

CHAPTER

8

Building Foundations and Site Structures

Almost all buildings, regardless of their size, shape, intended purpose, type of construction, or geographic location, share a common problem: They must rest on the ground. Thus the design of adequate foundations is a general problem in building design. Since each building site is unique in terms of specific geological conditions, each building foundation presents unique design problems.

Most buildings have relatively simple foundation systems. However, there are all kinds of problems that may occur at or below the ground surface. Modern geotechnical science and technology offer a vast array of special solutions to both ordinary and severe problems. Some of these measures are discussed here.

Much of the material presented in this chapter is derived from *Simplified Design of Building Foundations* (Ref. 20). For amplification of most of the topics developed here, reference may be made to that publication.

8.1 GENERAL CONSIDERATIONS

This section summarizes the general issues involved in foundation design, the properties and behavioral characteristics of foundation materials of significance for design work, and the problems of establishing useful design data and criteria.

Basic Problems in Foundation Design and Site Development

The design of the foundation for a building cannot be separated from the overall problems of the building structure and the building and site designs in general. It is useful, nevertheless, to consider the specific aspects of the foundation design that must typically be dealt with.

Site Exploration

For purposes of the foundation design, as well as for building and site development in general, it is necessary to know the actual site conditions in some detail. This investigation usually consists of two parts: determination of the ground surface conditions and of the subsurface conditions.

The surface conditions are determined by a site survey that establishes the three-dimensional geometry of the surface and the location of various objects and features on the site. Where they exist, the location of buried objects such as sewer lines, underground water supply lines, power and telephone lines, and so on, may also be shown on the site survey.

Unless they are known from previous explorations, the subsurface conditions must be determined by penetrating the surface to some depth to obtain samples of materials at various levels below the surface. Inspection and testing of these samples in the field, and possibly in a testing lab, are used to identify the materials and to establish a general description of the subsurface conditions.

Site Design

Site design includes the positioning of the building on the site and the general development, or redevelopment, of the site contours and features. The building must be both horizontally and vertically located. Recontouring of the site may involve both taking away of existing materials (called *cutting*) and building up to a new surface with materials brought to the site or borrowed from other locations on the site (called *filling*). Development of controlled site drainage for water runoff is an important aspect of the site design.

Selection of the Foundation Type

The first part of the foundation design is the determination of the type of foundation system to be used. This decision

cannot be made until subsurface conditions are known in some detail and the size, shape, and location of the building are determined. In many cases it is necessary to proceed with an approximate design of several possible foundation schemes so that results can be compared.

Design of Foundation Elements

With the building and site designs reasonably established, the site conditions known, and the type of foundation determined, work can proceed to the detailed design of individual structural elements of the foundation system.

Site Structures

Although they may have little direct relation to the building and its foundations, design of site structures must also be done using the same information base as that for the foundations. With unusual sites, such as those with waterfront locations or very steep slopes, site structures and building foundations may have some direct relationships and require a coordinated design.

Construction Planning

In many cases the construction of the foundation requires a lot of careful planning. Some possible problems include conditions requiring dewatering the site during construction, bracing the steep sides of excavations, underpinning of adjacent structures, excavating difficult objects such as large tree roots or existing construction, and working with difficult soils such as wet clay, quick sand, or soils with many large boulders. The feasibility of dealing with these problems may influence the foundation design as well as the positioning of the building on the site and the general site development.

Inspection and Testing

During the design and construction of the foundation there may be times when it is necessary to perform additional discovery and testing of site materials. This information may be required because of choices for the foundation design or because of inadequacy of the information obtained before design work was started. Testing may also be required if soil materials or conditions not revealed by other discoveries are encountered during construction. With very large sites, it is often not reasonable to do investigations on a widespread basis before any design work begins.

Soil Considerations Related to Foundation Design

The general character of soils as well as some specific physical properties must be established for planning and design of the building foundation and site structures. This information may be related to the structural design work or simply to the necessary planning of the site work in general. The general areas of concern include the following.

Structural Properties

The principal properties and behavior characteristics of soils that are of direct concern in foundation design are the following:

Strength. For bearing-type foundations the main concern is the resistance to vertical compression. Resistance to horizontal pressure and to friction are of concern when foundations must resist horizontal forces of wind and earthquakes or retained earth.

Strain Resistance. Deformation of soil under stress is of concern in designing for limitations of the movements of foundations, such as the vertical settlement of bearing foundations.

Stability. Frost action, fluctuations in water content, seismic shock, organic decomposition, and disturbance during construction are some of the sources that may produce changes in physical properties of soils. The degree of sensitivity of the soil to these actions is called its *relative stability*.

Properties Affecting Construction Activity

A number of possible factors may affect construction activity, including the following:

- Relative ease of excavation
- Ease of and possible effects of site dewatering during construction
- Feasibility of using excavated materials for required site fill operations
- Ability of the soil to stand on a near-vertical cut at the edge of an excavation
- Effects of construction activities—notably the movement of workers and equipment—on unstable soils

Miscellaneous Conditions

In specific situations various factors may affect the foundation design or the problems to be dealt with during construction. Some examples are the following:

- Location of the water table, affecting soil strength or stability, need for waterproofing basements, requirements for dewatering during construction, and so on
- Nonuniform conditions on the site, such as pockets of poor soil and soil strata that are not horizontal
- Local frost conditions, possibly producing heave (swelling) and settlement of foundations and paving
- Deep excavation or dewatering operations, possibly affecting the stability of adjacent properties, buildings, streets, and so on

Foundation Design Criteria

For design of bearing-type foundations several structural properties of a soil must be established. The principal such values are the following:

Allowable Bearing Pressure. This is the maximum permissible value for vertical compression stress at the contact surface of the bearing elements. It is typically quantified in terms of pounds or kips per square foot of the contact surface.