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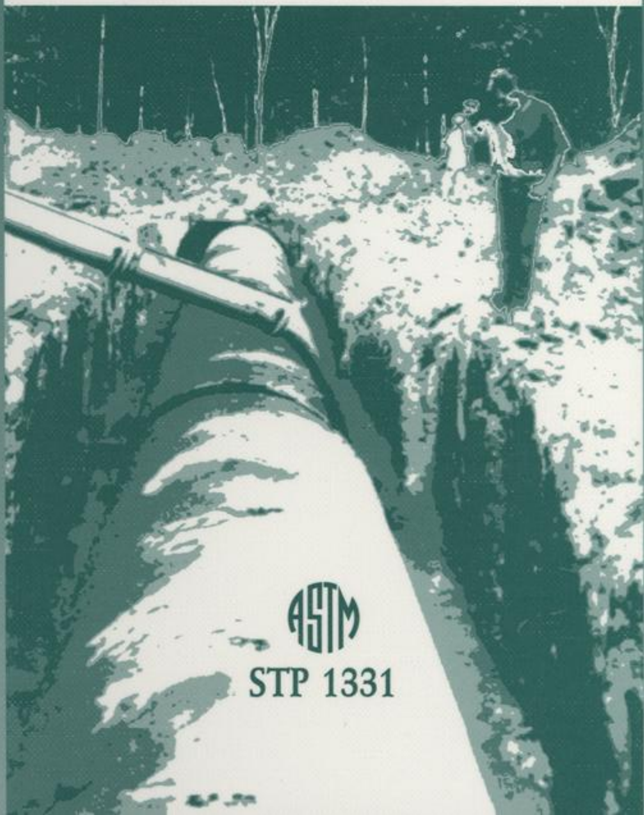
The Design and Application of CONTROLLED LOW-STRENGTH MATERIALS *(Flowable Fill)*

Amster K. Howard
Jennifer L. Hitch
editors



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To make technical information available as quickly as possible, the peer-reviewed papers in this publication were prepared "camera-ready" as submitted by the authors.

The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution of time and effort on behalf of ASTM.

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Foreword

This publication, *The Design and Application of Controlled Low-Strength Materials (Flowable Fill)*, contains papers presented at the symposium of the same name, held on 19–20 June 1997 in St. Louis, Missouri. The symposium was sponsored by ASTM Committee D-18 on Soil and Rock and its Subcommittee D18.15 on Stabilization with Admixtures, in cooperation with ASTM Committee A-4 on Iron Castings, ASTM Committee C-9 on Concrete and Concrete Aggregates, the American Concrete Institute, and the National Ready Mixed Concrete Association. Amster K. Howard of Lakewood, CO and Jennifer L. Hitch of Pozzolanic Intl. in Mercer Island, WA presided as symposium chairpersons and are editors of the resulting publication.

Contents

SPECIFICATIONS, STANDARDS, AND TESTING

APPENDIX—CLSM STANDARDS

OVERVIEW

The symposium on Design and Application of CLSM (Flowable Fill) was held in St. Louis, Missouri on June 19-20, 1997. The symposium was sponsored by ASTM Committee D 18 on Soil and Rock in cooperation with Committee A 4 on Iron Castings, C 9 on Concrete and Concrete Aggregates and with the American National Ready Mix Concrete Association.

Over the last decade and a half, the use of Controlled Low Strength Material (CLSM) or flowable fill as it is more commonly known, has increased dramatically. The purpose of this symposium was to present new design procedures, new applications, and installation innovations to help assess the need for new or improved standards on flowable fill. As discussed by Jenny Hitch in her paper in the symposium, ASTM Subcommittee D 18.15 has recently developed four new standards on CLSM to bring the number of standards concerning CLSM to five.

CLSM is also known as flowable fill, flow fill, controlled density fill, soil-cement slurry, and K-crete, among others. It is a mixture of cementitious material (portland cement or Class C fly ash), soil, water and sometimes fly ash and admixtures. CLSM is used in place of compacted backfill and the most common use has been for pipe embedment and backfill. However, CLSM has many uses as illustrated in the symposium by the papers by Hook and Clem, Green et al, Snethen and Benson, Gray et al, Gardner, Mason, and Dolen and Benavidez.

The symposium was divided into 5 parts to cover the wide range of new developments in the use of CLSM, as follows:

* Ingredients
* Properties of CLSM
* Test Methods, Standards, and Specifications
* Case Histories
* Pipeline Applications

INGREDIENTS

<u>Fly Ash</u> Two papers dealt with using fly ash in CLSM mixes:

Bruce Dockter described testing to determine how fly ashes that do not meet specifications for use in concrete can be used in CLSM.

Tarun R. Naik, et al, discussed the development of mixture proportions of clean coal ash from atmospheric fluidized bed combustion for acceptable use in CLSM mixtures.

<u>Aggregate</u> Two papers dealt with the use of non-traditional materials as aggregates in CLSM:

L. K. Crouch, et al, reported the successful use of limestone screenings with high fines (passing No. 200 sieve) content as an aggregate for flowable fill.

Todd R. Ohlheiser investigated the use of recycled glass to replace 100 % of the aggregate in flowable fill. The use of recycled glass has been approved by the Colorado Department of Transportation.

Other Gilbert Tallard addressed a flowable fill material composed of attapulgite clay and a finely ground blast furnace cement. The resulting material has a very low unit weight and permeability.

PROPERTIES OF CLSM

Five papers dealt with the properties of flowable fill:

Pons and Landwermeyer compared the bearing strength, diggability, and subsidence of regular CLSM to a quick setting CLSM. Penetration resistance and compressive strength were also determined.

R. J. Hoopes concluded that air-modified low-water content CLSM retains the compressibility, shear, load bearing, and flowability characteristics of regular CLSM, while improving permeability, subsidence, bleeding, and freeze-thaw properties.

Jon Mullarky addressed the long-term strength gain of CLSM and described a two year study to evaluate mix parameters to control strength gain.

Hepworth, et al, investigated the use of wash out resistant CLSM as a stabilizing and entombing agent for the remediation of tanks containing contaminated materials.

Angel Abelleira, et al, described an experiment with steel coupons placed in soil or in CLSM to evaluate their effect on the corrosion of the steel.

TESTS METHODS, STANDARDS, AND SPECIFICATIONS

Amster Howard reported on a proposed ASTM standard practice for installation of buried pipe using flowable fill. This standard is currently being developed by Subcommittee D 18.15 and would apply to all types of pipe.

E. H. Riggs and R. H. Keck compared the specifications for flowable fill being used by transportation agencies in several southern states and gave recommendations for standard specification language.

Elizabeth Kunzer gave a paper authored by Robert Scavuzzo and herself that described a laboratory test to determine the cement content of CLSM by measuring the heat of neutralization created when adding acid to the CLSM. The test is faster and simpler that the current titration method.

Jenny Hitch related the history of CLSM testing and the current efforts of ASTM Committee D 18 to develop standards for test methods.

CASE HISTORIES

Many interesting uses of flowable fill were described by the following speakers:

W. Hook reported on the use of flowable fill to backfill culverts used to replace substandard bridges, to fill an abandoned culvert, in tilt-up construction, in foundation wall backfill, and in pipe bedding.

B. H. Green, et al, discussed the use of flowable fill to fill the void left by microtunneling machines when forced to abort the tunnel and withdraw. They also described the use of flowable fill to stabilize the soil surrounding the sheet-piled shaft that would be used to launch a microtunnel boring machine.

Snethen and Benson evaluated the use of CLSM to construct the approach embankments to a bridge to minimize the bump that sometimes occurs when compacted soil embankments settle.

D. D. Gray, et al, described the trial use of a CLSM composed of a cementitious fly ash, bentonite, and water to backfill abandoned mines.

M. R. Gardner discussed the use of flowable fill to backfill over a bus tunnel, support a parking garage on a dumpsite, replace compacted soil to reduce the construction traffic, quickly backfill a water main under a railway minimizing any disruption to train traffic, and to encapsulate contaminated soil.

M. P. Walker and J. R. Ash reported on the use of flowable fill as backfill in sequential excavations.

T. Mason described how flowable fill was used to fill a void underneath a building slab.

Dolen and Benavidez related the development of a mix design for flowable fill to be used as a cutoff wall constructed in an existing dam to reduce foundation seepage through the dam.

PIPELINE APPLICATIONS

There were 5 papers that dealt specifically with using flowable fill for pipeline construction.

D. Brinkley and P. E. Mueller described the use of a zero-slump CLSM mixture that has a high void content. The material is easily excavated and is now required for all utility trench backfill in Prescott Arizona.

T. J. McGrath, et al, investigated the use of flowable fill for installing three types of pipe, reinforced concrete, corrugated HDPE, and corrugated metal. The study was part of an National Science Foundation research project on installation procedures for buried pipe.

Hegarty and Eaton reported on the use of flowable fill for the embedment of concrete pipe with 60 feet of backfill under an airport runway.

T. J. McGrath and R. J. Hoopes gave the results of a finite element study to develop the bedding factors and E prime values for buried pipe installations using flowable fill.

T. H. W. Baker addressed the potential problems associated with frost penetration when using flowable fill for pipe backfill.

The symposium papers were a reflection of the versatility of the rapidly growing use of flowable fill and its ingredients. Many useful ideas and comments were generated for the use of ASTM Subcommittee D 18.15 for their updating and development of CLSM.

ASTM STANDARDS
ON CLSM

The Appendix to this STP contains the current ASTM Standards on CLSM developed by Committee D-18 on Soil and Rock, as follows:

D 4832 Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders

D 5971 Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material

D 6023 Standard Test Method for Unit Weight, Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low Strength Material

D 6024 Standard Test Method for Ball Drop on Controlled Low Strength Material to Determine Suitability for Load Application

D 6103 Standard Test Method for Flow Consistency of Controlled Low Strength Material

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We wish to thank all the authors, reviewers, and session chairmen whose hard work made the symposium an interesting and very useful forum for discussing the current use and application of controlled low strength material. We would also like to thank the staff at ASTM for their help in organizing this symposium.

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