

METHOD OF SCREENING CHEMICAL BONDING AGENTS FOR CLAY SOILS

V. H. RODES

Engineer Research and Development Laboratories
Fort Belvoir

ABSTRACT

The constant consideration, punctuated by periods of almost frantic concentration of effort and by periods of dull lassitude, given to chemically bonding soil particles into structural materials has yielded some useful products, some laboratory curiosities, and some ideas as to how current and future efforts may be more meaningfully evaluated. Current work indicates that attempts to evaluate chemicals for bonding clay soils are significantly clouded by: (1) lack of knowledge of the soil-chemical bond; (2) lack of knowledge of the type of soil surface susceptible to bonding; (3) lack of knowledge of the inhibitors to chemical reactions present in soil systems; (4) lack of a correlation of the differences in response to treatment between readily identifiable clays and soil fractions apparently composed of these clays; and (5) lack of satisfactory laboratory techniques by which rapidly reacting chemicals can be properly incorporated with soils.

A program is proposed whereby standards of response to treatment are established for different categories of known bonding agents when used with fractionated silica, kaolin and kaolinitic soils, montmorillonite and montmorillonitic soils. A device suitable for laboratory use in this program is suggested.

Wherever clay soils are found there also probably will be found someone trying to bond these soils by mixing them with chemicals. Often the primary purpose is to develop faster, better, or cheaper ways of converting soils into surfaces on which land vehicles and aircraft could operate. This paper is an outgrowth of such an attempt by the Army Corps of Engineers and is intended as an effort to generate assistance for like investigations now and in the future.

A meaningful investigation of chemical solidification of clay soils requires a working knowledge in several fields of science. Steady progress is being made toward integrating this knowledge. Specialists in one or more of these fields are becoming conversant with the factors involved in the other sciences. Chemists, soil scientists, mineralogists, and chemical, mechanical and civil engineers are being exposed to each other's capabilities and problems. Competence in each field is being recognized; armed with his required information each specialist is able to furnish competent advice. Unfortunately, the number of investigations directed toward solidifying soils far exceeds the availability of specialists. Even where this availability exists, gathering the information required for each to contribute his knowledge constitutes a research project in itself. There seems to be no escaping the requirement for this information to be channelized through the civil

engineer. He either is, or represents, the user of the products of soil solidification research. With the help of the mechanical engineer he must decide when an investigation has progressed sufficiently to warrant evaluation of research results. This decision should be based on the most lucid premises obtainable. These grubby-handed engineers will be up to their ears in the problems of selecting and devising equipment, techniques and procedures for the evaluation tests. Any doubts as to the bonding potential of the chemical agents handed them should be allayed before they start. Tailoring investigations to avoid raising these doubts is a possibility well worth consideration.

Before we begin tailoring, perhaps we can pin-point our main difficulties. Although the selection of soils to be used for an investigation of a chemical solidifier is the first step, the characterization of these soils is the point where the real work begins. Particle size, particle shape, type of particle surface, condition of particle surface, presence and activity of trace elements, and availability of particle surface to additives as a function of water content and energy of processing techniques are all matters of prime concern. Few investigations are of sufficient scope to support the determination of these factors; almost invariably, even in the most comprehensive programs, the necessary effort is expended only as a last resort in an attempt to evaluate results already obtained.

Accordingly, even without considering the compounding difficulties of the internal behavior of the bonding agent, our projected investigation is at best doomed to come to an incomplete, and, probably, inconclusive end. And this discouraging picture is still further darkened by the lack of standard laboratory processing techniques. Faced with these obstacles, there is little wonder that very few chemical soil solidifiers live long enough to receive the only fully convincing evaluation — that of a full-scale performance test.

Despite these obstacles, the widespread interest in developing improved traffic bearing surfaces prompts numerous chemical soil solidification studies each year. Without question, the evaluation of the results of these studies, and also of those now under way, will be significantly clouded by deficiencies in fundamental information and in laboratory techniques. These can be summarized as (1) lack of knowledge of the soil-chemical bond; (2) lack of knowledge of the type of soil surface susceptible to bonding; (3) lack of knowledge of the inhibitors to chemical reactions present in soil systems; (4) lack of a correlation of the differences in response to treatment between readily identifiable clays and soil fractions apparently composed of these clays; and (5) lack of satisfactory laboratory techniques by which rapidly reacting chemicals can be properly incorporated with soils. Our tailoring job must be designed to alleviate doubts arising from these deficiencies.

A study of past research leads to a suggestion which, it is hoped, will increase the value of all soil solidification studies whose scope cannot in-

clude sufficient fundamental background. Why not prepare standard soils for use in soil solidification studies and establish standards of response for these soils when used with selected bonding agents? This would provide a means by which a wide range of potential investigators, from the college student to the chemical manufacturer, would come to conclusions which would be meaningful not only to the investigator but also to the potential user.

Selecting the standard soils for such a program could, of course, be a major undertaking if we were to cover even the well-defined variables existing in natural systems. Accordingly, the simplest possible range is suggested. Because grain size is a prime factor, the selected materials should be fractionated. Since particle shape is also a must, both silica and clay particles should be included. Since surface availability must be considered, the use of both kaolin and montmorillonite is suggested and since significant differences in behavior exist between the clays found in large deposits and those contained in surface conglomerates, the fine grained fractions of a selected kaolinitic and montmorillonitic soil should be included.

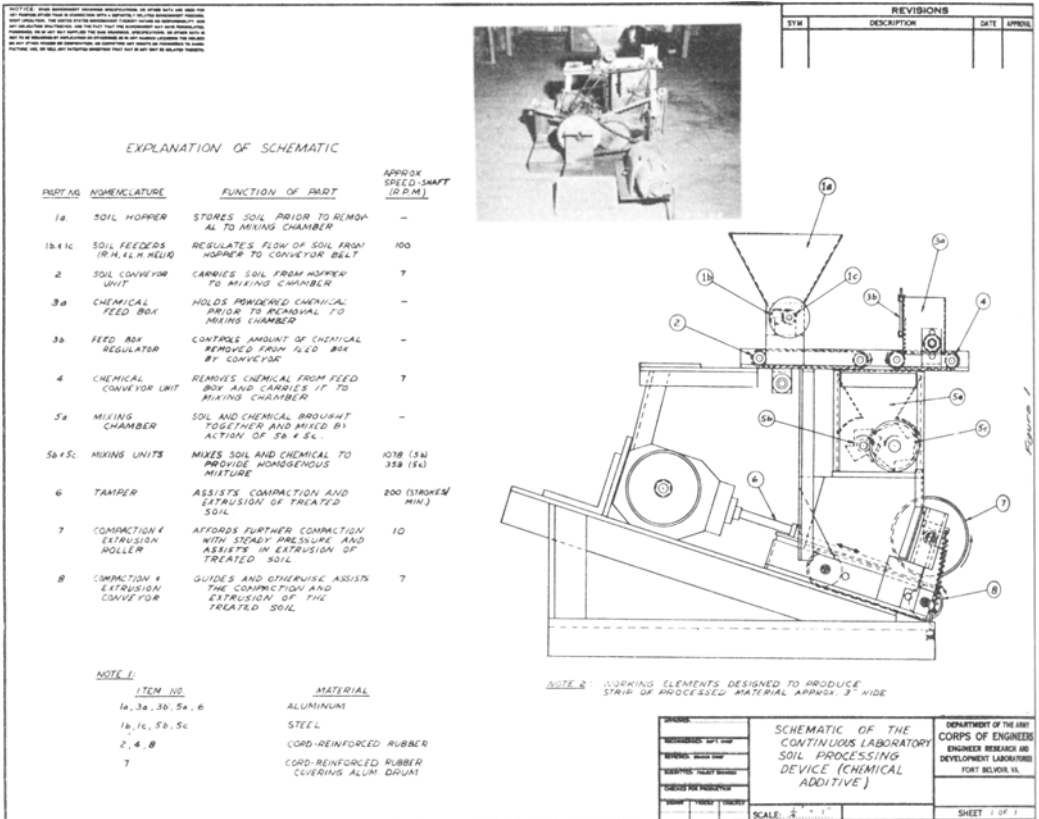
The selection of bonding agents to be used could provoke just as great a controversy. Accordingly, a selection limited to those of some proven utility seems wise. Portland and asphalt cement, the latter in cut-back, emulsified and undiluted forms, head the list because of their long-established utility. Aniline-furfural and urea-malamin formaldehyde have shown promise in research studies and are nominated as bonding agents of the condensation polymer type. Calcium acrylate, an addition polymer, is suggested for inclusion as a representative of this type of bond because it too has shown promise in research studies.

A standardized method of preparing and treating laboratory specimens is just as much a requirement as are standard materials. A great deal of good work has been done with arbitrary techniques, but recent work with rapidly reacting chemicals has emphasized the need for standardized techniques. It has long been recognized that methods of introducing materials into a process, the time and energy expended in mixing these materials and the time and energy expended in densifying and placing the finished product, are all matters of primary concern. It is perhaps unfortunate that the soil stabilization techniques used in the field for roads and airfields construction have been allowed to govern, in a large measure, laboratory research on stabilization materials. Admittedly, it is a distinct advantage to be able to conduct laboratory research knowing essentially how the future of that research will be put to use. However, sufficient data is becoming available to indicate that grievous overdesign is required in using even the conventional stabilization materials, asphalt and cement, due to field equipment deficiencies. For instance, reactions in a mixture of cement and soil begin the moment moisture is available, which, for practical purposes, is instantaneous. The intervening time between the moment that cement contacts the soil and the moment the finished soil cement product is left for the

curing process to take place, has significant effects on the final product. With more rapidly reacting chemicals, these effects are obviously more critical.

From necessity, most rapidly reacting chemicals are capable of generating internal reactions and also reactions with soil and water. The effects of soil particle geometry and composition have been shown in some cases to be a function of time. Accordingly, close control of process time is an essential factor. Any successful technique, then, would include control of materials, time, introduction, incorporation, mixing and densification.

There is no mechanical means now available even for laboratory research which provides control of these items. In recognition of this situation some study has been directed toward building a device which would answer this requirement (Fig. 1). The components of the device are well known in full scale; however, there is no known full scale device which incorporates these components. Briefly, the item consists of a soil feeder and a dry



chemical feeder, each discharging at controlled rates into a blender which is placed in a chamber, the bottom of which is a powered belt of controlled rate of speed and at the front of which is a powered roller. The mixture is forced between the belt and roller by a piston-actuated tamper of slightly smaller cross sectional area than the space between belt and roller. The moving belt lining the bottom of the chamber, together with the tamper and the powered roller at the exit, helps extrude the treated soil from the apparatus in a continuous dense strip. Initial trials of the model showed that the principles involved were sound but full evaluation of the model awaits redesign and fabrication.

It is hoped that these suggestions, or better ones, will evoke responsive action. The solidification of clay soils as a field practice may be a near reality or a will-of-the-wisp, but considerable time and effort is being directed toward this goal. The assistance of clay technologists is required; their help in devising ways of minimizing the difficulties which can be directly attributed to their stock-in-trade would be a significant contribution.