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RCC Limit State Design

FREE PREVIEW

Limit State Design of Reinforced Concrete

A PRACTICAL COURSE

Limit State Design of Reinforced Concrete

A Step-by-Step Learning Approach to IS 456 : 2000

NIRMAANPRO

First Edition

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A note on the code. This book explains and applies IS 456 : 2000, "Plain and Reinforced Concrete — Code of Practice", published by the Bureau of Indian Standards. Clause numbers, table numbers and the design values quoted in this book are referred to for the purpose of teaching. No part of the code itself is reproduced here; every figure and table in this book has been prepared afresh by the author. Readers must consult the current official edition of IS 456 and the other standards named in the text before using any of this material in practice.

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How to use this book

Most students meet limit state design as a list of formulas to memorise. $0.36 f_{ck} x_u b$, $0.42 x_u$, $0.48d$ for Fe 415. The formulas get learned, the exam gets passed, and the understanding never arrives.

This book takes the opposite route. Every number in the list above is **derived** here, from the two stress-strain curves in the code and one geometric assumption, and nothing is asked to be taken on trust. By the time you reach the end you should be able to reconstruct any of those constants on a blank sheet of paper.

The material is arranged as six chapters, each building directly on the one before it:

- ▶ **Chapter 1** sets up the idea of a limit state, characteristic values and the two partial safety factors.
- ▶ **Chapter 2** takes the design stress-strain curves for concrete and for steel.
- ▶ **Chapter 3** introduces the members of a building and the assumption that a plane section remains plane.
- ▶ **Chapter 4** derives the compressive and tensile forces a section can generate, and where they act.
- ▶ **Chapter 5** works through what happens as the load rises to failure, giving the balanced, under-reinforced and over-reinforced cases.
- ▶ **Chapter 6** puts all of it to work on a complete beam design.

Keep a copy of IS 456 : 2000 beside you. This book explains the code; it does not replace it, and the habit of turning to the clause itself is one worth forming early.

Worked numbers are carried through to three significant figures. Where a value in the code has been rounded — 0.446 to 0.447, 0.416 to 0.42, 0.479 to 0.48 — both the calculated and the code value are given, so that you can see where the difference comes from and know which one to use.

Notation

A_{st}		area of tension reinforcement provided
$A_{st,lim}$		area of tension steel for a balanced section
b		width of the beam
C		total compressive force carried by the concrete
C_c		nominal (clear) cover to reinforcement
D		overall depth of the beam
d		effective depth — top fibre to the centroid of the tension steel
E_s		modulus of elasticity of steel, taken as 2×10^5 N/mm ²
f_{ck}		characteristic compressive strength of concrete (28-day cube)
f_y		characteristic yield strength of steel
f_c, f_{st}		stress in the concrete and in the steel at a given instant
l_{eff}		effective span
M_u		ultimate (design) moment of resistance
T		total tensile force carried by the steel
w		uniformly distributed load per unit length
x_u		depth of the neutral axis from the top fibre
$x_{u,lim}$		limiting neutral-axis depth for a balanced section
z		lever arm, $d - 0.416x_u$
γ_m		partial safety factor for material strength
γ_f		partial safety factor for loads (load factor)
ϵ_c		strain in the concrete at the top fibre
ϵ_{st}		strain in the tension steel
ϵ_y		strain in the steel at its design yield stress, $0.87f_y/E_s + 0.002$

CHAPTER 1

What “Limit State” Really Means

Characteristic strength, characteristic load, and the two partial safety factors that sit between them.

Limit State is a state of impending failure.

What does this means? Let us understand this with an example.

Suppose Amit can lift 30 kg of load and at 30.1 kg he fails. So, this 30 kg loading condition can be called as limit state for Amit.

Now let us take another example to move forward.

Assume a table where we have put a load of “P” unit. Now as we all know there must be some resistance/ Reaction from the table let us assume that as “R” unit.

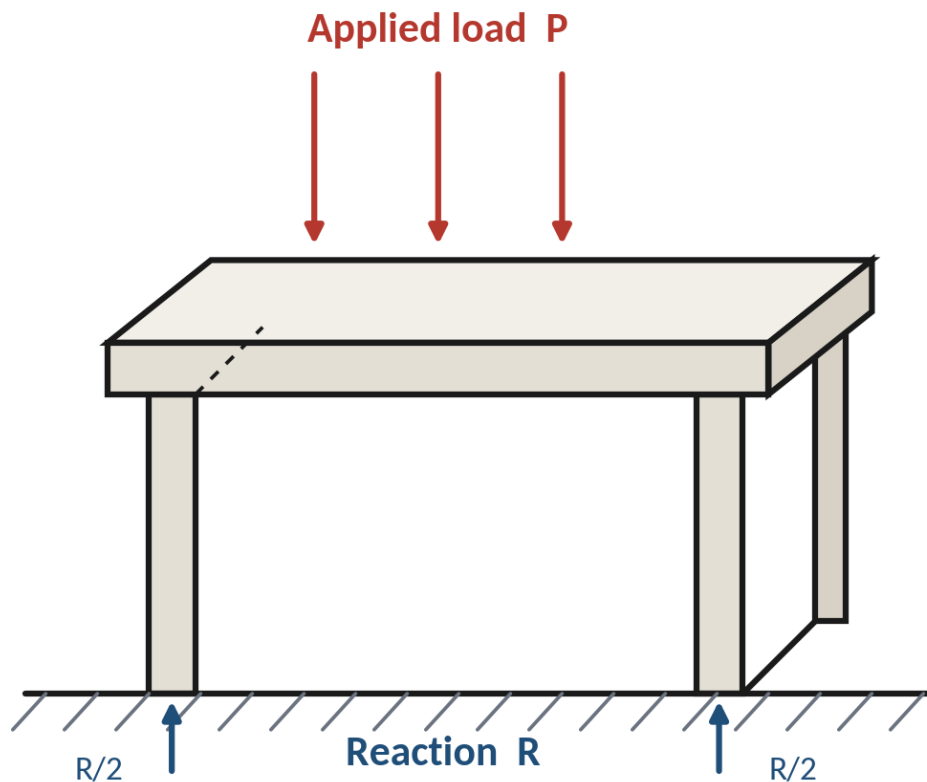


Figure 1. A table carrying a load P . The table pushes back with a reaction R .

So, to be safe to carry the given load

Reaction $\geq$ Applied Load this equation need to be satisfied.

Here Reaction (R) is depends on type of materials like Wood. Steel etc.

It is also to be noted that “ R ” will increase as we increase “ P ” and after a certain time “ R ” will be maximum and then table will fail.

Now, In case of Limit State Design instead of wood if we consider concrete then this value of “ R ” is considered as f_{ck} (**Characteristic strength** of concrete) and similarly for steel this will be f_y (Yield strength of steel). If we go by definition then we can say the strength of the concrete below which not more than 5% of the test results



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