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Structural Concrete Laboratory
Department of Civil Engineering
Tokyo Institute of Technology

Mechanics of Structural Concrete

by

Prof. Junichiro NIWA

1 STRUCTURAL DESIGN CONCEPT OF REINFORCED CONCRETE STRUCTURES

1.1 Structural Design

A structural design is to assure that the structures and structural members possess adequate safety against all loads during both service and construction stages, and provide their functions efficiently for ordinary services and their sufficient durability against the environment during the design service life.

The design service life of a structure is normally determined by

- **intended service period of the structure**
- **environmental conditions**
- **durability of the structure**

1.2 Various Methods of Structural Design

In principle, the structural design (safety design) is to check whether the section force due to external loads (S) is less than the resistance of the cross section of the structure (R).

Check $S < R$

This relationship should be maintained considering the balance of two different aspects, such as the function of the structure (or safety) and the construction cost (or economy).

The determination of both values of section forces due to external loads and resistance of the cross section of the structure mostly involves an uncertainty due to the lack of information. This leads to the difficulty in establishing a rational method of the structural design.

At present, the design codes of reinforced concrete in Europe, USA, Japan, and so on have been changed from the working stress design method (allowable stress design method) to the ultimate strength design method or the limit state design method. This might be due to the reason that the results of recent research works on reinforced concrete have shown that the existing working stress design concept was not suitable for a composite material like reinforced concrete, and more elaborated design method such as the ultimate strength or the limit state design method is required.

Three types of design method, which is widely used at present, are as follows:

1.2.1 Working Stress Design (Allowable Stress Design)

The design formula is expressed as follows:

$$\sum_{i=1}^{k} f_i \le f_a = \frac{f_o}{\nu} \qquad (1.1)$$

where,

k	**: number of types of external loads**
f_i	**: stress of a member caused by each type of external load, *i*.**
f_a	**: allowable stress of material**
f_o	**: ultimate strength of material**
ν	**: safety factor**

In this method, all of uncertainties, such as variation of material properties or external loads, error in structural analysis and construction, are incorporated into only one safety factor, ν. The drawbacks of this method applied to design of reinforced concrete are as follows:

(1) In general, the safety factor for characteristics of external loads and that for material properties are different and could not be combined into one factor.

(2) In practice, the safety factor ν is determined by experiences. Thus, the safety margin is not clear.

(3) This method involves the behavior of reinforced concrete only in elastic range, and hence the ultimate strength involving the behavior beyond elastic range cannot be accurately determined (Fig. 1.1).

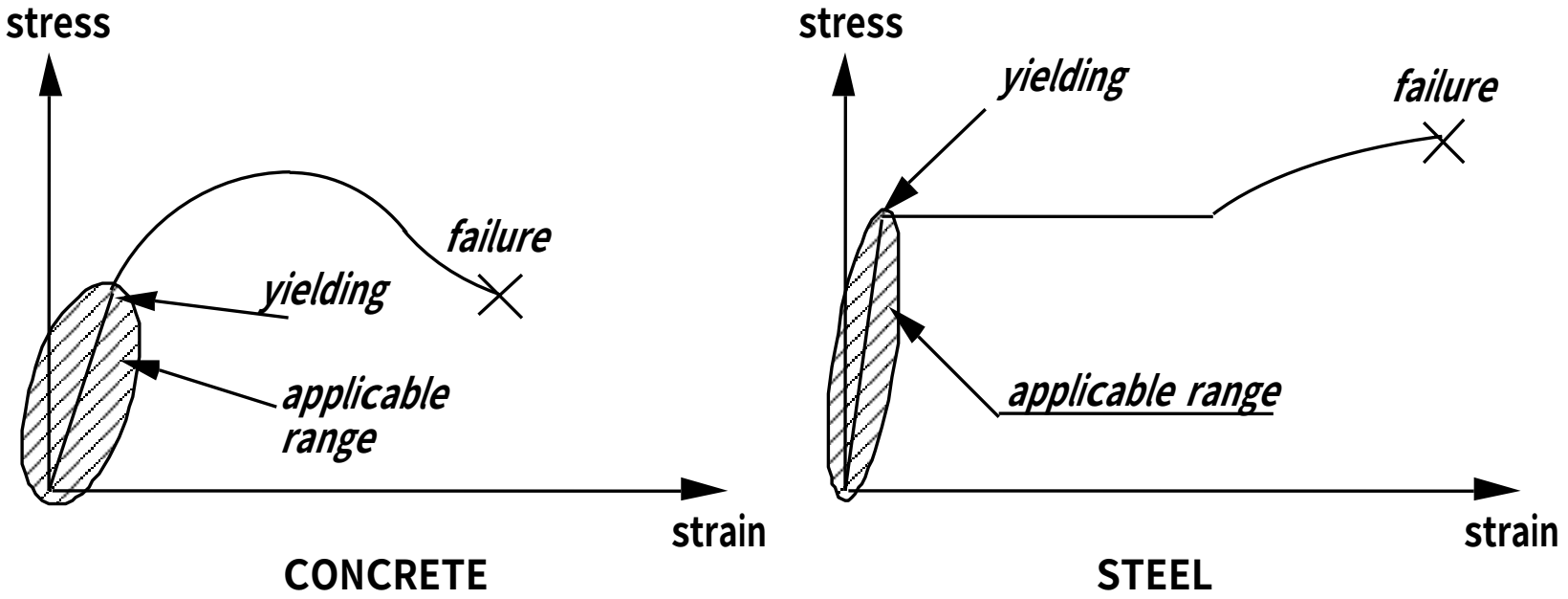

Fig.1.1 Applicable range of allowable stress design method