MECHANICS OF A CAVE-IN. AN EXAMPLE

An open excavation is an unnatural situation. The average landscape shows no vertical or near vertical slopes.

Soil or dirt is a very heavy material. A cubic foot can easily weigh 114 pounds and a cubic yard can be as heavy as a pick-up truck.

Consider a column of soil which is one foot by one foot and several feet high. At one foot of depth a horizonal plane one foot by one foot is carrying the cubic foot which lies over it. The stress, or load per unit area is 100 lbs. per square foot (psf). At a depth of two feet the horizontal plane is carrying two cubic feet or 200 psf. At a depth of five feet the vertical stress is 500 psf, and so on.

The column described would soon collapse if not supported by similar adjacent columns. Stresses are developed which act horizontally on the column. These lateral stresses can be considered ½ as large as the vertical stresses. At a depth of five feet the vertical stress is 500 psf and the lateral, or horizontal stress is 250 psf.

Undisturbed soil may be visualized as an infinite number of columns of soil adjoining and supporting one another. The system is in equilibrium and is perfectly stable.

When an excavation is cut the system is disturbed. Lateral stresses which existed on the excavation wall are removed as the excavation is done. The soil in the excavation wall immediately begins to move, however slowly, into the excavation.

At the same time the surface of the ground next to the excavation subsides, creating an unnatural situation. The surface of the ground is in tension and some of the weight of the soil in the excavation wall is transferred to the soil back away from the wall face by a phenomenon called shear.

The combination of tension in the ground surface and shear stress causes cracks to form back from the edge of the excavation. Cracks occur from the edge of the excavation. Cracks occur from about ⅓ to ⅔ of the depth of the excavation back from its edge. For example, if an excavation 10 feet deep is dug the cracks may be found somewhere between three to seven feet back from the excavation edge. There may be several cracks. They are usually vertical and they may be ½ the depth of the excavation.

When cracks develop, the weight of the soil in the excavation wall is no longer partly carried by the soil back from the excavation's face.

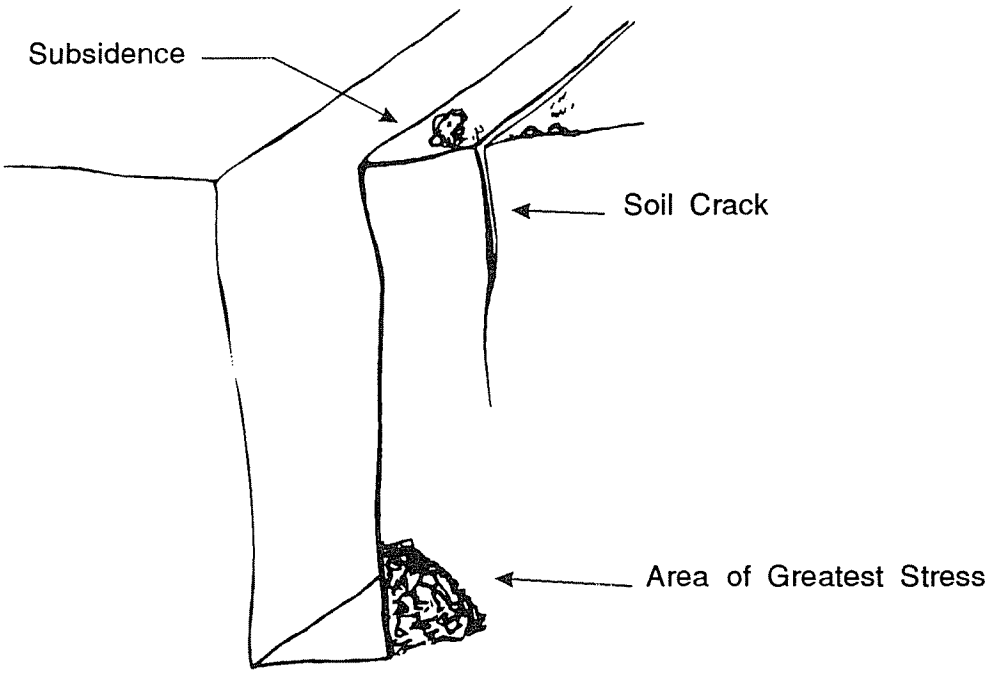
Then the lower part of the excavation wall fails under the great stress from the weight of the soil above it. There is no lateral stress to prevent the failure.

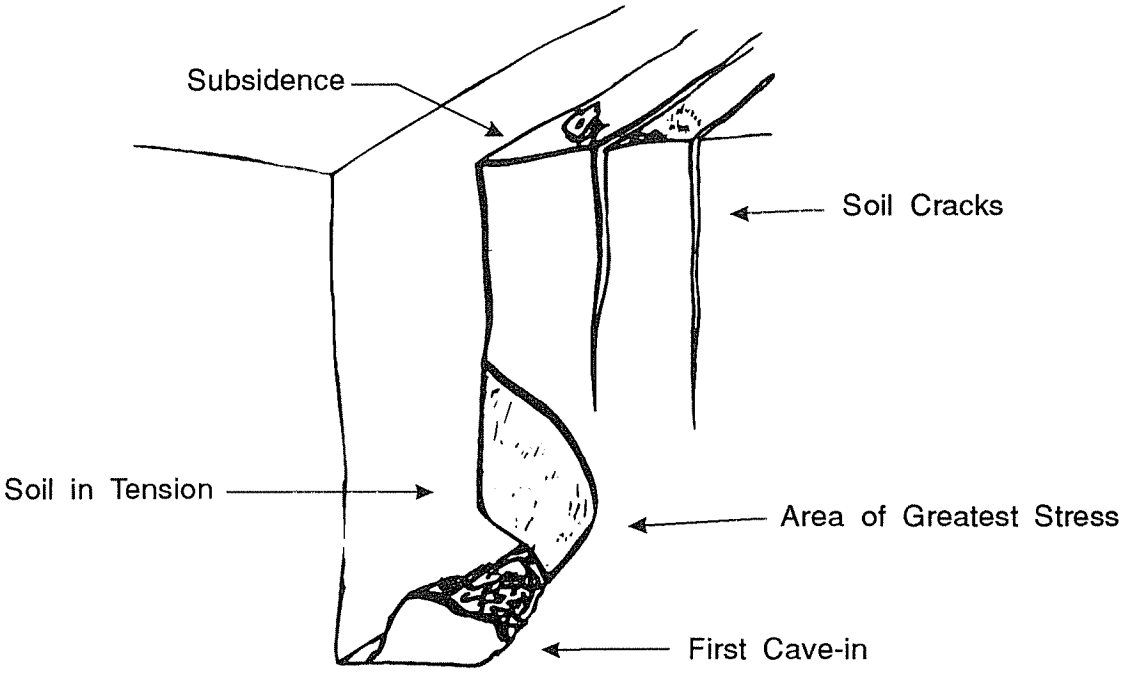
When the bottom of the excavation fails, or "kicks," into the excavation the support for the upper part of the excavation wall is now essentially hanging only be shear and tension forces. Failure occurs.

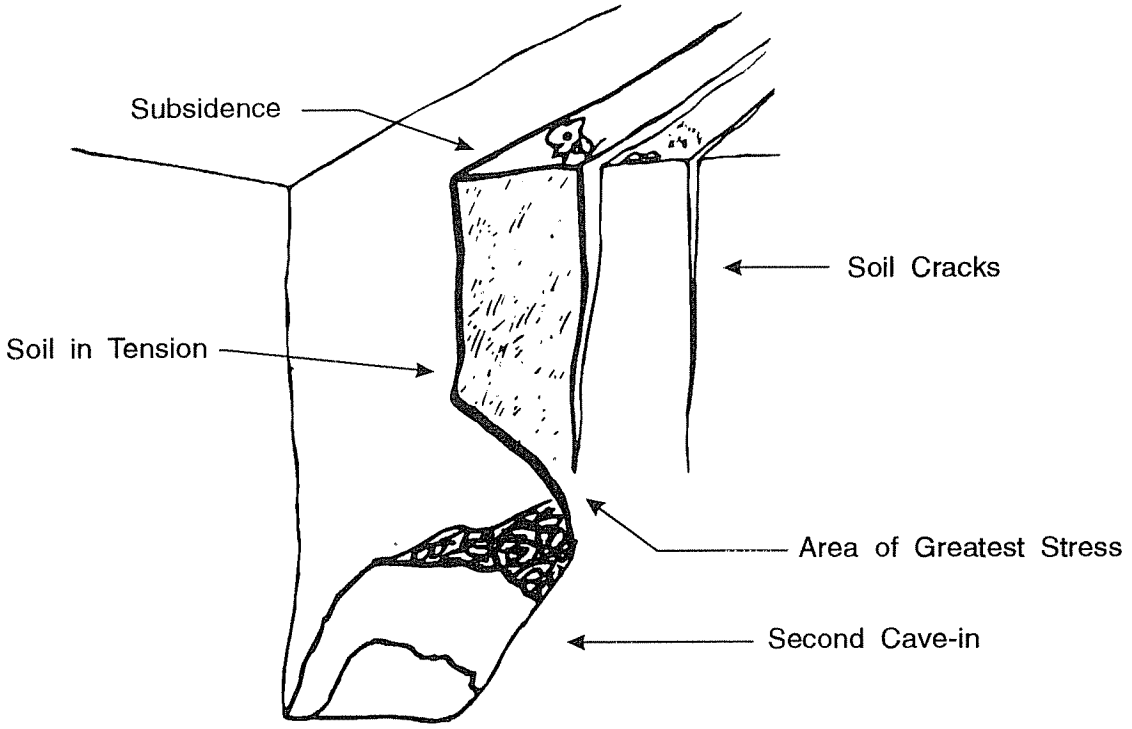
A third cave-in quickly follows. Soil, like concrete, is normally strong in compression but not at all strong in tension. Reinforced concrete makes use of the compressive strength of concrete and the tensile strength of steel. There is no steel in the soil.

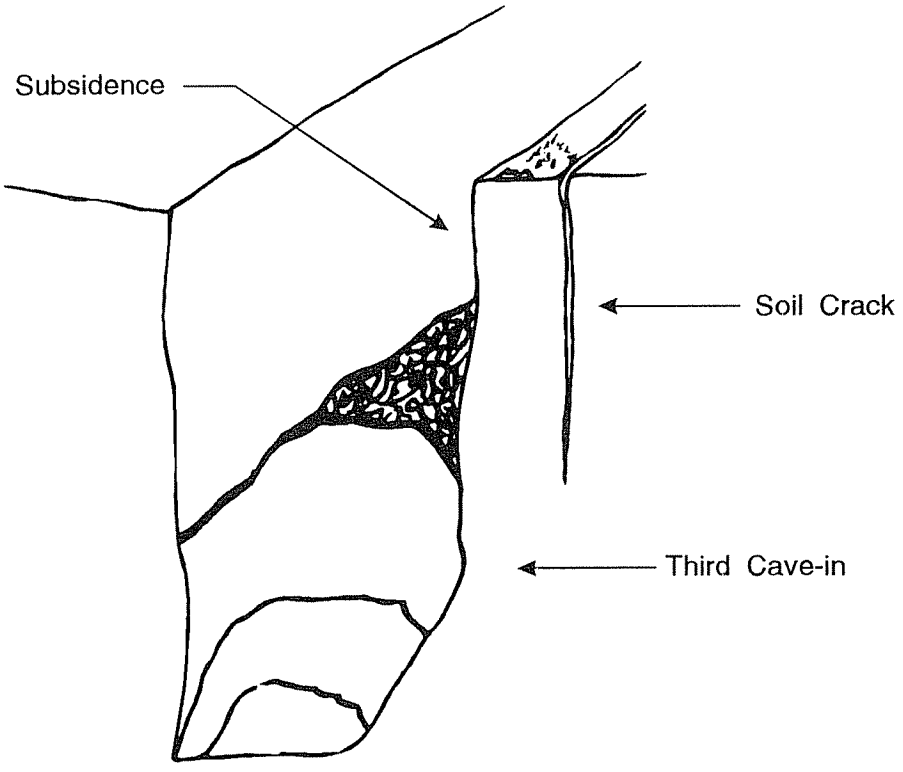
Cave-ins generally come in multiples. If the first one doesn't get you, the second one may and the third is always a possibility.

This example of the mechanics of a cave-in has offered a discussion of some of the forces involved in such accidents. It has by no means considered all of the forces which may be involved in such an occurrence. Weathering, water, vibration and superimposed loads may add to the hazardous conditions leading to cave-ins.


Subsidence
Soil Crack
Area of Greatest Stress


Subsidence
Soil Cracks
Soil in Tension
Area of Greatest Stress
First Cave-in


Subsidence
Soil Cracks
Soil in Tension
Area of Greatest Stress
Second Cave-in


Subsidence
Soil Crack
Third Cave-in