CVNG 1009 ENGINEERING GRAPHICS

By R. Clarke

1.0 Introduction

1.1 Learning Outcomes:-

At threshold, the student shall be able to:

1. Do freehand sketches.
2. Draw scaled civil engineering drawings using a drawing board and "T" square.
3. Draw and print a scaled civil engineering drawing using AUTOCAD.

1.2 Scope:-

The course only discusses engineering graphics in a civil engineering context. Furthermore, consideration is given to the practice of civil engineering drafting within the Caribbean region. Hence, the course content is limited to:

- 2-dimensional (2D) hand-drawn representation of 3-dimensional (3D) objects
- The use of AUTOCAD for 2D drawing
- Simple use of settings and styles in AUTOCAD

1.3 Civil Engineering Applications

Civil engineering is a specific set of activities that gives rise to the built environment. Civil engineering culminates in the construction of an object of substantial size that is required to contain either people, equipment, or materials, or that links regions of the environment. Examples of the former are: buildings; tanks; silos, and retaining walls. Examples of the latter are: roads; bridges; culverts, and drains. A civil engineering project usually entails the construction of several such objects or components.

Each of these objects must be built following an unambiguous description of the object. Drafting is the exercise of providing this clear and complete description on paper, or digitally, or both. For any of the aforementioned objects, a set of drawings is typically required for a complete description of the object.

As with any activity meant to involve other people who may be scattered over space (say in other countries), or over time (as the same role on a project may be executed by different persons as time moves on), standardized ways of providing this description of the object are required, or there may be misunderstanding.

2.0 Civil Engineering Graphics Fundamentals

"Graphics" is a term used by professionals of many disciplines – tailors, ergonomists, interior, designers, architects, engineers, etc. They all have as a common meaning, the use of drawing as a form of communication between the person who conceptualized the object to be physically made, and the person who will make it. "Graphics" is a noun but "drafting" (also known as "technical drawing") is a verb and they both refer to images. "Graphics" connotes the properties of lines and marks in general, whereas "drafting" connotes the activity of their creation.

As an activity, "drawing" is a more general term that can be used to also describe creating works of art as images, which can be interpreted in several ways. The output of the activity called "drafting", is a drawing which is typically an image on paper, or a computer screen. However, unlike a work of art, the drawing which is the result of drafting, is meant to have only one interpretation.

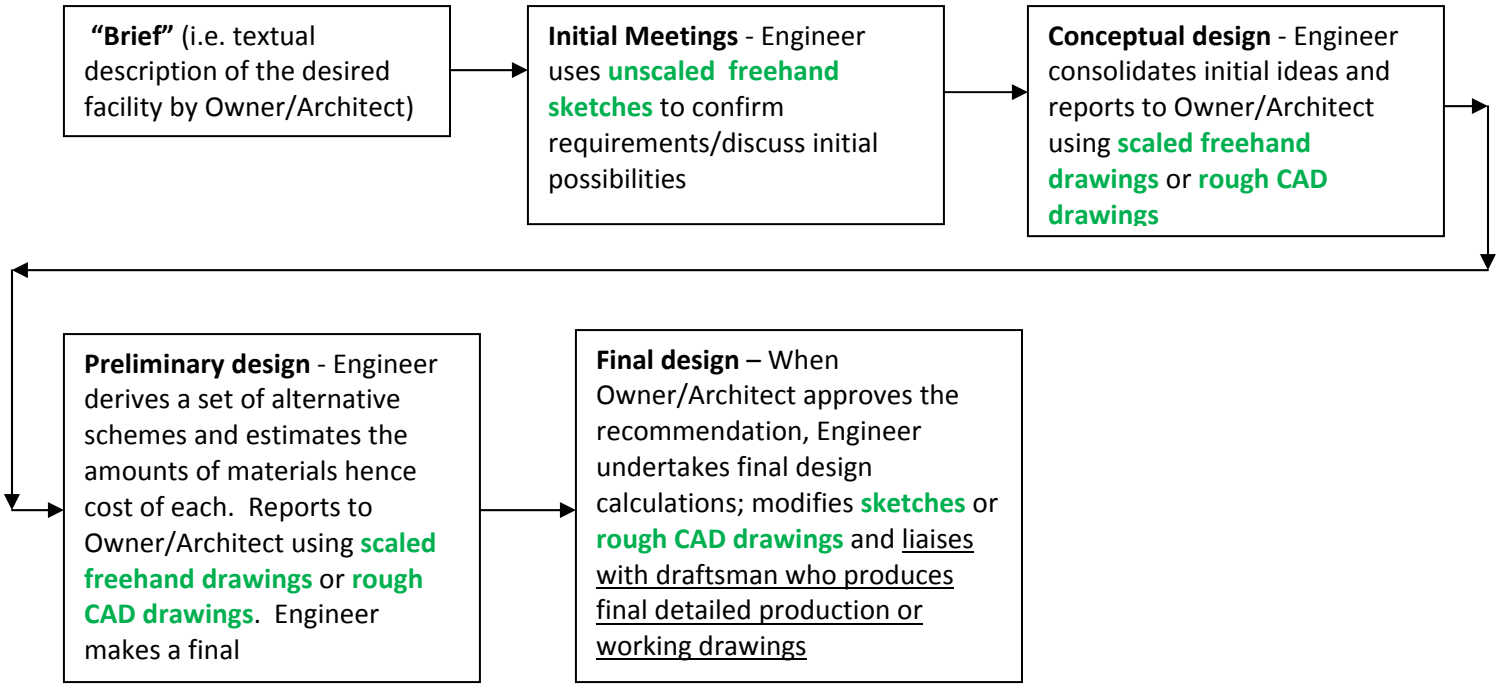
There are various types of engineering – civil; mechanical; electrical; computer, etc. Each of these also has sub-disciplines. For example, in civil engineering there is structural, environmental, water and wastewater, geotechnical, transportation, highway, and coastal engineering.

Because of the differences in the size, shape, and texture of the object in question, the actual drawing, and the practice of its creation, are usually quite different from one graphics professional to another. However in engineering, the form that graphics takes is additionally and primarily affected by the activity called "engineering design" because of the role of engineering design in the practice of engineering as a whole. Each engineering discipline has its own typical types of elements that comprise a set of drawings for a project. These typical elements will be discussed in a subsequent section.

2.1 Civil Engineering Design and the Design Process

In engineering, "design" can be defined as the control of phenomena by the derivation or selection of systems (i.e. collections of objects or components) with the appropriate properties to meet certain desired performance requirements for those systems. Henceforth, the term "design" shall refer to civil engineering design only.

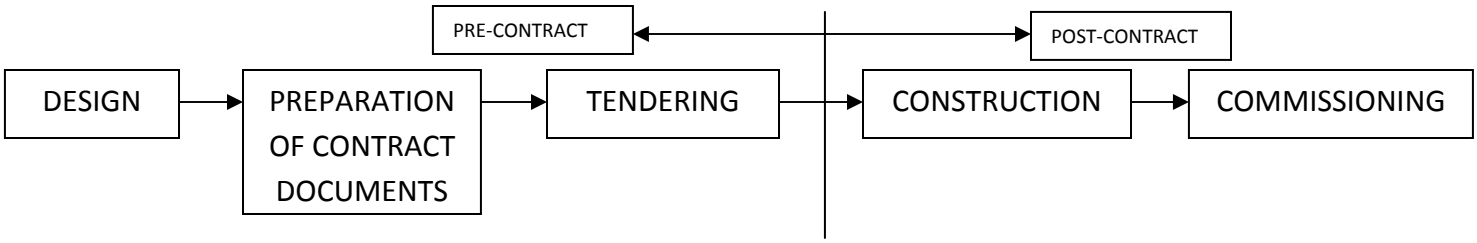
Design begins with a set of ideas about an object, and ends with its full description as a set of drawings. The design process itself involves a number of stages as shown below. Note that different kinds of graphic communication are used by the engineer – sketches and computer-aided drafting (i.e. CAD) drawings.



THE CIVIL ENGINEERING DESIGN PROCESS

2.2 The Role of Design in Engineering Practice

The Owner of a proposed facility commissions a professional engineering firm to provide all the services required for the development of that facility. This begins with the design of each component. Traditionally, this is followed by the preparation of the contract documents, the invitation of tenders, the selection of a tender, then the construction and commissioning of the facility. Collectively, the phases of work from meeting with the Owner, through design, the preparation of the contract documents, and the award of tender is called the "Pre-Contract" work stages. The stages of construction, construction administration, and commissioning of the facility are called the "Post-Contract" work stages.



TYPICAL PHASES OF A CIVIL ENGINEERING PROJECT

As indicated in the above diagram, design is the foundation of all the activities of a civil engineering project. Of main relevance for Engineering Graphics is that the drawings resulting from the design are one of the central parts of the contract between the contractor and the Owner. This is because the contract is to build what is shown on the drawings.

This fact is very important and cannot be understated – the drawings are central to a project because any incorrect or incomplete information that are or should be on the drawings can cause significant safety issues, construction delays, increased costs, damaged relationships, and legal problems.

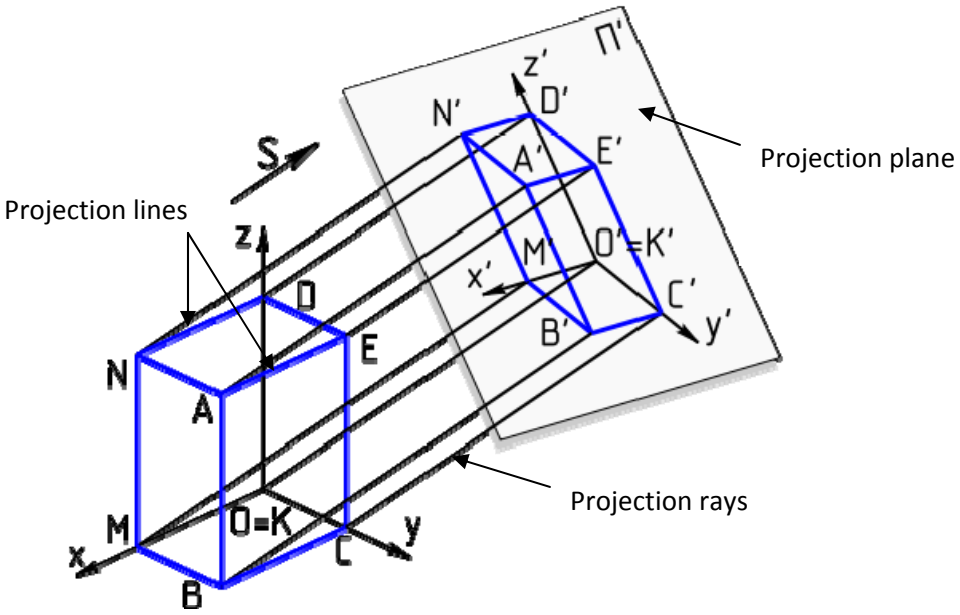
3.0 3D Objects and Projections

Any object that is the focus of a civil engineering project is a 3-dimensional (3D) object (i.e. a building, tank, bridge, etc). The object can be depicted using views obtained by projecting the lines of the object onto planes, and planes are by definition 2-dimensional (i.e. 2D). Such a view is called a "graphical projection".

A projection is drawn by projecting rays from the 3D object, onto the viewing plane, then connecting the points on the plane. The main types of projection are parallel projections and perspectives.

3.1 Parallel Projections:-

Parallel projections have lines of projection that are parallel both in reality and in the projection plane.



EXAMPLE OF PARALLEL PROJECTION (credit to: *Yuri r at the Yuri Raysper project)*

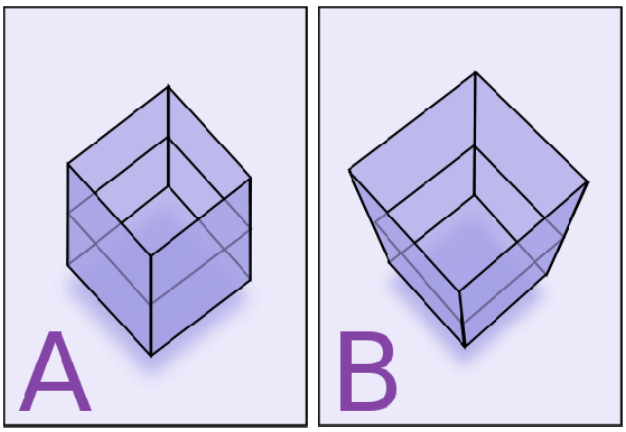
Axonometric Projection:
The projection shown in the diagram above is called an "axonometric" projection. In such a projection, the plane or axis of the object depicted is not parallel to the projection plane. Hence multiple sides of the object are visible in the projection plane. Lines in axonometric projections appear foreshortened, and the projection rays are at right angles to the projection plane. Foreshortening refers to the visual effect that an object appears shorter than it actually is because it is angled toward the viewer.

Isometric Projection:
An isometric is a special case of an axonometric projection. In an isometric drawing, the viewing direction is such that the 3 axes of space appear equally foreshortened and the angles between them are 120°.

Orthographic Projection:
In an orthographic projection, the plane or axis of the object depicted is parallel to the projection plane. Hence multiple sides of the object are not visible in the projection plane and the lines in the projection are not foreshortened. That is, the object appears 2D, and the lines are of true length. The term "orthographic" is also used when the projection rays are at right angles to the projection plane. Therefore in this sense, an axonometric projection can be considered a type of orthographic projection.

3.2 Perspective Projections:-

Unlike parallel projections, perspective projections have lines of projection that are parallel in reality but not in the projection plane. A perspective projection is a view as it is seen by the eye. Any perspective representation that includes parallel lines has one or more vanishing points. All lines parallel with the viewer's line-of-sight recede to the horizon towards this vanishing point (e.g. highway lane lines). In the example below, image B is the perspective projection.

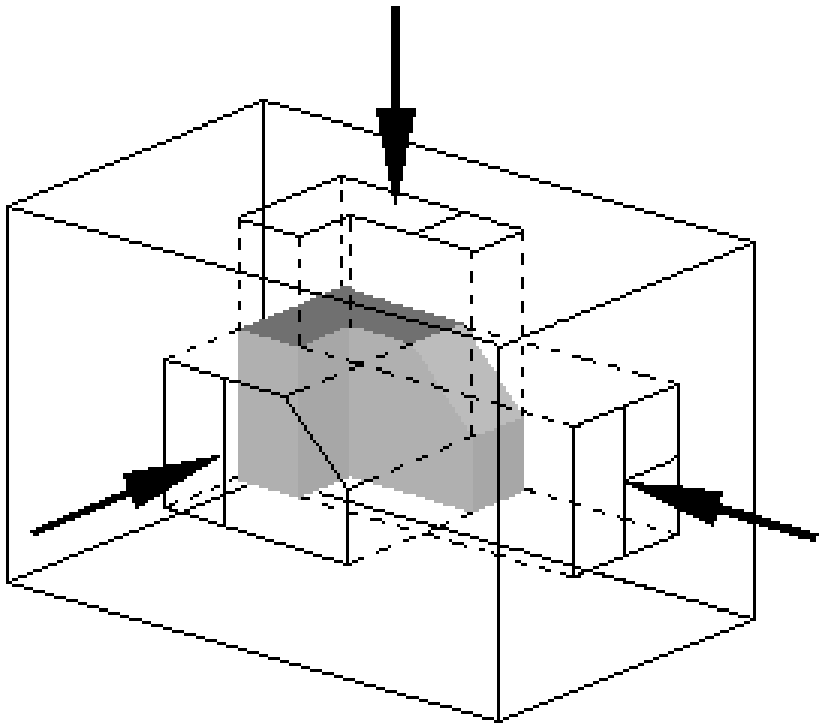


EXAMPLE OF PERSPECTIVE PROJECTION (credit to: Mysid)

3.3 Use of Projections in Civil Engineering Graphics

In civil engineering application, experience has indicated that the most cost-effective, complete, and unambiguous representation of a 3D object is obtained by using multiple orthographic projections. Therefore, this is by far the most used type of projection.

There are two types of orthographic projection used in engineering graphics – first-angle projection, and third-angle projection. In the former, common to Europe, the resulting image is like an X-ray image of the object so is shown on the opposite side of the object. In a third-angle projection (U.S and Canada) the left-side projection is placed on the left side, the right-side projection on the right side, etc. Multiple orthographic projections are the bases of the typical elements of a set of civil engineering project working drawings.



EXAMPLE OF THIRD-ANGLE PROJECTION (credit to: BAxlerod*)*

Axonometric projections, especially isometric projections, are typically used for pipe-work drawings, especially plumbing. Architects frequently make use of perspective projections, but civil engineers rarely do. With the prevalent use of computer-aided drafting however, any desired type of projection can be readily generated.