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The Impact of New Surveying Instruments on the Construction Surveying Course of Study

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Construction Surveying has been highly affected by advances in technology. Technological development has led to new surveying instruments being produced at fairly regular intervals for the construction industry. The new instruments offer many advantages including accuracy, productivity and interconnectivity. Owing to the advantages offered by the instruments, many construction companies readily adopt the use of these instruments in their businesses. Trends in the manufacture of new construction surveying instruments are presented. A study using a questionnaire was done to establish how this developmental trend should be approached in teaching construction surveying to students in the Construction Management Technology programs. This paper also gives the results of the questionnaire sent to all 4-year degree awarding members of the Associated Schools of Construction (ASC), which are accredited by the American Council for Construction Education (ACCE). Fourteen schools responded. The finding of the study is that the schools favor the inclusion of the cutting edge "High Tech" equipment in surveying in the teaching of the course so that students can be better prepared for the workplace. After the students have been taught the use of the basic surveying instruments, it is recommended that the use of the new surveying instruments and their applications in construction should be taught.

Key Words: Electronic, surveying, construction, robotic total station, theodolite, transit, levels, Global Positioning System (GPS), Global Information System (GIS)

Introduction

The use of the principles of surveying is not limited to the professionally registered surveyor and his or her employees. From the initial mapping and selection of a construction site to a final check of the roof slope, nearly everyone involved in the control of a construction project must be aware of a variety of surveying instruments and techniques. Anyone doing surveying work must be able to accurately measure long distances and elevations within hundredths of a foot and angles within fractions of a degree. In addition, this precision must be accomplished efficiently in terms of time and labor (Leica Report 27, 1991).

Construction Surveying is an integral part of the Construction Management Technology program. It serves as an introduction to a variety of surveying equipment and techniques and encompasses the process of gathering information about a proposed job site, laying out the location of structures on the site, checking the dimensions of the structures during construction and documenting the completed work (McCormac, 1991). One of the course objectives is to give students proficiency in the use of surveying instruments. The instruments currently used in

teaching the course include measuring tapes, range poles, plumb bobs, levels, theodolites, and traditional total stations.

Electronic distance measuring devices are extensively used in the present construction industry. The electronic distance measurement (EDM), first introduced in the late 1950s has since those early days undergone continual refinement. The early instruments, which were capable of very precise measurement over very long distances, were large, heavy, complicated and expensive. Technological advances have provided lighter, smaller, simpler and less expensive models (Roberts, 1995).

Current EDMs generate and project an electromagnetic beam of either microwaves or infrared (lightwaves) from one end of the line being measured to the other. The beam is received and either retransmitted (as for microwave) or reflected (as for infrared) back to the transmitting instrument (Kissam, 1988). Infrared EDMs come in long range (10-20 km), medium range (3-10 km) and short range (0.5-3 km). EDMs are generally used in conjunction with theodolites; vertical angles must be measured so that the slope distances obtained by the EDM can be reduced to horizontal distances. The electronic digitized theodolite, first introduced in the late 1960s, set the stage for modern field data collection and processing. When the electronic theodolite is used with a built-in EDM, the surveyor has a very powerful instrument. Adding to such instrument an onboard microprocessor that automatically monitors the instrument's operating status, and a data collector that records and processes field data will produce an electronic Tachometer Instrument (ETI) - known as a **Total Station** (Kavanagh, 1992).

Construction Surveying is a specialized course. Owing to advances in technology, new surveying instruments are produced from time to time. These new instruments offer many advantages ranging from cost and time saving features to higher degrees of efficiency. In addition, they are also generally much easier to use. Because of these advantages, construction companies readily adopt the use of these instruments in their businesses. Since students in the Construction Management Technology program are being prepared to enter the construction industry, there is, therefore, a need for the course of study in Construction Surveying to reflect the new methods and instruments used in the dynamic construction industry.

The objective of this paper is to present the trends in the manufacture of new instruments in the construction surveying industry. It also presents the results of a questionnaire administered to determine the need to have the course of study in Construction Surveying to reflect new methods and instruments used in the construction industry.

Current Trends

There has been a quick pace of improvement in the quality of surveying equipment within the past twenty-five years. The most significant areas have been in the development of Auto Focus Levels, Laser Levels, traditional Total Stations and Robotic Total Stations. There has also been much progress made in the introduction of the Geographic Information Systems (GIS) and Global Positioning Systems (GPS). In addition, there has been a corresponding development of new field data collectors and computer software for use with these instruments. These

developments have had a great impact on the construction industry. A brief description of each these now follow.

Auto Focus Levels

Auto Focus Levels have seen great improvements since the first auto level appeared in the industry twenty-five years ago. Some of the latest auto levels are the Pentax Auto Focus Levels Series. The Auto Focus Level uses autofocus techniques to automate the troublesome focusing procedure. Pushing the Auto Focus (AF) key will focus the target in an instant to dramatically improve the operational efficiency. The Autofocus function uses the Phase Contrast Method. Automatic and Manual modes are easily changeable so that the two modes can be selected freely. The automatic compensator uses special alloy ribbons so that stable measurement accuracy is obtained even under adverse conditions such as heavy vibration. The level's operational efficiency is dramatically increased by the use of Auto-focus.

Laser Levels

Advancement in laser technology has been utilized to produce surveying instruments that cover a wide range of applications in the construction industry. These instruments produce visible laser light that range from a pencil-thin line of light to a plane of light that covers a whole work site. The instruments consist of the laser beam transmitters and receivers for the infrared ray. The instruments have long range (1000-ft radius). Some of the instruments can be used on grade (slopes) and can be used in conjunction with several excavating equipment. Some are used for both interior (e.g. layout of metal studs for drywalls) and exterior work (e.g. general construction work). Most also establish horizontal and vertical planes to guide workers. An example of a specialized laser instrument is the pipe laying laser level. The Cordless Pipe Laying Laser sets lines and grades. It has a large grade and line display that lets the user see the display outside the trench or in a manhole up to 10 feet away. Dialgrade is cordless with power options and battery life that is very good. It has a wide self-leveling range.

The Laserplane Leveling Systems is one of several laser level products by Spectra Physics. The Laserplane transmitter (operating unmanned) sends a continuous self-leveled 360° reference plane of light covering the work area. This reference can be picked-up by one or more receivers simultaneously which may be hand held or attached to a grade rod or machinery. This is used for all construction applications: setting and adjusting, elevations, marking, excavation cutting depth etc. The transmitter can be mounted on a regular tripod or can be set free standing. The receiver's Liquid Crystal Display visually indicates when high, on-grade, or low, with up to nine channels of grade information. The user may also select distinct audio tones that match the display. The receiver allows the user to locate the level reference to perform all leveling applications. It is used to provide a precise vertical reference plane for faster installation of drywall, layout or other vertical applications. It is also produces a rotating, pencil-thin beam of highly visible red laser light. This beam generates a continuous horizontal reference plane for installing acoustical ceilings, raised computer floors, and sprinkler systems. It is designed for quick, easy setup in either the horizontal or vertical mode. The laser level has assured accuracy. If the unit is knocked out of level, it will automatically shut off until it has re-leveled itself;

hence inaccurate readings cannot be made. The self-leveling feature assures fast, accurate setup and a one-man crew can operate it.

Traditional Total Stations

In the surveying profession today, there is a very strong movement away from theodolite and levels toward the use of electronic total station instruments. With total stations the surveyor can measure slope distances as well as horizontal and vertical angles. Furthermore, these devices have the capacity to compute and display horizontal distances, differences in elevation as well as directions and coordinates. These instruments may also be used with superb results for differential leveling and for stadia readings for topographic work. When total stations are used for topographic maps, readings can be made so quickly that many more points may be sighted than with the old procedures. This is particularly true when one uses an electronic data collector and AutoCAD to plot the needed maps. The use of additional points should result in better maps. Even though chaining techniques with a metal tape are still important in everyday layout and basic surveys, electronic distance measuring devices are the number one method of today's and tomorrow's survey and engineering work. The old fashioned transit with the method of using a magnifying glass to read verniers is not being used in the field as it once was (Kirby, 1992).

Robotic Total Stations

The latest advance in the field of surveying is the Robotic Total Station. A one-man crew can operate this system. The Geodimeter System 4000 is one of several different Robotic Total Stations on the market. The operator can control this fully robotic surveying unit, from as far as 1500 feet away by a Remote Positioning Unit (RPU). Similar to conventional total stations, the Robotic Total Station is positioned over a point (station) and oriented to a back sight station. When the setup and orientation is completed, a button is pushed on the instrument keyboard that allows the instrument to be controlled from the RPU. The RPU is about half the size of the total station and is mounted on a pole similar to a conventional prism pole. From the RPU, the operator can serve as the "Rodman", collect data and control the movement of the total station. All data, which are usually shown on the total station, are shown on the RPU, thereby being at the operator's disposal at all times. After moving to the point, which needs to be surveyed, the operator pushes a button and a signal is transmitted by radio link, to the robot. The robot then begins to search for the retro prism on the RPU (Roundtree, 1998).

Using appropriate computer software programs to accompany the Robotic Total Station cuts down on office work and produces quality reports. The new technology allows for increase in productivity, cuts office time in half, and allows for obtaining of permits in a very short time. The advances in surveying technology have helped companies large and small, to take huge strides in efficiency and customer satisfaction.

The Robotic Total Station can be used in the dark. The system operates both in the unattended robotic mode and in the conventional mode. This innovative technology has caught on with firms of all sizes, making their surveying work easier, faster and thus more efficient.

Geographic Information Systems (GIS) and Global Positioning System (GPS)

Geographic Information System (GIS) is a mapping system that integrates position information of an object with descriptive information about that object. GIS stores and displays both spatial and non-spatial data. For example, the shape, size, and location of a parcel of land constitute spatial data whereas the name of its owner is a non-spatial descriptor.

A GIS is comprised of a database and a map. Coordinate data is retrieved by the database and then displayed (with relation to other objects) using the mapping engine. A major advantage of GIS software is the ability to maintain data associated with different elements in separate layers (or coverages) that are based on the same geographic referencing system which can be superimposed spatially to support data queries and analysis (Hobbs, 1991).

The Global Positioning System (GPS) is a system for providing precise location information. This information is transmitted from a constellation of 24 satellites that continuously orbit the earth at high altitude. This constellation of satellites orbits high enough to avoid the problems associated with land-based systems and yet provides accurate positioning 24 hours a day anywhere in the world. Uncorrected positions determined from GIS satellite signals have accuracy in the range from 50-100 meters. This accuracy may be further refined to less than 2 centimeters using a technique called Differential Correction.

GPS has found its greatest utility in the field of Geographic Information Systems (GIS). By integrating the two technologies, users can now navigate to a position using the output from a GPS device, and then query this location using the GIS application. This query will provide users with all the data related to that location such as the object's attributes.

A large number of engineering and business applications require the tight integration between "real-world" positioning of objects and information related to these objects. The system capable of providing the information above is developed using the marriage of two related technologies, namely a Geographic Information System (GIS) and a Global Positioning System (GPS).

Once GIS and GPS systems are integrated, the possibilities are endless. For example, a utility company may be interested in dispatching a maintenance crew to fix a transformer. A system based on these technologies can lead this crew to the transformer's location; and then supply all the information related to that transformer such as its size, manufacturer, etc. In the highway application, roadway information, alignment, and condition are supplied by the system to engineers to assist them in planning. The railroads can benefit greatly from the integration of GPS to track roadbed information such as tilt, soil stability, or rockslide likelihood (ASCE, 1998).

With a continuous improvement in the quality of GPS and mobile PC devices and a continuing reduction in their costs, such systems are becoming more affordable. There is therefore the need to provide students with an in-depth understanding of GIS and GPS hardware and software, operational concepts, performance characteristics, and engineering and business applications.

Field Data Collectors and Surveying Computer Software

There are currently in the market several data collectors and computer software for use with the electronic surveying instruments. These are flexible and make field data collection, retrieval, and management easy. Some of the data collectors and software available are:

TDS Survey Pro

The **TDS Survey Pro** is a powerful and versatile tool for survey design and layout. The **Survey Pro** card takes the most popular data collector, the TDS 48GX, and adds functionality and ease-of-use enhancements. With its industry standard menu-screen interface and new on-line help screens, **Survey Pro** also has one of the fastest learning curves in data collection software.

TDS Easy Survey Plus

Easy Survey Plus is a Computer Aided Surveying (CAS) program for surveyors who want a flexible, graphic environment to use in computations and plotting. It provides Automated Mapping, Graphical COGO, Road Design, Data Collection and File Transfer. Easy Survey Plus is built around a powerful, 32-bit graphics engine and operates on 386 or better laptop and desktop PC's with VGA compatible graphics Cards. It provides crisp accurate on screen views of field data and accurate plots of finished designs. It is the field to finish solution that saves time and effort. With Easy Survey Plus, contour plots and least squares adjustments are just a few keys away. Automated Mapping provides an instant screen plot of the job, including different symbol and line types, curves and text. All screen plots can easily be output to printers, plotters or DXF and DGN files.

TDS Easy Survey plus w/TFR Software

The TDS Easy Survey plus w/TFR is DOS compatible software that offers automated mapping with user-definable feature codes. Site plans can be viewed or edited on-screen, plotted directly or translated into a DXF file for import into external CAD systems. It has a two-way data transfer with DR-48 data collector.

Carlson Survey Software

Carlson produces the **SurvCADD** and **SurvStar** software for the surveying industry. The latest in the series of this software are:

Standalone COGO-Design Software

This software merges SurvCADD functionality powered by Autodesk Technology into a single standalone product. It has most of the COGO-Design module of the SurvCADD 98 and AutoCAD Release 13. Contouring and volume calculations are also included in Carlson Survey.

SurvStar

This software a complete data collection system for Real Time GPS and Total Stations with in-field coordinate geometry.

GradeStar-GPS Grade Control System

This system allows GPS-guided grading according to a pre-set surface grid. Cut/fill values and cross-section and plan views are updated in real-time. The on-board computer-GPS system provides an operator with all the necessary information about differences between existing and design surfaces. The existing surface is updated automatically as the equipment moves around the site. No other total station, laser or GPS surveying is necessary for precise grading.

MapPlus

This is a collection of enhanced routines and features that takes full advantage of AutoCAD MAP Release 2. Automated database connectivity is among the many improvements of Map Plus. Enhanced features allow the user to edit, create, and manage ODBC compliant database tables, within the AutoCAD MAP environment. Table links are automatically registered with the Map Plus database administrator. Analysis of map features becomes a simple point-and-click process. Map Plus reduces database configuration time, effort, and maintenance.

Other **SurvCADD Software Modules** are: COGO/DESIGN, CONTOUR/DTM, SECTION/PROFILE, HYDROLOGY, MINING and AUTOCAD for GOVERNMENT.

The electronics surveying instrument manufacturers have developed several computer software and data communication links within their instruments. For example, Geotronics uses the Geodimeter software and data communication system in its instruments. The system collects and stores data in both internal and external memory units. There is flexible and well-designed data communication built in with all systems. Other features of the Geodimeter surveying systems are: **UDS** (User Defined Sequences) software which allows the user to set up 20 registration sequences; **Pcod** (Point code) which allows the user to use his own point code list; **View**, which allows one to rapidly retrieve stored data in the instrument's display in order to check its contents; **Edit**, which not only lets the user rapidly seek stored data and see them on the instrument's display (View) but also provides full editing capability; **StnEst**, is a program for station establishment; the **Z/IZ** program, helps the user to determine the absolute elevation of the instrument rapidly; **Angle/Meas**, a program for angle measurement which handles the time-consuming search for different targets when doing a round of angles; **SetOut**, a program designed to set out a point; **RefLine**, a program which allows the user to set out any point along or parallel with a known or unknown reference line; **Area/VolCalc**, a program that calculates surface and volume between points that have been measured; **DistOb**, a program which gives the user rapid and easy to use calculation of distance, height difference and slope in percent between two points where sight between the points is blocked; **Roadline**, a software package with which the user can set out roadlines in a very rational manner. This is a complete program for station establishment in three dimensions, with routines for setting out and collecting data as well as for checking and storing data; and **RoadLine 3D**, an all inclusive program package which gives the user completely new prerequisites when setting out and checking roadlines in three dimensions.

This program contains all the functions of RoadLine but will also furnish the user new productive “tools”.

The Need

A survey of the Construction Management Technology graduates and comments from the Construction Technology Advisory Council of the University of Maryland Eastern Shore revealed that it is increasingly important for the construction graduates to be familiar with electronic surveying instruments.

The feedback from some students who participated in the Construction Management Technology Internship Courses and the current trends in the construction industry indicate the need to use modern electronic surveying equipment in the course on Construction Surveying. The Construction Management Technology Internship courses are designed to provide the students with work experience as interns under the supervision of construction professionals. Some of the student interns have been involved in construction site development and layout projects that included the use of electronic surveying equipment. For these students, the internship experience was the first opportunity to use these instruments. It is believed that if the students have experience in the use of electronic surveying instruments as part of the course on Construction Surveying, this will not only be of good benefit and advantage which may be strengthened during internships but will be a good preparation for them as they graduate and enter the real world of construction. Knowledge of and experience in the use of the electronic surveying instruments will greatly improve the quality of the course on Construction Surveying and provide a good background for future work. This will also be of good advantage to the students as they go on the construction management internship courses.

Furthermore, the students should be taught the use of the electronic measuring instruments and their maintenance and safe use. They should also learn to use the computer software for storing and processing surveying data and should use these to produce survey drawings and reports. It is therefore, very important that a course of study in Construction Surveying should reflect new methods and instruments in the construction industry.

The Questionnaire and Responses

A questionnaire was designed to determine the need to reflect the changes in the development of new instruments in the teaching of construction surveying. The questionnaire was sent to all American Council for Construction Education (ACCE) accredited 4-year universities teaching Construction Surveying requesting course descriptions and other relevant information. A copy of the Questionnaire is shown in the Appendix. Responses were obtained from 14 institutions out of the 40 institutions selected for the study.

Analysis of Responses

The various schools gave different course names to the course. Table 1 shows the different titles given to the course. The popular trend is calling the course Construction Surveying as seen in Table 1.

Table 1

Course Titles

S/No.	Course Title	Number of Universities With This Title
1	Construction Surveying	6
2	Plane Surveying	3
3	Surveying	3
4	Construction Surveying Fundamentals/Construction Layout	1
5	Engineering Measurements	1
6	Engineering Surveying	1

Prerequisite

As a prerequisite to the course in surveying all the colleges required some Mathematics course to have been completed. This is appropriate because some concepts of mathematics especially trigonometry, are required to compute some distances and angles.

Course Description

The description of the course by the various programs included the theory and principles of surveying applied to construction. They also included the use of instruments and field exercises and field note preparation.

Course Objectives

The objectives of the course as recorded by all the institutions are to develop in students the skills and knowledge needed in the accurate use of surveying instruments.

Some institutions offer two courses in surveying e.g., Purdue University offers a Construction Surveying Fundamental and Construction Layout in its Building Construction Management program. Texas A & M University has two courses: Plane Surveying and Surveying in the Civil Engineering program. In some programs, the surveying courses are taken as service courses from other departments like the Department of Civil Engineering.

There is a need to include in the objectives of the course in construction surveying, the introduction of new instruments and systems in the construction industry. The instruments taught should include Auto Focus Levels, Laser Levels, Conventional Total Stations, Robotic Total Stations, Geographic Information Systems (GIS) and Global Positioning systems (GPS). This will make the skills and knowledge the students acquire in college relevant to the work place.

Recommended Text Books

The Text Books used by the various institutions and their authors are shown in Table 2. Textbooks in surveying with construction applications are popular.

Table 2

Recommended Textbooks

Title	Author	No. of Schools
Surveying with Construction Applications	Barry Kavanagh	1
Principles of Surveying	Herobin	1
Construction Surveying and Layout	Wesley Crawford	5
Elementary Surveying	Wolf & Brinker	5
Surveying	Moffit & Bouchard	1
Surveying: Principles & Applications	Kavanagh & Bird	1
Construction Surveying Layout and Dimension Control	Jack Roberts	1

Student Enrollment

The average yearly enrollment of students in the Surveying courses in the Colleges that responded to the Questionnaire is shown in Table 3. All students enrolled in a Construction Management Technology program take a course in Construction Surveying. The course is important to the program.

Table 3

Student Enrollment

Institution	Course Name	Avg. Student Enrollment	Credit Hours
Central State University	Plane Surveying	25	4
Northeast Louisiana University	Construction Surveying	20	3
Georgia Southern University	Construction Surveying	24	5
Purdue University	Construction Surveying Fundamentals	120	3
Purdue University	Construction Layout	120	3
Southern Polytechnic State University	Surveying	20	5*
University of Washington	Plane Surveying	30	4
Bowling Green State University	Construction Surveying	25	3
University of New Mexico	Engineering Measurements	45	2
East Carolina University	Construction Surveying	18	3
Oregon State University	Plane Surveying	67	3
Boise State University	Engineering Surveying	25	3
University of Northern Iowa	Construction Surveying	18	3
Texas A & M University	Surveying	120	4
North Dakota State University	Surveying	100	4
University of MD Eastern Shore	Construction Surveying	18	3

Instruments

Table 4, shows a list of 'major' instruments commonly used in surveying. The Respondents were asked to indicate which of the instruments they used in their programs. The instruction for completing this section of the Questionnaire was: **"Directions:** For each item, circle an appropriate response 'YES' or 'NO''.

Table 4 shows their responses. The "**% YES**" column in the Table is the percentage of schools that use the instrument with respect to the total number of respondents. The instruments widely used are Dumpy Levels (50%), Automatic Levels (86%), Transits (79%), Theodolites (57%) and Total Stations (64%). The least used instrument is the Compass (7%).

Table 4

Instruments Used in Construction Surveying Courses

	Instruments	Yes	% Yes	No
A	Compasses	1	7	9
B	Construction (Dumpy or Wye) Levels	7	50	4
C	Automatic Levels	12	86	0
D	Laser Levels	6	43	6
E	Engineer's Levels	5	36	4
F	Transits	11	79	2
G	Theodolites	8	57	2
H	Electronic Theodolites	5	36	4
I	Total Stations	9	64	0

Other instruments reported being used are: Digital Level, Zenith/Nadir Instrument and GPS Hand-held Receivers.

Rating the Importance of Instruments Used

Note: The Respondents were requested to circle the appropriate response to signify what they perceived to be the level of importance of each of the instruments used in the teaching of construction surveying.

Scale for level of importance

1 = No importance
2 = Little importance
3 = Important
4 = Great importance

Table 5 shows the rating for each instrument. Automatic Levels (90%) and Total Stations (89%) were highly rated. Laser Levels (50%) and Theodolites (78%) had high ratings also. Compasses had the lowest rating (0 %). Automatic Levels, Laser Levels, Theodolites and Total Stations are seen to be quite important to the surveying course.

Table 5

Instrument Rating

Level of Importance	1	2	3	4	*% of* Levels 3 & 4
Compasses	7	3			0
Automatic levels		1		9	90
Engineer's levels	1	3	1	4	56
Laser levels	3	2	3	2	50
Transits	2	3	2	4	55
Theodolites		2	2	5	78
Electronic Theodolites		4	2	3	50
EDMI (Electronic Distance Measuring Instruments)	1	1	3	4	78
Bolt-on Accessory Type EDMI	1	5	2	1	30
Total Stations	1		3	5	89

Cost of Surveying Instruments and Software

Surveying Instruments are quite expensive. For example, the Nikon AZ-2 Automatic level costs $600, the Nikon NE-205 Electric Theodolite, $1, 950; the Top Gun A20LG Total Station, $11, 545; the TOPCON AP-L1A Robotic Total Station, $35, 985; the Dual Frequency Real Time Kinematic GPS System and accessories, $64, 870; and a GIS with accessories, $10, 480. The cost of the SurvCADD COGO/DESIGN, CONTOUR/DTM and SECTION/PROFILE software modules is $800 each; and the TDS Easy Survey Plus w/TFR, is $1, 500. Although educational discounts can be obtained, the cost of procuring these instruments to any construction program is high. On a short-term basis, these instruments can be rented from local vendors for specified period for students' use.

Integrating New Surveying Instruments in the Curriculum

As indicated earlier, all the construction programs have a semester course in construction surveying, in which surveying basics including the use of traditional surveying instruments are taught. These instruments include the dumpy level and the transit/theodolite. These basics are invaluable to the students and must still be taught. However, also recognizing the importance of the new instruments to the construction industry, the course syllabus should be modified to include the use of new instruments. This can be done by either including the use of new instruments in the current one semester course or designing another course that will fully incorporate the use of the new instruments. Owing to the fact that there is a limit to the number of courses that can be added to the program, the first option is favored.

First Option

The first option is to include the teaching of the use of new surveying instruments in the existing semester course. The new instruments may include Auto Focus Levels, Laser Levels, Total Stations, and the use of data collectors, and survey computer software. In particular, emphasis should be placed in the "Field to Finish" process, in which the data collector is seen as an

intermediary between the field and office operations that will produce the necessary plots and reports, by using the relevant computer software on the data collected. It has been observed that the students easily learn the use of the new instruments after being taught the use of the traditional instruments. Most of the field exercises can then do done with the new instruments. In the case of tight budget, the desired instruments may be rented for use in the field exercises. The instrument vendors will normally give educational discounts for these rented instruments.

Second Option

There are some programs that have two courses in surveying. This second course can be modified to include the use of new surveying instruments. The course should include Electronic Distance and Angle Measurement Instruments and their application to construction site planning, layout and control. Other areas may include, topographic maps, building foundation and stake-out, road, bridge, dam, and utility construction. These instruments should include the laser level, total station, robotic total station, GIS, GPS, and the use of data collectors and computer surveying software.

Recommendations

While it is important that some of the more traditional surveying instruments like the automatic levels and transits/theodolites should still be taught in the Construction Surveying course, it is important that new instruments, which are being widely used in the construction industry today, should be incorporated into the course. It is recommended that the use of the new instruments be taught. These instruments should include, Auto Focus Levels, Laser Levels, Traditional Total Stations, Robotic Total Stations, Global Positioning Systems (GPS) and Geographic Information System (GIS) and appropriate field data collectors and computer software. This will give students an opportunity to gain proficiency in the use of these instruments. This can be achieved by:

- Incorporating the use of the new instruments in the syllabus of the current semester course in surveying, and/or,
- Teaching the use of the new instruments in a second course. This may be feasible for the programs teaching two semester courses in surveying.

Instruments selected for use, should include the state-of-the-art instruments for electronic surveying, which are being widely used in the construction industry.

Conclusion

The advances in Construction Surveying Technology have made available new surveying instruments and systems that are efficient, easy to use, and affordable. This innovative technology has caught on with firms of all sizes, making their surveying work easier, faster and more efficient. These instruments and systems include Auto Focus Levels, Laser Levels, Traditional Total Stations, Robotic Total Stations and Geographic Information Systems (GIS),

Global Positioning Systems (GPS), and the use of field data collectors and computer surveying software. Owing to the wide use of these instruments and systems in the construction industry, there is a need to introduce students in the Construction Management Technology programs to these instruments since they will be the executors of projects in the future. In view of this, the Course Description and Curriculum for Construction Surveying Course of Study should be modified to include the use of new instruments and systems. In particular, the "Field-to-Finish" process should be adopted so that students can learn how to use data collectors in the field, transmit these data to a computer in the office, and by using appropriate software, produce required maps, plots and reports.

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Appendix

QUESTIONNAIRE ON CONSTRUCTION SURVEYING

1. General Information.

2. Please provide the following general information.

Name of Respondent: _____

Name of Institution: _____

Department: _____

Course Name: _____

Average Student Enrollment: _____Number of credit hours: _____

Recommended Text:_____

_____

3. Course Description:
   Please include a catalog description of the course:

4. Course Objectives:
   What are the objectives as listed in your course description?

5. Field Exercises:
   Please list Field Exercises undertaken in the course:

6. INSTRUMENTS

The following list of instruments is commonly used in surveying. Please indicate which of the following instruments you use in your program.

Directions: For each item, circle an appropriate response 'YES' or' NO'.

Compasses	YES	NO
Construction (Dumpy or Wye) Levels	YES	NO
Automatic Levels	YES	NO
Laser Levels	YES	NO

Engineer's Levels			YES	NO
Transits	YES	NO		
Theodolites	YES	NO		
Electronic Theodolites	YES	NO		
Total Stations	YES	NO		

Please list below any other major instrument in use in your program:

_____
_____
_____
_____
_____

7. RATING THE IMPORTANCE OF INSTRUMENTS USED

Direction: Please place a circle around the number of the appropriate response to signify what you perceive to be the level of importance of each of the instruments used in the teaching of construction surveying.
Scale for level of importance

1 = No importance
2 = Little importance
3 = Important
4 = Great importance

	level of importance (Circle one)			
Compasses	1	2	3	4
Automatic levels	1	2	3	4
Engineer's levels	1	2	3	4
Laser levels	1	2	3	4
Transits	1	2	3	4
Theodolites	1	2	3	4
Electronic Theodolites	1	2	3	4
EDMI (Electronic Distance Measuring Instruments)	1	2	3	4
Bolt-on Accessory Type EDMI	1	2	3	4
Total Stations	1	2	3	4

Others:

_____
_____
_____
_____
_____

I will appreciate any general comments you may have concerning this questionnaire:

_____
_____
_____
_____
_____

I appreciate very much your assistance, time and effort in completing this questionnaire.

Please return completed questionnaire to:

Dr. J. O. Arumala,
Department of Technology,
11931 Art Shell Plaza,
University of Maryland Eastern Shore,
Princess Anne, MD 21853-1299

Thanks for your cooperation