Hitting paydirt when there’s poor dirt

As homebuilders begin to run out of prime sites for residential developments, they’re having to settle for sites with potential problems such as low-strength soils, high water tables or fill materials of questionable quality. In the Northwest, that situation has created an opportunity for increased use of controlled-density fill (also called flowable fill or controlled low-strength material).

Used as a subfooting, a mass fill over thick layers of marginal-quality soils, or as a vapor-barrier covering in residential crawlspaces, CDF offers several advantages over alternative materials.

The CDF subfooting advantage

On some sites, soil of suitable bearing capacity is as much as 15 feet below low-strength surface soils. Excavating and replacing the poor soil with compacted fill presents some problems. If the required trench depth beneath the footing is greater than 4 feet, sides of the excavation have to be sloped to prevent them from collapsing on workers compacting the fill. This increases the amount of required fill. If the workers use vibrating equipment for compaction, soil sloughing from the sides of the trench may force the contractor to excavate the whole footprint of the house and replace it with compacted fill.

Two properties of CDF help it to overcome the financial and practical limitations of placing imported fill on a residential site. CDF can be placed by pump, and it requires no vibration.

The earliest residential applications were on sites where saturated bearing soils several feet below the surface could provide required foundation support, but imported compacted fill was still needed above the bearing soil (Fig. 1). If the site was wet, trucking of the fill had to be delayed until the site dried enough to permit construction traffic that wouldn't disturb the bearing soil. Also, the saturated site soils didn’t always provide enough support for adequate fill compaction.

Instead of tolerating the expensive delay while waiting for the soil to dry, contractors started reaching over the wet site with a pumpline and placing CDF in trenches dug to the depth of...

Suitable bearing-capacity soil was 10 to 13 feet beneath the surface on this building site because the site had been leveled with poor-quality imported fill. Subfootings of controlled-density fill solved the builder’s problem.
undisturbed bearing soil at the footing locations. With care, they could even place the material in trenches that weren’t fully dewatered.

The method can also be used on sloping sites that were leveled with imported fills of questionable quality (Fig. 2). In this case, the contractor has two conventional foundation choices: building engineered auger-cast piers with grade beams or excavating the poor-quality fill down to bearing soil beneath each footing and replacing it with a compacted fill of adequate quality. The design fee alone for the first approach often exceeds the total cost for the excavate-and-replace option, which still presents the problems of slope-sided excavations and compaction difficulties. Thus, a CDF subfooting makes good economic sense on these sites too.

The first contractors to use CDF subfootings over poor-quality imported fills dug trenches up to 7 feet deep while simultaneously pumping the CDF. This minimized the time the trench was open and reduced trench-wall sloughing. It also made the work site safer by eliminating the danger of falls into open trenches.

As engineers and contractors have gained more confidence in the method, excavation depths have increased to as much as 15 feet. These extreme depths in poor-soil areas can make it difficult to maintain straight sidewalls during the whole process. Sometimes excavator operators keep the bucket in the trench to hold back portions of poor soil until the CDF reaches the bucket, which is then withdrawn slowly as the CDF level rises, covers and applies pressure to the poor-soil area. On these difficult sites, a geotechnical engineer may monitor trench-wall sides and ensure that the required excavation depth is attained.

Other residential uses

On sites such as river valleys, where soft, boggy surface soils may be 100 feet deep, excavate and replace is the only option for improving bearing capacity. In a few instances of this type, contractors have filled the whole building footprint with CDF a few feet deep. This helps workers overcome the difficulty of compacting imported fill on an unstable base.

Crawlspace fill is another CDF application. In new construction, it’s used to prevent vapor-barrier punctures and provide a stable, level surface. A stiff-consistency CDF that slopes to drain can also be used to fill over-excavated areas that collect water in existing houses. The fill material can be pumped through a foundation vent.

Mix-design work for controlled-density fill normally is not extensive. Building officials or engineers who are concerned about the material’s bearing strength soon realize that even a low-strength CDF (40- to 50-psi compressive strength) has a higher unconfined compressive strength than most compacted fills, since 50 psi corresponds to 7,200 pounds per square foot.

In many cases, the mixes used to produce these strengths are the same ones used to backfill utility trenches. Typical proportions for a cubic yard include 50 pounds of Type I cement, 300 pounds of Class F fly ash, 300 pounds of water, and an air-entraining-agent dosage that produces a 10% to 15% air content. The lower value is used for fine sands and the higher value for coarse sands. Enough sand is added to yield the required 27-cubic-foot volume.

Adding small amounts of coarse aggregate—about 30% by weight of the combined aggregate—helps to reduce boot-heel scuffing of the subfooting surface and also improve the ability of the subfooting to hold steel stakes the day after the CDF is placed.