Chapter III: Design of Reinforced Concrete (RC)

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Objectives

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- Identify the behavior, building members, factors affecting choice, historical development buildings of RC
- Design and Analysis of RC sections of beams

1. Reinforced Concrete (RC)

II

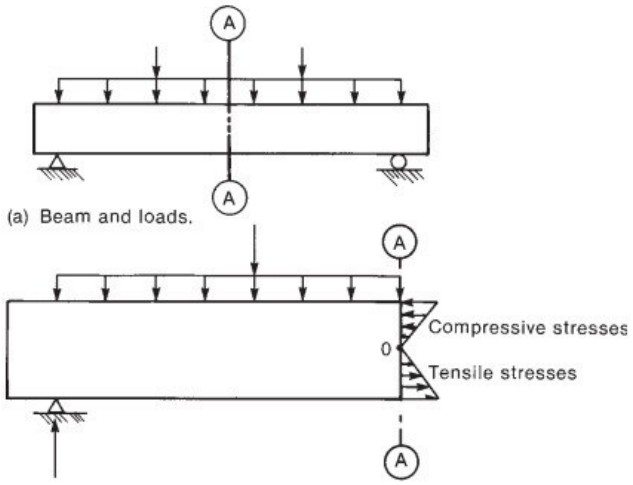
A. 1.1. Definition

Definition

Reinforced concrete is a dominant structural material in engineered construction. The universal nature of reinforced concrete construction stems from the wide availability of reinforcing bars and of the constituents of concrete (gravel or crushed rock, sand, water, and cement), from the relatively simple skills required in concrete construction, and from the economy of reinforced concrete compared with other forms of construction. Reinforced concrete is used in buildings of all sorts.

B. 1.2. Behavior of RC

Concrete is strong in compression, but weak in tension. As a result, cracks develop whenever loads, restrained shrinkage, or temperature changes give rise to tensile stresses in excess of the tensile strength of the concrete. In the plain concrete beam shown in the bellow figure, the moments about point O due to applied loads are resisted by an internal tension–compression couple involving tension in the concrete. An unreinforced beam fails very suddenly and completely when the first crack forms. In a **reinforced concrete** beam (c), reinforcing bars are embedded in the concrete in such a way that the tension forces needed for moment equilibrium after the concrete cracks can be developed in the bars.



(a) Beam and loads.

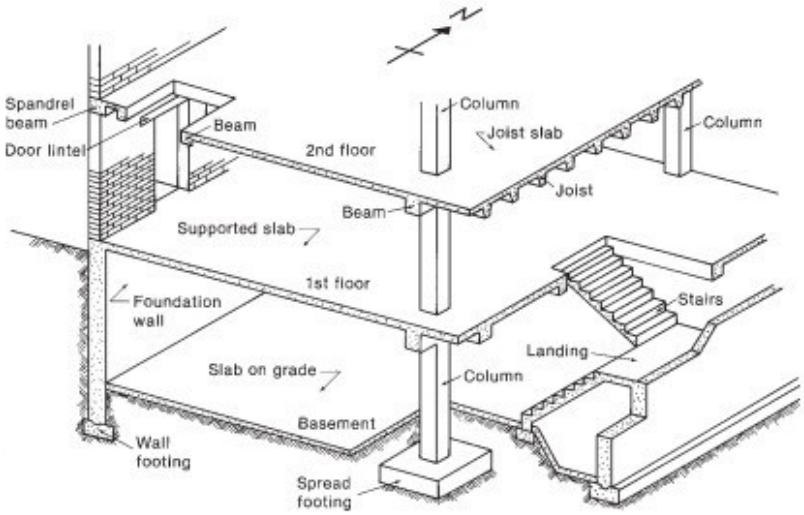
(b) Stresses in a plain concrete beam.

(c) Stresses in a reinforced concrete beam.

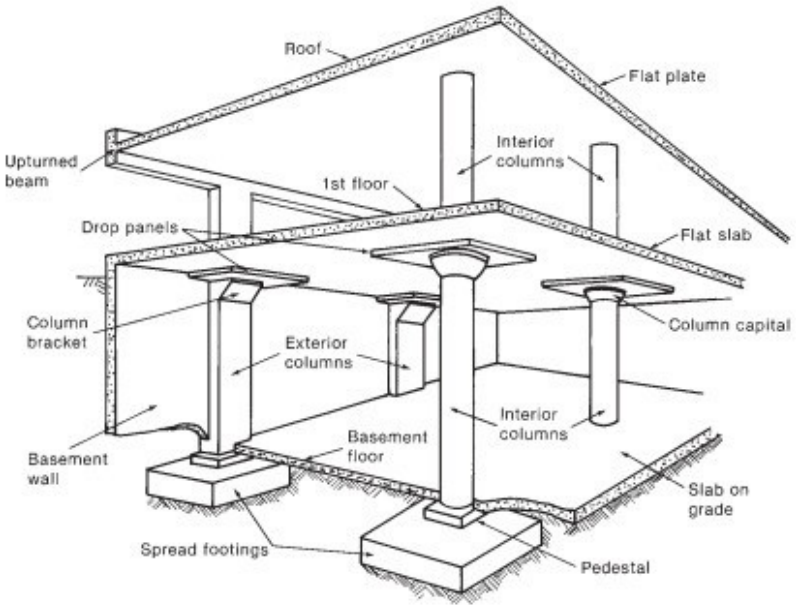
Plain and reinforced concrete beams.

C. 1.3. RC structures members

Reinforced concrete structures consist of a series of "members" that interact to support the loads placed on the structure.



Reinforced concrete building elements.



D. 1.4. Factors affecting choice of RC for a structure

The choice of whether a structure should be built of reinforced concrete, steel, masonry, or timber depends on the availability of materials and on a number of value decisions:

- **Economy**: it has considerable compressive strength per unit cost compared with most other materials.
- **Suitability of material for architectural and structural function**: a reinforced concrete system frequently allows the designer to combine the architectural and structural functions. Concrete has the advantage that it is placed in a plastic condition and is given the desired shape and texture by means of the forms and the finishing techniques.

- **Fire resistance**: A concrete building inherently has a 1- to 3-hour fire rating without special fireproofing or other details.
- **Rigidity**: the occupants of a building may be disturbed if their building oscillates in the wind or if the floors vibrate as people walk by. Due to the greater stiffness and mass of a concrete structure, vibrations are seldom a problem.
- **Low maintenance**: concrete members inherently require less maintenance than do structural steel or timber members.
- **Availability of materials**: sand, gravel or crushed rock, water, cement, and concrete mixing facilities are very widely available, and reinforcing steel can be transported to most construction sites more easily than can structural steel.
- **Low tensile strength**: as stated earlier, the tensile strength of concrete is much lower than its compressive strength (about 0.1); hence, concrete is subject to cracking when subjected to tensile stresses.
- **Forms and shoring**: the construction of a cast-in-place structure involves three steps not encountered in the construction of steel or timber structures. These are (a) the construction of the forms, (b) the removal of these forms, and (c) the propping or shoring of the new concrete to support its weight until its strength is adequate.
- **Relatively low strength per unit of weight or volume**: the compressive strength of concrete is roughly 10 percent that of steel, while its unit density is roughly 30 percent that of steel. As a result, a concrete structure requires a larger volume and a greater weight of material than does a comparable steel structure.
- **Time-dependent volume changes**: shrinkage and creep.

E. 1.5. Historical development of RC buildings

Here is a brief overview of the historical development of reinforced concrete (RC) buildings:

- Early History

  The first known use of RC is attributed to Joseph-Louis Lambot, a French gardener, who built a series of concrete flowerpots reinforced with iron mesh in the 1840s. In 1868, François Coignet, another Frenchman, patented a system for building reinforced concrete buildings using prefabricated slabs and beams.

- Late 19th century

  RC construction began to gain popularity in the late 19th century. In 1892 Francois Hennebique patented his pioneering reinforced-concrete construction system (using steel bars), integrating separate elements of construction, such as the column and the beam, into a single monolithic element. He built the first building in the reinforced concrete system in 1, rue Danton, Paris.

Hyatt designed the first RC skyscraper, the Ingalls Building (1904)

- 20th century

  RC construction continued to evolve in the 20th century, with the development of new techniques and materials. In the 1920s, the American engineer Eugene Freyssinet developed prestressed concrete, a type of RC that is stronger and more durable than traditional RC. Prestressed concrete was used to build some of the most iconic structures of the 20th century, such as the Sydney Opera House (1973).

- Today

  RC is still one of the most widely used building materials in the world today. It is used to construct a wide range of structures, including houses, apartments, office buildings, bridges, and dams. RC is also used in a variety of specialized applications, such as nuclear power plants and offshore oil platforms.

Bibliography

III

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