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## MODERNIZING THE SURVEYING CURRICULUM

by  
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The title of this paper may seem rather indefinite and perhaps should be further clarified. One definition of "modernizing" is "to make conform to". In this discussion I would like to propose ways of making our surveying courses better conform to their proper place in a progressive civil engineering curriculum and to the needs of our students.

All of us are keenly aware of the growing dissatisfaction with our present surveying courses -- particularly those required of all civil engineering students. I agree completely with those who say our surveying is being taught for technicians -- not for professional engineers. The task of improving our courses rests with the surveying teachers. If we cannot meet this challenge and make our surveying courses really vital, then I for one am willing to see surveying completely eliminated from the civil engineering curriculum and left to the trade schools. In our already over-crowded curriculum we have no room for deadwood -- every course must contribute its fair share to the student's education while in school and to his professional career afterwards.

What can we do to improve our surveying instruction? Many worthwhile papers have been published on this subject during the past several years, but apparently they have had little effect. Possibly one reason for this is the fact that most of these papers have been rather generalized and idealistic, and, while they stimulate the desire for improvement, they offer little in the way of practical suggestions for bringing it about. Although this paper must be short, I would like to make this discussion as detailed and as specific as possible.

The trend in engineering education seems to be toward the basic sciences and away from the art and application courses. It is beyond the scope of this paper to discuss the merits of this trend, but if we accept it, our surveying courses should conform if possible. With this in mind I would like to suggest that the following questions be used as a guide in selecting course material and deciding on teaching methods:

- (1) Will it be useful in the student's professional career?

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- (2) Does it efficiently teach basic scientific and engineering principles in such a way as to directly contribute to the student's better overall understanding of these principles?

I am sure that every surveying teacher is keenly aware that many engineers, both in industry and in engineering education, feel that surveying should be either eliminated entirely from the engineering curriculum or should be drastically reduced -- that it is sub-professional work and, as such, should be left to the sub-professionals. Possibly the practice of surveying on routine surveys is sub-professional, but I am sure that the direction and supervision of surveys and the use of the end results in planning, design, and construction are professional. No large project can be planned without surveys. The detail, accuracy, and scope of the survey could hardly be outlined specifically by a technician who has but little understanding of the methods of planning. Certainly design must be based on data obtained in surveys, and it would be impossible to construct any project without first staking it out on the ground. Therefore, the civil engineer who is traditionally associated with planning, design and construction is also directly associated with surveying. If the primary functions of the civil engineer are so directly dependent upon surveying, is it then reasonable to assume that this vital part of his work should be planned, directed, and performed by technicians? Is it logical to assume that the planner or the designer need have no concept of how his basic data were obtained nor of the accuracy and limitations of these data.

If we grant that a knowledge of surveying is vital to the professional engineer, the question then arises as to how much he should know. Evidently his job will not usually require him to perform surveys. Does he need to be accomplished at the art of surveying? I think it should be evident that he does not. An engineer directs the work of technicians in many fields without being able to perform efficiently their routine tasks. He should, however, thoroughly understand the basic theories and concepts.

Does surveying contribute in a worthwhile way to the student's understanding of basic scientific and engineering principles? Surveying is essentially a study of measurements. Engineering is directly dependent upon measurements. Therefore surveying can teach a very fundamental and important principle of engineering. I say "can" because I do not believe we are stressing this principle in our present courses -- we are obscuring it by too many details and applications.

Both of our objectives point to the fact that the science of surveying rather than the art should be stressed. This idea is nothing new. It has been expressed in a number of papers. I believe most of us agree with this idea but we haven't done much about it. Why? For two very good reasons. First, this statement really doesn't say a whole lot -- it doesn't propose specifically what should be included and what should be eliminated, nor does it shed any light on how it should be taught. Secondly, the easiest way to set up a course, and the easiest way to teach one, is to choose some good textbook and then follow it. This, unfortunately, fixes both the course content and the order of presentation. There is a very real objection to this method as far as our present surveying courses are concerned. Our textbooks on this subject have changed very little in the past fifty years -- all are remarkably uniform as to material covered and as to the order and method of presentation. We are actually teaching our surveying courses in much the same manner they were taught fifty years ago. As long as we try to conform to our present texts we may as well resign ourselves to the fact that any progress we make will be very limited and probably only temporary.

Our main difficulty then is that we are tied by tradition -- the traditional approach to surveying instruction.

Perhaps the best way to present my ideas on what should be included in a course and how it should be taught is to discuss in as much detail as time will permit, the surveying curriculum that will be initiated at Colorado A & M College this fall. This course -- I prefer to think of it as one integrated course even though it extends over two quarters and a three-week summer camp -- has been developed during the past three years and much of it has already been tried in the classroom with what I believe to be considerable success. This course will replace our conventional program of elementary and advanced surveying, and curves and earthwork. The course material has been divided into the four rather broad classifications of:

1. Basic theory and concepts
2. Methods of measurement
3. Applications
4. Miscellaneous

Basic theory and concepts:

The purpose here is to present as a unit those fundamental concepts, theories, and definitions, that are the bases on which surveying is built. This

material has been sub-divided into four topics: the geometry of the earth and related definitions, the basic theory of surveying, errors, and significant figures.

Under the first topic the geometry of the earth and the definitions denoting the locations of points and the directions of lines on or near the earth's surface will be thoroughly covered. Our textbooks and our present courses present each new concept or definition at the time it is first applied. The student is faced with these new definitions and concepts at the time he is primarily concerned with learning new methods and applications. He never really understands their interrelationship nor does he fully appreciate their importance

The next logical step is to introduce the basic theory of surveying -- the location of points on or near the earth's surface by the measurement of angles and distances. The methods of locating a point in both the vertical and horizontal will be carefully explained and emphasized. This, I believe, will give the student a much better perspective when methods and applications are discussed later on.

The third topic will be a thorough discussion of errors. This is one of the most important subjects covered in the course as far as engineers are concerned and yet in the past we have skipped over it in a lecture or two giving the student some formulas and some rather vague ideas of what we have been talking about. The theory of errors should be thoroughly covered as should the derivations of all formulas.

The last topic under this section will cover significant figures. No course in the engineering curriculum affords a better opportunity to develop the concept of significant figures than does surveying. I am afraid that the average graduating senior knows far too little of this concept.

The above sequence leads logically from one subject to another. All of this material can be understood thoroughly by the student before he has the slightest idea of how to make a measurement. It is a clean, concise presentation of basic theory unobscured by details, methods, or applications. It

should give the student a good, clear understanding of these basic fundamentals and by properly stressing them throughout the remainder of the course they can become a part of his way of thinking.

#### Methods of measurement:

The basic measurements of surveying consist of the measurement of horizontal distances, vertical distances, and angles. This section of the course is divided into three topics each discussing a basic measurement. Since the method of teaching each will be essentially the same, it doesn't seem necessary to discuss them individually in this paper.

Our present texts and our present courses cover all of the points that are significant here, but they include too much detail. The material should be carefully considered and only that material which contributes directly to the theory of making the measurement should be included. The non-essential detail usually included in these discussions should be completely eliminated. These details serve only to obscure the basic considerations and to confuse the student. The explanation of instruments should be condensed to its simplest elements. For instance, instead of describing in detail the dumpy level, the wye level, the precise level, the hand level, etc., it would be much simpler to point out to the student that the essential parts of a level are a bubble and a means of fixing the line of sight with respect to this bubble and that all of the nuts, bolts, etc., are for convenience only. The instruments we explain in so much detail today may be obsolete tomorrow.

In other words, while we have always covered those aspects of making measurements that are important to the engineer, we have also included so much detail that the basic theory has been obscured. The main problem here is one of elimination -- the elimination of insignificant detail, procedures, instrument descriptions, alternate methods, etc.

#### Application:

It is the application part of our surveying that seems to be catching the brunt of the criticism. Surveying is an art as well as a science. Perhaps, as

many claim, it is more art than science. If we eliminate all application we may as well eliminate surveying as such and teach a course in measurements. Probably it is the method we have used in teaching applications rather than the fact that they are taught that is at fault. We teach far too many details and procedures.

Traverses, topographic surveys, field astronomy, curves, hydrographic surveys, and triangulation will each be covered. To what extent? Only the basic concepts and theory could or should be covered. No two surveys are alike in practice. If the student is well grounded on the fundamentals he will have no difficulty extrapolating to a new situation.

#### Miscellaneous:

This section would include land surveys, photogrammetry, and earthwork.

Some knowledge of land surveying is essential to the engineer. I believe the legal aspects of land surveying should be given greater emphasis and the time devoted to the rectangular land survey system reduced.

The use of aerial photographs is becoming increasingly important but I do not believe it is necessary to understand all phases of photogrammetry to be able to use aerial photographs intelligently. The inherent errors and limitations of aerial photographs should be presented in detail. The principles of photogrammetry insofar as they illustrate and clarify these points should be covered.

Earthwork could be covered in this section but we will cover it in our senior highways course where it has more significance.

There are two major difficulties encountered in using this proposed course outline; both stem from the traditional approach to surveying instruction.

The first of these is our field laboratory which has always accompanied at least our first course in surveying. What will the student do in the lab while the basic theory and concepts of

surveying are being discussed in the lecture? The laboratory should be for one purpose -- to acquaint the student with the various measuring devices and to give him some experience in making measurements. Much of the second section of this course, the methods of measurement, could be taught much more efficiently in the laboratory than in the classroom. The balance between classroom and laboratory on this second section will have to be worked out in detail but I can foresee no difficulty. This procedure would, however, require a competent laboratory instructor -- not a graduate student.

The second difficulty is not so easy to solve. If we use this approach, there is no textbook that will fit the course. I have found it impossible to make assignments from the text. This fall I will furnish the student with a very detailed outline of the course and assignments will be made to cover sections of the outline. The student will use his text strictly as a reference.

In conclusion I would like to summarize briefly some of the advantages which I believed can be achieved by this new course.

1. It would pull together the basic concepts into one section where the student can better understand their importance and relationship.
2. It would avoid much of the undesirable repetition.
3. It would eliminate many of the frills and much of the art that are not important to the engineer and that have a tendency to obscure the basic concepts and theory.
4. It would condense the subject so that it can be taught in a shorter time and, if the first three conclusions are correct it would thereby increase the efficiency of the course.

As I mentioned at the beginning of this paper, the challenge of improving our surveying course is to the surveying teachers. Can we meet it?