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Comparative Study of Analysis and Design of Building using Indian Standards (IS), European Norms (EN) and American Concrete Institute (ACI)

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Abstract: The purpose of structural analysis is to determine the behavior of structure subjected to certain loads. In other words finding out internal forces (axial force, shear force, moment), stress, strain, deflection, etc. in a structure under applied load conditions. Similarly, structural design ensures safety, serviceability and economy of building for the applied loads. The analysis and design of structure depends on various factors which varies with respect to location. Different standard provides guidelines for analysis and design of structure. This project deals with study of such different guidelines provided in different standards and comparing to get critical analysis values and economical design. For this, a structural grid with certain specifications is taken as a datum and with the help of structural analysis software (STAAD.Pro), analysis is done for Indian, European and American standard codes. It also includes design of same grid for respective analysis values as per the guidelines given in respective codes. The comparison of analysis and design from software output is done.

Keywords: Structural Analysis, Design, Bending Moment, Shear Force

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I. INTRODUCTION

Analysis and design of RCC framed building can be done by various international standards such as Indian, American, European, Chinese, Japanese, Russian, etc. In India most of the structural analysis and design work is done by Indian Standard Codes, but Indian codes are somehow restricted and not confirming to complete dynamic analysis of structures. Different standards have different design guidelines which are depending upon conditions like weather and etc. IS codes are based on LSM which has some limitations and restrictions when compared with USM. Currently in India many structural engineers are using foreign codes and specifically American and European codes for analysis and designing to achieve more precise analysis values as compared to Indian codes. The increase in use of foreign code in India needs proper analysis whether the codes are suitable for Indian conditions. The other main factor for comparison is economy in design. It is very essential to check whether foreign code proves economical or not. Currently in industry, the requirement for code study and comparison for analysis as well as design is in demand.

A standard is a document established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.

Fig. 1.1: Logos of standards (Source: Google)

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A. Problem Statement

In the problem statement the location of building selected is Delhi as it comes under active earthquake zone and also having high basic wind speed, hence this location is suitable for both the parameters. Structure selected is G+20 (wind and seismic both forces becomes predominant for structures above 4 storey).

Analysis and design of a building for the following data :

1) Type of Building - RCC Residential Building
2) No. of storey - G + 20
3) Floor to Floor height - 3.0 m
4) Plan dimensions - 24.7 m × 18.2 m
5) Location - Delhi, India
6) Seismic Zone - IV
7) Basic wind speed - 47 m/s

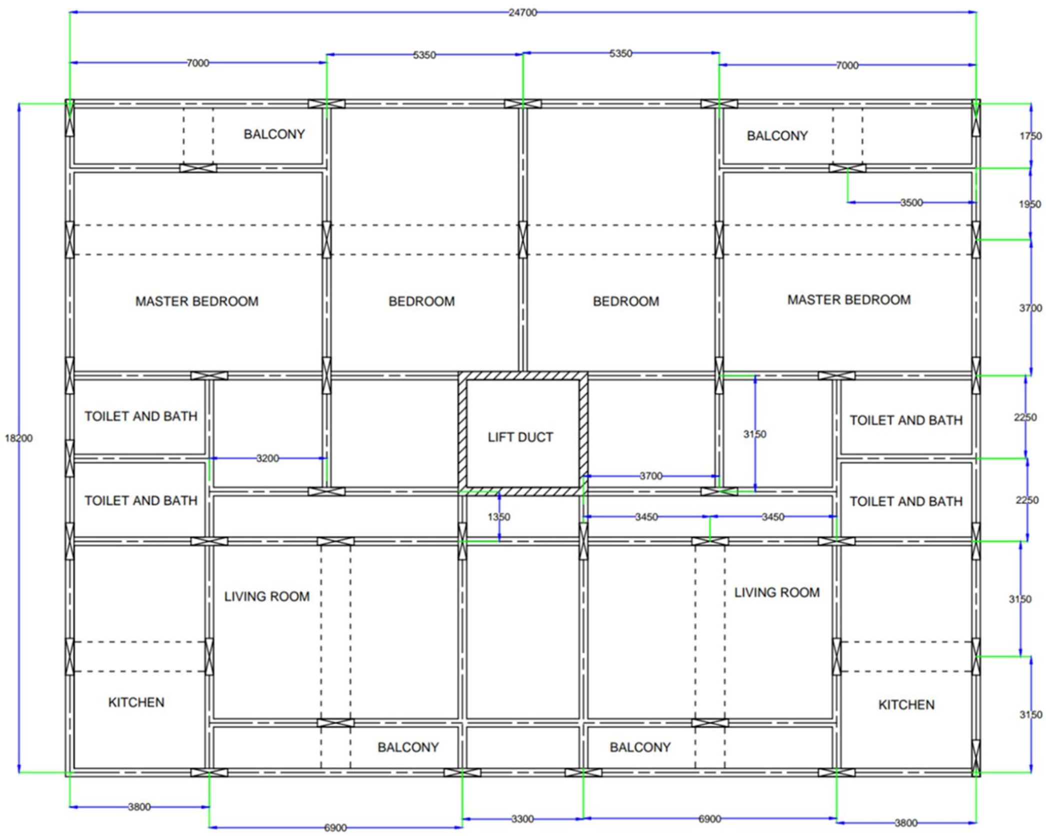

Fig. 1.2: Structural floor Plan (Source: Autocad Software)

B. Aim of Project

To analyze and design (G+20) residential building located in Delhi using structural analysis software following guidelines given in Indian Standards (IS), European Norms (EN) and American Concrete Institute (ACI).

C. Objectives of Project

1) To study guidelines of analysis and design of RCC building as per Indian Standards (IS), European Norms (EN) and American Concrete Institute (ACI)
2) To prepare structural model of building in software
3) To analyze building for seismic force and wind force
4) To design building as per Indian Standards (IS), European Norms (EN) and American Concrete Institute (ACI)
5) To compare the analysis and design

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II. IDEA OF WORK

The above stated structure is analyzed by Indian standards, European Norms and American society for civil engineers for respective loading. Design is done by two ways. The one with respective loading for respective code and other with constant loading. The comparison based on both ways is given.

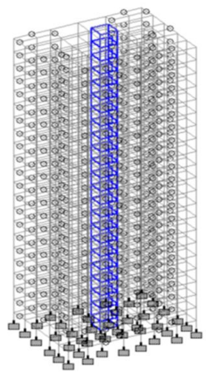

Fig. 2.1: Nodal Frame
(Source: STAAD.Pro Software)

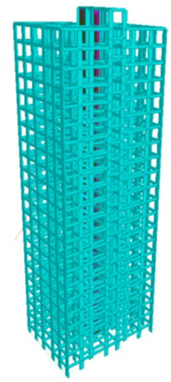

Fig. 2.2: 3D Rendered view
(Source: STAAD.Pro Software)

Table no. 2.1 Description of Common Load

Sr. No.	Description of load	Intensity	Unit
1	Internal Wall (150mm)	8.50	KN/m
2	External Wall (200mm)	10.4	KN/m
3	Floor Load (DL)	4.75	kN/m^2
4	Lift load	10.00	Tonnes
5	Water Tank load	380	kN

Table no. 2.2 Description of Live Load as per different standards

	INDIAN	EUROPEAN	AMERICAN
	kN/m^2	kN/m^2	kN/m^2
Balcony	3	3	2.87
Others	2	1.75	1.44

III. ANALYSIS RESULTS

Table no. 3.1 Max Bending Moment and Shear Force for 5^{th} Floor

Beam no.		IS	EN	ACI
578	Max Fy (kN)	270.627	182.85	172
578	Max Mx (kN-m)	198.69	128.62	123.6

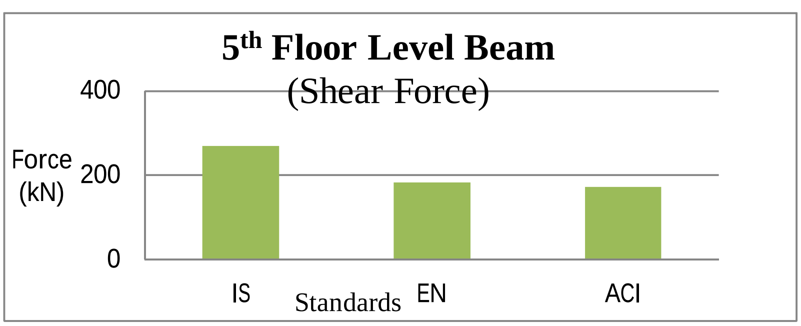

Fig. 3.1 Graphical comparison of maximum Shear Force of 5^{th} floor

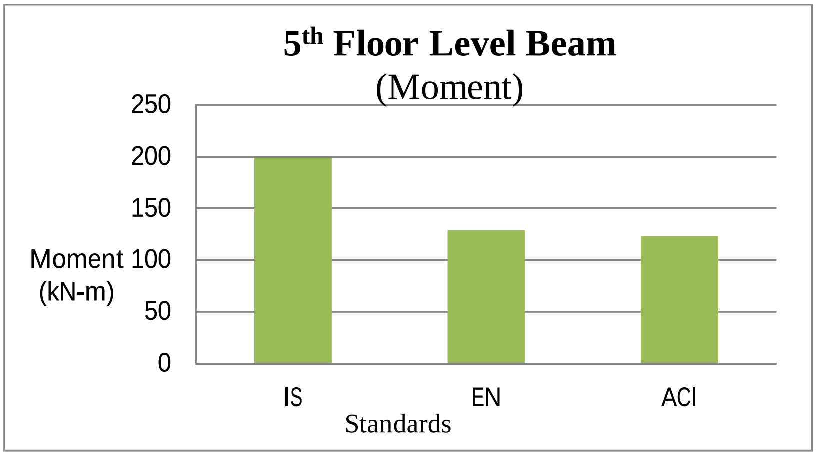

Fig. 3.2 Graphical comparison of maximum Bending Moment of 5th floor

Table no. 3.2 Max Bending Moment and Shear Force for 15th Floor

Beam no.		IS	EN	ACI
1578	Max Fy (kN)	319.544	272.57	228
1578	Max Mx (kN-m)	235.57	197.49	164.56

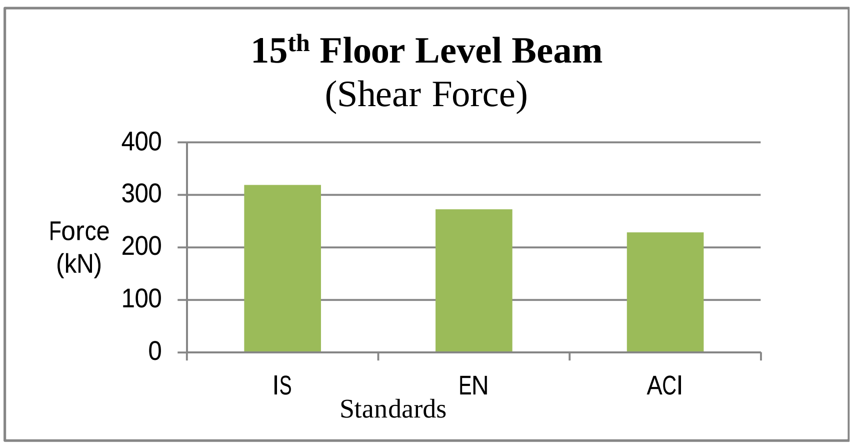

Fig. 3.3 Graphical comparison of maximum Shear Force of 15th floor

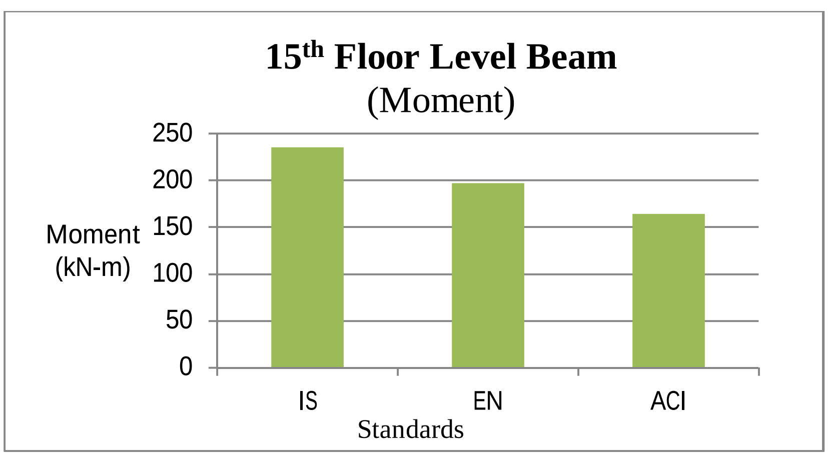

Fig. 3.4 Graphical comparison of maximum Bending Moment of 15th floor

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Table no. 3.3 Max Bending Moment and Shear Force for 20th Floor

Beam no.		IS	EN	ACI
1378	Max Fy (kN)	329.401	270.16	223
1378	Max Mx (kN-m)	243.26	195.698	160.19

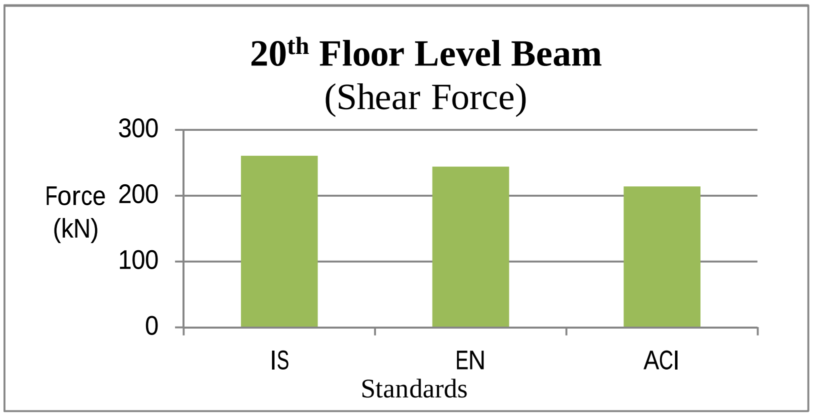

Fig. 3.5 Graphical comparison of maximum Shear Force of 20th floor

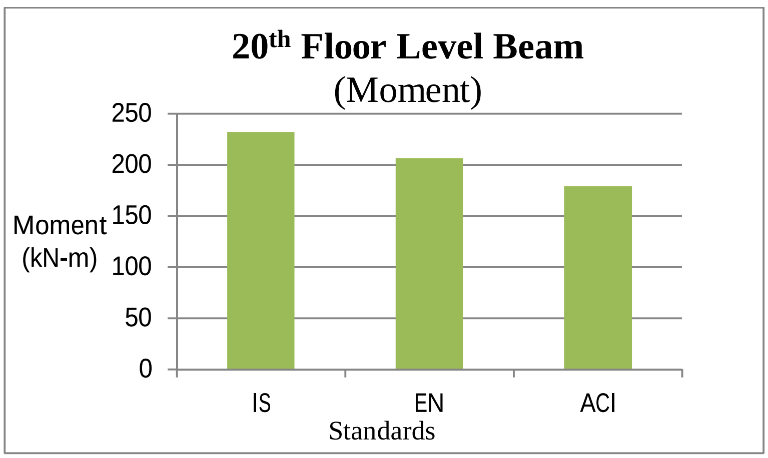

Fig. 3.6 Graphical comparison of maximum Bending Moment of 20th floor

Table no.3.4 Max Bending Moment and Shear Force for column

Column no.		IS	EN	ACI
5038	Max Fy (kN)	4440.35	4737.11	4327
5038	Max Mx (kN-m)	270.86	87.067	39.022

A. Observations From Results

(Considering 15st floor results for comparison)

1) The member which is found critical (1578) by IS is the same member which is found critical by EN & ACI
2) The maximum value of shear force in Y-direction obtained by IS (319.544 kN) is higher than EN (272.570 kN) and ACI (228 kN) respectively
3) The maximum value of bending moment in X-direction obtained by IS (235.57 kN-m) is higher than EN (197.490 kN-m) and ACI (164.560 kN-m) respectively
4) The value of bending moment in Z-direction obtained by IS, EN & ACI is negligible
5) The value of imposed load is higher in IS code, hence the value of shear force and bending moment are on higher side

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IV. DESIGN

A. Observations From Design

1) From Design Obtained By Respective Values

Table no.4.1 Total quantity of steel provided for beam

	IS	EN	ACI
Steel (kg)	76.48	67.35	51.48
Difference w.r.t. IS (%)	-	11.93	32.68

Table no. 4.2 Total quantity of steel provided for column

	IS	EN	ACI
Steel (kg)	105.11	73.63	51.46
Difference w.r.t. IS (%)	-	29.94	51.04

Table no. 4.3 Total quantity of steel provided for slab

	IS	EN	ACI
Steel (kg)	32.70	40.30	39.05
Difference w.r.t. IS (%)	-	23.24	19.42

2) From Design Obtained By Constant Values

Table no. 4.4 Total quantity of steel provided for beam

	IS	EN	ACI
Steel (kg)	76.48	67.35	53.98
Difference w.r.t. IS (%)	-	11.93	29.42

Table no. 4.5 Total quantity of steel provided for column

	IS	EN	ACI
Steel (kg)	89.70	61.96	51.47
Difference w.r.t. IS (%)	-	30.9	42.62

Table no. 4.6 Total quantity of steel provided for slab

	IS	EN	ACI
Steel (kg)	32.70	40.30	39.05
Difference w.r.t. IS (%)	-	23.24	19.42

V. CONCLUSION

A. The values for shear forces and bending moments obtained using IS code are 15 – 35 % higher than EN and ACI

B. For beam, design as per EN and ACI is higher by 10 - 35 % than IS code for respective loading

C. For beam, design as per EN and ACI is higher by 10 - 30 % than IS code for constant loading

D. For column, design as per EN and ACI is higher by 30 - 50 % than IS code for respective loading

E. For column, design as per EN and ACI is economical by 30 - 40 % than IS code for constant loading

F. For slab, design as per IS code is higher by 20 - 25 % than EN and ACI for respective loading

G. For slab, design as per IS code is higher by 20 - 25 % than EN and ACI for constant loading

H. With consideration of total steel quantity required for building, EN and ACI gives higher design as compared to IS code

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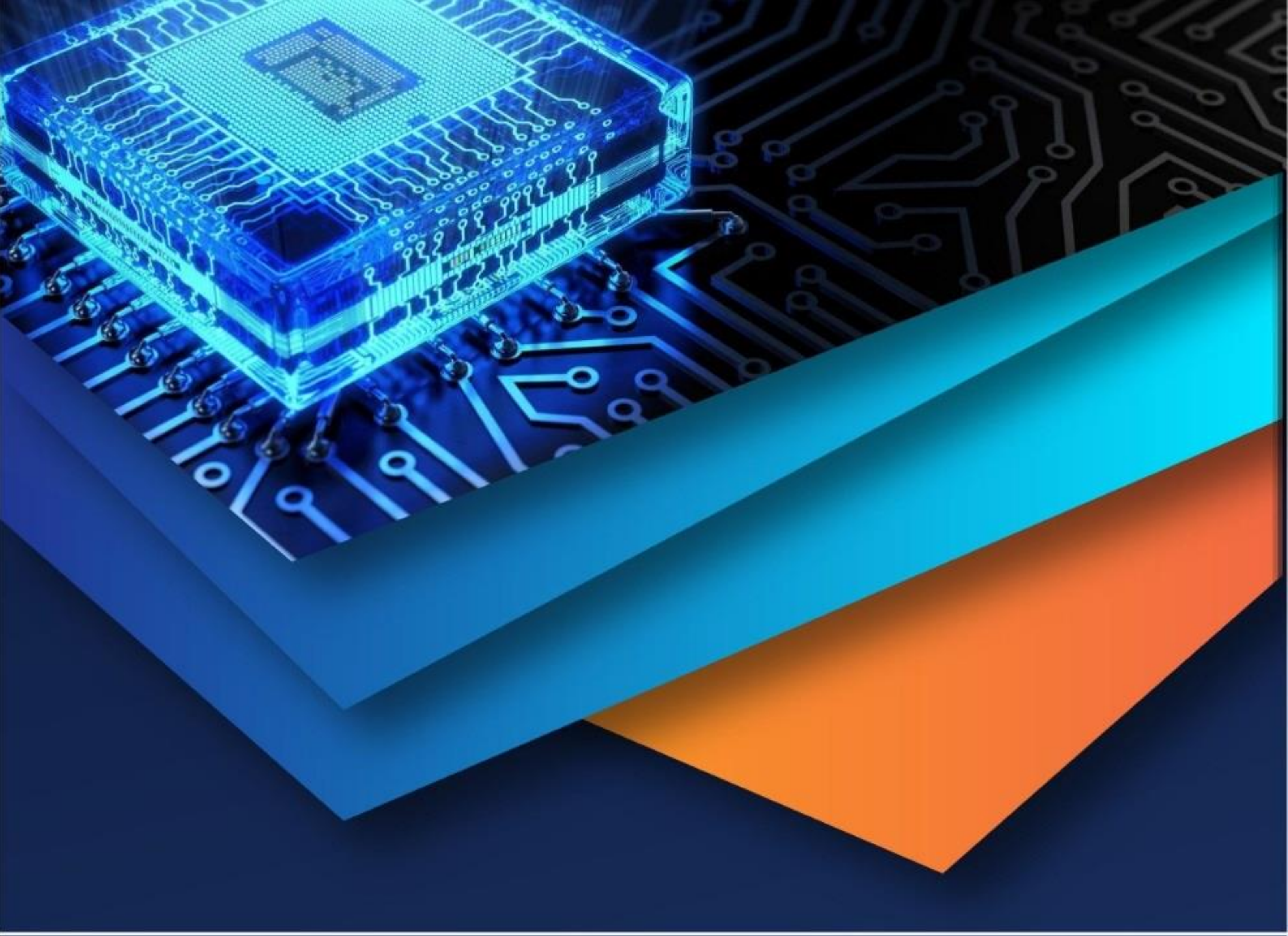
3) IS 875 : 2015 (Part III) – Wind Load
4) IS 456 : 2000 – Design of RCC Structures
5) IS 1893 : 2016 (Part I) – General provisions for earthquake resisting structures
6) IS 13920 : 2016 – Ductile detailing
7) EN 1 : 1991 (Part I) – Dead Load & Live Load
8) EN 1 : 1991 (Part III) – Wind Load
9) EN 2 : 1992 (Part I) – General rules for design of RCC Structures
10) EN 8 : 1998 (Part I) – General rules for seismic actions
11) EN 8 : 1998 (Part III) – Assessment & retrofitting of buildings
12) EN 8 : 1998 (Part V) – Foundations, retaining structures & geotechnical aspects
13) EN 8 : 1998 (Part VI) – Towers, masts & chimney structures
14) EC 2 : Manual for detailing of reinforced concrete structures
15) ASCE 7 : 2007 – All types of Loads
16) ACI 318(14) – RCC Design



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