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SD-E - Structural Design for Non-Structural Engineers

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Short Description

This manual will help you gain the basic knowledge of structural engineering including principles of analysis of structures and their application, behavior of materials under loading, selection of construction materials and design fundamentals for RCC and steel structures.

The emphasis has been kept on the determination of the nature and amount of stress developed under loads, and the way structures offer resistance to it. Being the most widely used construction materials, RCC and steel have been covered in detail, though masonry and timber have been described briefly as well.

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This chapter describes the basic objectives of the course and provides an insight to various aspects of structural engineering, including its scope and the fields of its application.

Learning objectives

After completing the study of this chapter, you will be able to:

- Understand the role of the structural engineer.
- Gain awareness of the processes governing structural engineering.
- Appreciate the overall objective of the course.

1.1 Introduction

Structural engineering is the branch of engineering that deals with the analysis and design
of structures. For this purpose, a structure can be defined as an assembly of various physical components, combined in a way which makes them act together effectively against loading conditions. This process of assembling or combining various elements together is
called construction.

At times it may be possible for a structure to have only a single element, but such simple cases usually are rare.

Bridges, buildings, transmission towers, trusses, water tanks, industrial sheds, etc., are some of the common types of structures that one frequently encounters in day-to-day life. Figures 1.1 to 1.4 on the following pages illustrate some structures under various classifications.

Figure 1.1

RCC Building – Under Construction

Figure 1.2

Bridge

Of the examples shown, building under Figure 1.1, bridge under Figure 1.2 and industrial shed of Figure 1.3 are those which one usually comes across more often. Whereas, concrete dome of Figure 1.4 are not so common to observe and can be termed as special purpose structures. The detailed classification of the structure has been described under the following chapter of the manual

Figure 1.3

Steel Framed Structure

Figure 1.4

RCC dome

1.2 Structural design – the process

The basic purpose of the design of any structure is to ensure that it remains safe as well as functional under the most severe conditions of uses during its lifespan. The designer is expected to achieve this in the most economical way following scientific principles.

The overall design operation follows well established set of processes. The functional planning takes into consideration the purpose for which the structure is being designed. It involves provision of areas and spaces including their interrelation, planning of utilities and services required, providing for special features for the structure, etc. This process enables finalization of shape and plans of the structure. These layout plans get refined further as more experts get involved providing their inputs on specific issues. These layouts are extremely important since they enable the designer to select the optimum structural system as well as the construction materials.

Further to deciding layout plan and structural arrangement, the designer starts working out the structural details of the individual components. This process involves determining the prospective loads applicable on the structure. The loads on the structure can be classified under several categories. This aspect has been dealt in detail in the following chapter of this manual.

In modern times, however, the complexity involved in the design process has gone up due to the following reasons:

- Due to advancements in manufacturing processes, the variety of construction materials available has widened considerably in the last few years. The characteristics of materials also are improving rapidly. The challenge for designers to keep themselves abreast of these developments need not be emphasized.
- The rate of flow of information coming out of various studies and researches, be it on method of analyzing or on the behavior of materials, has increased substantially during recent years. The speed of their adoption within the engineering profession has also gone up. This means that designers are constantly updating themselves on new principles,

philosophies, analysis tools, etc.
- Design tools, which include software programs too, are being refined and upgraded quite regularly.

With these technological advancements in the field of engineering, it is specialist structural engineers nowadays who handle the task of designing the structures. At the same time, the engineering applications are often interdisciplinary, involving the participation of several disciplines of engineering. Construction engineers have always been involved in the overall installation and maintenance of structures. In the case of buildings, the architect plans and decides on the features of the project. Therefore, it is imperative that construction engineers and architects have some basic knowledge of structural design and engineering in order to perform their functions effectively. For industrial structures, the end-user is usually a manufacturing engineer. The awareness of the structure's behavior and limitations can help him decide on safe operational practices. Building inspectors, surveyors, etc., can also benefit from the knowledge of principles of structural engineering.

1.3 Elements of structural design

An engineering design activity may be defined as the application of basic principles of science to ensure a safe, easy in practice and cost-effective solution for a situation. In accordance with it, the structural design exercise simultaneously applies the principles of the following streams of science:

- Mechanics
- Strength of materials
- Statistics

The principles of mechanics are applied to analyze the behavior of each and every component of the structure under specified loading conditions. For this purpose, the members are commonly assumed to be rigid bodies, thus ignoring any deformations caused by induced stress. The principles of mechanics help in establishing external load-reaction relationships for the structure and its members. It is useful in determining the best structural arrangement for a particular situation.

The strength of materials is the science of relationship between an externally applied load and its internal effect on the bodies. For this, the bodies are no longer assumed to be rigid and their deformations under stresses are focused on. The application of the science of strength of materials helps in mainly determining the probable characteristic of material and through this, the optimum construction material itself. Also obtained are the sectional properties of the members for a given structural system. In addition, these principles help in the determination of internal stresses too for the more complex structural systems.

Statistics as a tool helps the design engineer work out the probability of a particular loading event occurring during the lifespan of the structure. With the help of this information, the engineer can identify the worst expected loading condition on a particular structural system during its entire lifetime. This is the most important set of information sought for the design process. Besides, statistics also helps in identifying the probable variation in the behavior of various construction materials, although the load conditions may remain similar. This information is useful to determine the allowance that needs to be considered towards the material characteristics in the given situation. The studies on construction materials, though, are almost always done independently with their results made available to the entire design fraternity that can apply them in the relevant situations. It is important to state that in the event of an uncommon design situation, it may become necessary for the design engineer or engineers to undertake this entire exercise prior to finalizing the design.

Information technology is a facilitator that helps maintain design databases that are useful during routine design as well as in situations while new design philosophies are being implemented.
In addition, with the help of the information technology, one also can undertake the conduction load simulations as well as modeling for the proposed structure, which can highlight certain behaviors as well as can validate the assumptions made. This is useful to finalize the form of the structure. The information technology assists the designer in even finalizing the drawings and design documents.

1.4 Course objectives

The main objective of this course is to bring good awareness of structural engineering principles to those who have no formal training in the subject but are still involved with the building industry in certain roles. Apart from providing fundamental knowledge, the course also aims to impart reasonable degree of skill in solving analysis and design related problems in structural engineering.

1.5 Course outcomes

- Acquiring basic knowledge of the properties and behavior of engineering materials.
- Gaining the ability to analyze the stress-state of members under tension, compression, shear, and bending.
- Acquiring the ability to analyze deformation of members under loading.
- Understanding concepts used for analyzing statically determinate and indeterminate structures.
- Understanding the basic design of reinforced cement concrete structures.
- Understanding the basic design of steel structures.
- Understanding the basic design of masonry and timber structural members.