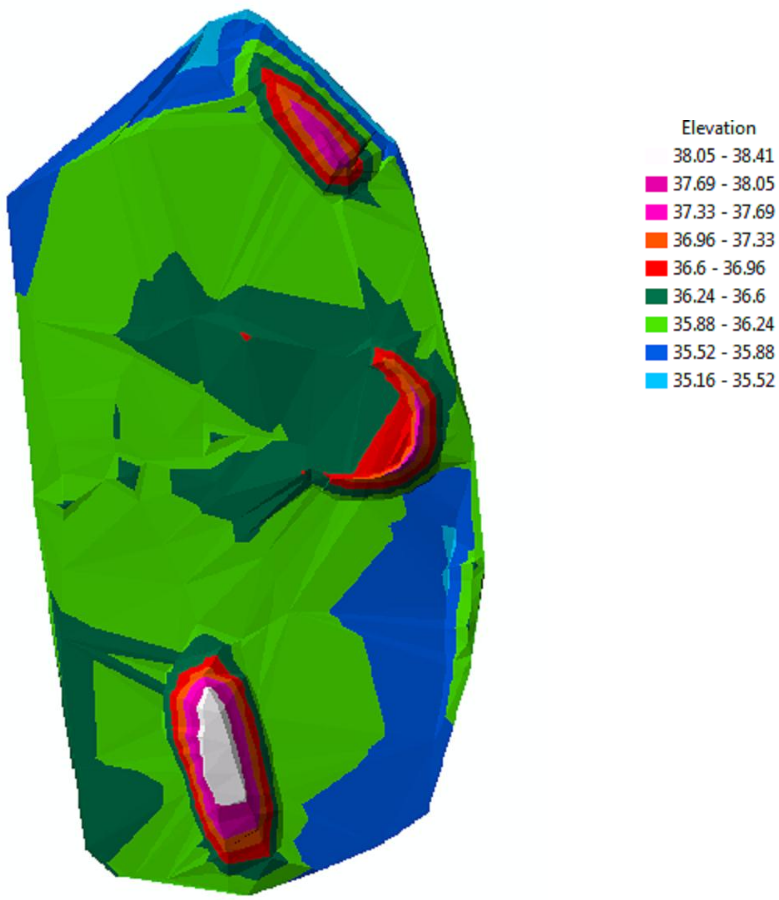


Figure 15; DTM (Topographical layer)

The model represents the differences of the level of the topography at the site. Based on the legend, the elevation level is differentiated from the difference of colours presented by the model. The elevation is measured from the sea level of the site, which is 35m.

The lowest elevation level is represented by blue colour, which ranges from 35.16m until 35.52m while for the highest elevation, it is represented by white colour, which has the elevation ranges from 38.05 until 38.41m.

4.3 MODEL ANALYSIS & MASS HAUL SIMULATION

Based on the model that have been rendered, the analysis for mass haul simulation is done, also by using the same spatial analysis software which is ArcGIS. The result of the analysis is represented by a layer in the software that has been created specifically for analyzing the mass haul that needs to be done to the site, which is in terms of excavation and embankment.

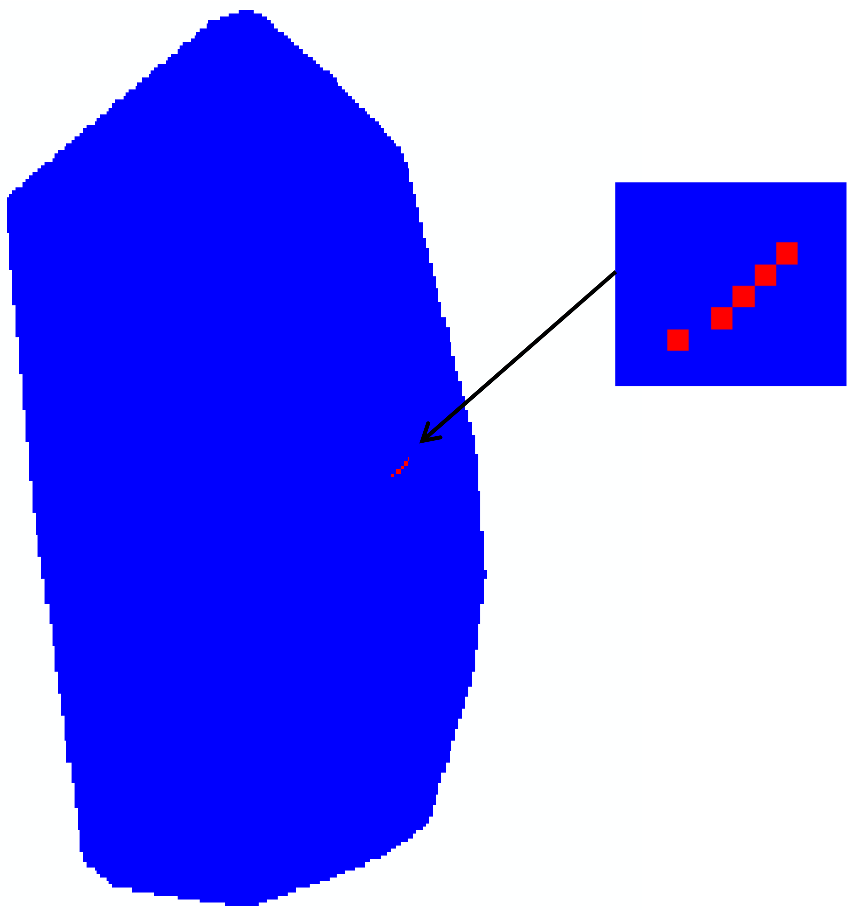


Figure 16; DTM (cut and fill)

The model shows the mass haul activity that needs to be operated to the site. The blue colour represents the area which the soil needs to be excavated out, while the red colour represents the area which the soil needs to be added onto it.

The total volume of the soil that needs to be excavated (net loss) will be 157,067m^3, while the volume of the soil that needs to be added to the site (net gain) will be 3.8m^3. Since some of the excavated soil will be reused to fill up the necessary area, the actual net loss of the soil of the site area will be 157,063m^3.

There are vast differences between the volume of the net loss and net gain, due to the natural condition of the site. The site is known to be a motorcross park, thus it is naturally elevated, although the level of elevation are different throughout the area of the site. Since the majority of the area is elevated from the datum of the site, the volume of the net loss will be much bigger than the net gain.

Cross reference between the cut and fill model and the digital elevation model that have been rendered is done in order to determine the exact areas for the mass haul to be performed.

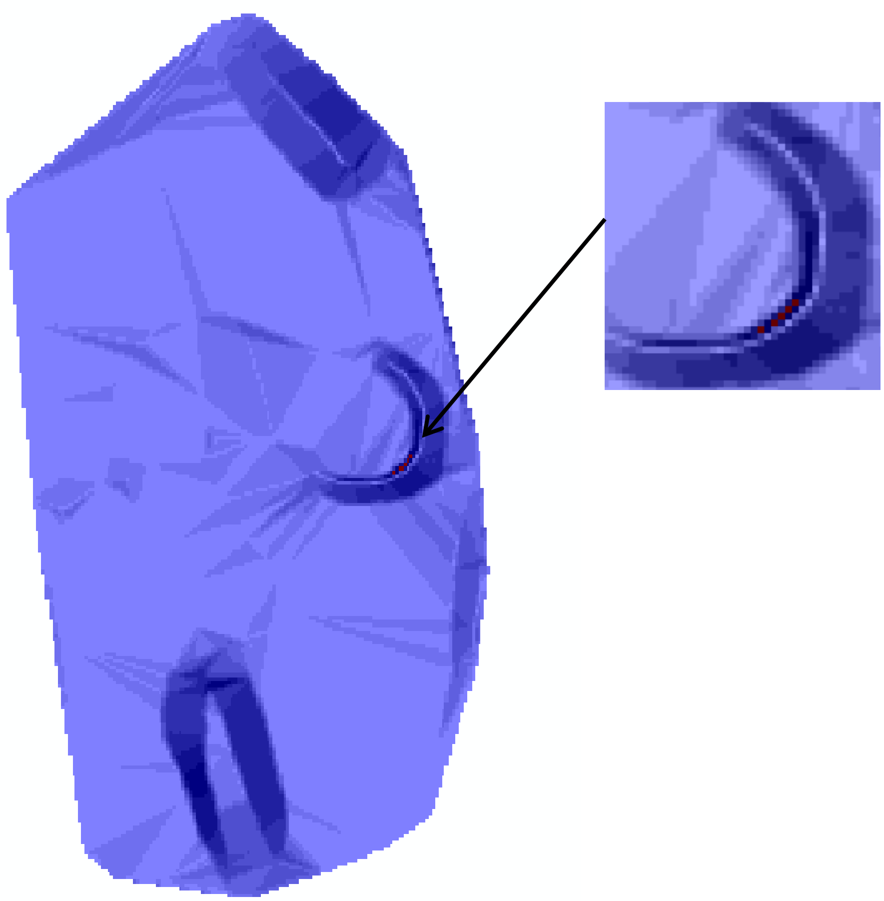


Figure 17; Cross reference between DTM-cut and fill

CHAPTER 5

CONCLUSION & RECOMMENDATION

As a conclusion, the project has been successfully completed as all the objectives of the project have been achieved. The author has managed to demonstrate the land surveying method by using RTK GPS, as mentioned in the earlier chapter of this thesis. The rendering of Digital Terrain Model (DTM) has also been completed, before the analysis and the simulation of the mass haul has been successfully performed by the author.

It is recommended that the land survey by using the total station should be done to the exact, same site to compare the precision of the data obtained by using RTK GPS, which have already been performed by the author.

RTK GPS has a vast potential in the field of civil engineering, and this project has only demonstrated a small portion of them. In the future, more and more function of RTK GPS may be discovered that will give a greater impact to the industry of civil engineering.

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