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ERROR ESTIMATION IN DEVELOPING GIS MAPS USING DIFFERENT INPUT METHODS OF LAND SURVEYING

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ABSTRACT- Surveying for Civil engineering is a particular type of surveying known as "land surveying", it is the detailed study or inspection, as by gathering information through observations, measurements in the field, questionnaires, or research of legal instruments, and data analysis in the support of planning, designing, and establishing of property boundaries. Land surveying can include associated services such as mapping and related data accumulation, construction layout surveys, precision measurements of length, angle, elevation, area, and volume, as well as horizontal and vertical control surveys, and the analysis and utilization of land survey data. Surveyors use various tools to do their work successfully and accurately, such as total stations, robotic total stations, GPS receivers, prisms, 3D scanners, radio communicators, handheld tablets, digital levels, and surveying software.

Survey data can be directly entered into a GIS from digital data collection systems on survey instruments. When data is captured, the user should consider if the data should be captured with either a relative accuracy or absolute accuracy, since this could not only influence how information will be interpreted but also the cost of data captured.

In this paper GIS maps were developed depending on the field surveying data made for a two traverses. First one has ribs less than 50m length and the other larger than 50m. Each traverse is holding five times using five equipments and instruments: Tape, Level, Digital level, Digital theodolite and Laser tape. Also those maps were drawn by using both of ACAD and ArcView softwares. Then a detail surveying map was produced. The precision was computed for both traverses in each method. Its value is range from 1/140 to 1/10000.

Keywords: ACAD, GIS, Land Surveying, Mapping, and Traversing.

I. INTRODUCTION

People have used maps for centuries to represent their environment. Maps are used to show locations, distances, directions and the size of areas. Maps also display geographic relationships, differences, clusters and patterns. Maps are used for navigation, exploration, illustration and communication in public and private sectors. Nearly every area of scientific enquiry uses maps in some form or another. Maps, in short, are an indispensable tool for many aspects of professional and academic work (Ibraheem 1997).

The rapid technological changes in surveying and geographic information system (GIS), is mainly the result of the recent explosion in information technology and is closely correlated with the general development of science and engineering. Looking back over the last few decades in surveying works and GIS, can be distinguished great development in several areas. The general development, in particular electronics and computer technology , undoubtedly has opened a new advances in GIS in the areas of instrumentation, methodology, and integration, many fields in surveying are now became applicable like the production of digital maps. GIS has benefited greatly from developments in various fields of computing. Better database software allows the management of vast amounts of information that is referenced to digital maps. Computer graphics techniques provide the data models for storage, retrieval and display of geographic objects. Advanced visualization techniques allow us to create increasingly sophisticated representations of our environment (Ibraheem et.al, 2012).

New information sources also shorten the time from project planning to operational database. The most important recent developments have been in navigation and remote sensing. The Global Positioning System (GPS) has revolutionized field data collection in areas ranging from surveying to environmental monitoring and transportation management. A new generation of commercial, high-resolution satellites promises pictures of nearly any part of the earth's surface with enough detail to support numerous mapping applications. The cost of precision digital mapping will fall significantly as a result of the close integration of GPS techniques and digital cameras in aerial photography.

Today, in the digital and computerized era, updating of digital databases, in theory and in practice, is evolving for a wide range of applications, in addition to mapping purposes. Several methods are in use: establishing a new GIS database, by re-mapping rather than digitizing existing maps; producing huge, unique and unified databases in large scale; working on large-scale updating and maintenance. The main approach lately, involves automatic change detection and incremental updating and versioning. This means automatically detecting, identifying and updating only these changes, which have occurred on the earth surface.

The requirement for maintaining up-to-date spatial data originates both from the end-user and from the information provider, since inability to do so may result in user reluctance to utilize the data. It involves the ability to optimize the integration of updated data into existing data sets, while upgrading it, preserving the uniform inner structure of the database.

II. DEFINITION OF DIGITAL SURVEYING

Digital Surveying strives to provide an unsurpassed level of quality and service to the surveyor.

Recent developments in surveying equipment have been closely associated with advances in electronic and computer technologies. Electronic distance measuring instruments for ground surveying now are capable of printing output data in machine-readable language for computer input and/or combining distance and angle measurements for direct readout of horizontal and vertical distances to the nearest 0.001 of a centimeter. The incorporation of data collectors and electronic field books with interfaces to computer, printer, and plotter devices has resulted in the era of total station surveying.

The recent refinement in global positioning systems and techniques developed for military navigation has led to yet another dramatic change in surveying instrumentation. Inertial surveying, with its miniaturized packaging of accelerometers and gyroscopes and satellite radio surveying have already revolutionized geodetic control surveying and promises to impact all phases of the surveying process. (Roy, 1999)

III. LAND SURVEYING FIELD WORKS

Traverse is a method in the field of surveying to establish control networks. It is also used in geodetic work. Traverse networks involved placing the survey stations along a line or path of travel, and then using the previously surveyed points as a base for observing the next point. Traverse networks have many advantages of other systems, including (16):

1. Less reconnaissance and organization needed
2. While in other systems, which may require the survey to be performed along a rigid polygon shape, the traverse can change to any shape and thus can accommodate a great deal of different terrains
3. Only a few observations need to be taken at each station, whereas in other survey networks a great deal of angular and linear observations need to be made and considered
4. Traverse networks are free of the strength of figure considerations that happen in triangular systems
5. Scale error does not add up as the traverse as performed. Azimuth swing errors can also be reduced by increasing the distance between stations.
6. The traverse is more accurate than triangulation and trilateration, and sometimes even triangulation.

IV. SURVEYING BY CLOSE-COMPASS TRAVERSE (POLYLINE)

To demonstrate the effect of traverse length on the accuracy of the work, two traverses would be taken. One has ribs less than 50m and the other larger than 50m. Each traverse is hold five times using five equipments and instruments:

1. Tape
2. Level
3. Digital level
4. Digital theodolite
5. Laser tape

Using the rules for precision of traverse bearings and distances, and propagation of variances, allows the estimation of precisions of the closing line of a traverse. These can be compared with actual misclosures to assess the quality of a traverse. Error in the measurement of angle occurs because of instrumental, personal or natural factors. The instrumental errors have been dealt with and, as indicated, can be minimized by taking several measurement of the angle on each face of the theodolite. Regular calibration of the equipment is also prime importance. Figures (1) and (2) show the first step in traversing.

Figure (1): Direction of the first rib in the small traverse with respect to the north direction.

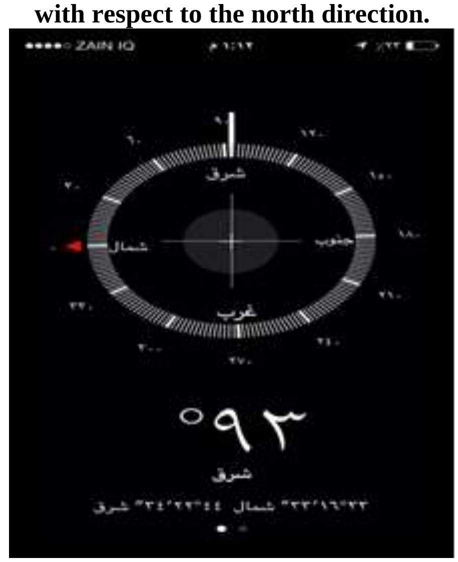

Figure (2): Direction of the first rib in the large traverse with respect to the north direction.

The precision of a traverse is expressed as the ratio of linear misclosure divided by the traverse perimeter length. It is usually a short line of unknown length and direction connecting the initial and final traverse stations:

$$LEC = \sqrt{(\sum Dep)^2 + (\sum Lat)^2} \qquad \dots (1)$$

$$\text{Tan}\ \theta = \left(\frac{-\sum Dep}{-\sum Lat}\right) \qquad \dots (2)$$

V. RELATIVE ACCURACY

The Accuracy Standards for ALTA/ASCM Land Title Surveys define Relative Positional Accuracy as "the value expressed in feet or meters that represents the uncertainty due to random errors in measurements in the location point on a survey relative to any other point on the same survey at the 95 percent confidence level". Thus relative accuracy compares the scaled distance of objects on a map with the same measured distance on the ground as (Schofied and Beach, 2007):

Relative Accuracy= dH/H ... (3)

where:

dH: Computed Error(m).
H : Total length of the traverse(m).

According to above, Tables (1) and (2) show the required calculations for finding the errors and the relative accuracy of each method for both large and small traverses.

Table (1): Small traverse analysis.

Method	∆Dep.	∆Lat.	Computed Relative Error(m)	Measured Relative Error(m)	θ	dH/H
1. Tape	-0.009	0.019	0.021	0.010	-25°20'46.23"	1/9019
2. Level	-0.214	-0.055	0.221	0.222	75°35'11.05"	1/859
3. Digital Level	-0.042	0.237	0.241	0.241	-10°02'57.65"	1/788
4. Digital Theodolite	-0.437	0.039	0.439	0.440	-84°54'0.57"	1/432
5. Laser Tape	0.532	0.024	0.533	0.532	87°25'1.13"	1/356

Table (2): Large traverse analysis.

Method	∆Dep.	∆Lat.	Computed Relative Error(m)	Measured Relative Error(m)	θ	dH/H
1. Tape	-1.383	3.666	3.919	3.919	-20°40'8.41"	1/141
2. Level	0.906	0.680	1.133	1.134	53°06'35.53"	1/488
3. Digital Level	0.409	0.225	0.467	0.467	61°11'1.78"	1/1182
4. Digital Theodolite	0.759	0.812	1.111	1.113	43°04'3.99"	1/499
5. Laser Tape	-1.514	3.457	3.774	3.774	-23°39'04"	1/146

VI. ANALYSIS OF THE RESULTS

A. *Taping method*

When looking at the two tables above we note that the tape is more accurate when it was used with small traverse (each ribs<50m)

The major reason that decreases the accuracy in the large traverse is the non accurate angles where determined by the cosine law as shown below:

$$\text{Angle} = \cos^{-1}\frac{b^2+c^2-a^2}{2ab} \quad \dots (4)$$

where:
a=3m
b=3m
c=the chord of the angle, which determined by tape.

The acceptable accuracy in the small traverse back to the ability to take a surely straight line between points, the thing that cannot be achieved in the large traverse. Therefore we must use poles in the large traverse to take approximate straight line between points.

That's mean the very small error in the cord results a large error in angle, which decrease the accuracy as shown in table (2) above.

B. *Traversing by Level and Digital level instruments*

Two reasons of error happened when level and digital level had been used in natural conditions:

1. Cannot take the true angle because the level has an integer angles and we must estimate the angle that may lie between two lines.
2. When measure angles you cannot surely that the poles are perpendicular or not.

C. *Traversing by* Digital theodolite

The digital theodolite is the better instrument for determining angles because you can dispense poles and measure angles from nail to nail, so you can approximately eliminate the error that may happen in angles. Thus the error will result in length mostly.

Table (2) above shows that the accuracy obtained in large traverse is better than the small traverse. This happened because of the ability to show the nails in large traverse compared with the obstacles in the small traverse.

D. *Traversing by Laser tape*

The reasons of error are the same at the tape above as well as the error of the instrument itself especially when used with large traverse. Also Laser tape is not designed to achieve outdoor works and we are using it in surveying works.

Figure (3) shows the relationship between the surveying methods and the relative accuracy dH/H of the small traverse. And Figure (4) shows the relationship between the surveying methods and the relative accuracy dH/H of the small traverse. Then figure (5) shows the comparison between them.

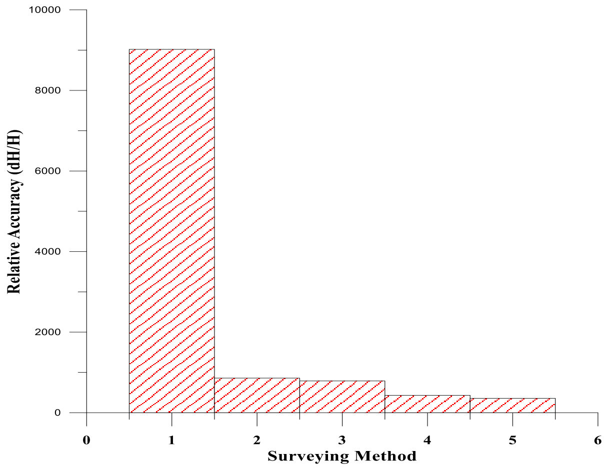

Figure (3): Small traverse analysis [y-axis represents 1/(dH/H)].

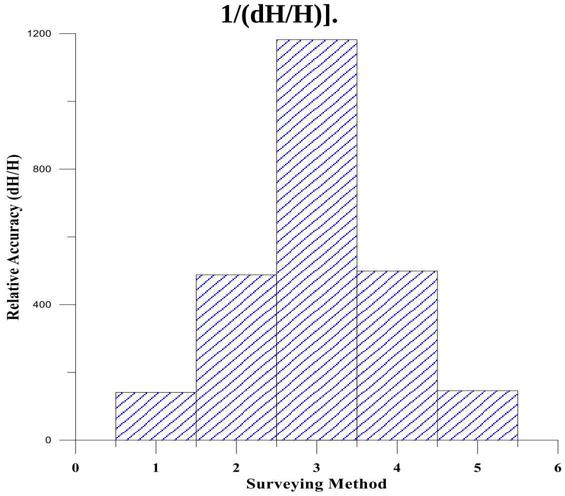

Figure (4): Large traverse analysis [y-axis represents 1/(dH/H)].

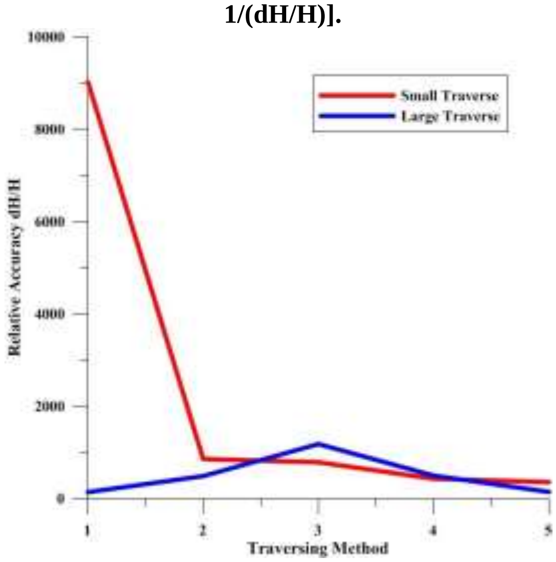

Figure (5): A comparison between two traverses analysis [y-axis represents 1/(dH/H)].

VII. DIGITAL TOPOGRAPHIC MAPPING

A topographic map is a type of map characterized by large-scale detail and quantitative representation of relief, usually using contour lines in modern mapping, but historically using a variety of methods. Traditional definitions require a topographic map to show both natural and man-made features. A topographic map is typically published as a map series, made up of two or more map sheets that combine to form the whole map. A contour line is a combination of two line segments that connect but do not intersect; these represent elevation on a topographic map. Figure (6) shows an example of the topographic map (Roy, 1999).

The digital map is not just a computer-readable file of map data. Visvalingam (1989) proposed that the term implies "a compact, structured, integrated and elegant representation of spatial data and their spatial attributes in a manner that facilitates rapid inference and retrieval and speedy but error-free update of data. This implies pre-processing and substantial restructuring of input data so that the digital post-processing system may infer spatial forms, relationships and patterns in a way, which matches, and if possible surpasses, human information processing capabilities". This definition excludes uninterrupted raster and video-scanned images and spaghetti vectors, despite their value and use as visual maps.

The full benefits of digital mapping can only be realized when the required data are already in computer-readable form. There is now a large primary sector within the computer mapping industry, which is mainly concerned with the collection, processing, validation, maintenance and distribution of spatial data. Both in theory and in practice the map database has become the ultimate reference map - the digital map, which is a commercial product in its own right (Visvalingam, 1989).

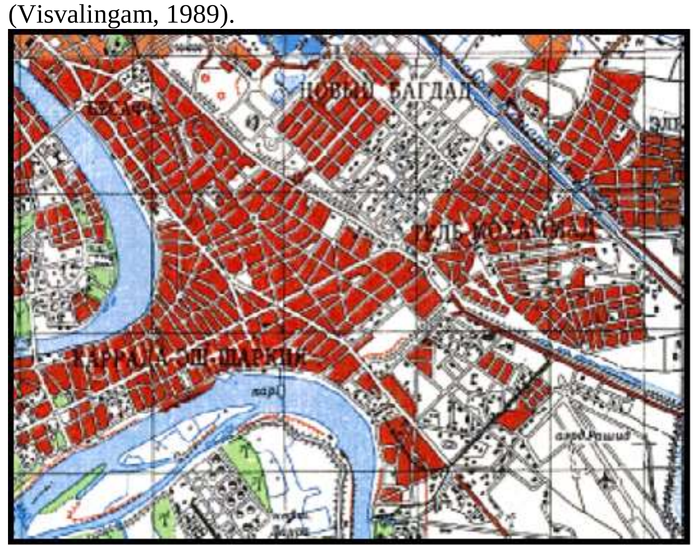

Figure (6): Topographic Map of Al-Mada'en City in Iraq.

ArcView software is one among several sotwares of GIS. It is a desktop system for storing, querying, modifying, analyzing and displaying information about geographic space. An intuitive graphical user interface includes data display and a viewing tool. Support for spatial and tabular queries, 'hot links' to other desktop applications and data types, business graphics functions such as charting, bar and pie charts, and map symbolization, design, and layout capabilities are supported. Geo-coding and address matching are also possible. The Spatial Analyst tool kit makes working with raster data such as terrain and DEMs possible. Other extensions permit network analysis; allow Web activation of ArcView maps, and support advanced display features such as three-dimensional data visualization. (ESRI, 2015).

In this paper we produced a digital map by utilization of geographic information system GIS and land surveying data for two traverses selected in the site of Al-Nahrain Uninversity. These two traverses are different in lengths: the sides of the first traverse are short and its length ranging from 20 to 50 meters. While the sides of the second traverse are ranging from 70 to 180 meters. These differences are useful for studying the accuracy of the developed map if it depends on the accuracy of the field work or not.

VIII. COORDINATES OF TRAVERSES

In this paper large and small traverses are drawn using ArcView 3.2 and AutoCAD 14. The required coordinates were calculated of the points of the traverses using equipments and tools by different methods of surveys.

A. Coordinates of Large Traverses

The final grid coordinates from the calculations for each method of the survey will be used to draw the large traverses as a digital map.

1. Tape

Point	X	Y
A	100.0000	100.0000
B	129.4313	17.3660
C	288.1006	100.3190
D	228.7884	185.8780
E	177.7274	96.4340

2. Level

Point	X	Y
A	100.0000	100.0000
B	127.8945	17.5350
C	289.5196	95.9380
D	232.1605	183.8690
E	178.0208	96.0140

3. Digital Level

Point	X	Y
A	100.0000	100.0000
B	127.8655	17.4490
C	289.0776	95.7210
D	231.9330	183.5540
E	178.1909	95.9370

4. Digital Theodolite

Point	X	Y
A	100.0000	100.0000
B	128.0771	17.0400
C	289.6494	95.6030
D	231.7779	183.7520
E	178.3994	96.0120

5. Laser Tape

Point	X	Y
A	100.0000	100.0000
B	129.2161	17.2200
C	289.2268	97.2040
D	231.9406	184.3180
E	177.9324	96.3950

B. Coordinate of Small Traverses

1. Tape

Point	X	Y
A	100.0000	100.0000
B	137.5760	81.0500
C	178.0951	98.5850
D	176.1872	121.8050
E	127.6865	112.9150

2. Level

Point	X	Y
A	100.0000	100.0000
B	138.0607	81.4560
C	178.1626	100.2820
D	175.5481	123.6900
E	127.5627	112.8600

3. Digital Level

Point	X	Y
A	100.0000	100.0000
B	138.1604	81.5040
C	178.2462	100.4790
D	175.5814	123.8880
E	127.6443	112.9330

4. Digital Theodolite

Point	X	Y
A	100.0000	100.0000
B	137.8858	81.6640
C	178.1521	100.5800
D	175.5241	123.8540
E	127.5697	112.8950

5. Laser Tape

Point	X	Y
A	100.0000	100.0000
B	137.8182	81.1880
C	178.2610	98.9020
D	175.8889	122.3690
E	127.4738	112.7760

A. Drawing the Large Traverses

By selecting all the themes, Tape, Level, Digital Level, Digital Theodolite and Laser Tape, the traverses will be as shown in figure (7).

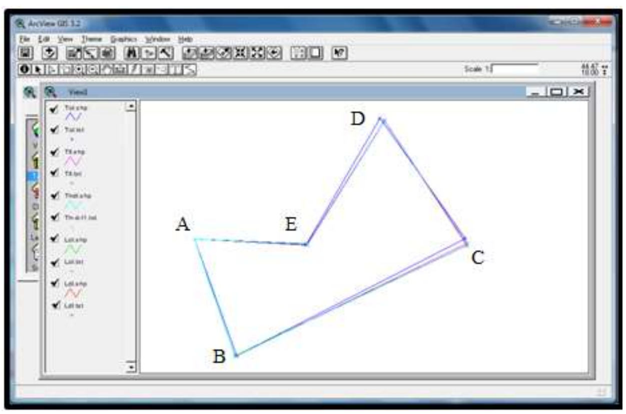

Figure (7): The digital map of all themes used for the large traverse.

B. Drawing the Small Traverses

By selecting all the themes, Tape, Level, Digital Level, Digital theodolite and Laser Tape, the traverses will be as shown in figure (8).

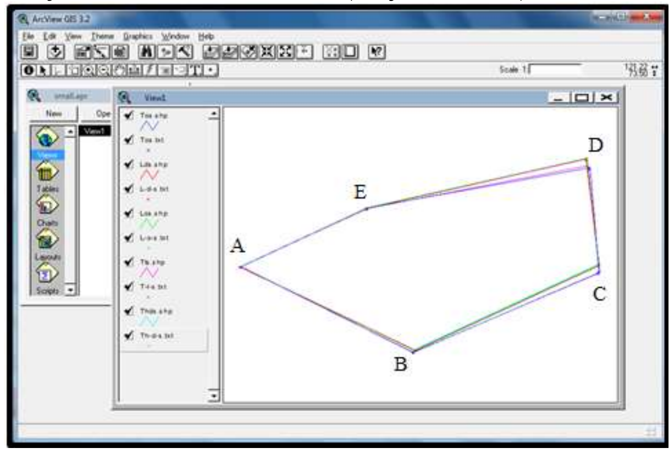

Figure (8): The digital map of all themes used for the small traverse.

IX. COMPUTING MAP ACCURACY

Thematic maps are produced for a wide variety of resources: soil types or properties, land cover, land use, forest inventory, and many more. These maps are not very useful without quantitative statements about their accuracy. Map users must know the quality of the map for their intended uses, and map producers must evaluate the success of their mapping efforts. Both users and producers may want to compare several maps to see which the best is, or to see how well they agree. For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of the two traverses. In general what is well defined will be determined by what is plot-able on the scale of the map within 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map.

By comparing the positions of points whose locations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Depending on the scale of the map, the actual ground distance represented by $1/30^{th}$ and $1/50^{th}$ of an inch will vary. To determine the minimum standards for horizontal accuracy in actual ground meters, the following calculation must be performed.

• If larger than 1:20,000-scale, use this calculation: 0.03333 x scale x 2.54 / 100 = ground meters.

• If 1:20,000-scale or smaller, use this calculation: 0.02 x scale x 2.54 / 100 = ground meters.

X. CONCLUSIONS

The following conclusion can be drawn based on the findings and analysis of this study:

1. To demonstrate the effect of traverse length on the accuracy of the traversing work, two traverses would be taken. One has ribs less than 50m and the other larger than 50m.
2. Each traverse is hold five times using five equipments instruments: cloth tape, laser tape,

automatic level, digital level and digital theodolite.

3. When using cloth tape in traversing the error was .021 m. In the small traverse and 3.919 m. in the large traverse. The amount of the error in the first traverse is very good but the error in the second traverse is not. This error may be happened because of several cause such as:
    a) Non accurate angles due to the use of poles which results error in the chord of the angle.
    b) The presence of obstacles was preventing the tape to be at the same level.
    c) Coefficient of linear expansion of the tape affects the accuracy of the work.
4. When using automatic level in traversing the error was 0.221 m. In the small traverse and 1.133 m. in the large traverse. The amount of the error in both traverses is very good because the level is not designed for measuring angles. Anyway the error may be happened due to several cause such as:
    a) personal errors have a significant impact on the accuracy, especially when determining the lengths, since the upper and lower stadia are seen difficulty:

    Length = (upper reading – lower reading) × 100

    b) The true angle couldn't take because the level has integer angles and you must estimate the angle when lay between two lines.
    c) When measuring angles you cannot surely that the poles are perpendicular or not.
5. By using digital level in traversing the error was 0.241 m. In the small traverse and 0.467m. in the large traverse. The amount of the error in both traverses is very good and it was enhanced in the second traverse. The error may be happened due to several cause such as:
    a) The rule of the digital level does not contain bubble so it affects on the lengths.
    b) When measuring angles you cannot surely if the poles are perpendicular.
6. Using digital theodolite in traversing the error was 0.439 m. In the small traverse and 1.111m. in the large traverse. The amount of the error in both traverses is not acceptable for accurate works. The error may be happened due to several cause such as:
    a) Instrument error affect on the lengths and angles.
    b) The presence of obstacles prevents vision of the nails, so you must use poles which affect the angles.
    c) Our personal errors.
7. When using laser tape in traversing the error was 0.533 m. In the small traverse and 3.774 m. in the large traverse. The amount of the error in the first traverse is fair for reconnaissance works, but the error in the second traverse is not. This error may be happened due to several cause such as:
    a) Instrument error affects on the lengths and angles, since the angles measured by cos law (length of the chord affect the angle).
    b) The presence of obstacles prevents you to put the laser tape directly on the nail and measure. So you must raises it by pedestal, thus you cannot surely that the laser tape directly over the nail.
8. Details map of the site using a satellite image taken from Google Earth for building the Department of Architecture, Al-Salam Hall, roads and gardens surrounding.
9. AutoCAD drawing program is easier and faster than ArcView, the large number of tools and commands in AutoCAD allows the user a lot of options to draw anything and this is not found in ArcView. GIS is a database program, and AutoCAD is a graphics program. With AutoCAD, it's the lines that are important, *i.e*. the drawing is the information. With GIS, the lines are just a representation of the data behind it.

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