

Settlement Caused by Imported Fill

Introduction

A previous issue of the GCES Construction Monitor discussed stress transfer from a building foundation to the soils below and how the soil may respond to the increase in pressure. This issue discusses the stress that imported fill transfers to the soil below.

Soil Contact Pressure

When building foundations transfer a load to the ground, the underlying soil experiences an increase in stress that can result in building settlement. A less recognized cause of settlement is fill from imported soil. This includes fill soils that are moved from other portions of the site or trucked to the site. These imported fills can be very heavy and can introduce large, new stresses to the soils below in the following ways:

1. The deeper the fill, the more stress is transferred to the on-site soils.

Soil has a wide range of possible weights. It can vary from 95 lb/ft³ (soft clay) to 145 lb/ft³ (sandy gravel). Most imported fills use sandy soils with unit weights of approximately 110 to 120 lb/ft³. Often, an area of thick fill can weigh more than a house or other building constructed on the site. An example will help illustrate the increase in soil stress and possible settlement from imported fills.

Assume that a residential building site uses imported fill to raise the existing grade. Because the contractor is concerned about the subsurface conditions, he digs a few test pits with a backhoe near the location of the proposed residence to determine the soil types. The pits are excavated to 4 feet below the proposed footing elevation. Sandy soils are encountered. They do not "look" like they will be a problem. (Note: the

contractor identified the soil type as "sandy soils," but the relative density or compactness of the in-place soils was not determined because soil density tests were not performed). The contractor feels comfortable about the soils because they are sandy rather than muck, peat or soft clay.



Residence under construction in area of possible soft soils

After construction of the residence has progressed, imported fill is delivered and placed on-site.

Let's assume that the sand fill weighs 120 lb/ft³ after compaction. The fill is placed so that the final height is 10 feet above the original grade. The increase in pressure to the soils below due to the fill is:

$$\text{Fill pressure} = 120 \text{ lb/ft}^3 \times 10 \text{ ft of fill} = 1,200 \text{ lb/ft}^2$$

This pressure from the fill is added to the foundation loads:

$$\text{Total pressure} = \text{fill pressure} + \text{footing pressure}$$

$$\text{Total pressure} = 2,500 \text{ lb/ft}^2 + 1,200 \text{ lb/ft}^2 = 3,700 \text{ lb/ft}^2$$

At this point, the question that should be asked is: "Is this enough new stress to cause substantial settlement?"

Unfortunately, there is not enough information to answer the question without a soils investigation. Some sites are able to support foundation loadings of 15,000 lb/ft². Other sites may have unacceptable settlements if the soil is loaded to 500 lb/ft². **A soils investigation is the only way to make an estimate of allowable soil bearing pressure with any confidence.**

2. The larger the fill area, the deeper the stresses extend into the sub-surface soils.

A previous issue of the GCES Construction Monitor explained that a large footing would transmit stresses deeper into the soil than a smaller footing. Imported fill soils are essentially the same as a very large flexible footing. Some fills can be several hundred feet across depending on the project size. This can drive stresses deep into the ground.

For example, let's say the wall footings around the perimeter of a residence are 2 feet wide, and the fill is roughly 60 feet on each side, as shown in Figure 1.

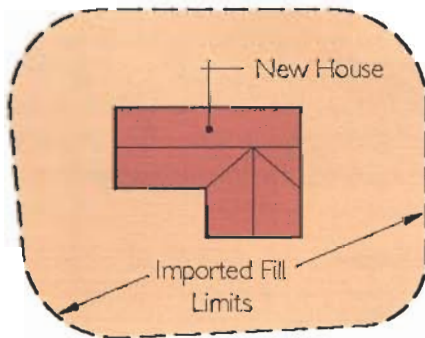


Figure 1 - Plan View of Project

It is possible that the imported fill itself (not the footings) could cause settlement by consolidating soft soils deep below the ground. The zone of stress influence in the native soil is shown in Figure 2.

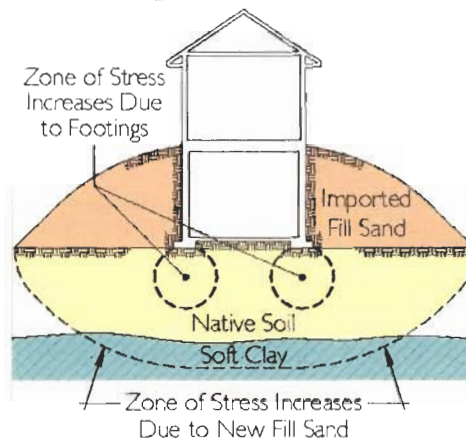


Figure 2 - Elevation view showing fill, basement, and stressed zones of soil

On a project in northern Michigan, 10 feet of imported fill was placed adjacent to a basement wall. As the siding was being placed on the new house, approximately 3 to 5 inches of settlement had already taken place. The differential settlement involved caused a 2- to 3-inch-wide crack on a portion of the poured concrete basement wall. A subsequent geotechnical exploration revealed a soft lake marl layer immediately below a native sand layer, much like the cross section shown in Figure 2. The highly compressible marl was never seen during foundation construction.

A geotechnical investigation is the only way to determine how solid the soil on your proposed project site is and how much the soil and foundation may settle.

For more information on geotechnical issues related to your project, contact Chuck Brumbaugh P.E., Manager of Geotechnical and Testing Services, or Mark Muszynski, P.E., Geotechnical Engineer at Gosling Czubak Engineering Sciences, Inc.

The GCES Construction Monitor is intended to provide discussion and information concerning engineering issues, and is not intended to provide technical or legal advice regarding any specific situation. Readers should consult with an engineer or attorney about specific situations. © 2008 GCES



Gosling Czubak
engineering sciences, inc.

Gosling Czubak
1280
Business Park Dr.
Traverse City, MI
49686-8607

Telephone:
231-946-9191
1-800-968-1062

Fax:
231-941-4603

Website:
goslingczubak.com