COORDINATION OF METHODS IN HIGHWAY LOCATION AND DESIGN

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As a modern highway will cost up to one half million dollars or more per mile, particularly in our urban areas, it is important that the location and design of these facilities be given most serious consideration. Although the need of a projected highway and the approximate location it should follow can be determined from traffic flow and desire lines, the exact location can generally be varied within normal limits to take advantage of economic features to be encountered along the proposed route. Many of the features that show above the ground can be determined fairly accurately by the designing engineer, but the knowledge of the geologist and seismologist is required to reveal conditions that exist below the ground surface. Because the subsoil conditions are very important economically, and because they control such details as alignment, drainage facilities, and foundations for bridges, all possible information dealing with subsoils and ground water should be derived to locate intelligently and to design our highways.

Under the cooperative program previously referred to, the Massachusetts Department of Public Works is securing valuable information relative to the nature of subsoil conditions for all of its principal projects. When the approximate location of each new facility is determined from reconnaissance survey, the project engineer prepares a reconnaissance plan showing the proposed line and this plan along with a topographic sheet on which the line is plotted, is furnished to the geologist who prepares a geologic strip map along the line shown. This geologic map informs the engineer regarding the kinds of soil materials, the location of bedrock outcrops, and the various land forms to be traversed by the highway. In preparing this map, the geologist also indicates locations where seismic explorations are needed to amplify his report (see Figure 1). These are generally at locations of cuts of ten feet or more, sites of important structures, clay formations, or swamps. These data are obtained, analyzed, coordinated with geologic data, and then furnished in report form to project engineer for use by him as a guide in determining the final location line and in preparing the design for all features of the project. A specimen report is appended to this paper. If seismic readings indicate heavy ledge cuts, the location of the highway can generally be changed to avoid this expensive type of excavation. If other controlling features preclude changing the line, an accurate estimate of the quality of ledge to be excavated can be made available from the geologic sections based on the seismic data, supplemented as may be necessary by borings; thus eliminating the possibility of seriously underestimating the quantity of ledge to be removed. On a project with heavy cuts, such an error when accompanied by a high unit of bid price for ledge could be more expensive than the cost of the present cooperative project for an entire year.

Information on ground water conditions in cuts and fills is obtained whenever necessary to insure

a proper design of subgrade and subdrainage. One of the interesting problems with ground water characteristics recently studied by the Water Resources Branch of the U.S. Geological Survey dealt with possible interference with a town water supply. A proposed relocation of one of our principal main routes passes between the drilled wells from which the town gets its water supply, and a pond from which the town authorities believe the wells are supplied by underground sources. The town authorities know that when we cross the valley between the pond and the wells with our new road we will excavate existing peat and other soft materials and will backfill with stable material. Even though our back fill will be of granular material, the town officials believe that there is a grave possibility that the new fill will act as an underground dam and shut off their source of water between the pond and the wells. The geologic study recently completed through our cooperative project indicates that the proposed highway at the planned location will not affect the town's water supply.

As stated, one of the primary purposes of the geologic survey is to make a complete detailed geologic map of the state, a feature of which will be to indicate all available sources of highway construction materials : trap rock gravel, sand, etc. This information, and especially that referring to granular materials, may soon be of greater interest to us than in the past, because of the depletion of existing deposits and the continued increase in demand for these materials.

Some of the specific applications of geological interpretations and seismic explorations to the location and design of highways in Massachusetts are listed below.

In Templeton, a portion of Route 202 was relocated so as to bring it above the flood level of the Birch Hill Dam. As construction of the highway required a large amount of fill, and as there was a proposed cut on the project from which a considerable portion of the fill could be obtained, it was desirable to establish the lowest practical grade through the cut, unless an extensive amount of ledge should be encountered. Seismic studies showed that no ledge would be met in this cut to the desired depth. This proved to be the case when the cut was made.

A similar problem was presented in the preliminary studies for the reconstruction of the Newburyport Turnpike in Topsfield. Here, the present alignment passes over the crests of several high and steep hills. If the present alignment were to be followed, it would be necessary to cut the crests of the hills as much as 50 ft. in order to achieve the high standards for sight distance required on such a highway. As large quantities of fill would be required, the heavy cuts would not be objectionable unless they involved a large amount of ledge. Four days were sufficient to run seismic profiles along 5700 ft. of highway to show that ledge is well below the bottom of the proposed cut.

In Chicopee, the Department is studying a proposed relocation of Route 20, the principal east-west route of the State, to bypass Springfield, crossing the Connecticut River north of Chicopee. A large prehistoric glacial lake occupied the area at one time, in which a considerable thickness of lake clays and silts were deposited. The eastern end of the strip investigated is on a high terrace about 140 ft. above the general level of the plain to the west (see Figure 7). The surface of the terrace is

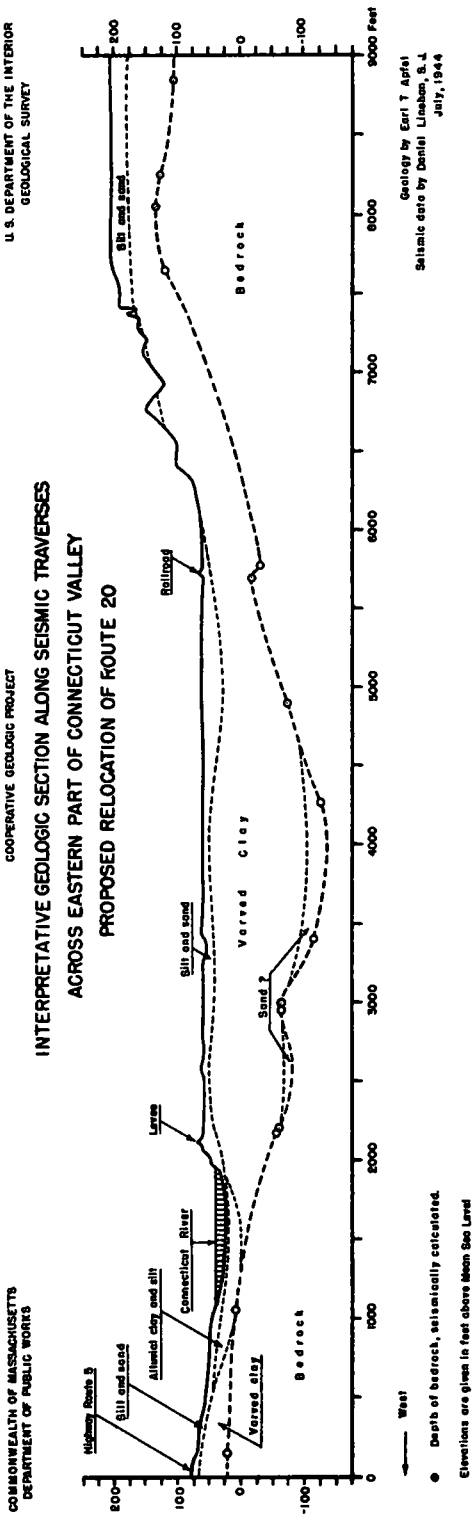

Figure 7

of fine sand over a laminated deposit of clay and silt, known as varved clay. Proceeding westerly, the line drops to the level of the plain, then westerly across the plain and the Connecticut River. As the proposed line comes off the terrace, a cut about 25 ft. deep will be required in the varved clay. Then as the proposed line crosses the low plain of the valley, several structures will be required where it crosses the railroad, the Connecticut River, and existing highways. Through surface geologic studies, and geologic interpretation of seismic surveys, the Department knows what soil and subsoil conditions will be found in the clay cut, at structure locations, and for the heavy fill required in the low area to keep the new road well above the flood level of the river.

On the Mohawk Trail, Route 2, the Department has made studies for a highway project in the towns of Shelburne and Buckland. The proposed project is to bypass Shelburne Falls by skirting the easterly side of the village and crossing the Deerfield River about three-quarters of a mile north of the present crossing, which is in the center of the town. At the point where the new line is to cross the river, the site of the proposed bridge abutments was investigated both by borings and by taking seismic profiles. All but one of the borings were driven to refusal, but seismic profiles later showed that refusal occurred practically at the surface of the till, which in this area contains a large number of boulders. Seismic data showed bedrock to be many feet below the refusals obtained through the borings (see Figure 2).

Although the depth to bedrock at the Shelburne Falls bypass location will not affect the bridge founda-

tions, the results of the two methods indicate a point which should be mentioned. It is not now the opinion of this Department that seismic data will obviate the need of borings or field observations, nor is it expected that further check data to be secured will result in any change. It is expected, however, that seismic data will enable the engineer to spot and interpret the borings more accurately and intelligently and thus to reduce the number of borings required.

While it should again be emphasized that the work being done is experimental, and that much further study is needed to develop the technique of seismic study and the correlation of geologic interpretation with our highway problems, the results already achieved are very encouraging. We are learning to apply intelligently the data being furnished through the cooperative projects.

As the highway construction program of the Massachusetts Department of Public Works continues to expand under the impetus of postwar needs, the geologic and seismic studies will continue to play their very helpful part in providing Massachusetts with highway facilities designed to meet existing subsoil conditions.