CHAPTER 7

General soil models

STRESS PATHS AND INVARIANTS

7.1 The implications of the Mohr–Coulomb model: It was shown in Section 6.18 above that the classical Mohr–Coulomb soil model has two important implications. These are:

(a) that the volume changes which commonly accompany shear strains have no effect on the shear strength, and

(b) that the shear strength is independent of the intermediate principal stress component.

In this chapter, we will examine the suitability of the Mohr–Coulomb model as a means of describing the behaviour of real soil, and will consider some other models which might be expected to describe soil behaviour rather better. In the light of this discussion, we will then consider how we should interpret the results of the routine tests described in Chapter 6. First, however, we must construct a reference frame within which our comparisons may be made.

7.2 Principal stress space: The behaviour of a three-dimensional soil element subjected to general stress changes can best be examined by plotting the stresses and yield loci in a three-dimensional principal stress space (Fig. 7.1). Any point in

![Fig. 7.1 Principal stress space.](image-url)
this space defines the magnitudes (but not the directions) of
the three principal effective stress components \( \sigma'_1, \sigma'_2 \) and
\( \sigma'_3 \) with reference to three orthogonal co-ordinate axes.
Since we generally assume that soil cannot resist effective
tensile stress, we are only concerned with that part of the
space in which all three principal stress components are
positive. In this chapter, we shall abandon the convention
that \( \sigma'_1 \geq \sigma'_2 \geq \sigma'_3 \); unless specifically stated to the
contrary, the greatest (or least) principal stress component
may be any one of the three.

Then point \( A \) (Fig. 7.1) represents a stress state in which
\( \sigma'_2 = OA \) and \( \sigma'_1 = \sigma'_3 = 0 \). The plane \( OCBD \) (produced if
necessary) represents all stress states in which \( \sigma'_2 = \sigma'_3 \) (the
condition of axial symmetry in the triaxial test apparatus).
\( OC = \sqrt{2\sigma'_2} = \sqrt{2\sigma'_3} \). The line \( OB \) (produced if necessary)
is the locus of all points for which \( \sigma'_1 = \sigma'_2 = \sigma'_3 \) (spherical
normal stress—see Fig. 5.1). This line is called the *space
diagonal* or *hydrostatic line*. The plane \( E_1E_2E_3 \) (Fig. 7.2) is
drawn normal to \( OB \), so that \( OE_1 = OE_2 = OE_3 \). This is
called an *octahedral plane* (because it would form one face of
a regular octahedron, symmetrical about \( O \)).

7.3 *The stress invariants:* The stress at any point in a body is fully
defined by the normal and shear stress components with
reference to any three orthogonal axes (\( x, y, \) and \( z \)). For
isotropic materials, therefore, it must be possible to state the

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**Fig. 7.2** The stress invariants and the octahedral plane. (a) In principal stress space. (b) View normal to the octahedral plane.