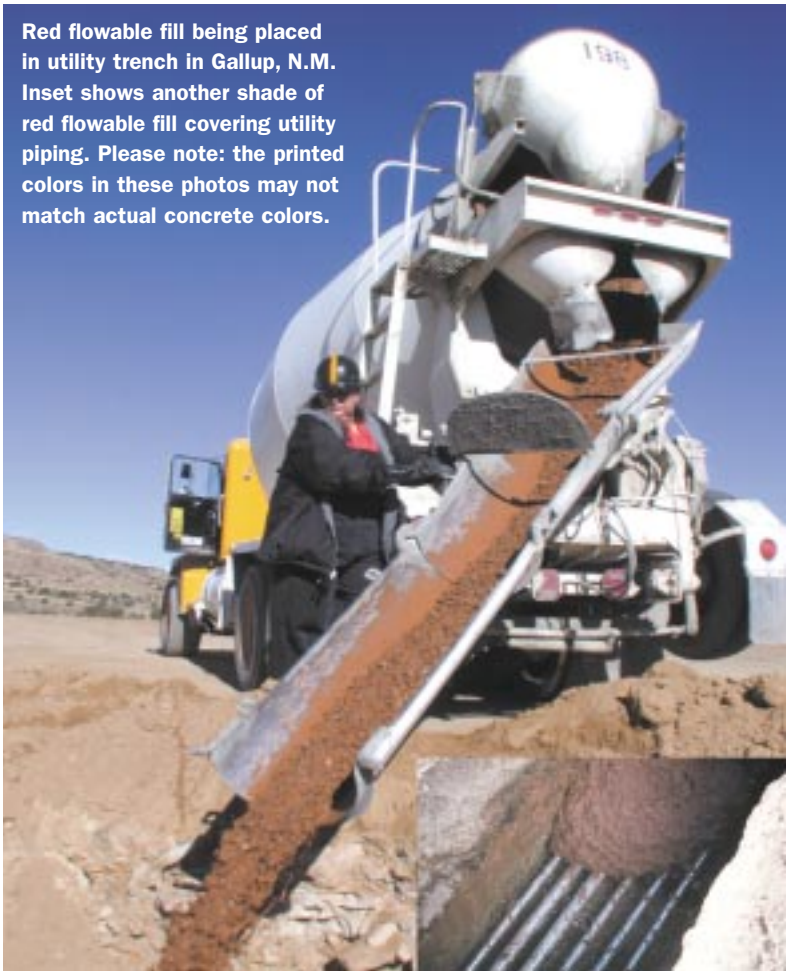
Colored Flowable Fill for Utility Trenches

Color in flowable fill accurately identifies both type and location of buried utilities, ensuring safe excavation operations



Red flowable fill being placed in utility trench in Gallup, N.M. Inset shows another shade of red flowable fill covering utility piping. Please note: the printed colors in these photos may not match actual concrete colors.

PHOTO BY WILLIAM SIEBERSMA; INSET PHOTO BY FRANK A. KOZELISKI

By Frank A. Kozeliski

The ideal way to work safely on any jobsite is to identify and locate the existing underground utility lines before beginning any site excavation. In the real world, though, existing site conditions aren't always clear, and as-built drawings may not be accurate or updated to reflect site utility modifications. Using colored flowable fill to backfill utility lines provides excavation crews with a reliable and clear visual warning of potential hazards.

Utility location and identification

When backfilling over a pipe, utility line, or cable, the soil that was initially excavated is generally reused. The original soil is compacted to a specified density or is pushed into the excavation and mounded so that finished grade is maintained after settlement occurs.

When utility trenches are backfilled, it is generally only the workers and project superintendent who know the purpose and location of the utility lines. Property owners are usually unaware of the function or location of buried utilities on the site. On large projects, there may be site drawings indicating the location of buried utilities, but this is not typical on small or private jobs. In addition, site drawings with utilities marked can be lost in property transfers or may not be revised with subsequent site construction.

During subsequent construction, whenever excavation or digging is required on the site, the contractor should assure that a locate has been done by the utility company or a location service in order to identify any buried lines. Buried utilities can include those for sewerage, telephone, electrical, water, gas, television, and other communication or security connections. The utility crew or location service generally marks the location of buried utilities with spray paint on the ground surface or with color-coded flagging. While this is what should happen, in the real world it is common for buried lines to be inadequately located and excavation activities to result in disruption to underground services. When a buried phone line, water pipe, or other utility is damaged during excavation, the best-case scenario is that service to the site's occupants is disrupted. More often, costly problems result. But even worse, serious construction accidents, including worker deaths, have occurred when excavating equipment inadvertently hits unexpected or improperly identified underground gas pipes or electrical lines.

Excavation safety

Making excavation operations safer for sites with buried utilities can be achieved in two ways:

- Using flowable fill to reduce the need for compaction and potential maintenance (resulting from compaction damage to the line)
- Adding a color pigment in the flowable fill used as backfill over utility lines to indicate the type of buried pipe or cable

You might ask why this is necessary. As noted earlier, for a given parcel of land, ownership can change hands many times, and site drawings with util-

ities marked are often lost in property transfers. By marking buried utilities with a lasting color-coded flowable fill, we can ensure the safety of future excavation operations. In this way, excavator operators and crews will have an accurate and timely visual warning. Whenever crews encounter colored backfill they will realize that a buried utility is present and will be able to identify the type (danger potential) of the line.

Materials

Flowable fill is a low-strength, self-compacting cementitious material used primarily as a backfill in place of compacted soil. Also known as controlled low-strength material (CLSM), flowable mortar, flowable fly ash, or KozCrete*, flowable fill has a compressive strength of 25 to 100 psi, making it easy to excavate with conventional equipment but strong enough to function well as backfill.

Flowable fill consists of cement, fly ash, water, admixtures, and aggregate. The cement is generally a Type I, Type II, or blended cement conforming to ASTM C 150 or C 595. The fly ash is the same as that commonly available in concrete plants and may be Class F or C. Fly ash improves the flowability of flowable fill and reduces bleeding, shrinkage, and permeability. For most flowable fill applications, the fly ash does not need to meet ASTM standards since it is being used as backfill, not as structural concrete. Some flowable fill incorporates only fly ash (no cement) because it is so economical. Flowable fill with all fly ash is generally black in color but can be a lighter color depending on the source of the fly ash. Flowable fill mixtures use potable water, the same as ready-mixed concrete.

Admixtures are added to flowable fill to make it more workable. Some flowable fills have a high amount of entrained air for flowability and to increase the volume of the fill. Additional additives may include integral color and swelling clays or bentonite to reduce permeability. Magnetite or hematite fines are added for radiation shielding at nuclear facilities.

The maximum aggregate size in the flowable fill is generally less than 1 inch. Smaller aggregates can range from 3/8 inch to the material retained on a No. 200 sieve. The aggregate can be from a well-graded source, or it can be a quarry waste product. Flowable fill is supposed to be economical and is generally the cheapest fill material available. Some quarry waste aggregate (including fines with up to 30% passing the No. 200 sieve) has been successfully used in flowable fill. Recycled concrete has also been used.

Color coding, dosage, and cost

The standard colors used to identify different types of utility lines are listed in Table 1. These colors, integrated into the flowable fill used for backfill, will provide a reliable and universally recognized identification system and visual warning that anyone can recognize while digging or excavating.

The intensity of the color of the flowable fill will depend on the dosage

*KozCrete: flowable fill developed and supplied by Gallup Sand & Gravel, Gallup, N.M.: 94 lbs/cy cement, 3000 lbs/cy limestone quarry fines (3/8 inch max), 416 lbs/cy water (50 gallons), for a total weight of 3510 lbs/cy.

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Left: Flowable fill is available in the colors shown on the samples. Below, left: Measuring flowable fill sample diameter to estimate flowability of material. Below, right: Test cylinders are filled with green flowable fill. Cylinders have drainage holes to simulate field conditions.

Neoprene (wet suit material) provides a uniform testing surface.

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Purple flowable fill is placed in a utility trench in New Mexico.

Table 1: Standard colors used to identify types of utility lines

Utility Type	Flowable Fill Color
Electrical power lines and cables	Red
Gas, oil, or steam	Yellow
Fiber optics, communications, alarms	Orange
Potable water	Blue
Sewer lines	Green
Non-potable water	Purple

Table 2: Dosages and costs for color pigments

Color	Code Number*	Dosage, lbs/bag	Cost, $/cy**
Red	100	3	$2.25
Yellow	569	5	$4.95
Orange	5084	5	$5.15
Blue	418	5	$111.00
Green	5376	3	$7.68
Purple	1395	4	$4.32

* Code numbers, dosages, and costs were provided by Davis Colors, Los Angeles, a color pigment manufacturer.
**The cost per cubic yard is approximate and will vary among manufacturers. The listed cost is based on 50-pound bags of pigment purchased in 2000-pound quantities with no added cost for freight or for the ready-mix company's handling fees, overhead, or profit.

of color pigment. Color dosage is determined in the dry form since it is dosed as pounds of color additive per bag of cement. The color achieved will vary depending on the pigment manufacturer, and liquid-dispensing systems will require different dosages. Consult your local color pigment manufacturer for tips on how to use its pigment in flowable fill. The specific color and dosage will vary with the type and color of cement and fly ash as well as the color of the aggregates.

Availability and advantages

Currently, red, yellow, and orange pigments are commonly available. Green pigment is more difficult to obtain, and blue pigment is the hardest to locate and is currently the most expensive. A major advantage of using colored flowable fill is that it is readily available from most local ready-mixed concrete suppliers. This material is delivered in a ready-mix truck and uses locally available aggregates and materials.

Adjustments to the mix can improve the flowability of the mixture. In some cases adding foaming agents to flowable fill will produce a lightweight

insulating material. Flowable fill applications can save earthmoving costs since less excavation is required for narrow trenches. Conventional soil backfilling requires compaction and wider trenches to safely accommodate compaction equipment. Worker safety is improved when using flowable fill because crews do not have to enter trenches for compaction operations, thus reducing their exposure risk to possible trench collapse.

Testing methods

The testing methods for flowable fill are similar to those used for conventional concrete. ASTM Vol. 04.09 provides testing methods for flowable fill since it is considered a soil. The consistency of flowable fill, per ASTM D 6103-97, is checked with a 3x6-inch cylinder filled with flowable fill; the cylinder is lifted, and the diameter of the slumped mass is measured. A diameter of 8 inches or greater indicates that the material is of a flowable consistency. The diameter is measured in two perpendicular directions.

Strength tests for flowable fill are also similar to those for concrete. The cylinder molds used are 4 inches in diameter and 8 inches high and have four ¼-inch-diameter holes drilled in the bottom so that the flowable fill can drain freely, better representing field conditions. Flowable fill gains strength at only about 5 to 10 psi per day, making it difficult to remove the cylinder from the mold without damage. The cylinder molds are then filled the same as if the material were concrete (molded), at a slump of 4 inches or greater.

Flowable fill can ensure the safety of future excavations.

The cylinder molds are then filled like concrete molded at a slump of 4 inches or greater. Once the samples harden, the pipe clamps are removed and the cylinders are removed and cured in a moist environment, not a curing tank; if water penetrates the flowable fill specimen, the sample may fall apart. This moist environment can be achieved by placing the cylinder in a covered bucket with wet rags placed over the sample, keeping the specimen moist, not wet.

The strength of the test specimens is generally tested with the pad cap system. The material in these pad caps is a wet suit material similar to neoprene. Heather Sauter, at Tennessee Technological University, developed this system, which provides more uniform testing results by using the soft capping material.

You can find more information on flowable fill in the American Concrete Institute report by ACI committee 229, "Controlled Low-Strength Materials," ACI 229R-99. The National Ready Mixed Concrete Association provides a tool kit with a CD on using flowable fill. ■

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