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A comparative study of the ductile design of column based on new is 13920-2016 and old is 13920-1993

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ABSTRACT

This paper presents a comparative study of ductile design of column based on New IS 13920-2016 & Old IS 13920-1993. The past earthquake experiences in India clearly demonstrated that the typical structural design and construction methods lacks the basic seismic resistance criteria. The implementation of ductile design and detailing practices in ordinary building is one of the major area need to be focused. The overall ductility in reinforced concrete structure is a tough issue. But in some strategic locations of the building structure certain design factor and reinforcement detailing can be adopted to minimize the seismic damage and life threatening collapse. The techniques are simple, inexpensive and elaborately discussed in the bureau of Indian standard code of practice (IS13920). The earthquake that occurred after the release of IS 13920-1993, (especially the 1997 Jabalur, 2001 Bhuj, 2004 Sumatra, 2006 Sikkim earthquake), it was felt that this IS 13920-1993 code needs further improvement. It is proposed to make Comparative study of Multi storied framed Building with its column c/s aspect ratio & also its minimum requirement of column by Equivalent Static method as per provision of new IS 13920-2016 and old IS 13920-1993.To make an excel sheet for the shear design of beam column joint and also the strong column weak beam design for moment resisting frame and check the models. It is also proposed to analyse and Design multi-story Building structure using Computational software like ETABS and compare the parameters like Time period, Base shear, Story drift, Roof displacement, Quantities, cost, etc.

Keywords: *IS 13920-2016, IS 13920-1993, Ductile Design.*

1. INRODUCTION

An earthquake is caused by movement of tectonic plates in earth crust results in severe ground shaking. In the past thirty years moderate to severe earthquakes have occurred in world at intervals of 5 to 10 years caused severe damages and suffering to humans by collapsing the structure, tsunamis, floods, landslides in loose slopes and liquefaction of sandy soils. Socio-economic losses have been increased significantly in the world due to establishment of new cities in earthquake prone areas. In the past these developments in construction have not been followed by guidelines of seismic codes. The effect of horizontal loads like wind loads, earthquake forces and blast forces etc. are attaining increasing importance and almost every designer is faced with the problem of providing adequate strength and stability against horizontal loads. However, structural engineers face major challenges to minimize these damages by proper designing of structure. By using state-of-the-art design and construction techniques in earthquake engineering may reduce life threats and damages to reinforced concrete buildings. Various types of damages have been found after each disastrous earthquake. Through investigation these damages leaded towards the improvement in the design and construction practices. The intensity of damages depends upon the magnitude of earthquake, its focus & distance from epicentre and soil strata on which structure stands.

Reinforced concrete is being used as major construction material for the construction of multi-storey buildings since 19th century. Large number of residential and commercial buildings in Middle East has been constructed with parking at basement and first story. These stories are called soft stories having less than 80% stiffness than the story above. As a result, soft stories become more vulnerable to earthquake. Reinforced concrete moment frame structure is most common type of construction to resist earthquake. Beam and columns in frame structure are properly proportioned and detailed to resist flexural, axial and shearing actions produced during strong earthquake ground shaking. Various seismic design codes define these frame structures in different ductility classes with specific response reduction factor based on proportioning and detailing of structure. This factor governs the seismic

performance of code-designed buildings In addition to; control of drift is an important factor in design and expected seismic performance of building. All codes define procedures to estimate drift and allowable limits of drift, however difference is found due to effective stiffness of structural members.

Earthquake is a global phenomenon. Due to frequent occurrence of earthquakes it is no more considered as an act of God rather a scientific happening that needs to be investigated. During earthquake, ground motions occur both horizontally and vertically in random fashions which cause structures to vibrate and induce inertia forces in them. Analysis of damages incurred in moment resisting RC framed structures subjected to past earthquake show that failure may be due to utilization of concrete not having sufficient resistance, soft storey, beam column joint failure for weak reinforcements or improper anchorage, column failure causing storey mechanism. Beam-column connection is considered to be one of the potentially weaker components when a structure is subjected to seismic loading.

1.1 New IS 13920-2016 Code Summary

BIS has released the first revision of IS 13920: 2016 [Ductile Design and detailing of reinforced concrete structures subjected to seismic forces-Code of practice] since it was first published in 1993. Most of the older provisions have been redrafted and modified for greater clarity and new provisions have been added. Much of this revision is based on the IITK-GSDMA document of proposed draft provisions.

Some of the major changes and additions in this version are as follows: -

- Title of the Code IS 19320: 2016 includes the word “Ductile Design” in addition to “Ductile Detailing”.
- The minimum dimension of a column has been modified.
- New requirements have been included for gravity-only columns (i.e., columns which are not part of lateral load resisting frame).
- Column-to-beam strength ratio provisions have been added in keeping with the strong column–weak beam design philosophy for moment resisting frames.
- Shear design of beam-column joints has been added.
- Design of slender RC structural walls is improved. The principle of superposition is dropped for estimating the design moment of resistance of structural walls with boundary elements and a new alternative procedure is mentioned.
- The detail of anchorage of longitudinal beam bars at exterior beam-column joint has been revised.
- Clauses giving details about mechanical couplers, welded splices in beam, column and shear wall have been added.
- The minimum diameter of a link has been changed.
- A limit is set for the factored axial compressive stress consisting of all load combinations related to seismic loads.

1.2 Procedure

The Finite element analysis software Etabs 16.0.0 is used to create 3D models and run all analyses. The software is able to predict the geometric nonlinear behavior of space frames under static or dynamic loadings, taking into account both geometric nonlinearity and material inelasticity. The model is created based on old IS 13920-1993, & Compare with the New IS 13920-2016 requirement.

1.2.1 Based On Column C/S Aspect Ratio (Model 1)

Analytical studies are carried out on a G+6 Multi-story Building with different C/S aspect ratio based on New IS 13920-2016 and Old IS 13920-1993.

- As per IS 13920-1993 for Column and frame members subjected to bending and axial load, the ratio of the shortest cross sectional dimension to the perpendicular dimension shall preferably not be less than 0.4.
- As per the required Size of Column & satisfy the c/s aspect ratio as per IS 13920-1993 is: 300 x 750 mm2.

Parameter	**Value**
Plan of Building	48 m x 48 m
Number of stores	**G+6**
Story height	3 m
Beam size	**230mm x 600 mm, 230 mm x 500 mm**
Column size	**300 mm x 750 mm**
Grade of concrete	M 25
Grade of steel	Fe 500

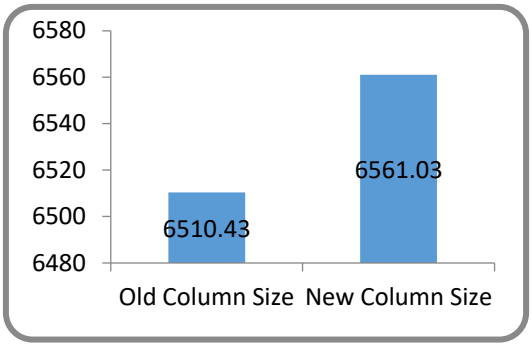
- General requirement check for Beam & Column sizes as per the code.

Based On Column C/S Aspect Ratio (Model 2)

- As per IS 13920-2016 for Column and frame members subjected to bending and axial load, the ratio of the shortest cross sectional dimension to the perpendicular dimension shall preferably not be less than 0.45.
- As per the required Size of Column & satisfy the c/s aspect ratio as per IS 13920-2016 is: 350 x 750 mm2. The design data is same for the model 2 with different Column Size as per new IS 13920-2016 code Requirement

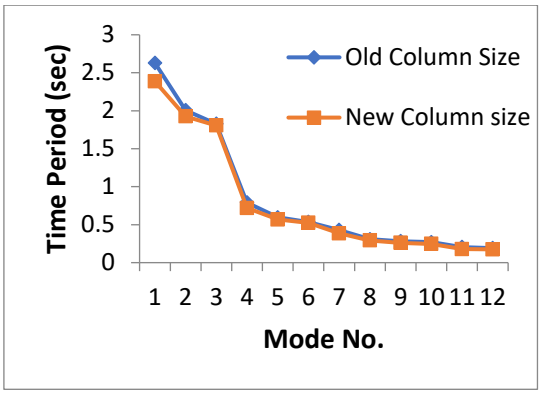
RESULTS

- **Base shear**



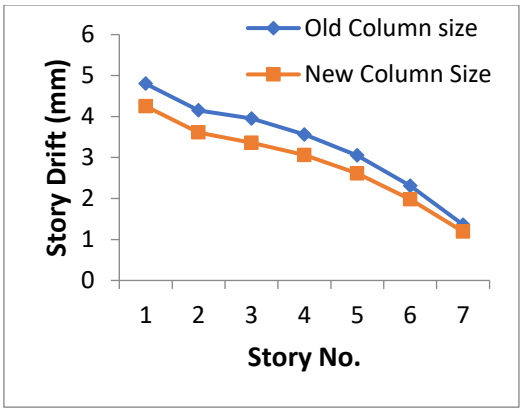
Results of Base shear

- **Time period**



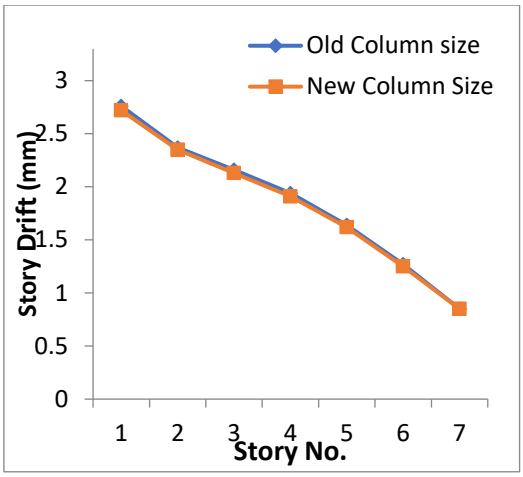
Results of Time period

A. Story Drift (EQX)



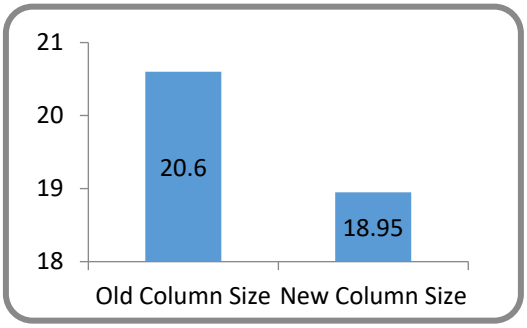
Results of story drift (EQX)

B. Story Drift (EQY)



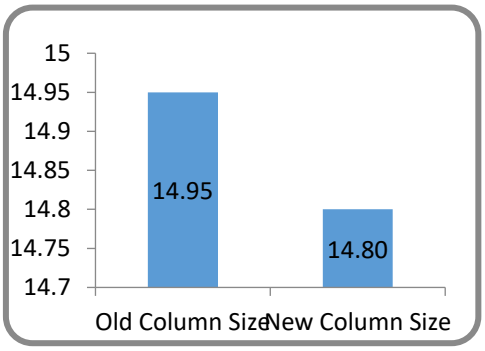
Results of story drift (EQY)

C. Roof Displacement (EQX)



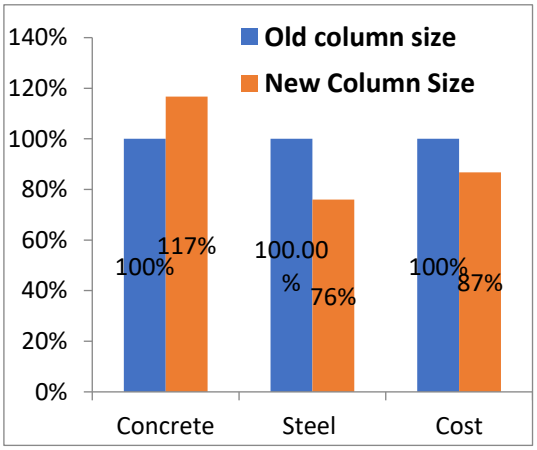
Results of story displacement (EQX)

D. Roof Displacement (EQY)



Results of story displacement (EQY)

E. Cost



Cost Comparison

1.2.3 BASED ON MINIMUM COLUMN DIMENSION: (MODEL 4)

Analytical studies are carried out on a G+6 Multi-story Building with minimum dimension of column based on New IS 13920-2016 and Old IS 13920-1993. ETABS is used for modelling and Analysis of RC Building with minimum dimension of column.

As per IS 13920-2016, the minimum dimension of column shall not be less than,

20 db, where db. is the diameter of the largest diameter longitudinal reinforcement bar in the beam passing through or anchoring into the column at the joint, or 300 mm.

The required column size as per minimum column dimension

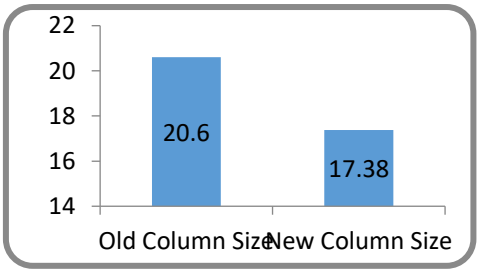
20db = 20*25 = 500mm or

300 mm.

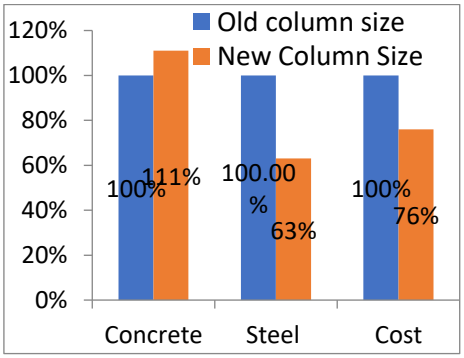
As per the required Size of Column & satisfy the minimum column dimension as per IS 13920-2016 is: 500 x 500 mm2.

Results:

A. Roof Displacement



B. Cost



2. BASED ON SHEAR DESIGN OF JOINT & FLEXURAL STRENGTH RATIO: (CASE 3)

2.1 General

Analytical studies are carried out on a G+4, G+9, G+14 Multi-story Building with the based on old IS 13920-1993, and then check the model data or joint in excel for beam column joint &check for flexural strength ratio in excel sheet, and revise the model as per new requirement of size as per IS 13920-2016.

Properties

Parameter	**Value**
Plan of Building	48 m x 48 m
Number of stores	**G+4**
Story height	3 m
Beam size	**230mm x 500 mm, 230 mm x 450 mm**
Column size	**400 mm x 450 mm**
Grade of concrete	M 25

Grade of steel	Fe 500

- General requirement check for Beam & Column sizes as per the code.
- After the analysis and design of G+4 Story Building model as per old IS 13920-1993 with Equivalent Static method & Response Spectrum method, check the model for shear strength design of beam column joint and also flexural strength ratio (strength column weak beam) , there criteria are provided in recent version of the IS 13920-2016 code. So check the model and compare the data.

General Details (From New IS 13920-2016 Code)

After checking the G+4 Story Building Model(as per old IS 13920-1993) in excel of shear design of beam column joint & flexural strength ratio, it has need to be revise because of the failure of the joints in shear & flexure.

So based on Trial & Error method redesign the model and check for shear design & flexure strength ratio, and make a model which joints are capable to resist the seismic forces during earthquake and pass on shear design & flexure.

After trial & error, redesign the model, the required Size of Column to satisfy the shear strength design of joints and flexural strength ratio as per IS 13920-2016 is: 600 x 700 mm2.

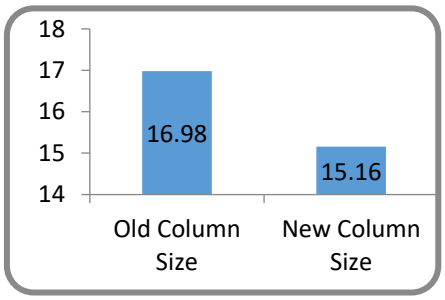
The design data is same for the model 5 with different Column Size as per new IS 13920-2016 code Requirement. All the combination is applied on the new code model and analysis and designs the model and compares both the model result & checks all the parameters.

Properties

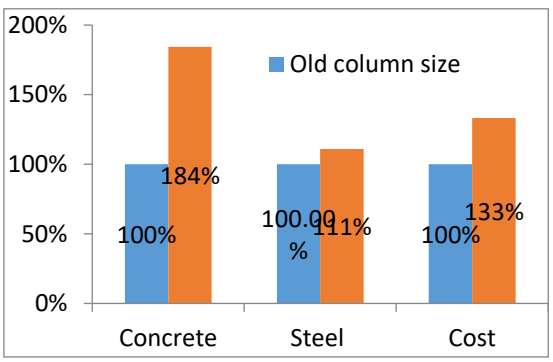
Parameter	**Value**
Plan of Building	48 m x 48 m
Number of stores	**G+4**
Story height	3 m
Beam size	**230mm x 500 mm, 230 mm x 450 mm**
Column size	**600 mm x 700 mm**
Grade of concrete	M 25
Grade of steel	Fe 500

Results: (G+4)

- **Roof Displacement**

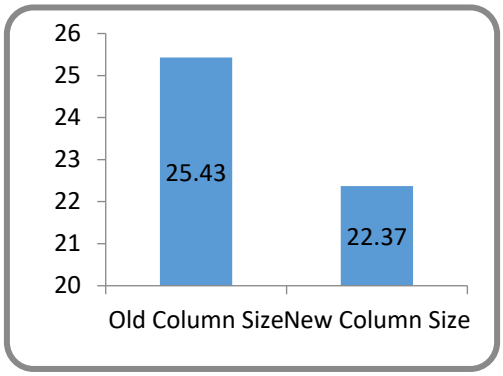


- **Cost:**

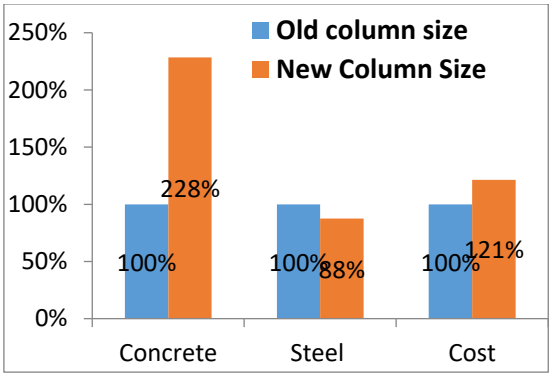


Results: (G+9)

- **Roof Displacement:**

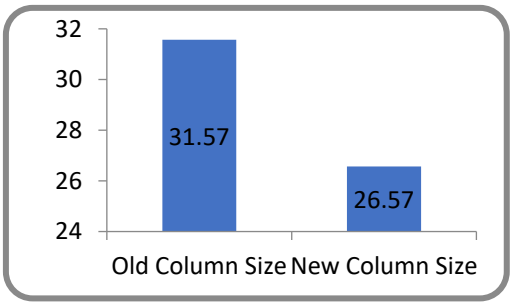


- **Cost:**

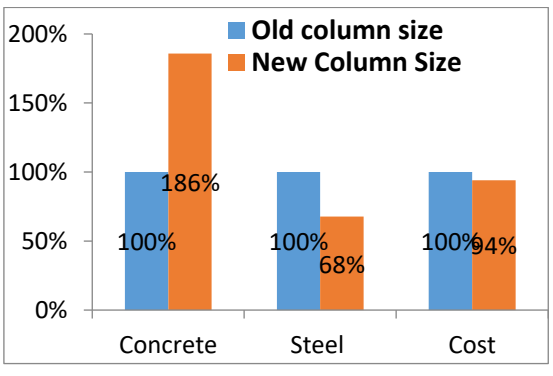


Results: (G+14)

- **Roof Displacement**



- **Cost**



3. CONCLUSION

Beam-column joints in moment resisting frames have traditionally been neglected in design process while the individual connected elements, that is, beam and column have a received considerable attention in design. Research on beam-column joints of reinforcement concrete moment resisting frame was started only in the 1970s. The 1993 version of IS 13920-1993 incorporated some provisions on the design beam column joints.

- Base shear is increase with using new IS 13920-2016 code column C/S aspect ratio & minimum dimension of column & shear design of beam Column joint.
- Time period & story Drift is decrease with using new code requirements compare to old code data.
- The roof displacement is also decrease with new IS requirements.
- Using the new code requirements of shear design of beam column joint, they are effective for high rise building.

The revision of codes is a periodic process which results from continuous and systemic research in the related field. IS: 13920-2016 is the first revision of the code on ductile detailing of RC structures subject to seismic forces. The first revision has added some design aspects also along with detailing. The provisions of earlier code have been suitably modified keeping in view more strength and stiffness and enhanced energy dissipation in the event of an earthquake along with ductility for seismic resistance of structures. The revised code will lead to major modifications in beam-column design owing to the inclusion of strong column-weak beam theory.

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