

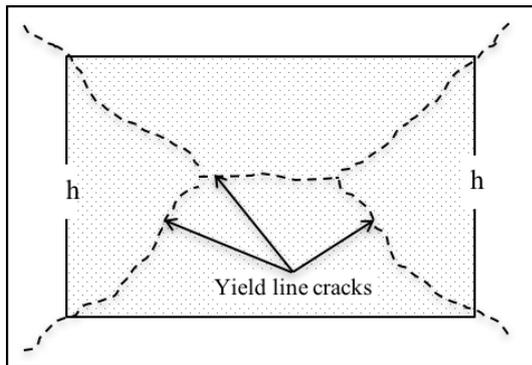
Failure mechanisms of slabs on moisture reactive soil

The self-evident conditions for slab failure are:

1. **Yield condition:** Slab is significantly cracked
2. **Mechanism condition:** Slab distortion is geometrically compatible with crack pattern
3. **Equilibrium condition:** Resultant soil pressure equals total foundation load

In the context of slabs on moisture reactive soil, the yield condition is taken as significant cracking. In this context, cracking due to concrete shrinkage is not significant. However, it should be noted that concrete shrinkage cracks may trigger yield line cracks. Taking a rectangular slab as an example, potential failure mechanisms for slabs on moisture reactive soil are:

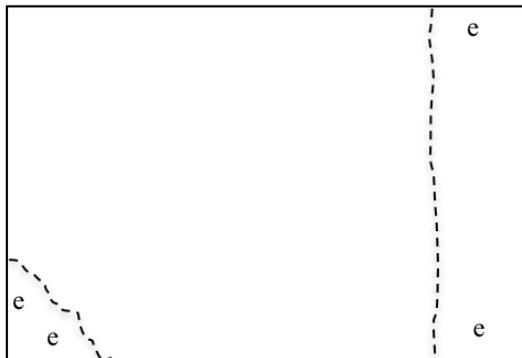
Global doming & dishing failures



Fully developed yield line cracks for global doming & dishing failures

The shaded portion in the diagram at left represents the soil-slab contact area in doming mode failures, and the non-contact area in dishing mode failures. The yield line crack patterns for global doming and dishing failure mechanisms develop as follows: The first yield line crack more than likely starts along the centerline parallel to the long side of the rectangle, where the bending moment is greatest. As foundation movement increases, the central yield line crack lengthens and then splits into two lines heading at about 45° angles to the corners. The fully developed yield line crack pattern looks like a shallow hipped roof. When the yield line cracks are fully developed, further distortion of the slab is like the motion of a three-dimensional mechanism consisting of four plane segments hinged together along the yield line cracks and rotating relative to each other about the yield line cracks. Cracking is on the top surface of the slab in doming distortion, and on the bottom surface in dishing distortion.

Local corner and edge failures



Fully developed cracks for local corner & edge failures

The problem with potential local corner and edge failure mechanisms is that there is no way of relating them to foundation movement. Designers wishing to explore corner and edge failures could consider taking distance e in the diagram at left as the edge distance defined in AS-2870.

Local slab panel failure

The yield line crack pattern for local slab panel failure is similar to global failures, with additional yield line cracks around the panel edges. The critical panel for stiffened rafts is where the upward soil pressure is greatest, at the center of the slab in subsiding foundation movement, in which case all four panel edges are continuous, and at the corner of the slab in heaving foundation movement, in which case only two edges are continuous. There is no soil pressure on the slab panels of waffle rafts, so the critical condition is a concentrated load in the middle of a panel with two continuous edges at a corner of the slab.

Governing failure mechanism

According to the upper and lower bound theorems* in structural mechanics, the governing failure mechanism for slabs on reactive soil exhibits the lowest foundation movement capacity and requires the highest strength to sustain the most severe combination of loading and foundation movement. It is impossible to predict a-priori which failure mechanism governs. Global doming failure usually governs on building sites under normal moisture conditions at time of construction. Global dishing failure may govern on building sites that are abnormally dry at time of construction, followed by a prolonged period of wet weather. Local corner and edge failures may govern on building sites exhibiting non-uniform soil characteristics, such as for example inadequately compacted soil on a cut-fill site, or the presence of gilgais, or the development of sink holes. Isolated slab panel failure may govern when stiffening ribs are too widely spaced or when isolated slab panels are too thin. The author has been made aware of anecdotal evidence of an isolated waffle raft slab panel failing when the owner jacked up a heavy 4-wheel drive vehicle in his garage.

* Like, "*The strength of a chain is that of its weakest link, a slab on moisture reactive soil fails when, where and how it most easily can*".