2. Don't set specific depths but rather state a minimum distance (1/2 foot) into the bottom layer. Approximate depths to substantial layers, or defining layers to be penetrated result in a better definition of project.

3. Do allow for splicing of wick drain material providing there is a resulting continuity of flow in the drain. Failure to allow splicing results in slower production rates and significant materials wastage.

4. Don't specify a maximum installation speed. Rate of installation of wick drains has no bearing on their function in the subsoils.

5. Do specify a maximum mandrel size rather than stating that mandrel sizes should be a minimum design to avoid displacement.

6. Don't set elaborate testing requirements for acceptable drains. It is important to understand that inflow rates are as important as flow rates through the drains.

7. Do specify a minimum cutoff length above the surface (6 inches to 1 foot) if drains are installed prior to the drainage blanket, but don't specify any significant cutoff length if the drainage blanket is placed prior to installation.

8. Do allow for unit price bid quantity and if possible a separate amount for mobilization of specialized equipment. Don't specify a lump sum price unless detailed subsoil information is available.

9. Do consider the use of previous experience lists as qualification for wick drain installers; especially if minimal data is available, completion time is a critical matter, or unusual installation methods or alterations might be required.

The specifications should provide the wick drain installer as much flexibility as possible while achieving the intended aim. Providing for inspection services or field control which assures that specification requirments are met while not appreciably slowing down the installation process is just as important. Initial installation trial drains should establish standard procedures. At this stage such items as mandrel size, depth gages, splicing procedures, verticality, and materials should be carefully inspected for compliance. Visual observations and spot checks can then determine any variances or concerns once production has started.

One major advantage of the wick drain installation over other vertical drainage systems is the simplicity of field control. Once trial drains have been satisfactorily completed, inspection mainly consists of recording depths and locations of each drain, observing splices and verticality of equipment, taking occasional material samples for inspection and testing, and noting any major variances in procedure. Items which are often not specified but which should be monitored are physical measurement of drain sizes (thickness and width) for compliance to specifications and noting any variances from material submittals. If significant differences are noted, laboratory testing may be required to see if wick drain materials comply with specifications.

DESIGN CRITERIA

The effect of the design criteria on unit costs is really a matter of spacing, installation depth, method of installation, and total quantity of drains. While all these items usually affect pricing by minor amounts, there are occasions where they will have a significant effect. Smaller quantities of wick drains are usually more expensive on a unit price basis because of mobilization and equipment preparation, training of local labor, higher material costs, initial adaptations to individual project conditions, trial procedures, etc. Spacing of drains has little effect of production rates until the spacing is greater than eight feet. In such cases moving time from drain to drain can be greater than normal. Wick drain material costs do vary but it may be worthwhile to use a more expensive drain at a wider pattern spacing if it is more effective. Installation methods are much the same as material in that the static method which creates the least soil disturbance might be more costly on a unit basis if predrilling is necessary, but also might be used at wider pattern spacing; thereby reducing the total cost.

In conclusion, understanding the impact of design requirements on the actual installation of wick drains and the adaptation of specifications to specific project conditions will result in the most effective and economical wick drain solution. Furthermore, in many organizations, it is important to transmit this understanding to those in the inspection or field control phase of the actual installation.

Research Activities in Wick Drains

By

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and
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The benefits of using wick drains (prefabricated vertical drains) instead of sand drains are well established. High installation speed, low transport costs, minor environmental impact, and less disturbance effects are some of the reasons wick drains are less expensive and more efficient than conventional sand drains. As a result wick drains have made sand drains obsolete in the United States and throughout most of the world in recent years.

The recent surge in popularity of wick drains has prompted FHWA to conduct a comprehensive research study to develop guidelines for using wick drains as a consolidation aid in the construction of highway embankments over soft, compressible soils. A preliminary review of current techniques revealed that most

installations are designed and installed by a wide variety of means which are based mostly on judgement and empiricism. As a result of this review a research contract was initiated between FHWA and Haley and Aldrich, Inc., in September 1983, to conduct analytical and laboratory studies to facilitate the development of an engineering manual of practice containing comprehensive technical guidelines for the design and installation of wick drains.

The study began with a literature search to identify important case history studies and engineering guidelines available in documented form. It was also hoped (and later found to be true) that other research studies would be in progress that could lead to answers to some of our questions. A series of in-depth interviews with leading consultants, specialty contractors, and wick drain manufacturers was also conducted to obtain current state-of-the practice information. Based on the above studies and interviews, a working draft of the manual was developed that included design procedures, specifications, laboratory test methods and construction guidelines. In addition a detailed laboratory evaluation plan was developed to obtain information necessary to improve the draft manual and to develop quantitative, generic criteria for the selection and design of wick drain systems.

The major specific objectives of the laboratory researach study are to 1) investigate the key parameters that affect wick drain performance, and 2) develop new and/or adapt standard laboratory test procedures that can be used to measure selected drain characteristics.

The key parameters and uncertainties associated with their determination have been identified as follows:

- Equivalent diameter (d_w) -- the effects of drain shape and of restricting the area of the drain exterior surface to inflow will be studied.
- Discharge capacity (q_w) -- flow capacity and head loss effects in specific wick drains will be quantified.
- Disturbance effects (d_s) -- extent and influence on design equations caused by insertion and withdrawal of the mandrel will be investigated.
- Permeability of the drain jacket (K_d) -- a threshold value will be determined to establish a specification of appropriate minimum K_d values.
- Jacket clogging -- effect on drain performance will be investigated (clogging is complicated by the presence of a void produced by the mandrel, which will subsequently collapse against the drain).

The equivalent diameter is believed to be a function only of the drain configuration itself; i.e., a geometric property that can be calculated for a given drain. Finite element analyses will be performed to confirm the validity of this hypothesis and to model the effect of restricted inflow area on the consolidation process. Criteria will be established relative to restricted inflow area that can be incorporated into design analyses and wick drain specifications.

Head loss and discharge capacity of 6 wick drains will be tested in a manner similar to European investigations wherein a test device and procedure will be developed that simulates the flow system in an isolated drain as a function of lateral pressure surrounding the drain. If test results compare favorably with those of previous investigators, the test will be proposed as a standard for determination of wick drain discharge capacity.

Primarily, insight into disturbance effects will be obtained from prior research on effects of penetration of piles and cone penetrometers on the surrounding soil. Recommendations may also be developed on optimal mandrel shapes and sizes. Disturbance effects will be evaluated by performing laboratory permeability tests on soils of various sensitivities, organic content, gradation and consolidation pressure. These soils will then be subjected to various levels of shear strain (disturbance) and permeability tests repeated.

Jacket permeability will be evaluated by a parametric study which will identify a threshold value and by a water permeability test recently adopted by ASTM for fabric testing. Jackets whose permeability is less than the threshold value will be considered to adversely retard the consolidation process. Preliminary results show that as long as the jacket permeability is at least equal to that of the surrounding soil, jacket permeability itself should not be a limiting factor.

Jacket clogging will be evaluated by reviewing the geotextile literature and research testing on clogging of fabrics which is applicable to wick drains. The existing results will be used to determine the feasibility of performing further specialized testing to evaluate the importance and/or likelihood of clogging of wick drain jackets.

The results of the laboratory program will be evaluated and used to confirm and/or enhance the procedures given in the technical manual. Possible additional lab testing and/or a field testing program will be considered and proposed for a future study, if appropriate. The research study is expected to be completed by the spring of 1986.

REFERENCES AND SUGGESTIONS FOR ADDITIONAL READING ON WICK DRAINS

by

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Although wick drains are a relatively new development, especially in the U.S., there is already a significant number of articles and technical papers written about them and related topics. The following list is selected from this extensive published literature. First articles of a more general descriptive nature as well as comprehensive groups of papers and reports are given. The second section lists some case histories and individual research papers which can provide additional valuable information to the design engineer.