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Parametric Study of Multistorey Buildings as Per Indian Seismic Codes IS1893:2002 & IS 1893:2016

Kiran Shanbhag[1], Dr. A.A.Bage[2]

[1,2]*Structual Engineering department, Sardar Patel College of Engineering*,

- ***Abstract*— Considerable improvement in earthquake resistant design has been observed in recent past. As a result Indian seismic code IS: 1893 has also been revised in year 2016, after a gap of 14 years. This project intended to present parametric study for multi-storey buildings as per IS: 1893-2002 and IS: 1893-2016 recommendations. Four multi-storey RC framed buildings ranging from fifteen storeyed to thirty storeyed will be considered and analyzed. The process will give a set of individual analysis sequences for each building and the results will be used to compare the seismic response viz. Lateral displacement, Base Shear, Mode Shape & Storey drifts are computed as per the two versions of seismic code. Steel Quantity of shear walls was compared using software 'Draftwin' which creates detailed quantities for concrete, reinforcement and formwork for RCC buildings.**

It is considered that such study needs to be carried out for individual structure to predict seismic vulnerability of RC framed buildings & also to check the buildings which were designed using earlier code and due to revisions in the codal provisions may have rendered unsafe.

- ***Keywords*— Response Spectrum Method, fundamental period, Etabs model, structural parameters, steel quantity**

I. INTRODUCTION

Seismic Engineering is a sub discipline of the broader category of Structural engineering. Its main objectives therefore are-

- To understand interaction of structures with the shaky ground.
- To foresee the consequences of possible earthquakes.
- To design, construct and maintain structures to perform at earthquake exposure up to the expectations and in compliance with building codes.

The methodologies available so far for the evaluation of existing buildings can be divided into two categories-(i) Qualitative method (ii) Analytical method. The Qualitative methods for evaluation are based on the background data of the building and its construction site available, which requires some or few documents like drawings, visual inspection report, past performance of the analogous buildings under seismic activities, and certain non-destructive test results.

The analytical methods for evaluation are based on the consideration of the ductility and capacity of buildings on the grounds of drawings which are already available.

As per IS 1893 (Part 1) effects of design earthquake loads applied on structures can be considered in two ways, namely:

A. Equivalent static method, and

B. Dynamic analysis method

In turn, dynamic analysis can be performed in three ways, namely:

- Response Spectrum Method
- Modal Time History Method, and
- Time history method

In this study we have used "Response Spectrum Method" for assessment with the use of software Etabs. Four different models of RC structure are considered like G+30, G+25, G+20 & G+15. As per code When Response Spectrum Method is used, the design base shear VB estimated shall not be less than the design base shear $\bar{V}$B calculated using a fundamental period Ta, where Ta for RC structural walls is

$$Ta = \frac{0.09h}{\sqrt{\text{d}}}$$

Where

h = height of building, in m;

d = base dimension of the building at the plinth level along the considered direction of earthquake shaking, in m;

Various parameters are analysed and compared using old (IS 1893:2002) and revised codes (IS 1893:2016). Also checked for the steel quantities for shear walls using both codes.

Also at the time of issue of completion certificate of the buildings, the authorities require structural safety certificate for structural design as per the codes published by bureau of Indian standards including latest revisions and amendments.

OBJECTIVE OF PRESENT STUDY

- Comparative study of IS1893-2002 & 2016 formulating important points to be considered.
- To design buildings with both codes and to compare seismic response of buildings designed with different codes.
- Modelling & analysing of various stories of structures like G+15, G+20, G+25 & G+30 using software Etabs.
- Comparing structural parameters such as Lateral displacement, Base Shear, Mode Shape and Storey drift etc.
- Comparative study on steel quantity using IS1893-2002 and IS1893-2016.
- To learn the method to analyse & design buildings with revised code IS1893-2016.

II. PARAMETRIC STUDY

COMPARISON BETWEEN TWO CODES:

Sr No	Description	As per code IS 1893 (part 1): 2016	As per code IS 1893 (part 1): 2002
A.	Importance Factor		
1	Important service and community buildings or structures (for example, critical governance buildings, school), signature structures, monument structures, life line and emergency structures (for example, hospitals, telephone exchanges, television stations, radio stations, bus stations, metro rail structure and metro rail stations, railway stations, airports, water mainlines and water tanks, food chain structures, fuel stations, electricity stations, fire stations, and bridges), and large community halls(for example, cinema halls, shopping malls, assembly halls and subway stations) and power stations.	1.5	1.5
2	Residential or commercial buildings or structures, with occupancy more than 200 persons	1.2	-
3	All other buildings or structures	1	1
4	Buildings with mixed occupancies (different I factor applicable for the respective occupancies)	Larger of the I values	-
B	Response Reduction Factor		
	For Buildings with Ductile RC Structural Walls with RC SMRFs	5	4
C	Value of Damping		
	a)Dynamic Analysis of Steel	5	2
	b)Dynamic Analysis of RC Building	5	5
D	Moment of Inertia		
	a)For RC Building Columns	70%	100%
	b)For RC Building Beams	35%	100%

III. DEFINING MATERIAL PROPERTIES

- Four models are considered namely G+30, G+25, G+20 & G+15

Material Properties:

- Concrete: M30
- Steel: Fe 500
- Size of Columns:

❖ **<u>For G+30 Building</u>:**

I)Plinth to 5th floor:

a) At corners: 300x2000 mm
b) In X- direction: 300x1500 mm
c) In Y-direction: 300 x 1200 mm

II) 6th to 10th floor:

a) At corners: 300x1800 mm
b) In X- direction: 300x1400 mm
c) In Y- direction: 300x1200 mm

III)11th to 15th floor:

a) At corners: 300x1600 mm
b) In X- direction: 300x1300 mm
c) In Y- direction: 300x1100 mm

IV)16th to 20th floor:

a) At corners: 300x1400 mm
b) In X- direction: 300x1200 mm
c) In Y- direction: 300x1000 mm

V)21st to 30th floor:

a) At corners: 300x1200 mm
b) In X- direction: 300x1200 mm
c) In Y- direction: 300x1000 mm

❖ **<u>For G+25 Building</u>:**

I)Plinth:

a) At corners: 300x2000 mm
b) In X- direction: 300x1500 mm
c) In Y-direction: 300 x 1200 mm

II) 1st to 5th floor:

a) At corners: 300x1800 mm
b) In X- direction: 300x1400 mm
c) In Y- direction: 300x1200 mm

III)6th to 10th floor:

a) At corners: 300x1600 mm
b) In X- direction: 300x1300 mm
c) In Y- direction: 300x1100 mm

IV)11th to 15th floor:

a) At corners: 300x1400 mm
b) In X- direction: 300x1200 mm
c) In Y- direction: 300x1000 mm

V)16th to 25th floor:

a) At corners: 300x1200 mm
b) In X- direction: 300x1200 mm
c) In Y- direction: 300x1000 mm

- **For G+20 Building:**

I)Plinth:

a) At corners: 300x1800 mm
b) In X- direction: 300x1400 mm
c) In Y- direction: 300x1200 mm

II)1st to 5th floor:

a) At corners: 300x1600 mm
b) In X- direction: 300x1300 mm
c) In Y- direction: 300x1100 mm

III)6th to 10th floor:

a) At corners: 300x1400 mm
b) In X- direction: 300x1200 mm
c) In Y- direction: 300x1000 mm

IV)11th to 20th floor:

a) At corners: 300x1200 mm
b) In X- direction: 300x1200 mm
c) In Y- direction: 300x1000 mm

- **For G+15 Building**:

I) Plinth:

a) At corners: 300x1600 mm
b) In X- direction: 300x1300 mm
c) In Y- direction: 300x1100 mm

II) 1st to 5th floor:

a) At corners: 300x1400 mm
b) In X- direction: 300x1200 mm
c) In Y- direction: 300x1000 mm

III) 6th to 15th floor:

a) At corners: 300x1200 mm
b) In X- direction: 300x1200 mm
c) In Y- direction: 300x1000 mm

- Size of Beams:

a) Peripheral Beams 300 x 650 mm
b) Service area Beams 300 x 450 mm

- Size of Slab:

a) Normal Slab: 125 mm
b) Service area Slab: 110 mm

- Size of floor Plate: 46.60 x 14.85 m

Load Consideration as per IS 875:

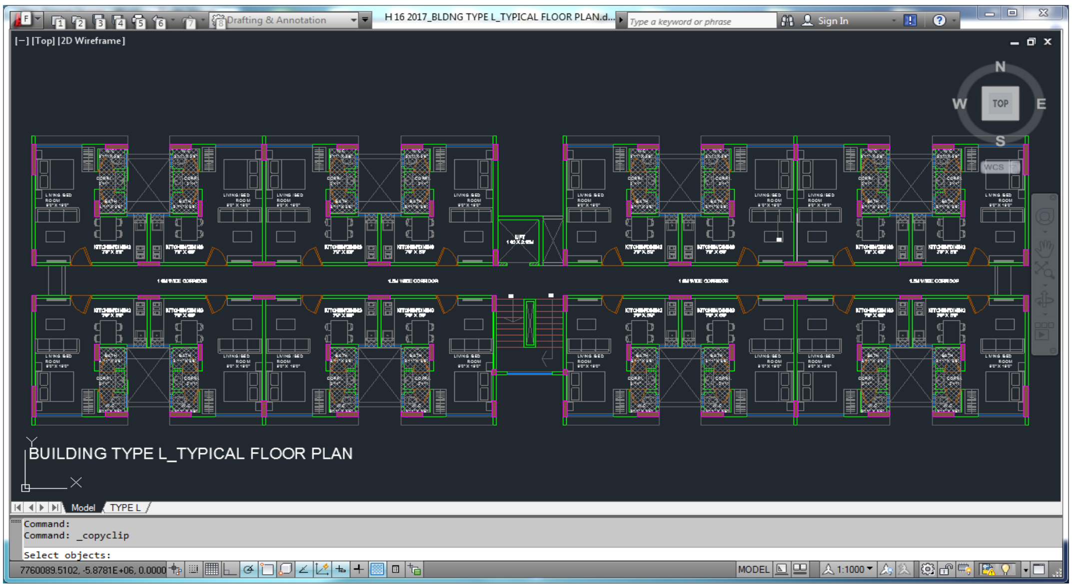
Sr. No.	Type of Load	Unit	Value
1	Dead Load: Floor Finish	KN/m2	1.5
2	Dead Load: Services	KN/m2	0.5
3	Self Weight of slab	KN/m2	3.125
4	Wall Load	KN/m	10.34
5	Beam self weight	KN/m	4.5
6	Total Dead Load on slab	KN/m2	19.465
7	Live Load	KN/m2	2

Calculation of time period for different story height structures:

Sr. No.	Particulars:	G+15	G+20	G+25	G+30
A.	**Time Period For building with RC structural walls:**				
1	h = height of building in m;	48.50	64.00	79.50	95.00
2.1	d = base dimension of the building at the plinth level along the considered direction of earthquake shaking, in m; and In X Direction	46.60	46.60	46.60	46.60
2.2	In Y Direction	13.65	13.65	13.65	13.65
3	$Ta = \frac{0.09\ X\ h}{\sqrt{d}}$ in X Direction	0.64	0.84	1.05	1.25
4	in Y Direction $Ta = \frac{0.09\ X\ h}{\sqrt{d}}$	1.18	1.56	1.94	2.31

Modeling using Etabs:

- Models are constructed using ETABS Computers and structures, Inc. of G + 15, G + 20, G + 25 & G + 30 residential Building.
- Typical Floor plan of Building:



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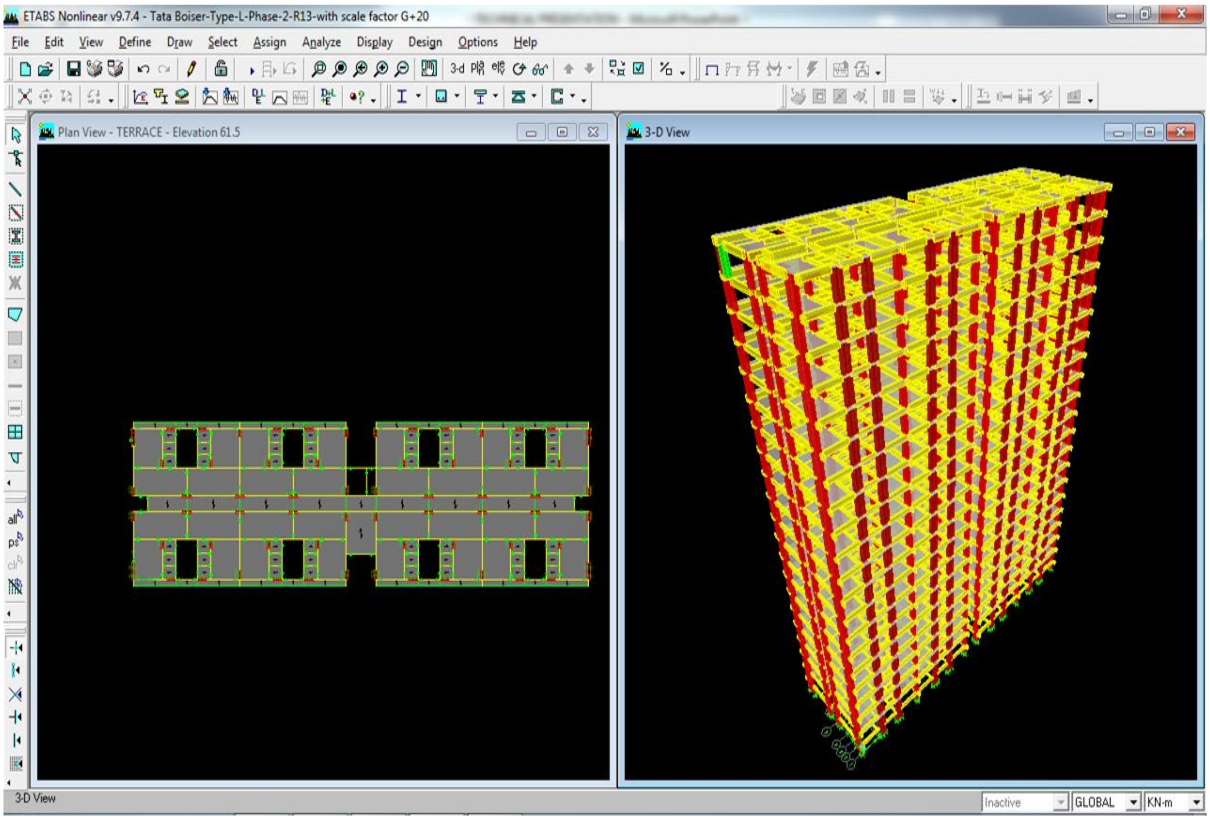
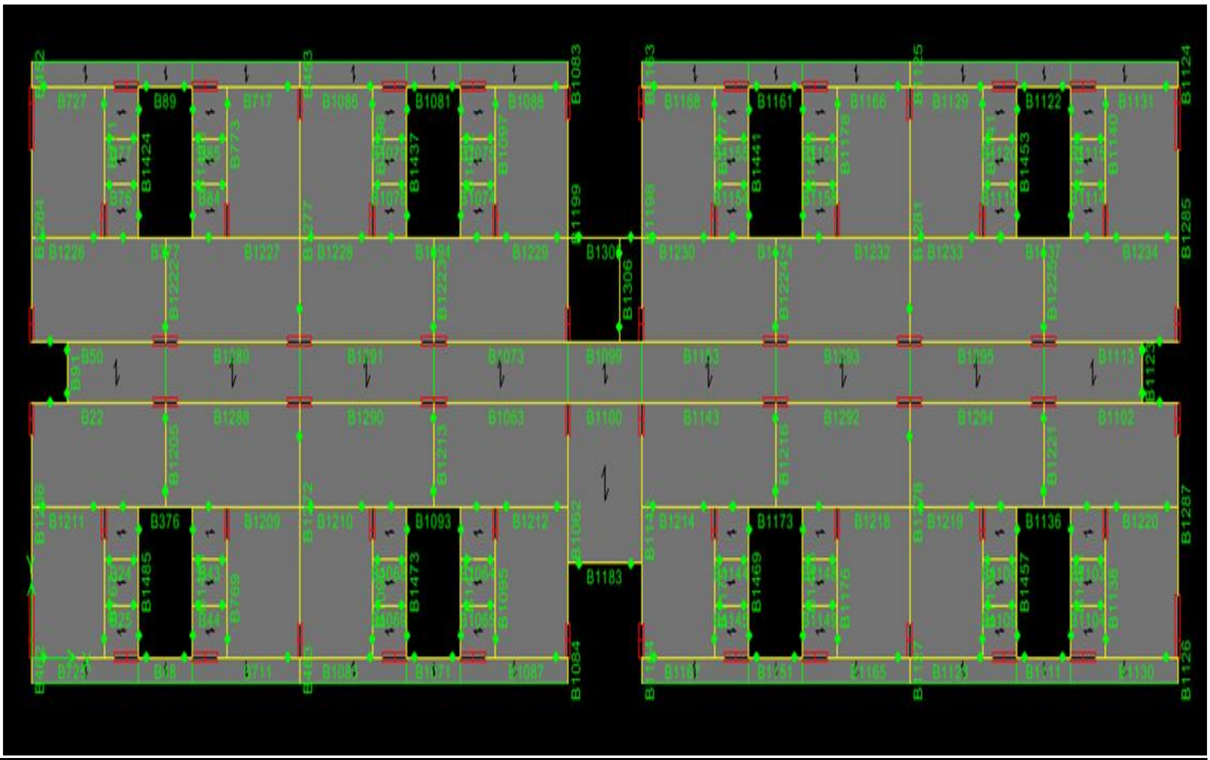
Analysis of RCC frame structures of Building:



<u>Floor plan with Beam Labels</u>



Comparing Parameters:

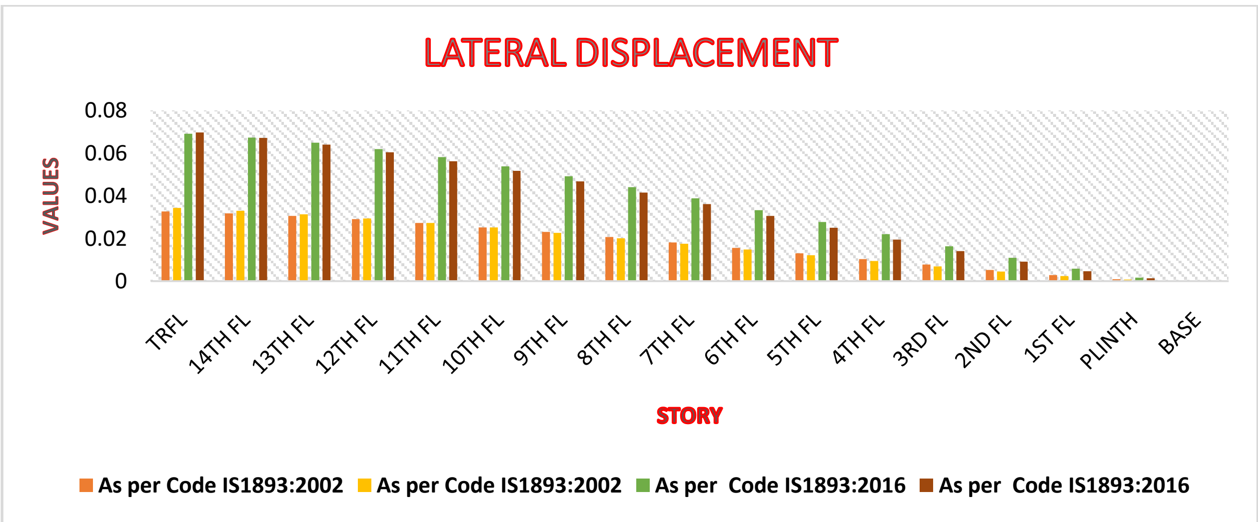
Four models viz. G+15, G+20, G+25 & G+30 are analysed using software Etabs for both the codes and results are extracted and compared. They are as follows:

G+15 Storey Building:

Comparing Parameters Lateral Displacement

Story	As per IS1893:2002		As per IS1893:2016		% Difference	
	EQ X	EQ Y	EQ X	EQ Y	EQ X	EQ Y
TRFL	0.0327	0.0343	0.0691	0.0697	111%	103%
14TH FL	0.0318	0.0329	0.0672	0.0671	111%	104%
13TH FL	0.0306	0.0313	0.0648	0.064	112%	104%
12TH FL	0.0291	0.0294	0.0618	0.0603	112%	105%
11TH FL	0.0273	0.0273	0.0581	0.0562	113%	106%
10TH FL	0.0252	0.0251	0.0538	0.0517	113%	106%
9TH FL	0.023	0.0226	0.0491	0.0467	113%	107%
8TH FL	0.0206	0.0201	0.0441	0.0415	114%	106%
7TH FL	0.0182	0.0175	0.0388	0.0361	113%	106%
6TH FL	0.0156	0.0148	0.0333	0.0306	113%	107%
5TH FL	0.013	0.0121	0.0277	0.025	113%	107%
4TH FL	0.0104	0.0095	0.022	0.0195	112%	105%
3RD FL	0.0078	0.0069	0.0164	0.0141	110%	104%
2ND FL	0.0053	0.0045	0.0109	0.0091	106%	102%
1ST FL	0.0029	0.0024	0.0058	0.0046	100%	92%
PLINTH	0.0009	0.0007	0.0017	0.0013	89%	86%
BASE	0	0	0	0	0%	0%

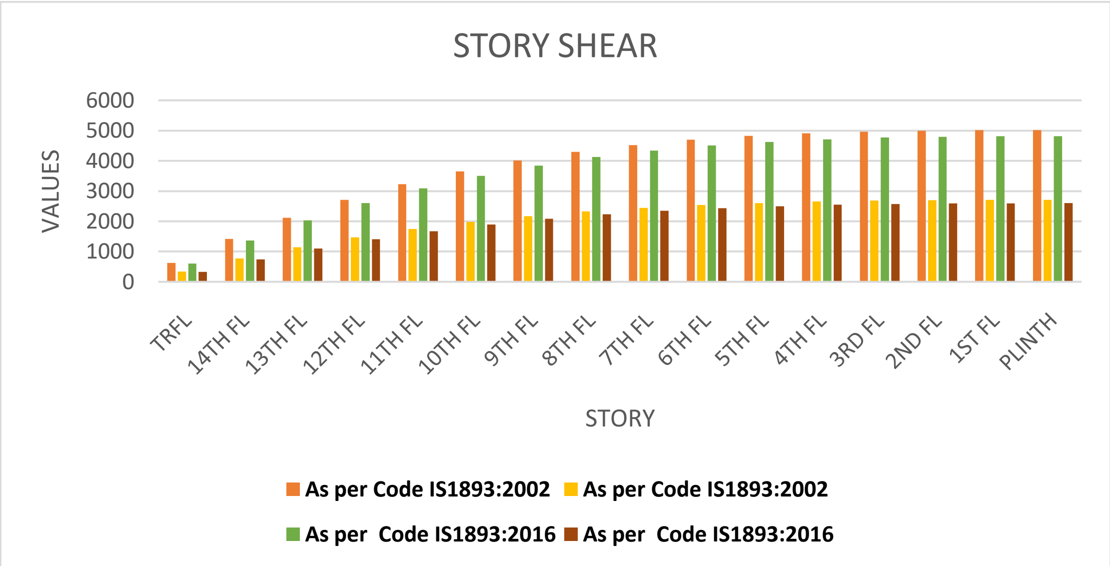
Chart showing Parameters:



Comparing Parameters: Base Shear

Story	As per IS1893:2002		As per IS1893:2016		% Difference	
	EQ X	EQ Y	EQ X	EQ Y	EQ X	EQ Y
TRFL	623.08	337.12	598.16	323.64	-4%	-4%
14TH FL	1420.32	768.47	1363.5	737.73	-4%	-4%
13TH FL	2114.62	1144.12	2030.03	1098.36	-4%	-4%
12TH FL	2713.43	1468.11	2604.89	1409.39	-4%	-4%
11TH FL	3223.41	1744.04	3094.47	1674.28	-4%	-4%
10TH FL	3652.14	1976.01	3506.06	1896.97	-4%	-4%
9TH FL	4006.47	2167.72	3846.21	2081.01	-4%	-4%
8TH FL	4293.47	2323	4121.73	2230.08	-4%	-4%
7TH FL	4520.24	2445.7	4339.43	2347.87	-4%	-4%
6TH FL	4693.73	2539.03	4505.98	2435.5	-4%	-4%
5TH FL	4821.19	2607.49	4628.34	2500.44	-4%	-4%
4TH FL	4909.76	2655.05	4713.37	2546.16	-4%	-4%
3RD FL	4966.44	2685.32	4767.78	2574.36	-4%	-4%
2ND FL	4998.32	2702.43	4798.39	2590.34	-4%	-4%
1ST FL	5012.49	2710.02	4811.99	2597.7	-4%	-4%
PLINTH	5014.77	2711.25	4814.18	2598.88	-4%	-4%

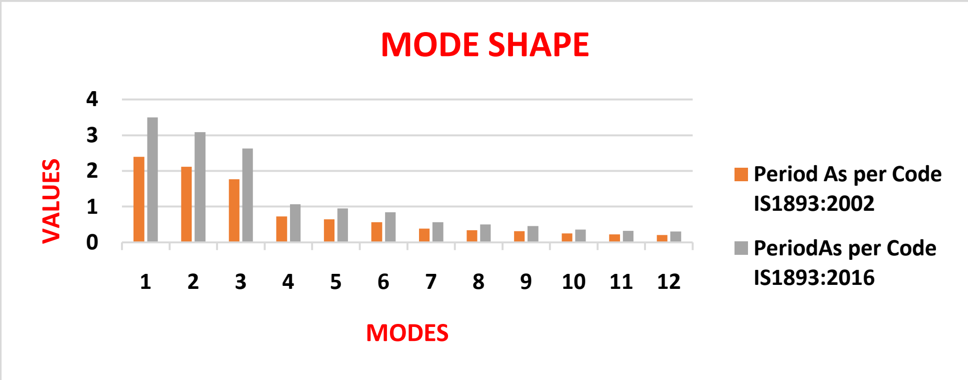
Bar Chart showing Parameters: Base Shear



Comparing Parameters: Mode Shape

Mode	Period As per IS1893:2002	Period As per IS1893:2016	% Difference
	Period	Period	
1	2.394555	3.501702	46%
2	2.114987	3.088787	46%
3	1.766891	2.629887	49%
4	0.728272	1.066754	46%
5	0.647924	0.948311	46%
6	0.565947	0.838987	48%
7	0.385699	0.562765	46%
8	0.345007	0.502171	46%
9	0.312655	0.460623	47%
10	0.25336	0.361966	43%
11	0.226372	0.322791	43%
12	0.208687	0.301753	45%

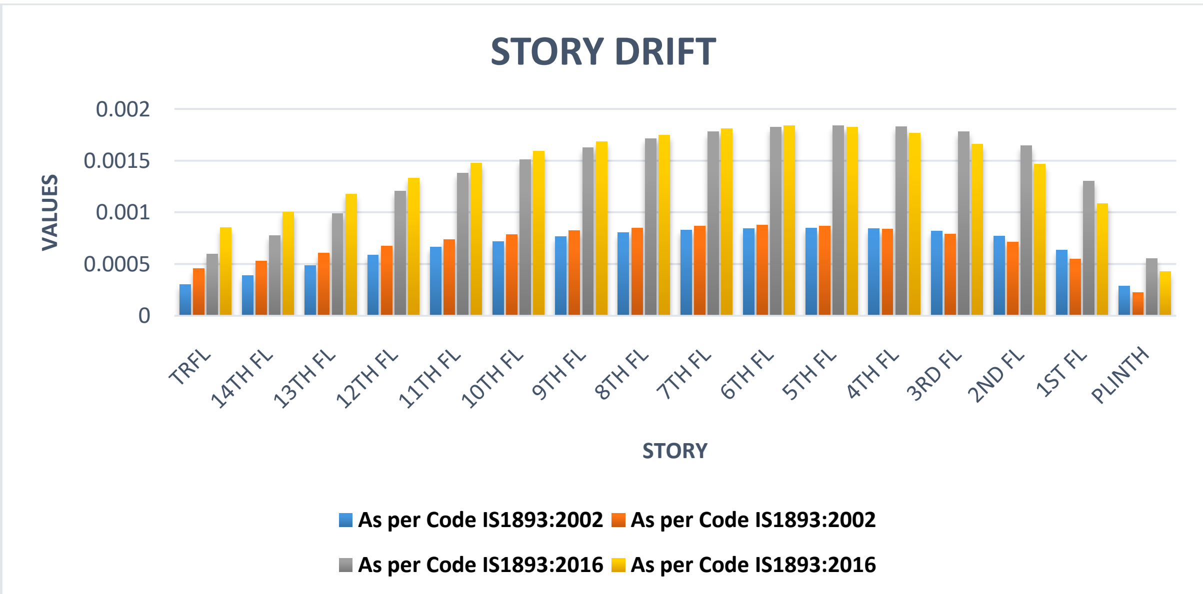
Chart showing Parameters: Mode Shape



Comparing Parameters: Storey Drift

Story	As per IS1893:2002		As per IS 1893:2016		% Difference	
	EQ X	EQ Y	EQ X	EQ Y	EQ X	EQ Y
TRFL	0.000303	0.000457	0.000599	0.000854	98%	87%
14TH FL	0.00039	0.00053	0.000779	0.001006	100%	90%
13TH FL	0.000489	0.00061	0.000992	0.001179	103%	93%
12TH FL	0.000587	0.000678	0.001205	0.001334	105%	97%
11TH FL	0.000664	0.000738	0.00138	0.001476	108%	100%
10TH FL	0.000718	0.000788	0.001512	0.001594	111%	102%
9TH FL	0.000767	0.000825	0.001626	0.001685	112%	104%
8TH FL	0.000804	0.000848	0.001717	0.001751	114%	106%
7TH FL	0.000831	0.000871	0.001783	0.001813	115%	108%
6TH FL	0.000845	0.000881	0.001825	0.001842	116%	109%
5TH FL	0.000849	0.000869	0.001841	0.001825	117%	110%
4TH FL	0.000843	0.000841	0.001831	0.00177	117%	110%
3RD FL	0.000823	0.000794	0.001781	0.001664	116%	110%
2ND FL	0.000774	0.000713	0.001646	0.001468	113%	106%
1ST FL	0.000639	0.00055	0.001305	0.001088	104%	98%
PLINTH	0.000288	0.000226	0.000557	0.000427	93%	89%

Bar Chart showing Parameters: Story Drift

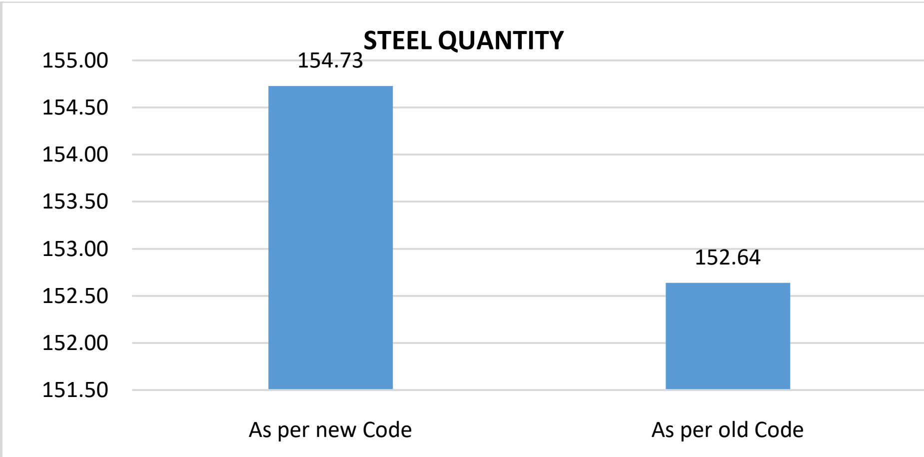


Steel Quantity Comparison for Shear Walls:

- Steel Quantity of shear walls were compared using software 'Draftwin' which creates detailed quantities for concrete, reinforcement and formwork for RCC buildings

G+15 Storey structure

Quantity	Ton
As per IS1893:2016	154.73
As per IS1893:2002	152.64



- Similarly models are analysed for G+20, G+25 & G+30 Storey structures.
- Results are extracted and compared.

IV. CONCLUSIONS

- Lateral displacement is increased by more than 100% in both EQ X & EQ Y as per code IS1893:2016 as compare to code IS1893:2002.
- Storey drift is increased by more than 100% in both EQ X & EQ Y as per code IS1893:2016 as compare to code IS1893:2002.
- In mode shape time period is increased by around 46% as per code IS1893:2016 as compare to code IS1893:2002.
- Storey shear is reduced by around 4% as per code IS1893:2016 as compare to code IS1893:2002.
- Steel quantity for shear walls in G + 15 Storey building is increased by 1.37% as per code IS1893:2016 as compare to code IS1893:2002.
- Steel quantity for shear walls in G + 20 Storey building is increased by 0.81% as per code IS1893:2016 as compare to code IS1893:2002.
- Steel quantity for shear walls in G + 25 Storey building is increased by 0.40% as per code IS1893:2016 as compare to code IS1893:2002.
- Steel quantity for shear walls in G + 30 Storey building is reduced by 0.01% as per code IS1893:2016 as compare to code IS1893:2002.
- Hence the code IS1893:2016 is economical for high rise structures where as it is slightly uneconomical for low height buildings in comparison with code IS1893:2002.

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