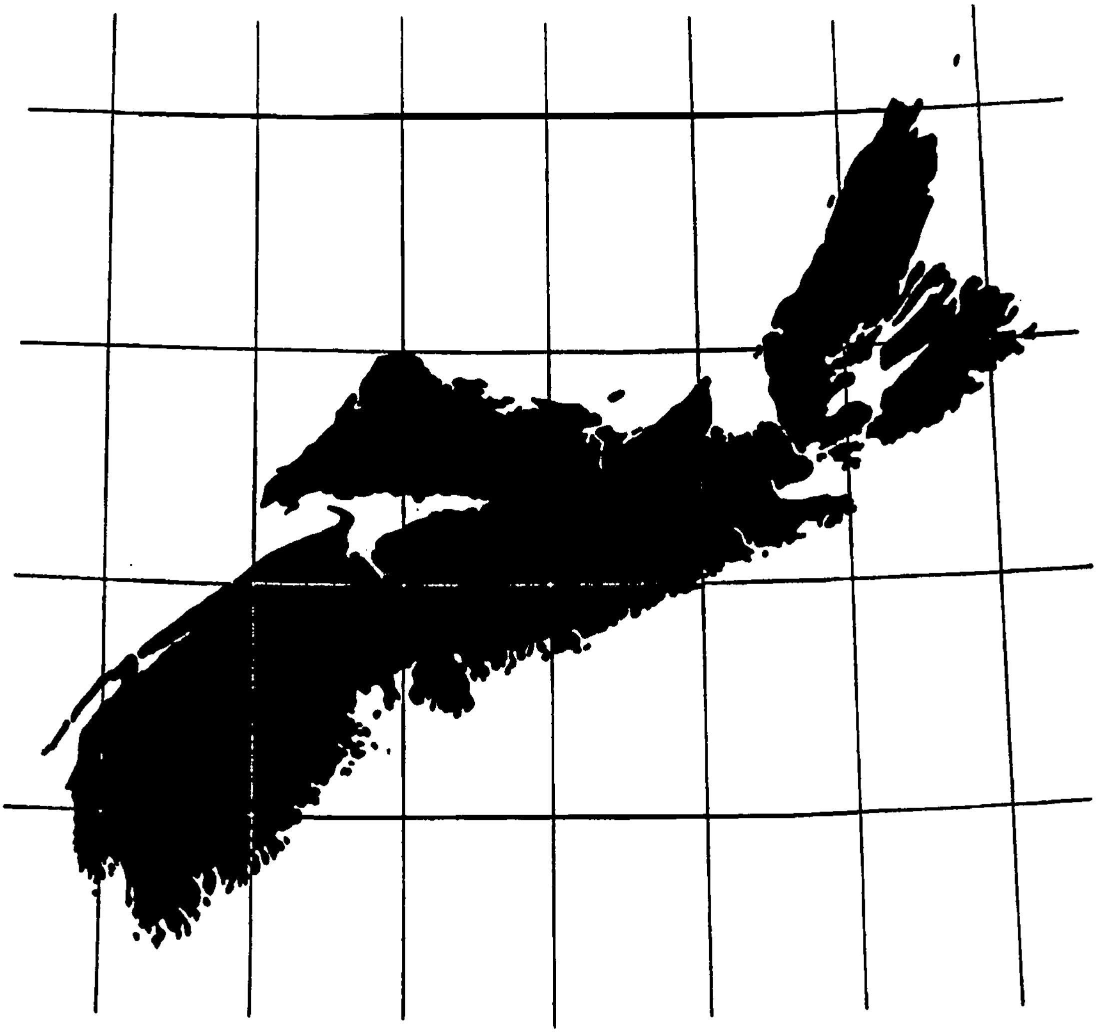
The NOVA SCOTIAN SURVEYOR



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Teaching of Mathematics

It is generally accepted in all parts that the teaching of mathematics leaves much to be desired. As professor of mathematics at the Nova Scotia Technical College, I was in a position to verify that this is true in Nova Scotia.

Several years in succession I gave a test to the incoming class of fourth year engineering students. The test consisted of ten problems ranging from fractions to logarithms, all necessary to carry on mathematical calculations.

The tools of the trade

Grades ranged from 100 to zero.

Had this been a regular examination I could have failed half of the class every year.

It must be recognized that math differs from all other subjects. No amount of hard study or intense memory work is of any value if the student cannot reason mathematically. It differs also in that the work must be built up step by step.

The present system with a sloppy 50 or 60 pass mark is absurd.

How can men get up to fourth year engineering when they are unable to think mathematically?

Many teachers give credit for home work which very frequently is done by one student and copied by four or five others. Most examinations have questions which can be answered by a student who has memorized the work, which he forgets next day. Some students have photographic memories and can see whole pages of calculations which they can copy down as if the actual page was in front of them.

Sometimes there is cheating in exams.

Under the present system the pupil is frequently promoted because the teacher is sorry for him and doesn't want to make him lose his year (perhaps he has already lost one).

Sometimes he is promoted because the teacher wants to get rid of him. If a reasonably severe system such as outlined above were applied the slaughter would be awful. The remedy is easy. Two changes only.

A. Make yearly promotions in grammar and high school entirely independent of mathematics.

B. Put the teaching of math in the hands of teachers who understand the work.

The student would progress in his math just as fast or just as slow as he was able. When he gets to the point where he is unable to go ahead, he stops. He, (or she) is not deprived of anything. He can try to pass as many times as he wants to, but he does not go on until he does.

The great advantage is that we, (and the boy himself) know where he stands. At the present time the affiliated colleges take in first year engineering classes up to say 50, and at the end of the third year pass on 10 to the Technical College. All the time and energy and money wasted.

All the loss to the other students because of the time spent by the teacher on impossible students.

There are also many professions where advanced math is not needed. Why hold back a student for a subject he will not require if he has trouble with it. (If he can do it, he can carry it on even if he does not need it.)

The same is true of the girls.

There should be no difficulty dividing the teachers. I do not think examinations would be necessary.

I cannot imagine anything more miserable than trying to teach a subject that the teacher does not understand and on the other hand a person who does understand math would be so delighted to get rid of the drudgery of endless English or History papers and exams. I think the teachers could be trusted to register "math" or "non-math."

E. O. TEMPLE PIERS

Stake Pulling Problem

On May 18, 1962, I was called by Mr. L. E. DeYoung to make a survey of his property at 158½ Portland Street in Dartmouth.

He furnished me with his deed and a plan made by an engineer in the City of *Dartmouth engineering department.*

The property measures about 45 ft. on Portland Street but widens out at the back, extending back of the properties on either side.

The property is used as a taxi stand, "The Blue Bell Taxi."

On Portland Street to the west is a lot measuring fifty (50) feet on Portland Street and sixty (60) feet in depth, owned by a Mr. Grant. The DeYoung property extends back of it down to the canal.

Both properties have the same neighbour to the west. The boundary is a straight line. The Grant property is occupied by a building fronting on Portland Street the east side being on the west boundary of the lot.

The main building on the Grant lot does not go to the rear of the lot on the west side, but a small ell, further east, projects south over the DeYoung boundary. I found that this west line of the Grant building produced the west line of the DeYoung property running down to the canal. I placed the corner stake of the DeYoung-Grant boundary on this line, sixty (60) feet from Portland Street and several feet south of the south west corner of the building. (It was still a couple of feet north of the rear of the ell which was on DeYoung land).

This steel stake was publicly pulled out by the tenant of the Grant property. Mr. DeYoung brought a charge against him and the case was tried in magistrates court. The accused was acquitted on the ground that the surveyor did not have an "abstract of title" from Mr. DeYoung. Mr. DeYoung was urged to appeal but refused to do so.

I wrote to the Crown Prosecutor, Mr. Peter O'Hearne. His reply and my answer to him are attached.

We have here two distinct separate problems.

It has always been understood that a surveyors stakes could not be removed under severe penalties. If thought to be in the wrong place the person aggrieved could bring a court action to have the stakes changed but only a judge could determine this, not a casual passer-by.

Secondly it is not usual to require the owner to furnish an abstract of title. This would place a heavy burden on the owner. The cost would usually be more than the cost of the survey. When dealing with an old grant, from which many pieces have been cut, such an abstract is necessary but not for small lots.

In the case of Mr. DeYoung, not only had a deed but a plan of the property, and was in active business, using it as a car park for his taxis.

I cannot remember ever having asked an owner to furnish an abstract, although in many cases he had had one ready.

These two points must be settled. It is hardly necessary to say that my survey bill has not been paid, nor has my half-day lost at the trial.

Mr. Peter O'Hearne, the Crown Prosecutor, tells me that the law 383 and 384 which provides a penalty of five (5 years for removal of surveyors stakes "lawfully placed" depends on the "lawfully", and that our case was weak because we did not prove legal ownership, i.e., Mr. DeYoung did not have an abstract of title.

I would suggest that the Association retain Mr. George Robertson, MacInnes, Cooper and Robertson, to look into the case and if the present law is not adequate to get new legislation. Where does this leave the Lands and Forests?

E. O. TEMPLE PIERS, P.L.S.

P. S. — I cannot see how an abstract of title can make a survey "legal". It is additional evidence of ownership but it does not differ in nature from deeds and plans. It is not like a court decision.

Two Views Airphoto Survey Scene

Photogrammetrist:

Take to the air for speed says J. M. Zarzycki, Chief Engineer, Engineering Services Division, Canadian Aero Services Ltd., Ottawa.

The present method of stadia and level has the virtue of going back to the Greeks, but I suggest it has finally shown its age.

There is a swifter and more accurate way.

Photogrammetry is a branch of civil engineering. It is the science of obtaining terrain data by means of special types of photographs and their interpretation.

The layman generally blurs the distinction between photogrammetry and aerial photography. Skill in aerial photography is basic to the photogrametric process, but it is not the skill of making precise measurements from photographs.

Digital photogrammetry first became possible with the construction of sophisticated stereo plotting instruments. These can perform precision measurements of x, y and z co-ordinates in a stereo model.

But the economical application of photogrammetric measuring to pay quantities only became possible with the marriage of the electronic co-ordinate printer to the precise stereo plotter.

This integration of the entire photogrammetric process with high-speed electronic computers and with data processing equipment is in fact a modern technological revolution.

In parts of the United States and Europe, photogrammetry is used for pay quantity calculation of highways and railways as standard practice. In Canada it has been used only on a test basis for these. However, it is used extensively for calculating open pit quantities and block pit inventories.

The process of obtaining pay quantities for highways can be divided in two main parts—field work and office work.

First step in the field work is to flag control points for the aerial photography. This is done during the restaking of the centre line for construction after the clearing and grubbing.

Extra labor is negligible. It consists in placing 1x1-ft cardboard squares at

100-ft intervals on the centreline stakes and in placing 5-ft long by 1-ft wide wooden crosses at 400-ft intervals outside the right-of-way.

These crosses are elevation points only and can be established with ease when the centreline stakes are leveled. When the flagging is completed the aerial photography is taken.

When precise photogrammetric instruments are employed the aerial photography is flown at scales of 1 in. = 300 ft or 1 in. = 350 ft. For less precise stereo plotters, larger scale photography is needed. Class A aerial cameras such as the Wild RC-8 or Zeiss RMK should always be used.

Flagged points will appear on the pictures and will serve as the control to adjust for tip and tilt. This control consists of the centreline stakes with their known position and elevation and of the permanently marked elevation points. Position of the latter is established photogrammetrically during the initial determination of the cross sections.

Office work begins with determination of the cross-sections of the original ground. Manuscripts are prepared at a scale of 1 in. = 50 ft. showing the centreline of the highway as staked on the ground. Aerial negatives are printed on glass and placed in the stereo plotting instrument and are adjusted for tip and tilt.

The operator first establishes the position of the points which will be used to control all further measurements of the same ground as construction proceeds. These points are pricked on stable plastic base manuscripts and their co-ordinates are recorded on punched tape.

Cross-sections are read beginning on the centreline. The stereo plotting operator works from the extreme left to the extreme right of the centreline He selects manually the station number and he puts the measuring dot on each break along the cross section, presses the button to record automatically the station number and x, y, z, co-ordinates.

Elevations are read twice and an average is taken for the computations. Data is recorded by punched tape and typewriter. Equipment used at this stage varies from company to company. Mine makes the measurements using the Swiss-made Wild A-8 Autograph, equipped with a Profiloscope and coupled to an EK-3 co-ordinate printer.

This is highly precise mechanical, optical and electronic equipment valued in excess of $40,000. The Profiloscope is the latest addition which allows the work to be done by one man. It permits convenient viewing of manuscripts and enlarges the cross-section so the operator is viewing it at 1 in. = 5 ft.

The first computation program transforms the x, y, and z co-ordinates obtained from the A-8 into the co-ordinate system of which one axis is identical with the centreline of the highway. Resulting data is presented in the familiar form of station numbers, distances to the left and right of the centreline and their corresponding elevations. Co-ordinates are given to 1/10 ft in elevation and position.

A second program is used for computing vertical curves, slope stake data and design quantities classified according to type of material. Soils information for the classifications provided from the field.

A third program produces punch cards for use in an electronic data plotter to enable presentation of cross-sections in a graphical form.

New photography is taken for progress quantities as construction proceeds; sometimes special photography will be needed when over-burden is removed so that accurate cross-sectioning of the bedrock can be done.

Final earthwork quantities are computed when the grading is completed. Photographs of finished grade at a scale of 1 in. = 300 ft or 1 in. = 350 ft are set up in the A-8 plotter using the permanent ground control located outside of the cleared right-of-way and surveyed during the initial stage of the project.

Cross-sections of the finished grade are read in the same manner as previously and at the same locations as before construction. In this phase of the project two basic types of programs are used:—

Progress pay quantities, which is a borrow pit circulation program.

Final pay quantities, circulation program.

For progress pay quantities and for borrow pit program, calculations are essentially a comparison between two surveys. Cross-sections of the ground before construction and cross-sections of the ground at a particular stage of the construction progress are compared and the differences computed.

Final pay quantities program takes into account design criteria and calculates cut or fill on that basis. In addition to quantities, the program provides a listing of profile grade deviations, that is, differences in elevation between final finish grade and design profile grade; and closure difference, that is, differences in elevation between the final and original survey at the farthest offset of either the final or original surveys.

There is also a complete tabulation system which allows for the individual calculation of rock and earth and earth quantities, totals between different stations and totals between different sides of the centreline.

Computation programs are designed to use cross-sections obtained either by photogrammetry or by ground survey methods. This feature is important because sometimes it might be impractical to obtain aerial photography of entire areas and hence cross-sections of some of it must be obtained by ground survey methods.

In the computation, this data must be integrated with the cross-sections obtained photogrammetrically. As a part of the overall quantity computation program, a separate routine is introduced which in the same operation provides special cards for electronic data plotters to provide graphical presentation of the cross-sections.

Every method of performing measurements, or any other engineering operation, must be evaluated from the point of view of accuracy and economy. These two factors cannot be divorced from each other in any critical evaluation.

To determine the accuracy of quantities and profiles determined photogrammetrically, a comparison was made between photogrammetric and ground surveys during construction of the Quebec Cartier Mining railway.

This comparison showed excavation quantities measured by photogrammetry agreed within 1% with surveys performed by conventional ground methods.

In addition, to check the accuracy of profiles obtained photogrammetrically, elevations of some 211 points were surveyed on the ground over a seven-mile long section of the railway.

This check revealed the mean square error of the elevation obtained photogrammetrically was + — .12 ft; this is equivalent to 1/15,000 of the flying height. Maximum error in elevation was .3 ft.

Distribution of errors:

80% of all points were within 1/10 ft.

* 18% of all points were between 1/10 ft and 3/10 ft and 2/10 ft.

Accuracies were achieved in a typical production project employing standard procedure. These results therefore are indicative of the degree of accuracy which can be expected in practical application.

Advantages of employing photogrammetry and electronic computation in highway engineering are:—

1. Aerial photographs provide a rapid and indisputable record of the undisturbed ground and progress of construction.

2. Cross-section profiles and earthwork quantities are determined by a third and impartial party.

3. Difficult terrain does not influence the accuracy of photogrammetric surveys nor materially slow down their process.

4. Cross-sections obtained photogrammetrically reflect the shape of the ground more accurately than the cross-sections surveyed on the ground.

This is particularly true in areas of large cut where survey cross-sections on the ground are often incomplete.

5. Possibility of human error is greatly reduced because cross-section data obtained in the stereo plotting instrument are punched on a tape, computations are performed electronically and cross-sections are drawn automatically.

6. Photographs obtained at different states of construction are of great assistance in observing erosion and drainage problems and will aid in anticipating future maintenance problems.

7. Integrated photogrammetric surveys provide a flexible tool which meets the fluctuating volume of surveys and avoids the cost of delaying the construction progress.

The application of photogrammetry of pay quantities of gaining momentum in Canada.

Some highway departments are seeking their own facilities and, although I am pleased to see the method gaining acceptance, I must offer a word of caution.

Establishment of photogrammetric facility capable of providing pay quantities is both expensive and difficult. It is not enough to purchase stereo ploting equipment and expensive electronic attachments; nor is it enough to hire technicians however experienced.

Photogramemtry is a complex branch of engineering which requires specialized professional training and experience. Unfortunately at the present time the profession is short of members. But those who attempt pay quantities without professional help will be disappointed and will likely condemn the method.

There are competent private firms which have been active in this field for many years. We have been involved in research and development of quantity estimating methods for some years. We know the techniques are not simply arrived at nor are they simply applied.

Highway departments and contractors should be aware that a competent industry is available offering to them a service in keeping with the high-speed technology of our time.

How to Prevent Errors in Tunnel Surveying

Some new techniques, based on field experience, to improve accuracy in underground survey work.

By T. J. G. SIMMS

(Mr. Simms, who is a project engineer with a prominent consulting firm in Toronto, has written several previous articles for Contract Record. Here, he describes some formulae and techniques he developed for his company while they were consulting engineers for the Humber sewer project. These observations will be a welcome addition to the fund of knowledge on surveying, because very little has been published up to now regarding errors in tunnel surveying.)

You may not believe it but it is quite possible to lose your way during the driving of a tunnel, especially when it has to be constructed through a curve.

However, despite numerous accounts of headings missing each other since engineers first built tunnels in the early Hebrew, Greek and Roman times, improved techniques and instruments have practically reduced errors to those resulting from carelessness and neglect.

The headings of the Greek tunnel of Samos missed each other by 20 feet and had to be joined by a crosscut. But today we have examples of a closing error of less than 1/4 in. in the China Bar tunnel on the Trans Canada Highway in B. C., and less than 1 in. at the end of a tunnel recently constructed by The Foundation Co. beside the Humber Valley in West Toronto. This tunnel snaked through 15 curves along its 2-mile length.

Precision is the keyword in tunnel surveying, both in the standard of workmanship and the quality of the equipment used.

In the narrow confines of a tunnel a surveyor has few points of reference to guide him and to check the continuation of the centre line. Therefore the points he does establish and then uses to determine others must be set with extreme care and accuracy. The following article shows the results of some of the mistakes that can occur.

Usually a change in direction on a tunnel is made through an arc of a circle. It is this form of curve which is considered here.

Above ground the arc is best set out by laying down convenient chord lengths at their corresponding deflection angles. There is ample opportunity to check the survey as layout proceeds. But underground the setting out of a curve is a more exacting job, for two main reasons.

1. Often there is no facility to check the alignment of a heading with the surface survey until the bore has been holed through. Then it is too late to make corrections. Sometimes this can be overcome by sinking alignment holes along the centre line. Then as they are encountered during tunnelling the two surveys can be compared through them. Later during the lining of the tunnel, if this is to be done the holes can be used as concrete chutes just as Keystone Contractors Limited did during the construction of a 9-ft finished diameter sewer in Windsor.

2. The line of sight ahead from any permanent station is limited to the extent of the excavation. In other words checks on the alignment of the excavation must always depend on the continuation of the line of survey through the last station from a backsight until the next permanent station can be established. This restriction is magnified when setting out a curve.

Figure 1 shows in exaggerated form what happens if one incorrect angle is turned when setting out the chords of an arc using each previous chord as a backsight for producing the next chord.

Similarly Figure 2 shows the resultant error if one chord is incorrectly measured. Various mathematical expressions can be evolved for the progressive displacement of the points of intersection of the chord, but they become cumbersome and are best developed to suit a particular demand.

In Figures 1 and 2 it was assumed the curves started at the correct chainage and on the line of their tangents. But, if the beginning of a curve (B.C.) is at the correct chainage but is not on the centre line, i.e., the line of the tangent, then a curve parallel to the designed curve will result.

If the B.C. is on the centre line but is at the wrong chainage, for example short of the correct B.C. then, as illustrated in Figure 3, the error of alignment will, within the limits of the normal arc, increase around the curve to an incorrect E.C. (end of curve) at point W.

Because the basic features of the curves are identical the movement of the tangents is parallel. Length ZW equals the shift of the B.C. and displacements YZ and WY are simple trigonometrical functions of length ZW and angle ——. This error emphasis that accurate chaining is as important as the accurate measurement of angels.

Now even though the surveyors may lay out the line of a curve correctly they will have wasted their time if when a tunnel is being concrete lined, the lining is not bulkheaded exactly at the B.C. before cantinuing it through the curve. For example, Figure 4 shows what happens if the concreting is allowed to continue beyond the B.C. before the first chord forms are placed. Obviously clearance around the forms will be lost if on one side and a sharp bend must be introduced to bring the forms back onto line. If the error is not corrected, the resultant alignment will be similar to that shown in Figure 3.

Checks on the centre line of excavation can be made by measuring radial offsets from either a tangent to the curve produced, or from a chord produced. Offsets measured at the face of a heading are always radial because the face should be at right angles to the centre line of the tunnel and therefore parallel to the radius of the arc being traversed.

Figures 5 and 6 illustrate the two methods of measuring radial offsets with the appropriate formulae. If in both of these methods, values of the offset YZ are calculated for increasing values of X and then plotted in graph form, the survey crews will have a convenient reference for checking the alignment at any time.

An alternative to this is to measure right angle offsets from a tangent produced. But this involves two instrument settings for each offset, and in a tunnel where most of the surveying is done near the crown it is often difficult to find room to set off a right angle.

Another alternative is to measure the distance to the centre of the tunnel face from the last established chord point and calculate the deflection angle for the measured chord. Then set off this deflection angle and measure the new length to the tunnel face. If the centre of the face is off line then the second measurement will be different to the first. Therefore a new deflection must be calculated and the procedure repeated until the measurement to the face and the deflection angle are coincident. It is obvious that this would be a very tedious method if frequent checks were required of the heading.

The designer can help the surveyor by remembering that it is easier to chain chord lengths measuring them to fractions of a foot than it is to turn deflection angles which include fractions of a degree. He can use Degree Curves, i.e. specify a radius which will allow a chord or an arc of 100 ft. to subtend an integral number of degrees at the centre of the circle.

The chord definition simplifies field work in that simple deflection angles can be used for chords which are multiples of 100 ft. Also the number of chords in a curve or the chord deflection angles can be calculated quickly with little thought. For example, if four chords are required to set out a curve limited by a chord of 100 ft. from the B.C. to the E.C., i.e. each chord is 25 ft. long, then the deflection angle for each chord will be 1/8 the degree of the curve.

Because it can alter the value of a contract, contractors should not forget that for a constant angle of intersection of the tangents, if the radius of a circular arc is altered, then the overall length of the tunnel is altered. For example, if the radius is increased, the length of the tunnel is decreased, for the new arc is shorter than the summation of the old arc and the increase in length of the tangents. We all know that the shortest distance between two points is a straight line and therefore the further a route diverges from his, the longer must be the distance between the end points.