"SEISMIC ANALYSIS AND DESIGN OF G+4 STRUCTURE WITH MODIFIED PROVISION"

[1] Akash A.Ingale, [2] S.G.Makarande, [3] A.B.Dehane,
[1]P. G. Student of structural Engineering BDCE, Sevagram, Wardha [2]professor of Civil Engineering Department, BDCE, Sevagram, Wardha, [3]Asst.Professor of Civil Engineering Department, BDCE, Sevagram, Wardha.

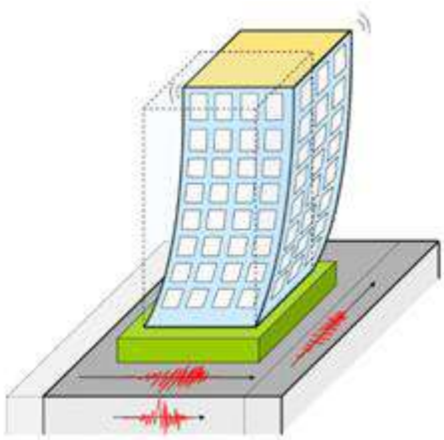
Abstract: In order to compete in the ever growing competent market it is very important for a structural engineer to save time. As a sequel to this an attempt is made to analyze and design a multistoried building by using a software package STADD PRO. As STAAD Pro is the current leading design software in the market, many structural designing companies use this software for their project design purposes. So, this article mainly deals with the analysis of the results obtained from the design of a building structure when it is designed using STAAD Pro Software. The software method of analysis is used for a G+4 Residential building located in Zone-II. The scope behind presenting this work is to learn how relevant Indian standard codes are used for design of various building elements such as beams, columns, slabs, and foundation and stair case by using STAAD Pro package when seismic loads and wind loads are acting on the structure. Earthquakes that occurred in past lead to the complete collapse of the buildings as structures are not well designed and constructed without adequate strength. To ensure safety against seismic forces of building, there is need to study the seismic analysis to design earthquake resistant structures. The present work deals with the analysis of a residential building of G+4 in which the dead load and live loads are applied and the structural design dimensions for beams, columns, footing is obtained. Beams and columns shall be designed as per IS 456:2000 and IS 875 (part1).

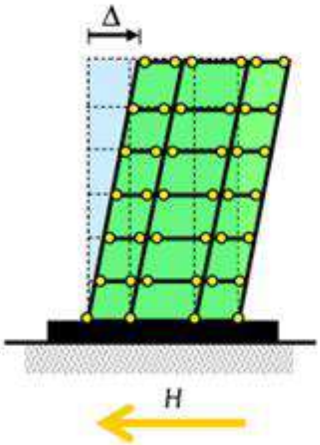
Index Terms- **Multistoried building STADD PRO,G+4 Residential building,IS 456:2000 and IS 875 (part1).**

1. INTRODUCTION

- The purpose of seismic resistant building is to provide comfort and safety which is done because of control on internal forces. Commonly, to protect structure damping has done i.e., to reduce the total seismic energy by structural members which provides the capacity to resist against earthquake. Conventional method of manual design of structure is time overriding as well as risk of human errors. So it is required to use some computer based software which gives more precise results and reduce the time. STAAD-PRO is the structural software is currently accepted by structural engineers which can solve emblematic problem like static analysis, wind analysis, seismic analysis using a variety of load combination to confirms various codes such as IS 456:2000, 1893:2002, IS 875:1987 etc.
- The Indian seismic code IS 1893 has now been divide into a number of part and the first part contain general necessities and those pertaining to structure has been released in 2002. There has been a break of 18 years since the earlier edition in 1984.Allowing for the advancement in accepting of earthquake-resistant design during these years; the new version is a major up gradation of the earlier version. The principal Indian seismic code (IS 1893) was distributed in 1962 and it has since been overhauled in 1966, 1970, 1975 and 1984. As of late, it was chosen to partition this code into various part, and Part 1 of the code contain general necessities and precise arrangements for structure has been distributed.
- The seismic codes are prepared with consideration of seismology of country, accepted level of seismic risk, properties of construction materials, construction methods, and structure typologies etc. Furthermore, the provisions given in seismic codes are based on the observations, experiments & analytical case studies made during past earthquakes in particular region. In India, IS 1893 (Part1) Criteria for Earthquake Resistant Design of Structures is used as code of practice for analysis & designing of earthquake resistant buildings. In the last decade, the detailed advanced research, damage survey was carried out by the Earthquake Engineering Sectional Committee of Bureau of Indian Standards. As a result, the huge data regarding behavior of various types of structures during earthquake was
- collected which gained the knowledge. This continuous effort has resulted in revision of IS 1893 (Part 1): 2002 [1]. Hence the sixth revision of IS 1893 (Part 1) was published in 2016. To implement the latest code in practice, it is necessary to understand the revised codal provisions in IS 1893 (Part 1):2016 [2] with respect to IS 1893:2002.

- In overhauling world, infrastructures have become omnipresent and it is inevitable to imagine today's world without it. Buildings made from concrete is one of the basic form of infrastructures which can be seen everywhere. Process of construction of a building entails different department such as architects, structure designer, contractors etc. with all the help of these departments, building is being erected such that it can withstand vigorous vertical loads and ground motion which is the result of earthquakes. Designer has to be very careful while considering these forces as little miscalculations will lead to failure of the structure because ground motions, being the complex concept, needs to be analyzed in a very scrutinized manner. Therefore, the resistance of a building and its design as per the guidelines of seismic codes has become an important research area. Sometimes, addition of members other than beams and columns are required to resist these produced lateral forces.
- IS: 1893-2016, being the latest Seismic Indian Code, provides amendments regarding the design of the earthquake resistant building. Various amendments and new guidelines were introduced in this code but the major one was related to the dynamic seismic analysis. It stated that dynamic seismic analysis shall be adopted for all tbuildings other than regular buildings lower than 15 m in height in seismic zone II.





- Seismic Analysis is a subset of structural analysis and is the calculation of the response of a building structure to earthquakes. It is part of the process of structural design, earthquake
- engineering or structural assessment and retrofit in regions where earthquakes are prevalent. The most important earthquakes are located close to the borders of the main tectonic plates which cover the surface of the globe. These plates tend to move relative to one another but are prevented by doing so by friction until the stresses between plates under the epicenter point become so high that a move suddenly takes place. This is an earthquake. The local shock generates waves in the ground which propagate over the earth's surface, creating movement at the bases of structures. The importance of waves reduces with the distance from the epicenter. Therefore, there exists region of the world with more or less high seismic risk, depending on their proximity to the boundaries of the main tectonic plates besides the major earthquakes which take place at tectonic plate boundaries, others have their origin at the interior of the plates at fault lines. Called intra plates earthquakes, these less energy, but can still be destructive in the vicinity of the epicenter. The action applied to a structure by an earthquake is a ground movement with horizontal and vertical components. The horizontal movement is the most specific feature of earthquake action because of its strength and because structures are generally better designed to resist gravity than horizontal forces. The vertical component of the earthquake is usually about 50% of the horizontal component, except in the vicinity of the epicenter where it can be of the same order. Steel structures are good at resisting earthquakes because of the property of ductility. Experience shows that steel structures subjected to earthquakes behave well. Global failures and huge numbers of casualties are mostly associated with structures made from other materials. There are two means by which the earthquake may be resisted:
- **Option 1** structures made of sufficiently large sections that they are subject to only elastic stresses
- **Option 2** structures made of smaller sections, designed to form numerous plastic zones.
- A structure designed to the first option will be heavier and may not provide a safety margin to cover earthquake actions

that are higher than expected, as element failure is not ductile. In this case the structure's global behavior is brittle. In a structure designed to the second option selected parts of the structure are intentionally designed to undergo cyclic plastic

- deformations without failure, and the structure as a whole is designed such that only those selected zones will be plastically deformed. The structures global behavior is ductile. The structure can dissipate a significant amount of energy in these plastic zones. For this reason, the two design options are said to lead to dissipative and non-dissipative structures. A ductile behavior, which provides extended deformation capacity, is generally the better way to resist earthquakes. One reason for this is that because of the many uncertainties which characterize our knowledge of real seismic actions and of the analyses we make, it may be that the earthquake action and / or its effects are greater than expected. By ensuring ductile behavior, any such excesses are easily absorbed simply by greater energy dissipation due to plastic deformations of structural components. The same components could not provide more strength (a greater elastic resistance) when option 1 is adopted. Furthermore, a reduction in base shear V (V reduced < V elastic) means an equal reduction in forces applied to the foundations, resulting in lower costs for the infrastructure of a building.

- **OBJECTIVES**

The primary objectives of this plan can be shortening as follows:

1. To study IS1893-2002 and IS1893-2016 for the different introduce in new code.
2. To remark the improvements and differences in results using new design code IS1893 – 2016.
3. To carry out relevant literature review by going through journal papers and conference proceedings.
4. To compare seismic analysis between IS1893-2002 and IS1893-2016.
5. To study practical design of G+4 structure.
6. To mark the improvements and differences in results using new design code IS1893-2016.

2. LITERATURE REVIEW

- **Malviya and Pahwa (2017)** had perform the seismic analysis of G+15 storey building using sap software using the revised new seismic code IS1893:2016. During this analysis he found that the load Combination is increases as compare to old seismic design code that is IS1893:2002. It is also seen that the column which is located in same building and at same position should increase the reinforcement as per new design code due to this the size of footing and depth of exaction is also increases. In this paper it is also show that the sizes of beam are also slightly increases due to the load combination of new design code that is IS1893:2016. Deflection, shear force and bending is also maximum in IS1893:2002 as compare to IS1893:2016.
- **S.K. Jain (2003)** This paper present the seismic burden appraisal for multistory structure according to Seems to be: 1893-1984 and IS: 1893-2002 suggestions. Four multistory RC confined structure go from three storied to nine storied are estimated and examined. The technique gives a lot of five individual examination grouping for each structure and the outcomes are used to assess the seismic response viz. story shear and base shear process concerning each the two form of seismic code. The seismic powers, process by IS: 1893-2002 are build up to be impressively higher, the distinction changes with structure properties. It is finished that such investigation should be done for self structure to conjecture seismic helplessness of RC surrounded structure that were planned utilizing earlier code and because of correction in the codal necessities may have render hazardous.
- **Daterao S. and Banarse M. (2018).** In this dissertation work, performance of steel multi storeyed buildings has been evaluated by using both codes IS – 1893:2002 and IS-1893:2016. For comparison purpose G+11 and G+6 buildings are selected. Sufficient bracing system is incorporated to control deflections. Performances of these models are studied and compared. Linear static analysis i.e. equivalent static analysis is carried out on the entire mathematical 3D models using the finite element software ETABS Version 15. It is observed that there is significant increase in the lateral drift and displacement demand which ultimately increases the member forces, and design. Importance factor for multi storey residential and commercial buildings has been changed from 1.0 to 1.2. As I increases, Ah will increase and therefore Base shear VB will increase. This may lead to increase in size of lateral load resisting members and reinforcement. Ultimately structure cost may increase.

- **Kumar A. and Chand J. (2019)** In present study, different storied building has been modeled using staad.pro software and analyzed with gravity and seismic loads to compare the results of seismic analysis as per IS:1893-2002. The loading and all other relevant considerations are same for various building. The performance of the structures has been evaluated in terms of different structural parameters such as axial force, bending moment, displacement, material quantity etc. Cost analysis has also been carried out on material (concrete and steel). Comparison of these results has been done to draw the conclusion of the present study. From the final outcomes of the study, it has been found that the total cost of the buildings designed with dynamic seismic analysis comes out to be 1.06 to 1.1 times higher than the building designed with static seismic analysis.
- **Gupta R. and Budhalani D.(2015)** The paper discusses the performance evaluation of RC (Reinforced Concrete) Buildings with plan irregularity. Structural irregularities are important factors which decrease the seismic performance of the structures. This study as a whole makes an effort to evaluate the effect of plan irregularity on RC buildings using IS 1893:2002 and IS 1893:2016 in terms of dynamic characteristics. Study concluded that seismic analysis as per guidelines of IS 1893:2016 shows higher value of base shear than as per IS 1893:2002. Also maximum lateral displacement in horizontal directions shows large value by response spectrum method as per IS 1893:2016.
- **Pandey R. and Arpan Herbert (2003)** had essentially manages the general investigation of the outcomes acquired from the plan of an ordinary and an arrangement unpredictable (according to IS 1893) multi story structure when planned utilizing STAAD Pro and ETABS programming's independently. These outcomes will likewise be contrasted and manual computations of an example shaft and section of the comparative structure planned according to IS 456. From the plan outcomes of pillars, it might end that ETABS gave lesser region of required steel as contrast with STAAD PRO. It is discovered from before concentrates on judgment of STAAD results with manual counts that STAAD Pro gives moderate structure results which is again demonstrated in this investigation by looking at the consequences of STAAD Pro, ETABS and Manual figuring (allude beneath table). Structure the plan results of section; since the required steel for the segment powers in this demanding issue is not exactly the base steel farthest point of segment (i.e., 0.8%), the measure of steel planned by both the product is equal. So judgment of results for this case is beyond the realm of imagination.
- **S.Ramanarayan and A.Manjunath (2003)** This article basically manage the investigation of the result acquired from the plan of a structure when it is planned utilizing STAAD Pro Software. The product strategy for investigation is utilized for a G+4 Residential structure situated in Zone-II. The degree at the back present this work is to figure out how relevant Indian standard codes are used for plan of an assorted variety of structure fundamentals, for example, pillars, segments, pieces, and establishment and stair case by utilizing STAAD Pro bundle when seismic loads and wind loads are performing on the structure. To ensure security by seismic powers of structure, there is require to think about the seismic investigation to plan quake reluctant structures. The present work manages the examination of a private structure of G+4 in which the dead burden and live loads are functional and the auxiliary plan measurements for bars, sections, balance is acquiring. Pillars and segments will be structured according to IS 456:2000 and IS 875 (part1).

- **METHODOLOGY**

- Study various literatures related to codal comparison of structure.
- Selection of structure and modeling in STADD-PRO.
- Modeling of two structures in STADD PRO according to IS1893:2002 & IS 1893:2016.
- Design of structure as per required IS code.
- Comparison of results for both the models will done to check the effect on seismic response of structure.

- **CODAL PROVISION**

The seismic codes are prepared with deliberation of seismology of country, accepted level of seismic risk, properties of construction materials, construction methods, and structure typologies etc. Furthermore, the provisions given in seismic codes are based on the observations, experiments & analytical case studies made during past earthquakes in particular region.

In India, IS 1893 (Part1) Criteria for Earthquake Resistant Design of Structures is used as code of practice for analysis & designing of earthquake resistant buildings. In the last decade, the detailed & advanced research, damage survey was carried out by the Earthquake Engineering Sectional Committee of Bureau of Indian Standards. As a result, the huge data regarding behavior of various types of structures during earthquake was collected which gained the knowledge. This continuous effort has resulted in revision of IS 1893 (Part 1): 2002 [1]. Hence the sixth revision of IS 1893 (Part 1) was published in 2016. To implement the latest code in practice, it is necessary to understand the revised codal provisions in IS 1893 (Part 1):2016 [2] with respect to IS 1893:2002. The paper aims to give brief idea about the revised clauses in latest seismic code.

3. ANALYTICAL DATA OF BUILDING

Table 3.1 Geometric and Material Data (IS1893:2002)

Parameter	**Values**
Structure type	RC special moment resisting frame
Storey count	G+4
Storey height	3 m
Size of column	Column 230X400mm
Size of beam	Beam 230mmX350mm
Depth of slab	125mm
Conc. Cube Comp. Strength, fck	25 N/mm^2
Reinforcement yield strength, fy	500 N/mm^2

Table 3.2 Geometric and Material Data(IS1893:2016)

Parameter	**Values**
Structure type	RC special moment resisting frame
Storey count	G+4
Storey height	3m
Size of column	Column 230X400mm
Size of beam	Beam 230mmX350mm
Depth of slab	125mm
Conc. Cube Comp. Strength, fck	25 N/mm^2
Reinforcement yield strength, fy	550 N/mm^2

3.3 Methodologies Used for Analysis

There is one method which used for the analysis stated below.

3.3.1 Equivalent static analysis

1. The ESA is performed with STADDPRO for all building models.
2. Medium soil condition is considered.
3. Fundamental natural period for R/C frame building is calculated by using clause 7.6.1 of IS 1893 (part 1):2002.
4. The analysis has carried out for four zones.

3.4 Seismic Analysis procedure

The following procedure is adopted to complete the analysis against earthquake.

3.4.1 Seismic Data Required for Analysis

To define earthquake, we need a precise factor according to the location of the site, so that it will be calm for us to consider factors specified in IS 1893 (part 1):2002 and IS 1893:2016 according to the specific zones, shown in Table.

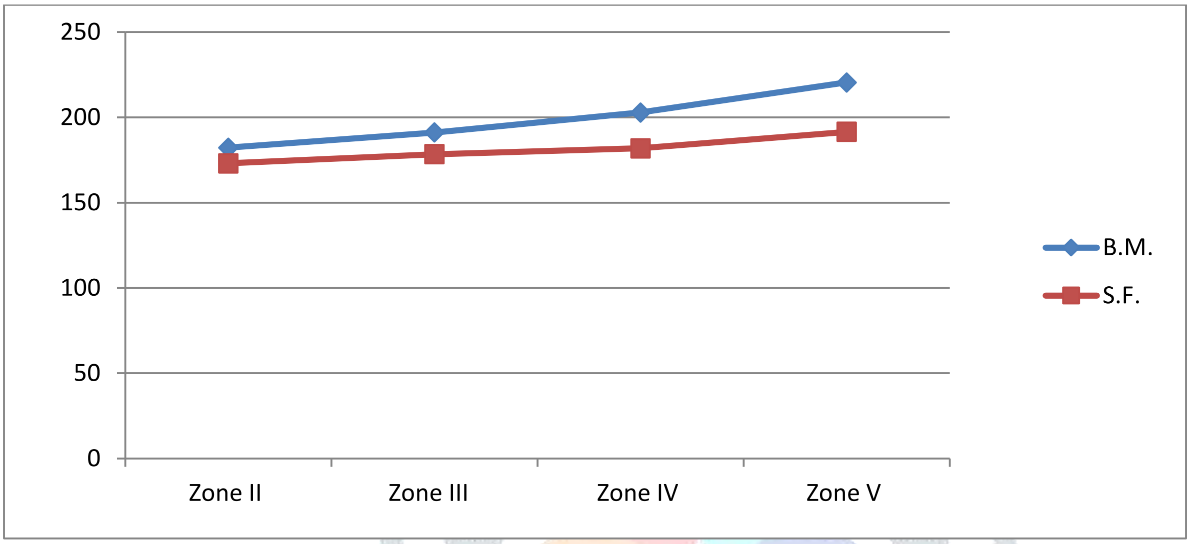
Table 3.3.1 Seismic data required for analysis Parameter	**Values as per IS 1893 (part 1):2002**	**Clause**
Type of structure	RC Special moment resisting frame	Table 7, Clause 6.4.2
Seismic zone	II	Table 2, Clause 6.4.2
Zone factor (Z)	0.10	Table 2, Clause 6.4.2
Type of soil	Medium soil	Clause 6.4.5
Damping	5 %	Figure 2, Clause 6.4.5
Importance factor (I)	1	Table 7, Clause 6.4.2
Time period	.075xh.75	Clause 7.6.1

Table 3.4.1 Seismic data required for analysis Parameter	**Values as per IS 1893 (part 1):2016**	**Clause**
Type of structure	RC Special moment resisting frame	Table 7, Clause 6.4.2
Seismic zone	II	Table 2, Clause 6.4.2
Zone factor (Z)	0.10	ANNEX E
Type of soil	Medium soil	Clause 6.4.5
Damping	5 %	Figure 2, Clause 6.4.5
Importance factor (I)	1	Table 7, Clause 6.4.2
Time period	.075xh.75	Clause 7.6.2

4.COMPARISION AND ANALYSIS

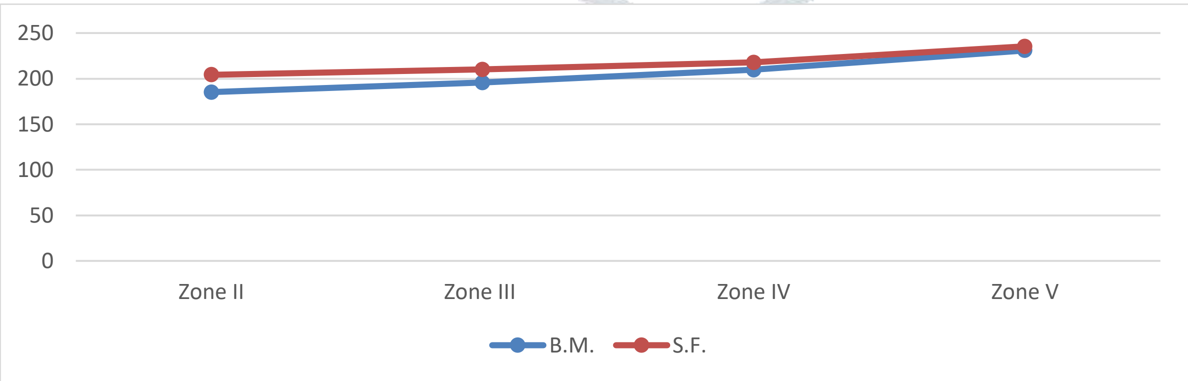
4.1 COMPARISON OF B.M. AND S.F.(2002)

Zone	B.M.	S.F.
Zone II	182.254	173.15
Zone III	191.078	178.36
Zone IV	202.842	181.824
Zone V	220.489	191.509



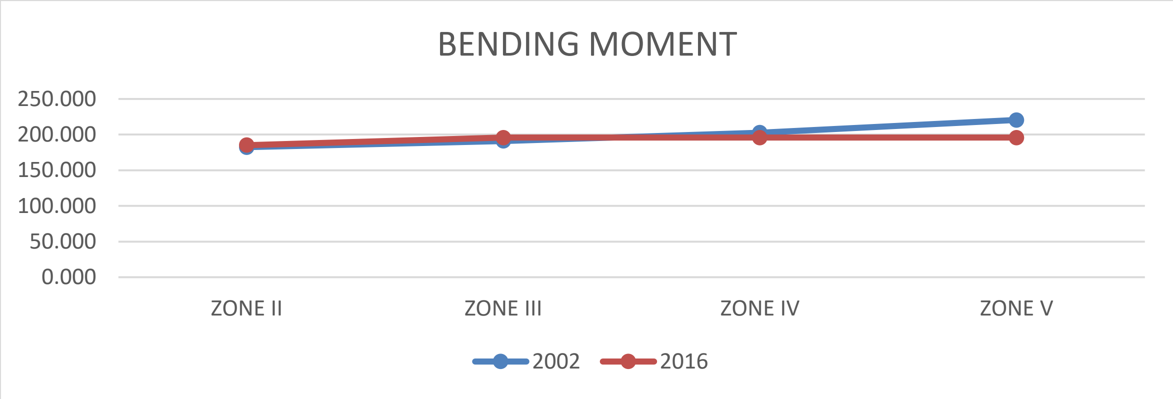
4.2 COMPARISON OF B.M. AND S.F.(2016)

Zone	B.M.	S.F.
Zone II	185.195	204.351
Zone III	195.783	210.162
Zone IV	209.901	217.910
Zone V	231.077	235.532



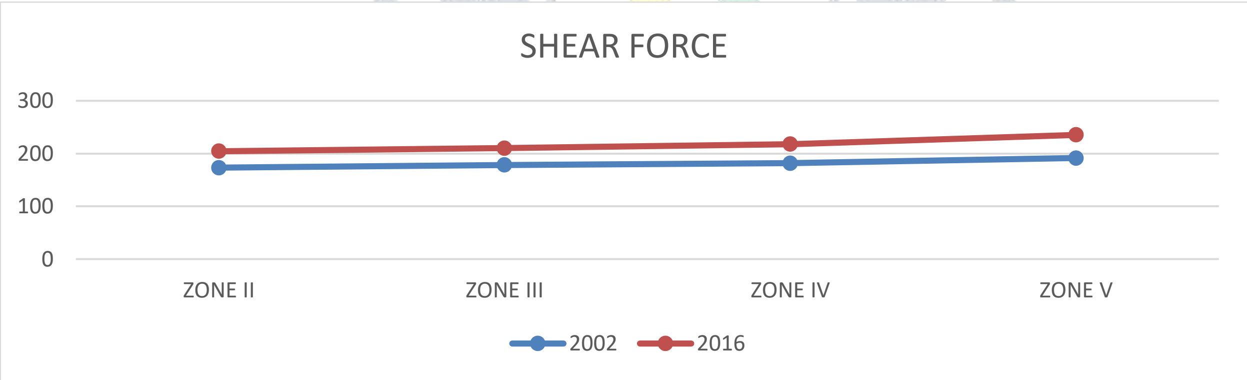
4.3 COMPARISON OF BENDING MOMENT

ZONE	**2002**	**2016**
ZONE II	182.254	185.195
ZONE III	191.078	195.783
ZONE IV	202.842	209.901
ZONE V	220.489	231.077



4.4 COMPARISON OF SHEAR FORCE

ZONE	**2002**	**2016**
ZONE II	173.15	204.351
ZONE III	178.36	210.162
ZONE IV	181.824	217.910
ZONE V	191.509	235.532



5. Design Results:

BEAM NO. 66 DESIGN RESULTS (2002) :

M25 Fe550 (Main) Fe550 (Sec.)

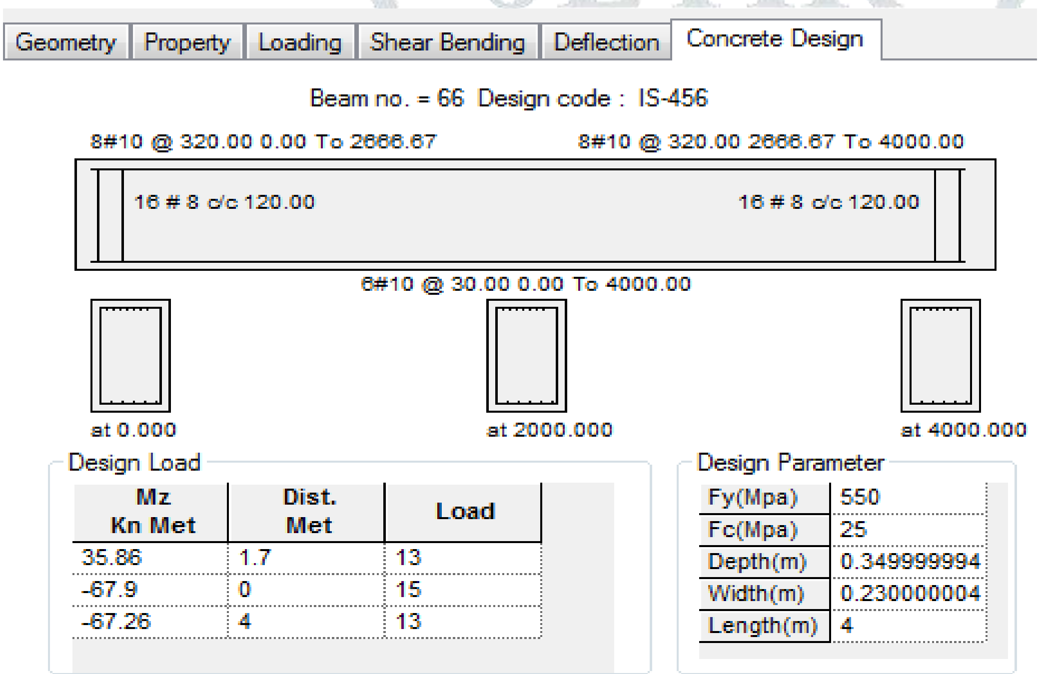
LENGTH: 4000.0 mm SIZE: 230.0 mm X 350.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP REINF.	541.72 (Sq. mm)	113.75 (Sq. mm)	0.00 (Sq. mm)	113.75 (Sq. mm)	535.47 (Sq. mm)
BOTTOM REINF.	113.75 (Sq. mm)	204.74 (Sq. mm)	247.55 (Sq. mm)	145.26 (Sq. mm)	113.75 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP REINF.	8-10í 2 layer(s)	6-10í 1 layer(s)	2-10í 1 layer(s)	6-10í 1 layer(s)	8-10í 2 layer(s)
BOTTOM REINF.	6-10í 1 layer(s)	6-10í 1 layer(s)	6-10í 1 layer(s)	6-10í 1 layer(s)	6-10í 1 layer(s)
SHEAR REINF.	2 legged 8í @ 120 mm c/c	2 legged 8í @ 120 mm c/c	2 legged 8í @ 120 mm c/c	2 legged 8í @ 120 mm c/c	2 legged 8í @ 120 mm c/c



BEAM NO. 66 DESIGN RESULTS (2016)

M25 Fe550 (Main) Fe550 (Sec.)

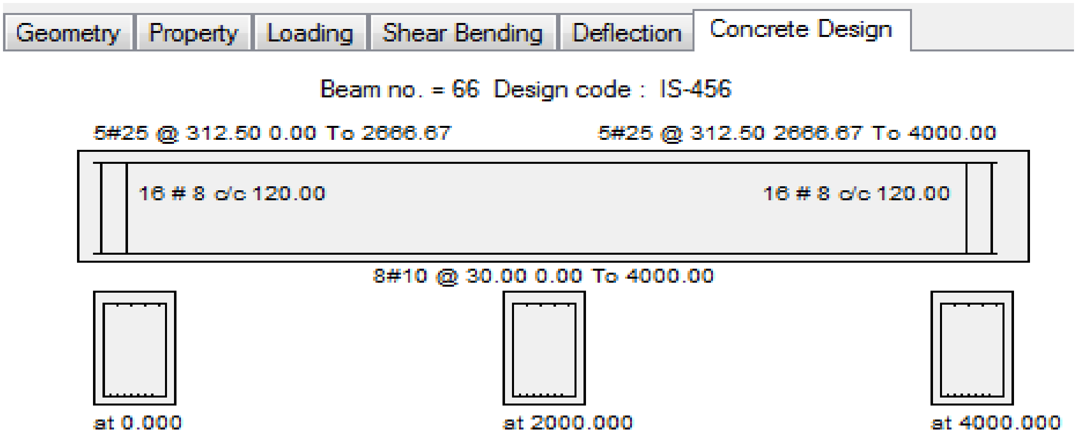
LENGTH: 4000.0 mm SIZE: 230.0 mm X 350.0 mm COVER: 25.0 m

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP REINF.	974.19 (Sq. mm)	313.50 (Sq. mm)	0.00 (Sq. mm)	206.06 (Sq. mm)	899.76 (Sq. mm)
BOTTOM REINF.	539.85 (Sq. mm)	455.70 (Sq. mm)	279.81 (Sq. mm)	304.59 (Sq. mm)	374.45 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP REINF.	5-25í 1 layer(s)	5-25í 1 layer(s)	2-25í 1 layer(s)	5-25í 1 layer(s)	5-25í 1 layer(s)
BOTTOM REINF.	8-10í 2 layer(s)	7-10í 2 layer(s)	6-10í 1 layer(s)	6-10í 1 layer(s)	6-10í 1 layer(s)
SHEAR REINF.	2 legged 8í @ 120 mm c/c	2 legged 8í @ 120 mm c/c	2 legged 8í @ 120 mm c/c	2 legged 8í @ 120 mm c/c	2 legged 8í @ 120 mm c/c



Design Load

Mz Kn Met	Dist. Met	Load
68.13	0	26
-123.96	0	19
-113.77	4	18

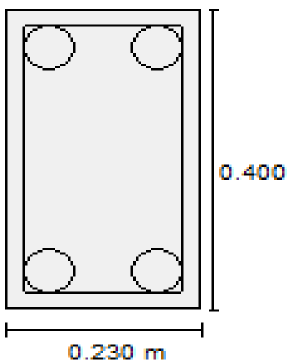
Design Parameter

Fy(Mpa)	550
Fc(Mpa)	25
Depth(m)	0.349999994
Width(m)	0.230000004
Length(m)	4

Design Results of Column :

Geometry | Property | Loading | Shear Bending | Deflection | Concrete Design

Beam no. = 82 Design code : IS-456

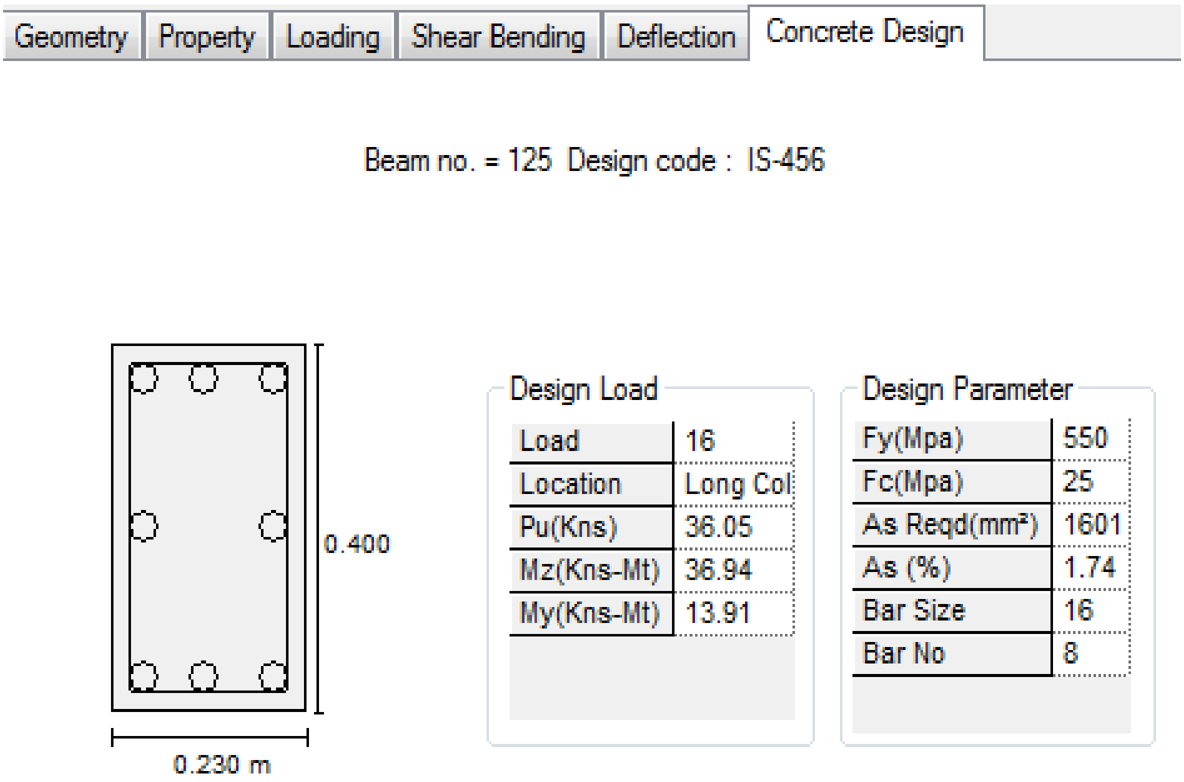


Design Load

Load	17
Location	Long Col
Pu(Kns)	317.06
Mz(Kns-Mt)	36.78
My(Kns-Mt)	25.31

Design Parameter

Fy(Mpa)	550
Fc(Mpa)	25
As Reqd(mm²)	3003
As (%)	3.49
Bar Size	32
Bar No	4



6.Conclusion

1. Shear force obtained with old code IS 1893-2002 for considered building in zone V is 191.509 kN whereas for new code IS 1893-2016 is obtained is 235.532 kN.
2. Bending moment obtained with old code IS 1893-2002 for considered building in zone V 220.489 KN-m whereas for new code IS 1893:2016 is obtained is 231.007KNm.
3. From above design results, it has been seen that due to variation in the load combination, beams and columns have different reinforcement detailing.
4. For column the area of steel for new code IS 1893-2016 is greater than old code IS 1893-2002.

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