

LIMITATIONS OF FIELD AND LABORATORY WORK IN HIGHWAY ENGINEERING IN CIVIL ENGINEERING CURRICULA.*

By C. S. Farnham,

Sheffield Scientific School, Yale University, New Haven, Conn.

FIELD and laboratory courses in selected branches of applied science occupy an established position in the curriculum of every fully equipped school of civil engineering. They constitute a recognized channel through which instruction and training in civil engineering is conducted. No defence is necessary for the inclusion of field and laboratory courses in so practical a subject. It is pertinent, however, to consider whether some limitations may not exist in field and laboratory courses which render them less effective in broad civil engineering training and more particularly in that recent application of civil engineering known as highway engineering.

The educational value of field courses in surveying as well as the practical value is sometimes limited by unnecessary repetition. Several weeks may be spent in carrying on a survey in which the same methods are continually employed, or each student in a party may occupy the same position and go through the same operations for whole days at a time. This practice is sometimes defended on the ground that students thereby become skilful in surveying and consequently prove more valuable to their employers immediately after graduation, and on this account secure a firmer hold in the early stages of their professional life. The object of any educational process should be to develop the student's intellectual power and not primarily to make him skilful. Skill can be rapidly acquired after entering professional work but principles and methods can best be learned in college. The student's lack of skill in field work or in laboratory work is therefore a justifiable limitation.

Limitations upon field courses in surveying arise from the conditions of available time and place for conducting the work. The former custom of conducting field work upon the college campus during selected afternoons in term time has largely given place to continuous work for several weeks during the summer vacation at a camp maintained for the purpose. Advantages resulting are increased amount of work accomplished, freedom from interruptions which divert the student's attention from his work, more suitable ground for the conduct of certain kinds of work and the closer relations between students and instructors.

The suggestion is sometimes offered that special instruction in highway surveying should be given in a manner similar to that ordinarily followed for railroad surveying, or that less time be devoted to railroad surveying and a portion of the available time be devoted to a number of field exercises illustrating the particular kind of surveying which is employed in staking out a highway.

In railroad surveying courses to which more than ten or twelve days are devoted exclusively to the details connected with the location of a line of railroad it would appear that some repetition of work must occur and that part of the time could be employed to better advantage upon some other kind of work such as the survey of a short piece of highway. On the other hand, since the differences between the two kinds of surveying are those of detail and not of principle, it would seem unwise in

view of the short time which some colleges give to railroad work to omit any essential operations connected with the location of a line of railroad for the sake of adding a few exercises in highway surveying. The engineering graduate who undertakes highway work usually enters the lower ranks of the organization of a highway department where opportunity is afforded him to learn the details of surveying through routine work.

Undergraduate laboratory courses in applied science in civil engineering include tests of materials used in construction, especially tension, compression and shear tests of steel and wood. Tests of simple structural joints, although less common, are sometimes made. Tests of masonry materials include the usual standard tests of cement with limited attention to fine and coarse aggregates and their proportioning in concrete. In view of the present standard quality of Portland cement certain tests formerly considered essential may well be omitted, thus allowing time for more careful examination of fine and coarse aggregates which engineers agree should often receive closer attention than the cement itself. Standards committees of the engineering societies perform a real service for educational as well as commercial testing laboratories by omitting unnecessary and non-essential tests which absorb the student's time and limit to that extent the effectiveness of his laboratory work.

The testing of concrete beams and slabs and waterproofing devices, together with detailed studies in proportioning, are valuable and important for the civil engineer preparing for highway work. Laboratory investigations of this character must be reserved for graduate study. Limitations which prevent their inclusion in undergraduate curricula are not so much insufficient appreciation of their value or meagre equipment as the lack of sufficient time available within the compass of a properly balanced undergraduate course.

Laboratory work in hydraulics is included in civil engineering curricula as generally as any course in experimental engineering. Field exercises in stream gauging not infrequently supplement the work of the laboratory. The usual undergraduate course in experimental hydraulics appears adequate for the purpose of the highway engineer.

The growing application of electricity to all fields of engineering is generally recognized and the inclusion of laboratory work in electricity in the curriculum for civil engineers is a logical development. Certain events have lately shown, if demonstration is necessary, that an engineer engaged exclusively in highway work may be called upon to supervise the maintenance of electrically operated draw bridges together with their illumination. Lack of time usually prevents the introduction of laboratory work in electricity into the undergraduate curriculum but the limitation can be overcome by graduate study.

Field and laboratory courses in geological studies are less common in civil engineering curricula than the subjects already considered. It is highly desirable that practical application of geology be made through field studies of soils and rocks which the civil engineer must consider in all work connected with excavation, drainage, foundations and selection of materials both for use in roads and in other structures. If this limitation exists it may be overcome, and in some civil engineering courses is overcome, through co-operation with the department of economic geology. In any event, field exercises in geology should be in charge of an instructor with sufficient experience in civil engineering to point out how knowledge of geological conditions may be of service to the civil

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