hoped that much useful data will be obtained for correlation with work done on soils in the laboratory.

Tests on the flow of water under dams have been conducted at Cornell, using an electrical analogy for determining the flow net in connection with various shaped cores and downstream faces. This work is to be carried on and amplified as graduate research, and the results published later.

Admixtures of various salts and subgrade soils are being subjected to careful routine tests and changes in the standard subgrade soil constants noted for each change in percentage of salt. This project will probably be completed early in the summer.

The apparatus for consolidation and permeability of soil has been completed recently, and a series of tests is under way at the present time. A duplication of test cylinders is contemplated, in order to facilitate the making of a large number of tests, and the school mechanician is expected to do this shortly.

Ithaca is located in the Finger Lakes Region of New York State, where the underground is composed of glacial till and unstratified glacial clay of the Pleistocene epoch. Sufficiently comprehensive tests have not been run by this laboratory, but in general the clay samples are well graded, true specific gravity approximately 2.72, water content 35% - 45%, shrinkage limit 15% - 20%, centrifuge moisture equivalent about 25%, and low plasticity indices.

The laboratory and research projects are in charge of Assistant Professor Herbert T. Jenkins.

No. A-8

REPORT OF SOILS TESTING LABORATORY FORT PECK DISTRICT, U. S. ENGINEER OFFICE FORT PECK, MONTANA

J.P. Hartman, Assistant Engineer

Introduction. The purpose of this paper is to discuss several types of tests being made in the Fort Peck District Laboratory, together with the equipment and technique used, in an effort to provoke constructive comments. Some of the methods and apparatus are believed to be novel in design and adaptability, while some other standard types have been improved. No attempt has been made to outline the operation of all the tests, because the procedures are more or less standard. For details of all types of tests, the reader is referred to the main paper submitted under this title.

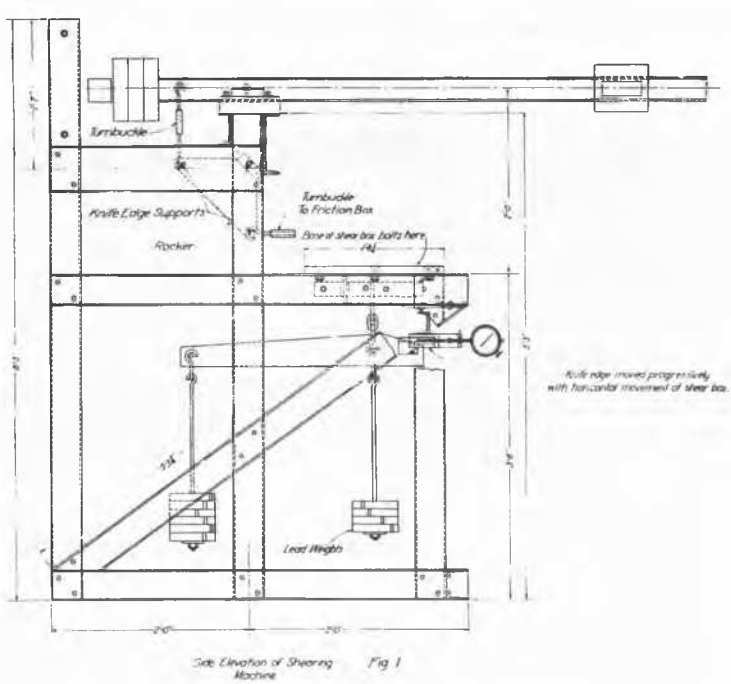
Synopsis. 1. The beam type shearing machine originally designed at M. I. T. has been improved by changing the fixed fulcrum of the vertical load lever arm to a sliding fulcrum, adjustable horizontally as the shear test progresses. This modification has given much more reliable results.

2. A shear machine and consolidation machine as originally designed in the Soils Laboratory of the U. S. Engineer Office, Zanesville, Ohio, are described together with the method of operation.

3. An inexpensive apparatus has been developed for consolidation, permeability under vertical load, and expansion pressure tests, which gives very satisfactory results.

4. A method is outlined for determining shearing stresses induced in the foundation under an earth fill by means of gelatin models and polarized light equipment. The manner of reproducing the prototypes is believed to be novel.

5. A comparatively inexpensive and simple method for taking undisturbed samples from foundations to depths of 120 feet is discussed.



Side Elevation of Shearing Machine Fig. 1

The Shear Test. The M. I. T. design--the original shear machine as designed at the Massachusetts Institute of Technology (1) (Figures in parenthesis refer to Bibliography) and later improved at Harvard University (2) has one feature that noticeably affects the accuracy of shear tests on undisturbed clay samples. The fulcrum point of the lever arm used in applying the vertical loads to the soil sample is fixed, which forces the vertical loading rods to rotate about the center knife edge on the lever arm as the upper section of the shear box is pulled horizontally. As movement progresses, this causes the upper section of the shear box to rotate, thus effecting the distribution of vertical pressure over the cross section of the sample. Also a horizontal component of the vertical load is created, acting opposite to the shearing load. The combination of these two effects results in an appreciable error in the test data.

The M. I. T. machine has been improved by rearranging the fulcrum so that it will slide horizontally in a guide. The fulcrum can be moved simultaneously with the movement of the shear box by turning a screw, thus keeping the

Fig. 4

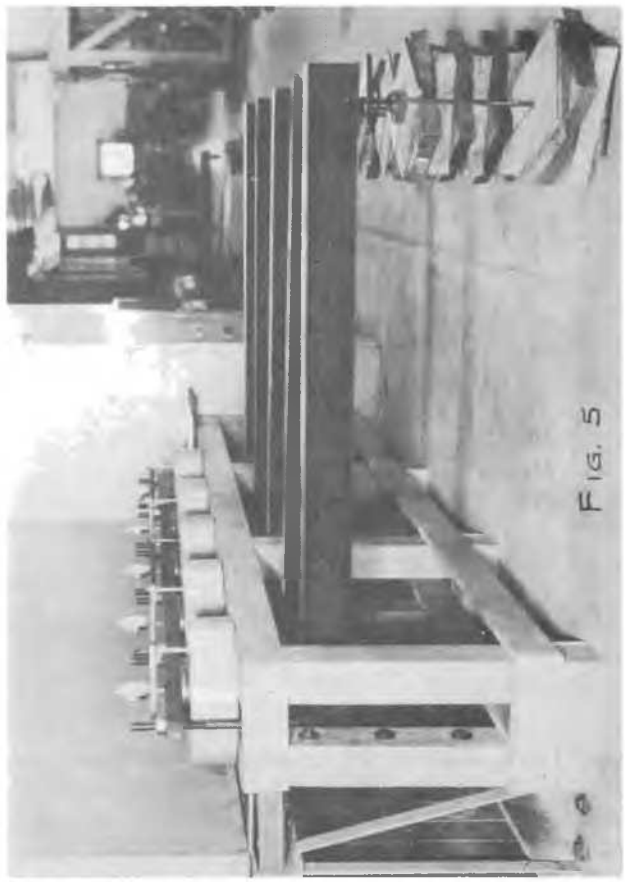


Fig. 5

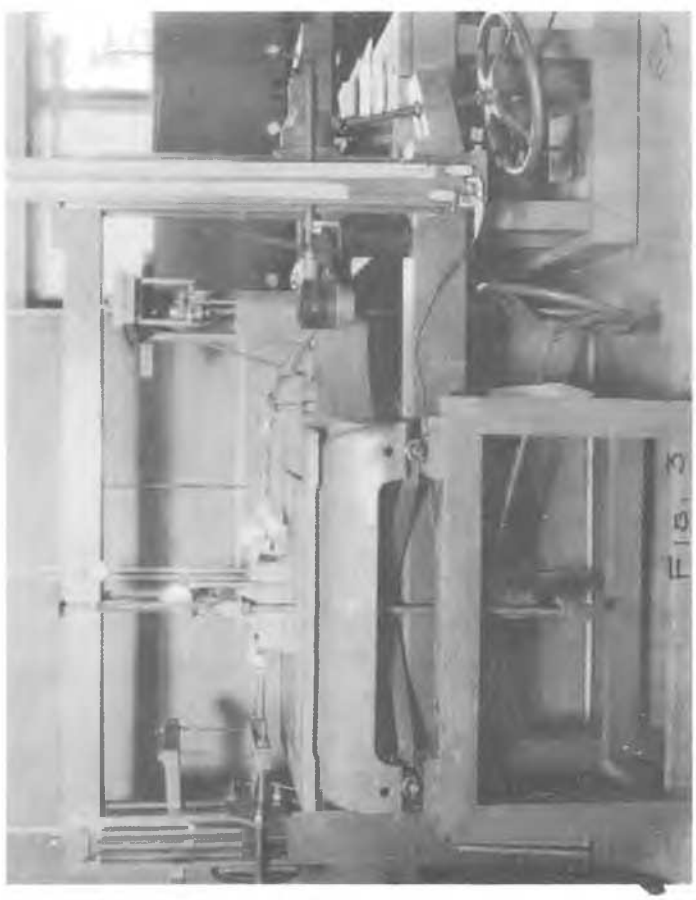


Fig. 3

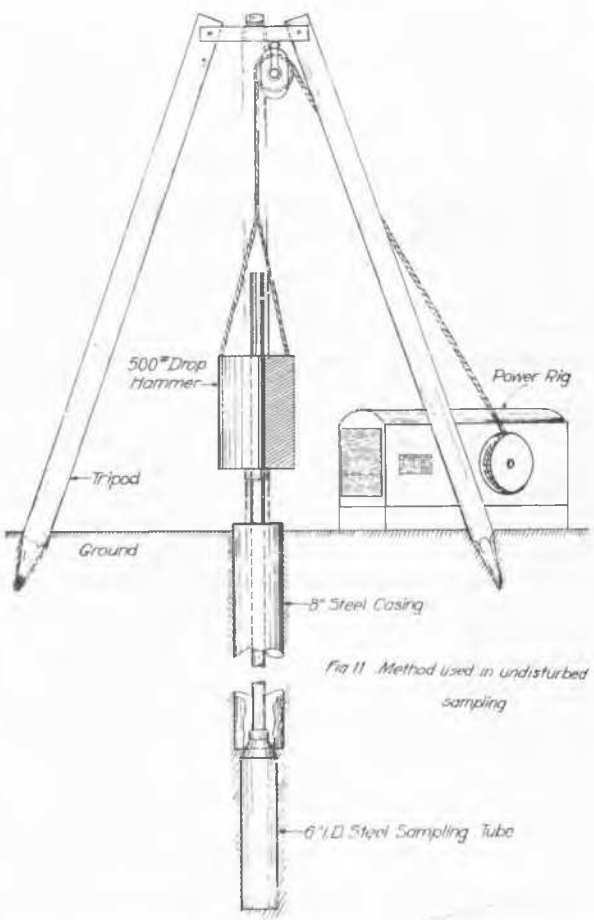


Fig 11 Method used in undisturbed sampling

vertical load normal to the cross section of the sample at all times. Ames dials are used to indicate movements of the upper shear box and the sliding fulcrum. Fig. 1 is a side elevation of the modified shear machine. Fig. 2 is a photograph of the apparatus in operation.

The Zanesville design--The shear machine designed in the Zanesville District of the U. S. Engineer Department is shown in Fig. 3. The shear box rests on the platform of a 2500 lb. capacity Fairbanks-Morse scale. The vertical load is applied by a handwheel operated screwjack through a yoke to the upper section of the shear box, until the scale balances at the desired load. The shearing load is applied to the lower section of the shear box by moving the scale horizontally with another screwjack. The upper half of the shear box is fastened to a copper bellows. A manometer attached to the bellows measures the horizontal reaction. Ames dials are used to measure both horizontal and vertical movements in the sample.

The Consolidation Test. The Zanesville design--This apparatus is shown in Fig. 4. The vertical loads are applied in a manner similar to that used in the shear machine described above, with the following exceptions: First, the yoke rods pass through guides in the wooden frame; second, the top yoke bar has a steel disc fastened to it to distribute the load over the sample; third, the platform scale is securely fastened to the wooden frame. Details of the consolidation device used in this apparatus have been described in (2).

The Fort Peck design--This apparatus is shown in Fig. 5. The lever arm having a ratio of 5 to 1 is loaded with lead weights and is maintained level by screwing up the nuts which fasten the steel yoke bar. The details of the consolidation device used in this apparatus are identical with that used in the Zanesville design except the diameter of the sample is 5 7/8" and the height is 2 1/2".

The Permeability Test. The apparatus described under the consolidation test, Fort Peck design is also used for permeability tests both for undisturbed and remolded samples. This permits either preconsolidation, or the maintaining of a constant volume of sample during the permeability test. Variable head equipment is used on soils having small permeability coefficients and constant head equipment on soils having large coefficients. See Fig. 6. In all cases the flow is vertically upward through the sample.

The Expansion-Pressure Test. The apparatus described above is also used for expanding-pressure tests. The method of cutting and setting up the samples is identical with that used in the consolidation tests. Both remolded and undisturbed samples are tested. The samples are maintained at a constant volume throughout the test as water is permitted to saturate the samples. Vertical loads are applied or released as the Ames dials show expansion or consolidation. The greatest vertical load necessary to maintain the constant volume is used to compute the expanding pressure developed. Elapsed time records are kept on all tests.

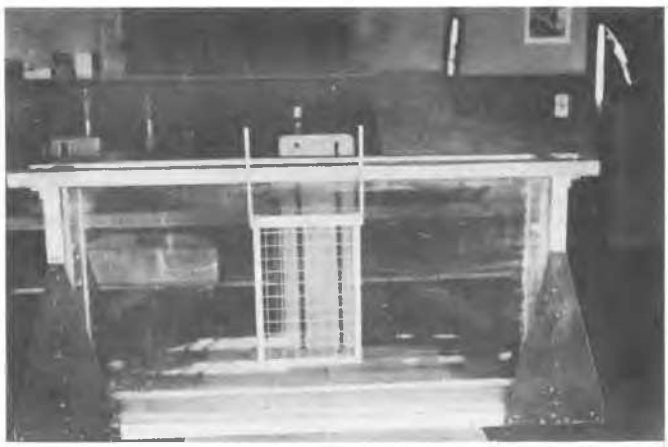
Photoelastic Testing of Gelatin Models. Model Sections of the prototypes are poured into molds, lying horizontal, and allowed to congeal in this position. When the models are placed in their normal positions the weight of the models give stress patterns in the gelatin similar to those in the prototypes. These models are placed in a polariscope, where the stress distributions are shown by color bands.

Two types of models were made and tested. In the one the embankment and foundation were poured as a homogeneous model of 7% gelatin. In the second type the fill was made of 15% gelatin and the foundation of 7% gelatin. This combination gives an approximate ratio of the moduli of elasticity of 4.1, which was considered to approximate the relation of the elastic moduli of sand and stiff clay in this vicinity. In the cases where two concentrations of gelatin were used, both were poured together with a wood spacer in between. After the gelatin had set this spacer was removed and the void space filled with gelatin and again permitted to set. See Fig. 7. A calibration model was poured in a vertical position simultaneously with the main model, from the same batch of gelatin. See Fig. 8. The fringe stress values were determined by applying a known uniform load to this model. The model was poured to considerable depth so as to approximate the condition of stress in an infinitely deep stratum, from which the stress can be determined mathematically (3). The loading was applied in these experiments by placing a hollow square tube made of light sheet metal and the bottom closed and sealed with a rubber membrane upon the gelatin and pouring water into the container. As the various color bands passed predetermined points on the grid system the load was recorded and the corresponding shear at the points computed. A number of different points were used in order to check and establish an accurate color calibration. Fig. 9 and 10 show the apparatus with a model being tested.

The gelatin was kept from adhering to the sides of the flumes throughout the tests. The calibrations and model tests were all made within two hours time in order to eliminate any effects due to the ageing of the gelatin.

A detailed report of the results of these model studies compared with the mathematical analyses is being presented to this conference in a paper entitled "Foundation Investigation of Fort Peck Dam Closure Section" by Mr. T. A. Middlebrooks.

Method of Sampling. Undisturbed samples were taken from the foundation to depths as great as 120 feet, using a power core drilling rig. The samples were taken in steel cylinders two feet long with an inside diameter of 6". The lower end was fitted with a removable cutting edge and the upper end screwed on to the drill rod. The sampler was driven with a 500 pound hammer. After each 2 feet of driving, the sampler was pulled up, the cylinder removed, and the ends thoroughly paraffined. The inside of the cylinders were coated with a thin layer of oil both to reduce effects due to driving and to aid in removing the samples. Fig. 11 is a sketch of the method used.



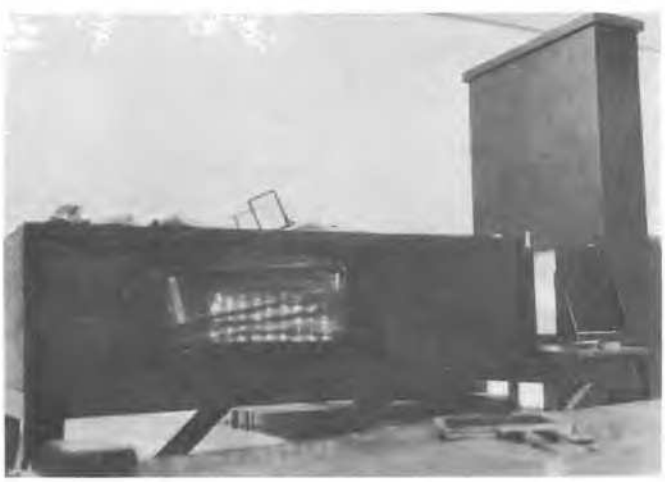


Fig. 8 (top) - View of clibration flume (empty).

Fig. 9 (middle) - View of model in position ready to be tested.

Fig. 10 (bottom) - View of model being tested.

An 8" steel casing was driven down as the sampling progressed, the procedure being as follows: The sample was taken, and then the casing was driven to the same elevation as the bottom of the sample. The casing was cleaned out and another sample taken. This procedure was repeated with the casing always lagging the sampling by about 2 feet, except upon the occasions when water bearing sand strata were encountered. As these water bearing sand strata were almost always under a considerable head, it was necessary to drive the casing entirely through the sand to prevent the hole from being filled with water and sand. This system has the desirable feature of taking continuous samples throughout the depth being investigated.

At the laboratory, the samples were removed from the cylinders by fixing a head on one end of the sample tubes and applying air pressure to blow them out. The samples were all thoroughly paraffined and stored in a humid room until tested.

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