Substations - Volume VIII: Site and Foundation Design

An Online Continuing Education Course for Engineers

Course Number: E-5010

Credit: 5 Hours / 5 PDH / 5 CPD

Substations – Volume VIII: Site and Foundation Design

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Preface

This course is one of a series of thirteen courses on the design of electrical substations. The courses do not necessarily have to be taken in order and, for the most part, are stand-alone courses. The following is a brief description of each course.

Volume I, Design Parameters. Covers the general design considerations, documents and drawings related to designing a substation.

Volume II, Physical Layout. Covers the layout considerations, bus configurations, and electrical clearances.

Volume III, Conductors and Bus Design. Covers bare conductors, rigid and strain bus design.

Volume IV, Power Transformers. Covers the application and relevant specifications related to power transformers and mobile transformers.

Volume V, Circuit Interrupting Devices. Covers the specifications and application of power circuit breakers, metal-clad switchgear and electronic reclosers.

Volume VI, Voltage Regulators and Capacitors. Covers the general operation and specification of voltage regulators and capacitors.

Volume VII, Other Major Equipment. Covers switch, arrestor, and instrument transformer specification and application.

Volume VIII, Site and Foundation Design. Covers general issues related to site design, foundation design and control house design.

Volume IX, Substation Structures. Covers the design of bus support structures and connectors.

Volume X, Grounding. Covers the design of the ground grid for safety and proper operation.

Volume XI, Protective Relaying. Covers relay types, schemes, and instrumentation.

Volume XII, Auxiliary Systems. Covers AC & DC systems, automation, and communications.

Volume XIII, Insulated Cable and Raceways. Covers the specifications and application of electrical cable.

Chapter 1: Site Design

This chapter covers the design factors related to the substation site. The objective of site work design for a substation yard is to provide an easily accessible, dry, maintenance-free area for the installation and operation of electrical substation equipment and structures. The utility should take advantage of the natural drainage and topographical features in the design consistent with the electrical layout since coordination of the two is essential.

Types of Graded Yards

There are generally three basic profiles for substation yards:

1. Flat—most prevalent
2. Sloped—occasionally required
3. Stepped—seldom required

1. Flat Yards

The basic flat yard is more desirable for the layout and operational function of a substation. It permits uniformity in foundation elevations and structure heights. Unless there are property restrictions, severe topographical features, subterranean rock, or other considerations dictate otherwise, the yard should be graded nominally flat. See Figure 1.

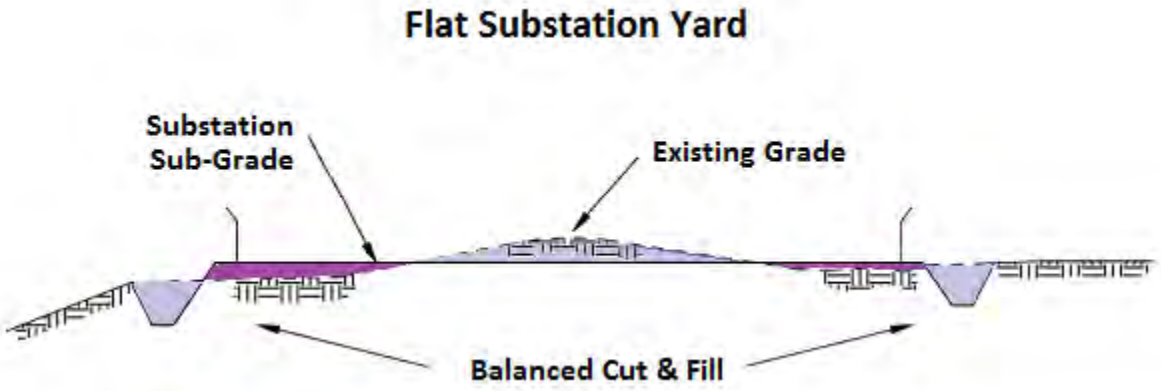

Figure 1

2. Sloped Yards

Occasionally, property restrictions or economic considerations will outweigh the desirability for a flat yard, and a continuously sloping yard may be advantageous. See Figure 2.

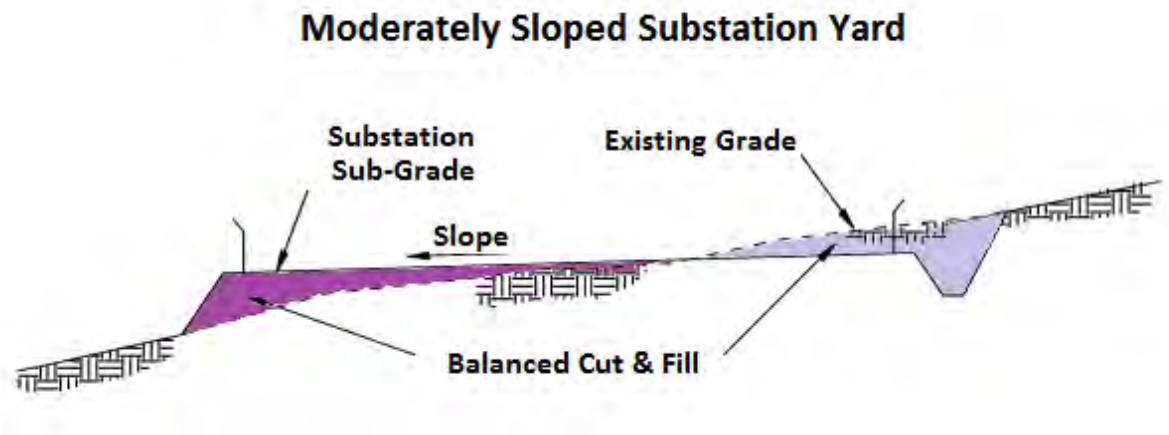

Figure 2

3. Stepped Yards (Two or More Levels)

Stepped yards are usually created by extreme property restrictions, adverse mountainous terrain, or underlying rock formations making excavation uneconomical. See Figure 3.

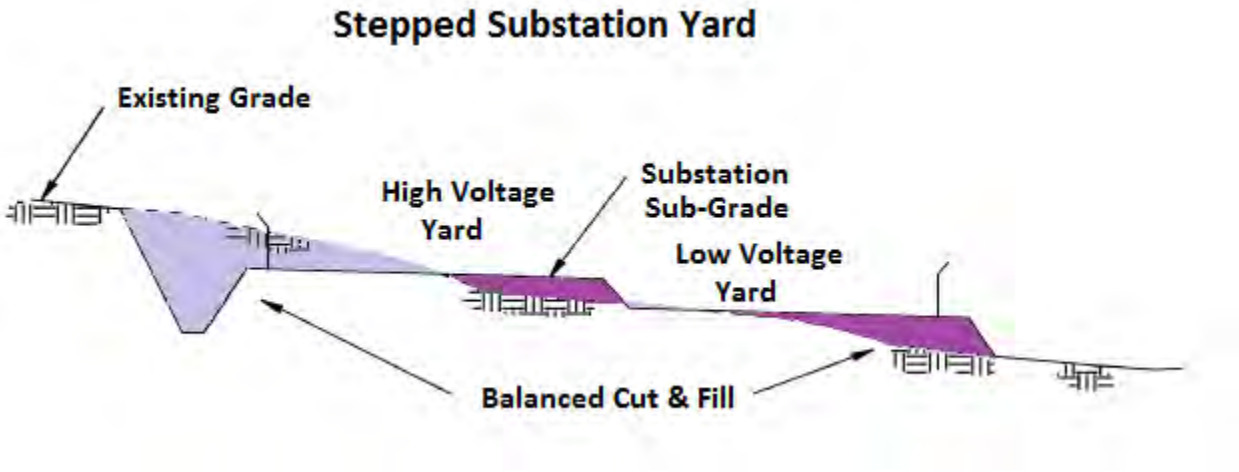

Figure 3

Modification of any of the three types may be necessary to arrive at the optimum yard design. Sloped and stepped sites entail extra design considerations and close coordination with the electrical layout. There may be more structures required and variable foundation elevations.

Preliminary Requirements

The following lists some of the basic information required for the site preparation design for a substation yard:

- Area maps
- Topographic drawing of immediate area showing:
  - Ground elevations on a grid system at 50-foot spacing
  - Location and elevation of existing roads, railroads, ditch inverts, and culverts
  - Location of pertinent overhead or underground utilities, particularly the exact location and depth of any pipelines
  - Property plan
  - Legal description of property
  - Location of the area's drainage exits
  - High water elevation in
  - Floo ny
- Soil borings

Drainage Consider

Review state and loca nent requirements. Many local governments ha stormwater detention or retention basins be pr ite.

Generally all three pro ch a system consists of a gently sloping (0.5 pe ater drains to the edge of the yard or to shallo e into culverts or shallow open channels

A *closed drainage syste* ewer pipe that provides a more positive means of yard d ystem is quite costly. Circumstances other than economics, however, may require the use of this system.

The yard surface drainage has to be coordinated with the location of cable trenches and roads within the yard. The yard profile (flat, sloped, or stepped) may present varying drainage design considerations. Careful review of the quantity, quality, and particularly the location of the discharge water from the yard is emphasized. Planning the initial drainage system for a future substation addition is sometimes required. Generally a good rule to follow is do not discharge any more water into an existing drainage area outlet than what originally occurred. Small interceptor ditches strategically located will prevent erosion of slopes or embankments.

Whenever it is necessary to calculate the amount of rainfall runoff for the design of culverts, storm sewer pipes, detention or retention ponds, or ditches, a widely used and accepted method is the *Rational Method*. The Rational Method is not recommended for drainage areas much larger than 100 to 200 acres.