

PART VI
Appendix E

Recommended Criteria for Identification and Classification of Expansive Soil

The following criteria may be adopted to identify and classify expansive soils:

- (1) Based on the values of plasticity index and shrinkage limit, United States Bureau of Reclamation (USBR) suggests the following classification criteria for expansive soil:

Plasticity Index	Shrinkage Limit	Degree of Expansion
>35	<10	Very High
25-41	6-12	High
15-28	8-18	Medium
<18	>13	Low

- (2) On the basis of previous data for linear shrinkage of Bangladesh soils, criteria for the degree of expansion proposed by Hossain (1983) is as follows:

Linear Shrinkage (%)	Degree of Expansion
> 14	High
10-14	Medium
0-10	Low

- (3) On the basis of the values of free swell, Indian standard (IS: 1948, 1970) recommends criteria of expansion is as follows:

Free Swell (%)	Degree of Expansion	Danger of Severity
<50	Low	Non-critical
50-100	Medium	Marginal
100-200	High	Critical
>200	Very High	Severe

- (4) Based on the value of free swell index, Indian Standard (IS: 2911, Part III, 1980) suggests the following criteria for the degree of expansion of soils:

Free Swell Index (%)	Degree of Expansion	Danger of Severity
<20	Low	Non-critical
20 to 35	Medium	Marginal
35 to 50	High	Critical
>50	Very high	Severe

- (5) Based on the values of liquid limit, plasticity index and shrinkage limit, Indian Standard (IS: 2911, Part 3, 1980) suggests the following criteria for the degree of expansiveness of soils:

Liquid Limit (%)	Plasticity Index	Degree of Expansion	Danger of Severity
20-35	<12	Low	Non-critical
35-50	12-23	Medium	Marginal
50-70	23-32	High	Critical
>70	>32	Very high	Severe

- (6) Based on the values of swelling potential, Seed et al. (1962) proposed the following four categories of expansion characteristics:

Swelling Potential (%)	Degree of Expansion
0-1.5	Low
1.5-5	Medium
5-25	High
> 25	Very high

- (7) Based on the values of swelling pressure, Chen (1965) proposed the following criteria for degree of expansion:

Swelling Pressure kg/cm ²	Degree of Expansion
0-1.5	Low
1.5-2.5	Medium
2.5-9.8	High
>9.8	Very high

- (8) Based on the values of volume change from air dry to saturated condition, Seed et al. (1962) proposed the following four categories of expansion characteristics:

Volume Change from Air Dry to Saturated Condition (%)	Degree of Expansion
0 – 10	Low
10 – 20	Medium
20 – 30	High
> 30	Very high

- (9) Look (2007) reports that the plasticity index by itself can be misleading, as the test is carried out on the percent passing the 425 micron sieve, i.e. any sizes greater than 425 μm is discarded. There have been cases when a predominantly “rocky/granular” site has a high PI test results with over 75 percent of the material discarded. The weighted plasticity index (WPI) considers the percent of material used in the test, where $WPI = PI \times \% \text{ passing the } 425 \text{ micron sieve}$. Degree of expansion with weighted plasticity index is presented as under.

Weighted Plasticity Index (%)	Degree of Expansion
< 1200	Very Low
1200 – 2200	Low
2200 – 3200	Moderate
3200 – 5000	High
> 5000	Very high

PART VI
Appendix F
Construction of Pile Foundation

F.1 Introduction

The pile driving process needs to fulfill assumptions and goals of the design engineer just as much as the design process has to foresee the conception and installation of the pile at the site. This is only possible through the selection of the right driving equipment especially hammer with proper assembly mounted on the most suitable leader, operated according to the specified practices of installation that consists of a series of principle and subsidiary procedures.

There are three methods of driving piles: jacking, vibratory driving, and driving. The first two, jacking and vibratory driving are comparatively rare. The reaction needed to push a pile into the ground is equal to the limit pile capacity, which can be a very large load. Until recently, this made jacking suitable only for small piles; large, heavy rigs are now available that can jack normal size piles for onshore applications.

Vibratory driving is only suitable for loose sands, particularly if saturated, because liquefaction of the sand results from the vibration, making it easy to drive the pile into the ground. Vibratory driving is routinely used to drive sheet piles and less frequently used to install relatively small steel H-piles.

The most common method of installing displacement piles is by driving the piles into the ground by blows of an impact hammer. Piles installed in this manner are referred to as driven piles. In order to understand this method of installation, we need to examine first the equipment that is required. A brief description of the driving equipment and procedures as given by Salgado (2011) are presented as under.

F.2 Piling Driving Equipment

Pile driving equipment are broadly classified into three groups; the leader for positioning the pile for driving, the hammer for delivering energy for driving and the driving system components for better and safe distribution of energy on the top of the piles. Hammers are used to install the driven piles. The leader, the pile and the hammer are often carried by a special crawler rig or crane.