FLOWABLE FILL USING INSITU SOILS

SUMMARY
Flowable fill for pipeline installation can use the native soils excavated from the trench as the aggregate in the mix. The flowable fill can be mixed using trench-side mixing equipment or portable batch plants that move along with the pipe installation. Using the soil excavated from the trench reduces spoil pile waste, spoil pile handling, importing aggregate materials, and transit mixer traffic from ready-mix plants.

Typically, flowable fill is obtained from a ready-mix plant and is a mixture of Portland cement, concrete sand, sometimes flyash, and water. Flowable fill is typically used as a replacement for compacted earth backfill. Priced close to concrete, the cost limits its application.

Several contractors and competitors to ready-mix have found ways to reduce the cost through on-site volumetric mixers, using Class C flyash in place of cement, and using waste or by-products as aggregates.

Additionally, there are some contractors who have been successfully using the native soils excavated from the trench to make flowable fill. In-situ soils that are sands or a mixture of sand and silt are ideal for flowable fill. The soil is easily processed and mixed. Clayey soils require more processing, but have been successfully used.

A photo of a chunk of hardened flowable fill made using insitu clay soil and Portland cement is shown in Figure 1.

Figure 1 Chunk of Flowable Fill made from Insitu Clay Soil

Clayey soils typically require more processing than sandy soils, but have successfully been used in pipeline construction (Finney et al 2009)
Two different equipment set-ups have been used for mixing the material. “Trench Side Mixing” will be used to refer to machines that travel beside the trench, mix the soil, cement, and water, and then discharge the flowable fill directly into the trench. “Portable Batch Plants” are mobile and can be set up near the trench and moved along the alignment as the construction progresses. Soil from the trench is stockpiled next to the batch plant, screened if necessary, and batched on a weight basis similar to ready-mix concrete.

**Trench Side Mixing**

A trench side mixer is shown in Figure 1. This is a rig used by Barnard Construction Co of Montana. This is a volumetric mixing operation. Soil from the hopper goes onto a conveyor belt to a mixing chamber at the beginning of a screw auger. Concurrently, cement and water are added to the mixing chamber. The material continues to mix as the screw auger moves the material down the chute. The flowable fill goes directly into the trench and around the pipe.

Barnard has been using flowable fill with insitu soil since the mid 1990’s.

![Trench Side Mixer (Barnard Construction)](image)

Figure 2  Trench Side Mixer (Barnard Construction)

Video of a different rig that is used by Barnard Construction can be seen by going to: AmsterHoward.com > links > Barnard Trench-Side Flowable Fill Mixing.
Ranger Construction Co of California uses a more traditional volumetric mixer as shown in Figure 3. The equipment has been used to make flowable fill out of clayey soils (SC, CL) but is not effective with Fat Clays (CH).

![Volumetric Concrete Mixer](image)

**Figure 3** Volumetric Concrete Mixer used for Flowable Fill (Ranger Construction)

The mixer has a hopper for soil, a cement bin, and a water tank. All are mixed with the screw auger as shown in Figure 4.

![Mixing and Screw Auger](image)

**Figure 4** Mixing and Screw Auger on Volumetric Mixer
The “California Soil Processor” developed and used by Mountain Cascade Construction of California can process and mix Fat Clay (CH) soils. These highly plastic clays are difficult to work with, but Mountain Cascade has successfully used the soil to make flowable fill. The Mountain Cascade rig is shown in Figure 5. The soil from the hopper is fed into a pugmill from a conveyor belt. Cement is added to the soil on the belt with a vane feeder. Water is introduced at the beginning of the pug mill.

Figure 5 Flowable Fill Processor (Mountain Cascade)

The Mountain Cascade rig can successfully mix Fat Clay (CH) soils because of the pug mill mixing operation as shown in Figure 6.

Figure 6 Pug Mill on Mountain Cascade Mixing Rig
The resulting flowable fill is shown in Figure 7. The clay clods are obvious. The flowable fill chunk shown in Figure 1 is from a Mountain Cascade project using clays. The Mountain Cascade operation is the one referred to in the 2008 paper by Finney et al describing the use of the rig to make flowable fill from Fat Clay (CH).

![Figure 7 Typically Fresh Flowable Fill from Mountain Cascade Operation](image)

A typical flowable fill operation using in-situ clay soil can be seen on the Mountain Cascade Construction website (www.mountaincascade.com). On the lower right of the home page, click on MC Innovations Page, and then click on the video. The shredding, mixing, and placement operations can be viewed. The video can also be viewed by going to AmsterHoward.com > links > Mountain Cascade . . . A video of a previous Mountain Cascade rig can also be seen at AmsterHoward.com > links > Flowable Fill Soil Processor.

All of these trench side mixing operations can produce flowable fill with a 28 day compressive strength of 40 to 80 psi. Typically the insitu soils are examined ahead of the mixing operation so that any changes to the percent cement can be adjusted as the rig moves ahead. Compressive strength cylinders are usually cast every day to monitor the strength of the soil-cement-water mixtures.

The fluidity of the mixture is typically in the 8 to 12 inch range as prescribed in ASTM D 6103 “Flow Consistency of Controlled Low Strength Material.”

Mountain Cascade has been using insitu soils for flowable fill since the mid 1990’s.
**Shredding**

Use of native soil requires processing to make the soil the proper size and consistency. The mixing of the flowable fill is more effective if the clod size is about ½-inch or less and if the soil moisture is about the Plastic Limit (PL) or less.

For cohesionless sands and fine gravels, a preliminary screening to remove oversize particles is all that is required. Moisture content is not a concern. Many times this step is incorporated into the mixing operation. Soils with a Plasticity Index (PI) below 20 can also be screened as part of the mixing operation if they are not too wet. Such soils can be spread out and let to dry for a day or more to obtain a workable moisture.

For the more cohesive soils, shredding is necessary to make the appropriate clod size. While some soil shredders can manipulate wet, sticky clays, the resulting material is usually too wet to mix. For soils that are too wet, the excavated material can be spread out and let to dry for a day or two. Since the excavators are usually a day or so ahead of the mixing and placing equipment, this does not significantly affect the overall installation time.

The critical part of re-using in-situ clays is the shredding of the soil into 0.25 to 1 inch clods. There are commercially available shredders (Allu, Remu) that can handle most materials. An Allu shredder is shown in Figure 8.

![Allu Shredder (Mountain Cascade)](image-url)
The typical operation is to excavate the soil with an excavator and put into a spoil pile. About a day later, a backhoe with the Allu shredder picks up the material, shreds it, and dumps into the flowable fill processor, as shown in Figure 9.

Figure 9 Allu Shredder on Excavator Loading Soil Hopper on Volumetric Mixer

Videos of the various uses and applications of the Allu shredder are available at the Allu website: [www.allu.net](http://www.allu.net). Search engines do not readily find the home page of Allu unless you search for allu.net.
Portable Batch Plants
Portable Batch Plants have also been used. One such plant is shown in Figure 10.

The soil hopper was charged with soil from the trench excavation. The soil, cement, and water were all added to a transit-mix truck that mixed the flowable fill on the way to the trench site.

On the CAP project, shown in Figure 11, flowable fill was used in the haunch area of a 21-ft diameter steel pipe (Randolph and Howard 2010) (Sayer and Howard 2010). The excavated soil was taken to a portable batch plant, screened, batched, and transported back to the pipe using transit-mix trucks as shown in Figure 11. The soil was a Clayey Sand/Clayey Gravel (SC, GC) with minus 3/8-inch particles and about 10-15% fines.
**Sustainability**

Sustainability is achieved through less time and energy consumption for excavation, handling of soil excavated from trench, hauling of materials (both to and from construction sites), compaction of soil in 6 to 12-inch lifts, reworking compaction due to density test failures, hauling water for compaction, transportation to landfills, personnel for inspection of the construction, for testing, detours and traffic delays.

In many cases, sustainable methods using insitu soils result in flowable fill that can be cost competitive with compacted earth fill.

**REFERENCES**


