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Comparative study of static and dynamic design analysis of RCC school building

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Abstract
Purpose: The present study deals in the zone 5 and for school building which constructed in district mandi, Himachal Pradesh. A multi-storied framed school structure of (G+3) pattern is selected. Linear seismic analysis is done for the building by static method using STAAD-Pro as per the IS-1893-2002-Part-1 and dynamic method (Response Spectrum Method) using STAAD-Pro as per the IS-1893-2016-Part-1. A comparison is done between the static and dynamic analysis, the results such as Bending moment, area of steel required, compared and summarized for Beams, Columns and Structure as a whole during both the analysis.
Design/methodology: In this research comparative study of static and dynamic analysis of structure has been done by the STAAD. Pro software. Schools, hospitals and institutional buildings are the major structures. These structures require proper structural design, detailing and construction. For the safety and stability of the building researcher use STAAD. Pro software which gives economical and efficient Output.
Findings: The present study found that the loads, moments, area of steel are different for different methods. The comparison has been done in the tabular form. Dynamic method is necessary in the zone 5 which is severe to earthquake. For the further research, zone, soil type and importance factors of the structure can be changed as per the researcher requirement.
Research limitations: The analysis of such type of buildings is not fully explored for different zones and soil condition**s.**
Practical Implications: Practical implications are related to the behaviour of structures in the earthquake excitation, especially to understand the response of structure in zone 5.
Originality/value: Analysis of G+3 RCC School Building

Keywords: RCC Buildings, Equivalent Static Analysis, Response Spectrum Analysis, STAAD. Pro, is Code 1893-2002, is Code 1893-2016

Introduction
There are many types of buildings exist in this world. Such as RCC, steel, timber and composite buildings etc. But the common types are RCC buildings constructed because the designing and construction of RCC buildings are easier. Availability of materials, labours and machinery are easier in this field. All these factors help in timely construction and economic buildings.
But on the structural design point of view many structures are constructed without design or on the guidance of lay men. This practice is not good for the buildings. Due to lack of awareness, buildings are not safe for earthquake and other forces. Due to construction of dams, mining and underground explosions buildings are not stable.
For the safety and stability of the building structural design is must. Now days, most of the buildings are designed and analysed by the software. STAAD. pro is the easy software used to designed buildings. Buildings are designed by the static method due to lack of time. On the other hand, dynamic analysis is a time-consuming process and requires additional input related to mass of the structure, and an understanding of structural dynamics for interpretation of analytical results.

Objectives
For both method objectives shows below in the form of steps:
i. Preparing of model of G+3 school building in STAAD. Pro.
ii. Assigning supports and properties to the structure

iii. Assigning load to the structure
iv. Assigning design parameter to the structure
v. The analysis is being done in zone 5.
vi. Add and assign load combinations according to code
vii. Analyse the program and compare the output results

Literature Survey

Analysis and Design of G+6 Storied Residential Building using Staad Pro. The aim of this project is to design and analyse a 6- storeyed hostel building for various load combinations using STAAD Pro software. The structure is designed and analysed by using the Indian Standard codal specifications which includes IS 456-2000 and IS 875 (I, II & III). The structural members of the building are safe in shear, flexure and deflection of horizontal members are within 20 mm.

The steel provided for the structure is economic. The sizes of the members proposed by software can be used in construction.

Comparative Study of Static and Dynamic Method of Seismic Analysis of RCC Multi-storeyed Building. Analyse building for seismic analysis and dead load, Live load and Earthquake load using static equivalent method and response spectrum method structure. The maximum horizontal displacement with equivalent static method shows more by 27% analysis done by response spectrum method. The maximum story drift with equivalent static method shows more by 36% analysis done by response spectrum method. In comparison between static and dynamic, drift values are higher in static analysis.

Seismic Analysis of Multistorey (G+7) Building using Staad-Pro and Manually. The main objective is to estimate and check seismic response of building and analyse & design it on that basis using STAAD.Pro software. A. Design Base Shear (Manually) = 2345.71 KN B. Design Base Shear (STAAD-Pro) = 1634.43 KN and we concluded that the base shear value on STAAD-Pro is correct value because we assign the required data using references on it and it gives us result without any manual defect STAAD-Pro C. The G+7 residential building has been analysed and deigned using STADD. Pro. D. Seismic forces have been considered and the structure is designed as an earthquake resistant structure.

Comparison of Seismic Analysis and Static Analysis of Residential Building Using Staad. Pro In this paper, a residential building with ground floor as partial parking located in seismic zone III has been considered for static analysis and seismic analysis by using STAAD.PRO software. Various load combinations as per IS 1893-2016 have been considered to obtain the worst condition. For Beam: we can conclude that with the effect of seismic forces the moment on the load carrying member gets increased.

For Column: The research paper enables to analyze the G+4 structure in Zone III under seismic as well as static loads wherein the displacements observed are nearly same.

The change in moment in Z direction is nearly same but the change in moment in y-direction is very high in case of seismic analysis. Because of the higher moment, we have to provide higher amount of reinforcement.

For Beam: The research paper enables to analyse the G+4 structure in Zone III under seismic as well as static loads wherein the displacements observed are nearly same.

The moment obtained in z-direction is very high in case of seismic analysis as compared to that in static analysis.

From our following results, we can conclude that with the effect of seismic forces the moment on the load carrying member gets increased.

Comparative Study on Analysis and Design of Reinforced Concrete Building under Seismic Forces for Different Codal Guidelines. The comparative study includes the comparison building base shear, bending moment, and shear force, percentage of steel, required area, displacement, and story-drift. A. For Beam: -

Concrete design as per IS loading

1 Required area is maximum as per ACI and minimum as per IS.
2 Percentage of steel is maximum as per IS and minimum as per AIJ.

Concrete design as per their loading

1. Required area is maximum as per IS and minimum as per BSLJ.
2. Percentage of steel is maximum as per IS and minimum as per AIJ.

For columns

Concrete design as per IS loading

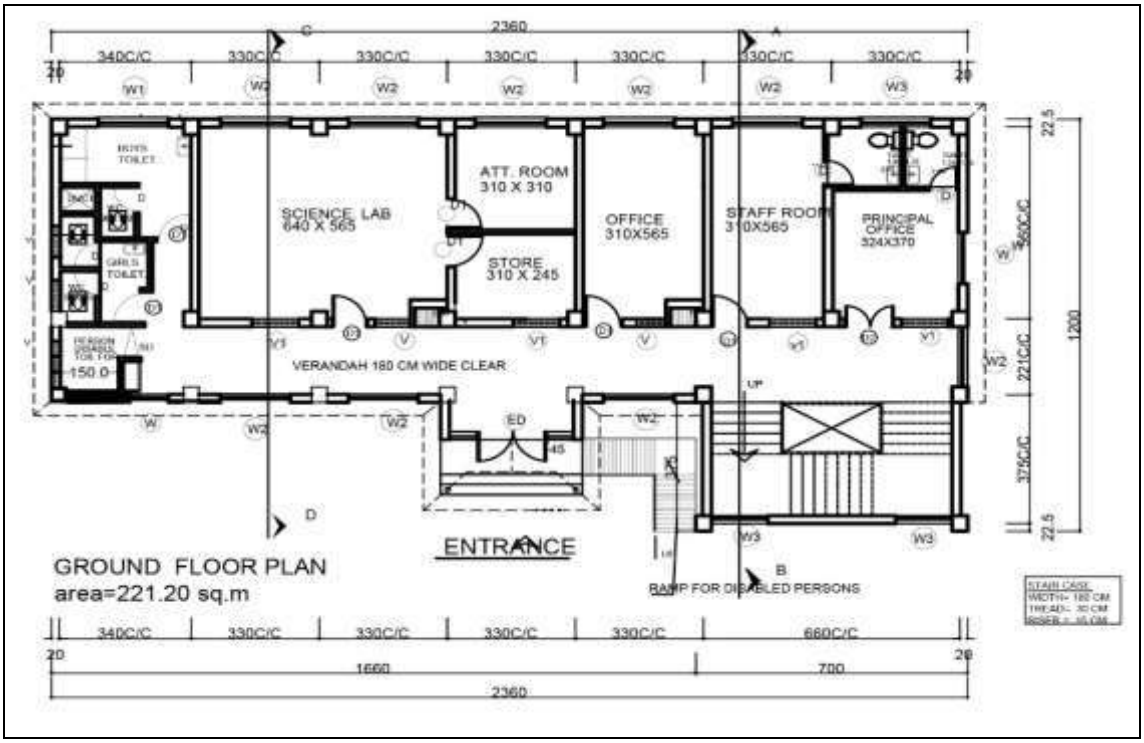
1. Required area is maximum as per EC and minimum as per AIJ.
2. Percentage of steel is maximum as per AIJ and minimum as per ACI.

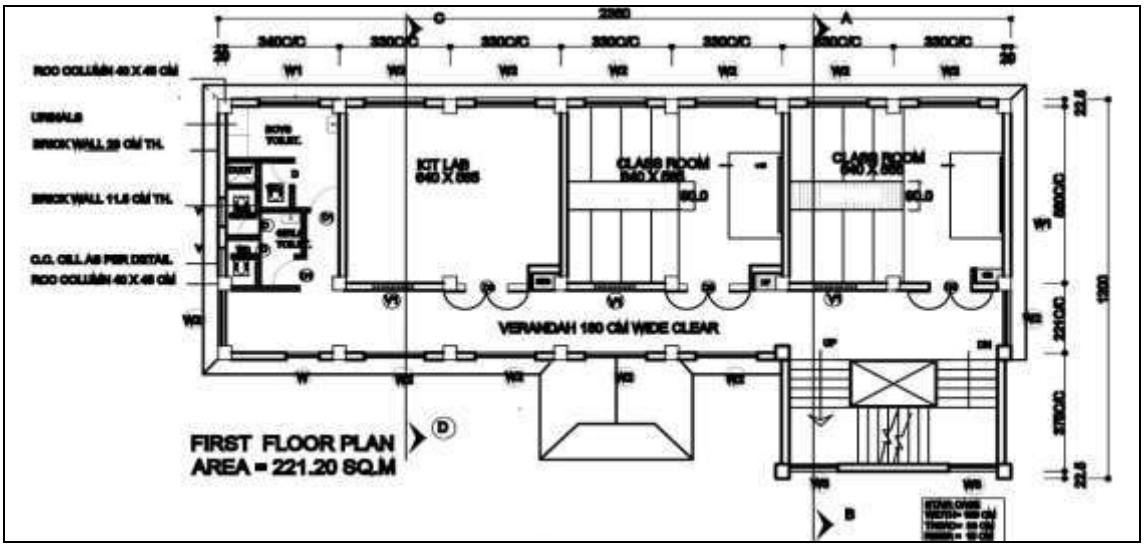
Concrete design as per their loading

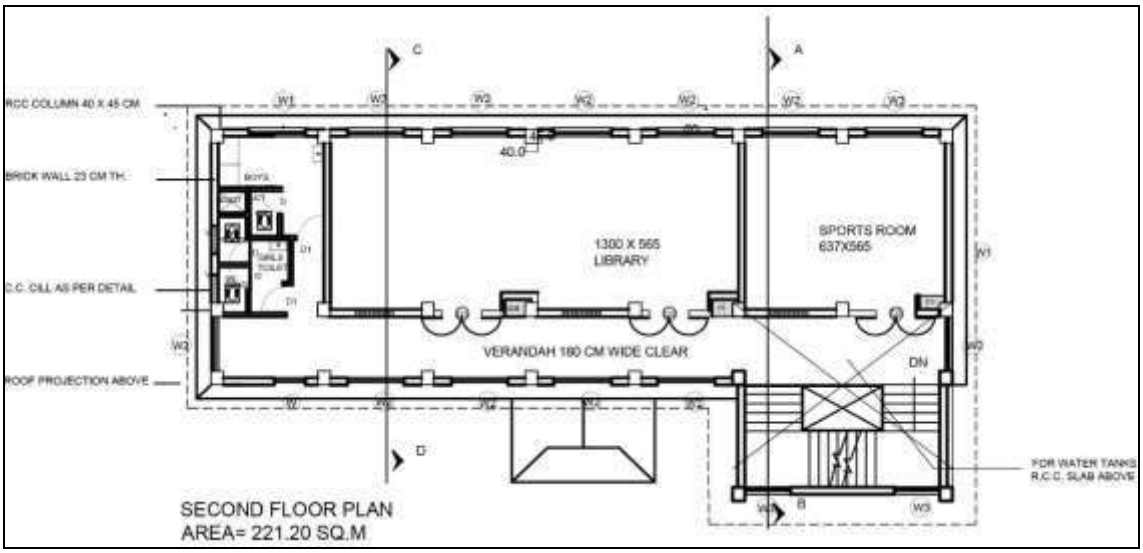
1. Required area is maximum as per IS and minimum as per EC.
2. Percentage of steel is maximum as per AIJ and minimum as per ACI.

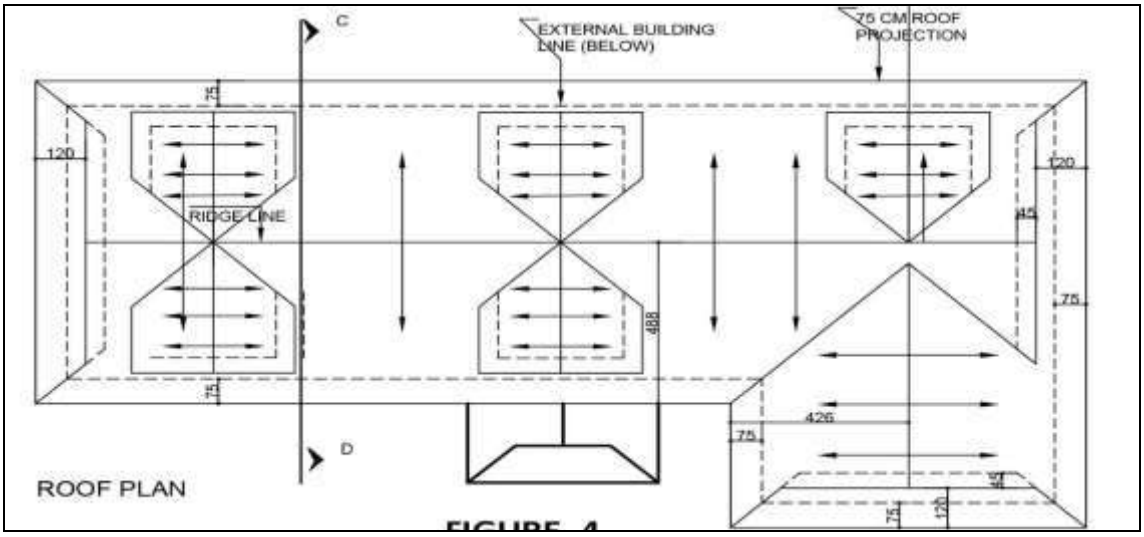
Methodology

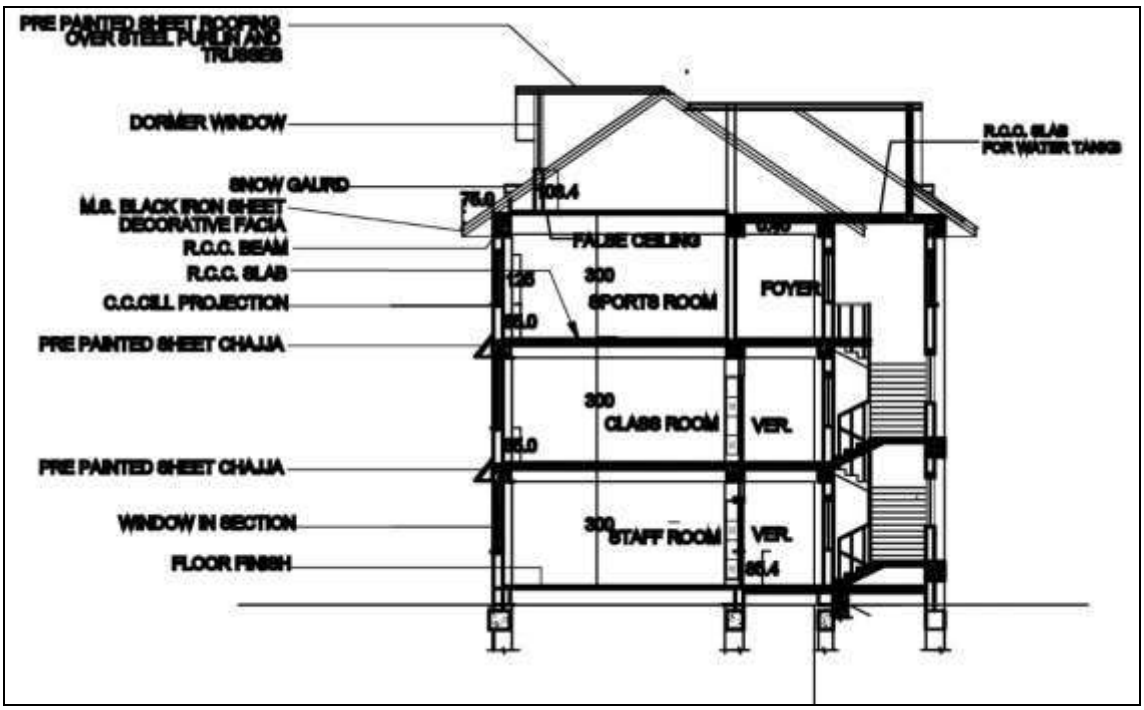
In this paper researcher consider the G+3 RCC school building which lies in zone 5. Due to severity of earthquake building analysed for both method static and dynamic in STAAD.Pro connect edition software. First of all, data collection of the building done by the researcher which includes the architectural drawings, soil bearing capacity, survey report. These are the architectural drawings of the building.


SCIENCE LAB
640 X 565
ATT. ROOM
310 X 310
STORE
310 X 245
OFFICE
310X565
STAFF ROOM
310X565
PRINCIPAL
OFFICE
324X370
VERANDAH 180 CM WIDE CLEAR
ENTRANCE
RAMP FOR DISABLED PERSONS
GROUND FLOOR PLAN
area=221.20 sq.m


VERANDAH 180 CM WIDE CLEAR
FIRST FLOOR PLAN
AREA = 221.20 SQ.M


1300 X 565
LIBRARY
SPORTS ROOM
637X565
VERANDAH 180 CM WIDE CLEAR
SECOND FLOOR PLAN
AREA= 221.20 SQ.M





Section: A-B

Analysis of building by Static Method: Firstly, researcher describe the static method of analysis for IS code 1893:2002 in this paper. Following steps has been done by the researcher:

After that preparation of geometry, assigning supports and properties to the buildings has been done according to architectural plans. Properties of the structures given in the tabular form: -

Table 1: Column and Beam Properties

	Properties	(b X d) mm
R1	Columns	(400x450) mm
R2	Beams	(450x350) mm
R3	Beams	(550x400) mm
R4	Secondary Beams	(300x300) mm
R5	Columns	(450x450) mm

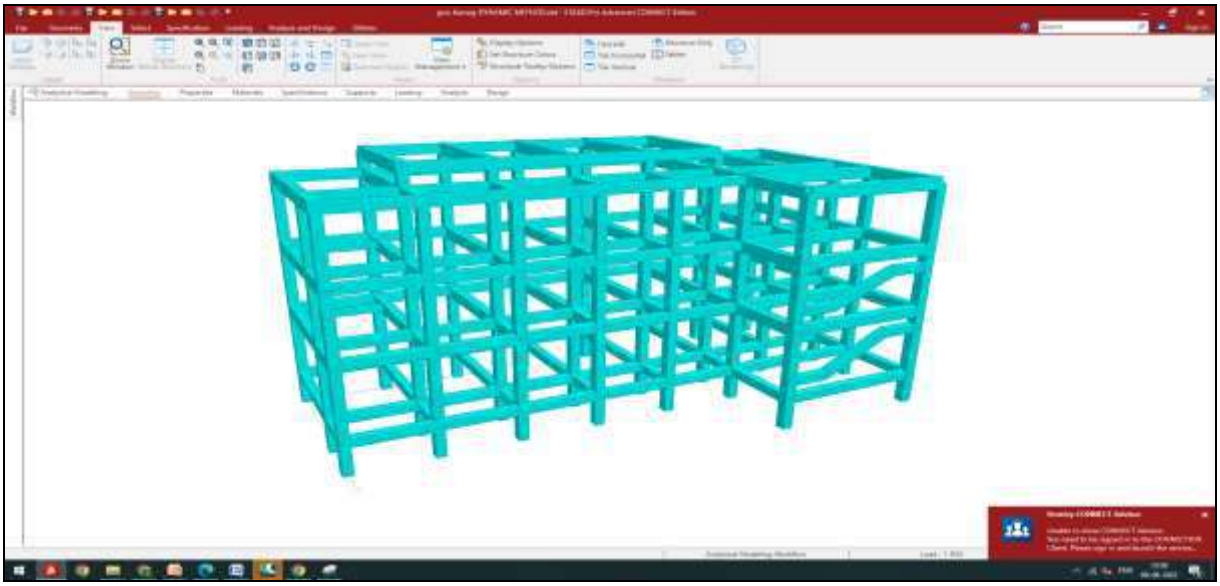


Fig 1: Shows the 3D Rendered View of the building

Now add seismic parameter of the building.

Table 2: Seismic Parameters of the Building

Parameters	Value
Code Indian	IS: - 1893-2002
Zone(z)	.36
Response Reduction Factor (RF)	5
Importance Factor (I)	1.5
Rock and Soil Site Factor (SS)	3
Type of Structure (ST)	1
Damping Ratio (DM)	.05
Depth of Foundation (DT)	1.5

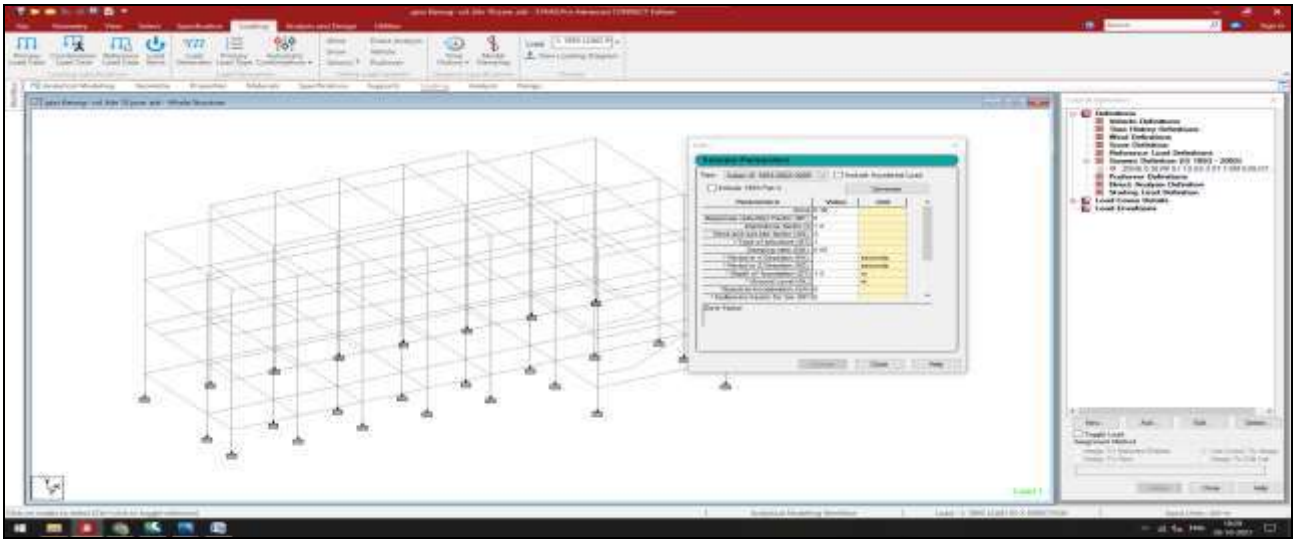


Fig 2: Shows the Seismic Parameters of the Building

Step 3: Now add self-weight, member weight and floor weight to different floors for seismic case.

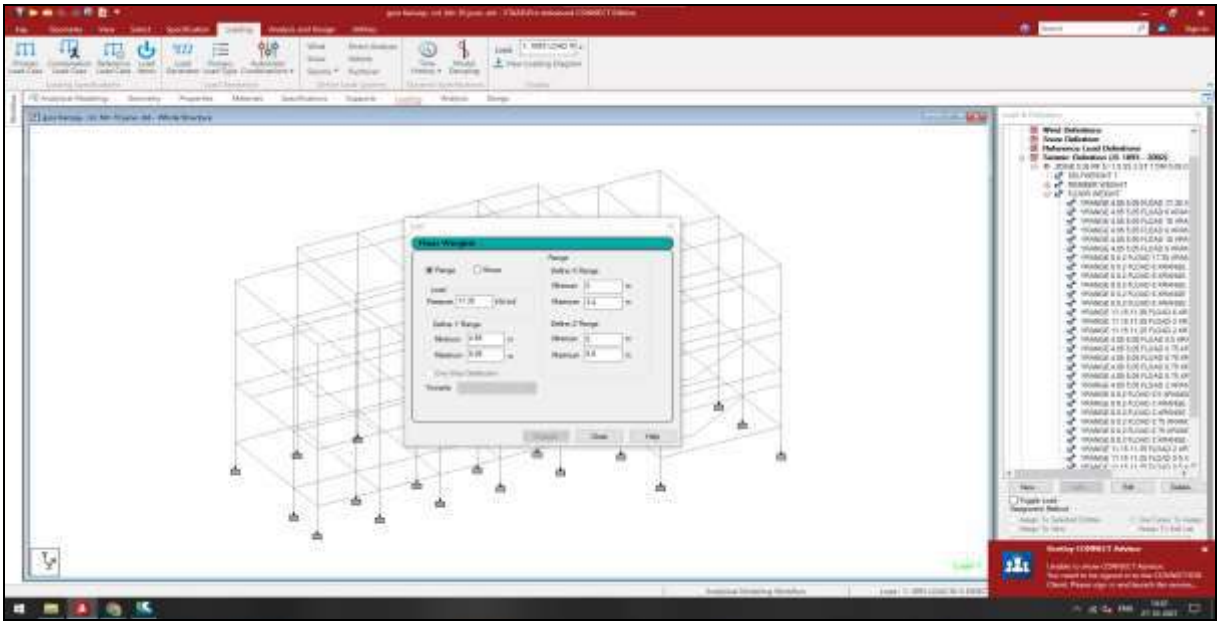


Fig 3: Shows the Seismic weight of the Building

Step: 4 Add Load Case 1: 1893 LOAD IN X DIRECTION

Add Load Case 2: 1893 Load In Z Direction

Step: 5 Add Load Case 3: Dead Load(includes self-weight, member loads and floor loads)

Now add member loads and assign to beams which includes the weight of walls. It's a different for different wall specifications which is related to the materials, thickness and height of the walls. We take uni gy -20, uni gy -19, uni gy -14.5 etc.

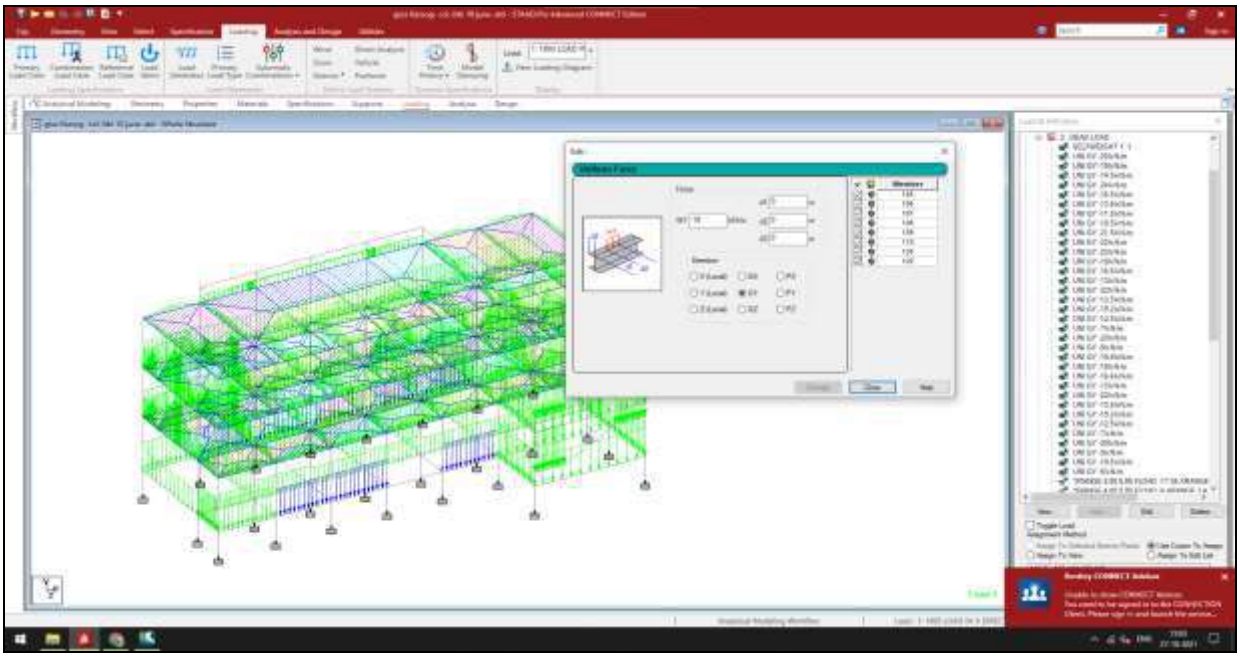


Fig. 4- Shows the Dead load of wall

Now add floor loads which include the dead weight of slab. Floor loads are different for different slab thickness. We take 6 kn/m2 for 150 mm thick slab and 17.35 kn/m2 for depressed slab.

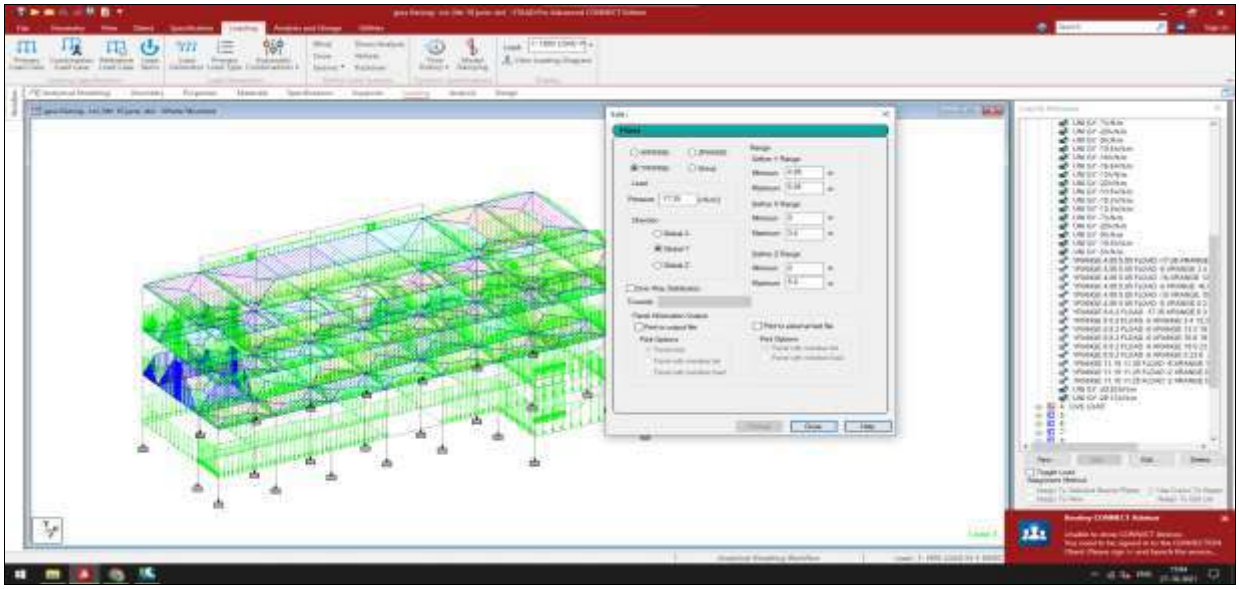


Fig 5: Shows the Dead load of slab

Add Load Case 4: Live load (add and assign different floor loads for floors based on the use of floor area.)

Table 3: Live Load on Floors for school building

Utlity of floor	Live Load (KN/m2)
Classroom	3
Toilet	2
staffrooms	2.5
corridor	4
lab	3
library	6

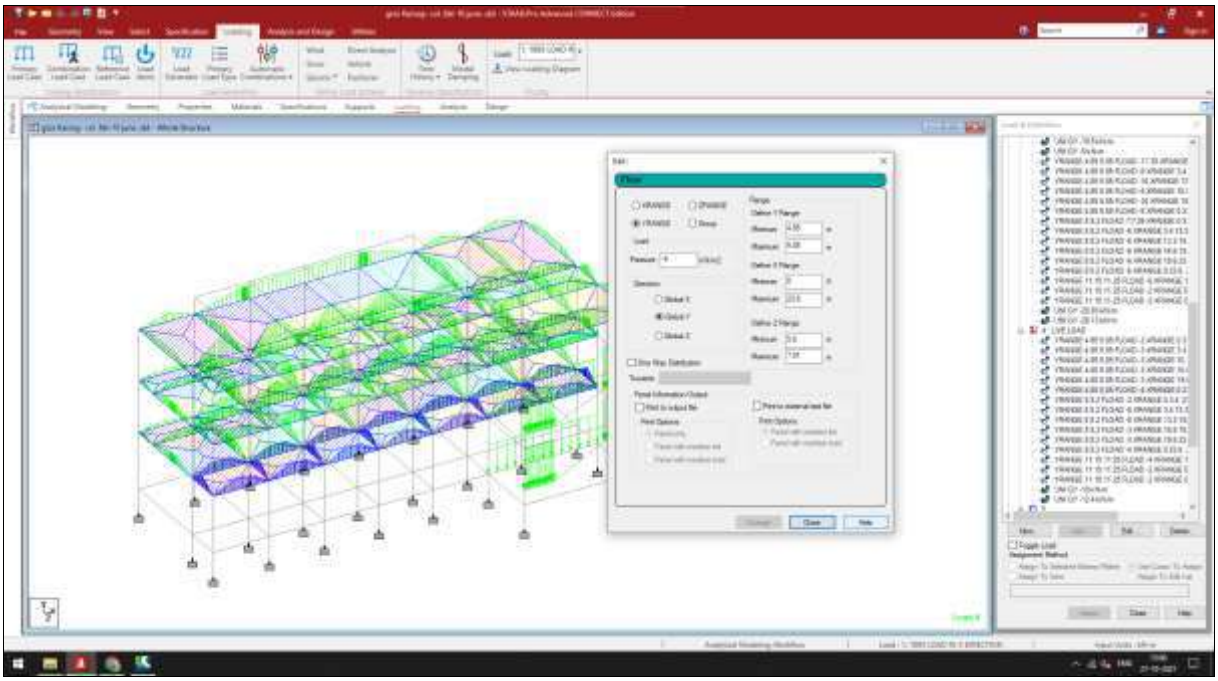


Fig 6: Shows the live load of floor

Add Load Case 4: Add auto load combinations IS 456-table 18. and assign different concrete design parameters for the building i.e. grade of concrete M20, Grade of steel Fe 415, clear cover for beam 25mm, clear cover for column 40 mm, primary reinforcement bars FY MAIN 415 N/mm2, secondary reinforcement bars FY SEC 415 N/mm2.

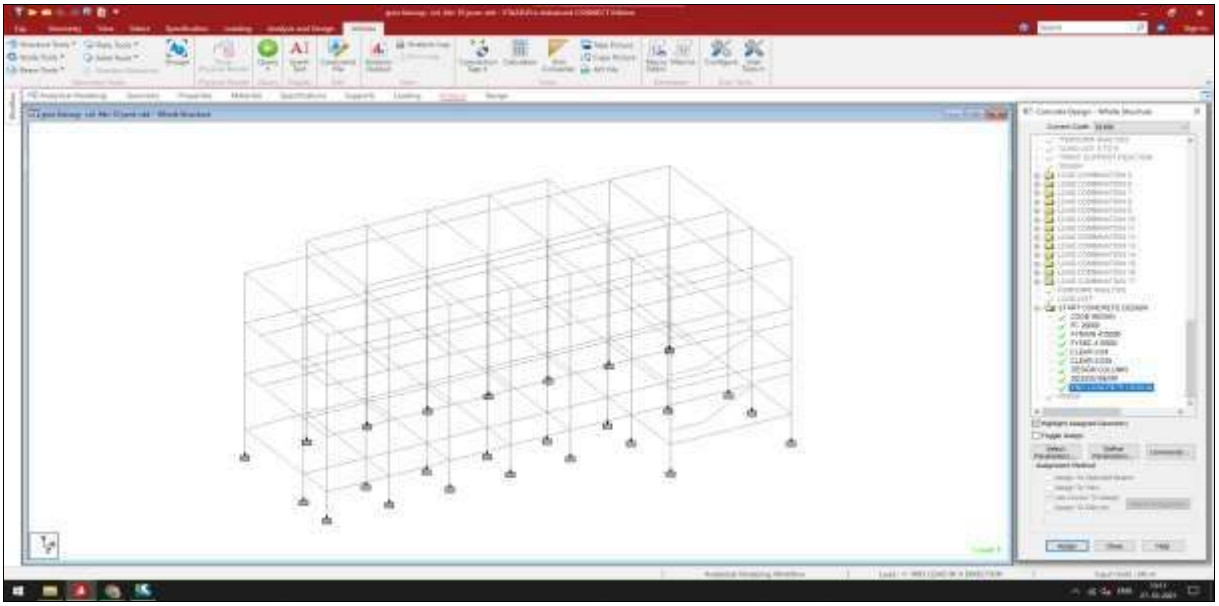


Fig 7: Shows the Design parameter of building

Perform and print analysis then run the program. Now we can see the results of the building which gives the column and beam reinforcement steel for the given input.

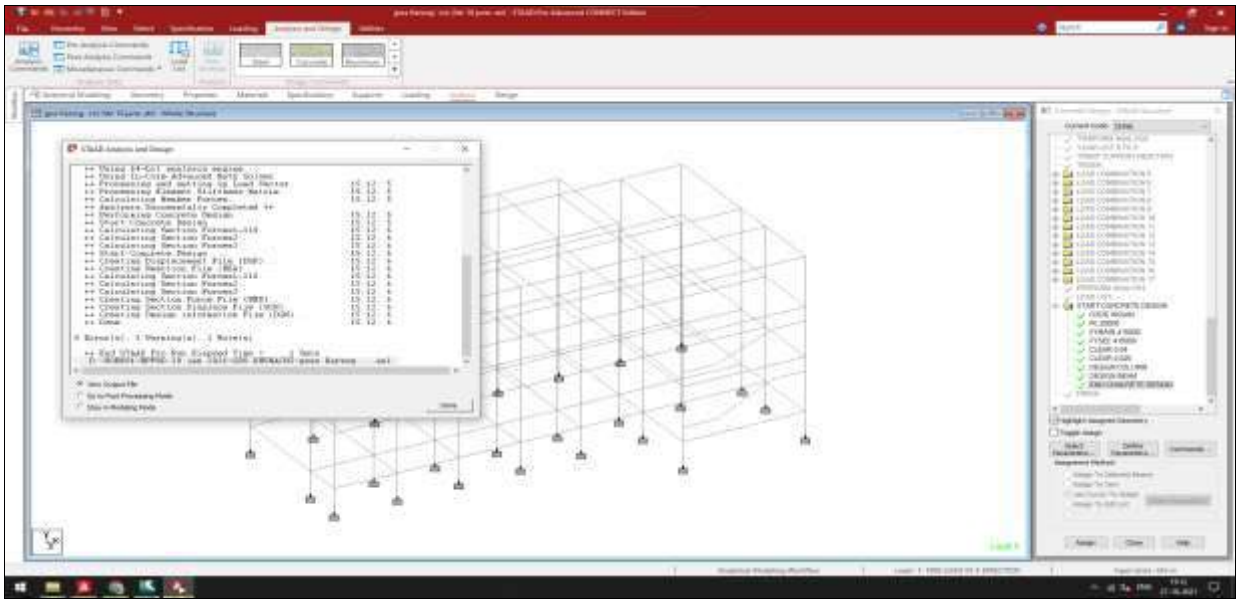


Fig 8: Shows the Run analysis of building

Analysis of building by Dynamic Method: -i. Response Spectrum Method: Now we will design same building by dynamic method. Follows same procedure up to step 3 except seismic parameters.

Table 4: Seismic Parameters of the Building

Parameters	Value
Code Indian	IS:-1893-2016
Zone(z)	.36
Response Reduction Factor (RF)	5
Importance Factor (I)	1.5
Rock and Soil Site Factor (SS)	3
Type of Structure (ST)	1
Damping Ratio (DM)	.05
Depth of Foundation (DT)	1.5

Step 4: Now add all member loads and floor load in seismic case by response spectrum method in RSX and RSZ direction.

Define Load 1 Loadtype Seismic Title RSX
Selfweight X 1
Selfweight Z1
Member Load
*ground floor
104 110 124 UNI GX 20
104 110 124 UNI GZ 20

Floor Load
*1st floor
Yrange 4.85 5.05 FLOAD 17.35 XRANGE 0 3.4 ZRANGE 0 5.6 GX
Yrange 4.85 5.05 FLOAD 17.35 XRANGE 0 3.4 ZRANGE 0 5.6 GZ

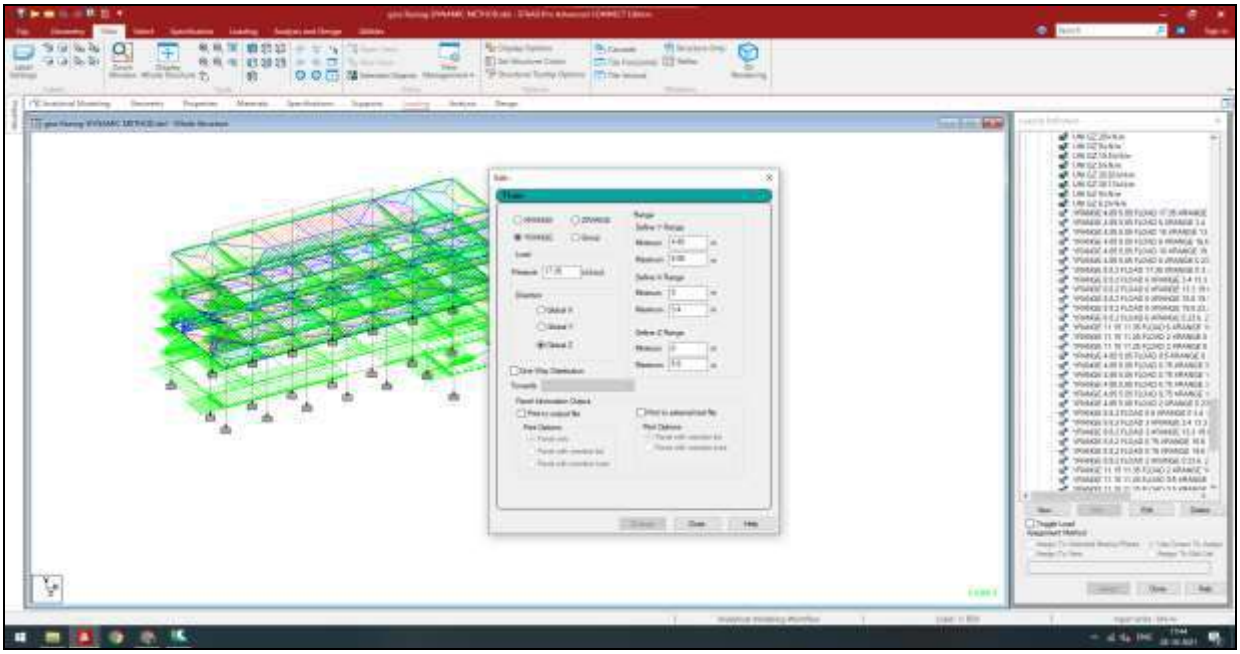


Fig 9: Shows the seismic member weight of building

Add Live Load in seismic case.
*Live Load
*1st floor
Yrange 4.85 5.05 FLOAD 0.5 XRANGE 0 3.4 ZRANGE 0 5.6 GX
Yrange 4.85 5.05 FLOAD 0.5 XRANGE 0 3.4 ZRANGE 0 5.6 GZ
In seismic case according to live load code, Live loads shall be 75% for 3 kn/m2 and 50% for greater than 3 in seismic case.

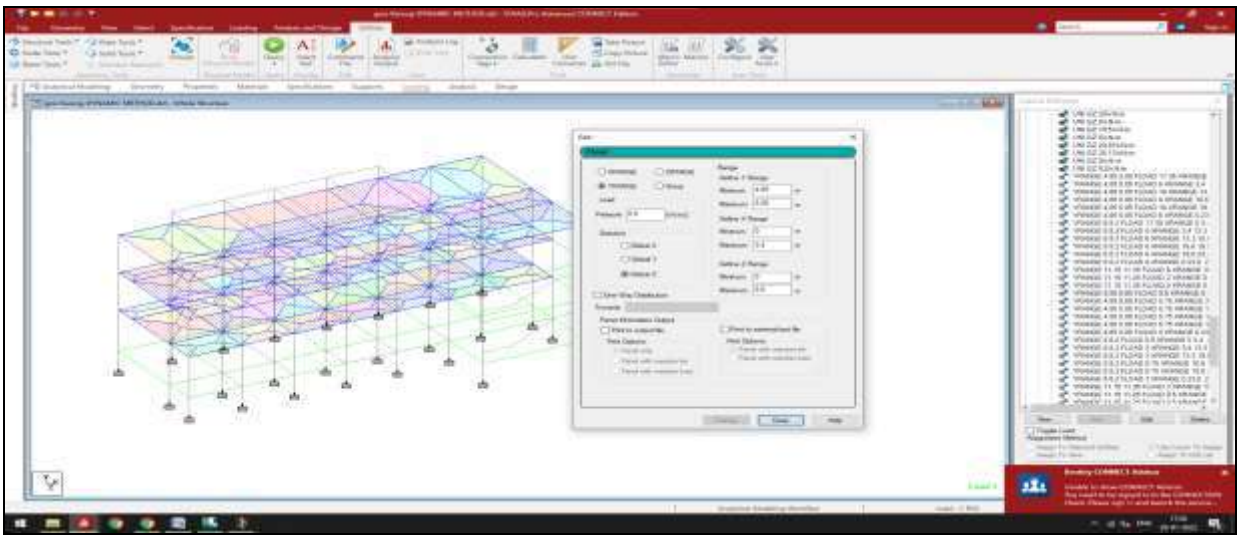


Fig 10: Shows the seismic floor weight of building

Add All Member Loads and Floor Loads (Dead +Live) as Like This.
Now add dead and live load for members and floors same as static method.
After that run the program and see the results for given input.

Comparative Column Results From Static And Dynamic Method:
Researcher take one complete column from building, foundation to roof floor level: -
Column 1 - Foundation to ground floor level
Column 19 - Ground floor level to first floor level
Column 37 - First floor level to second floor level
Column 218 - Second floor level to roof floor level

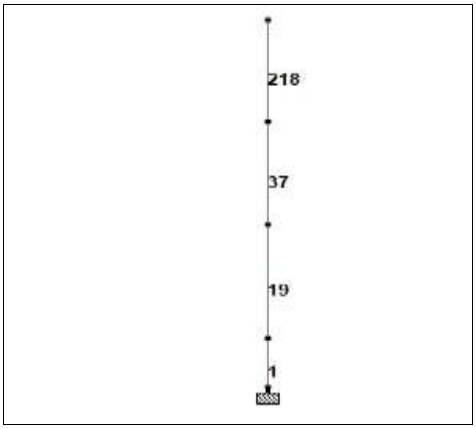


Fig 11: Shows the column from Foundation to Roof floor level

Design load for is code 456

Table 5: Design Load of Column 1 For Is Code 456

Column 1	Static Method	Dynamic Method
Load Combination	14	19
Pu (KNS)	172.43	225.07
Mz (KNS-M)	117.83	174.44
Mx (KNS-M)	17.43	100.13

Design Parameters for is Code 456

Table 6: Design Parameter of Column 1 For Is Code 456

Column 1	Static Method	Dynamic Method
Fy(MPa)	415	415
Fc(MPa)	20	20
As Reqd(mm2)	2114	5205
As percentage	1.257	3.128

Design load for is code 456

Table 7: Design Load of Column 19 For Is Code 456

Column 19	Static method	Dynamic Method
Load Combination	11	14
Pu (KNS)	892.01	484.93
Mz (KNS-M)	172.59	208.66
Mx (KNS-M)	61.28	118.88

Design parameters for is code 456

Table 8: Design Parameter of Column 19 For Is Code 456

Column 19	Static Method	Dynamic Method
Fy(MPa)	415	415
Fc(MPa)	20	20
As Reqd(mm2)	3760	6437
As percentage	2.094	4.189

Design load for is code 456

Table 9: Design Load of Column 37 For Is Code 456

Column 37	Static Method	Dynamic Method
Load Combination	11	12
Pu (KNS)	461.38	430.71
Mz (KNS-M)	163.09	174.4
Mx (KNS-M)	88.03	152.03

Design parameters for is code 456

Table 10: Design Parameter of Column 37 For Is Code 456

Column 37	Static Method	Dynamic Method
Fy(MPa)	415	415
Fc(MPa)	20	20
As Reqd(mm2)	4428	6297
As percentage	2.681	3.574

Design load for is code 456

Table 11: Design Load of Column 218 For Is Code 456

Column 218	Static Method	Dynamic Method
Load Combination	13	14
Pu (KNS)	97.1	53.84
Mz (KNS-M)	29.65	37.68
Mx (KNS-M)	101.33	81.76

Design parameters for is code 456:

Table 12: Design parameter of Column 218 For Is Code 456

Column 218	Static Method	Dynamic Method
Fy(MPa)	415	415
Fc(MPa)	20	20
As Reqd(mm2)	1932	1829
As percentage	1.257	1.257

Comparative Results Of Beams From Static And Dynamic Method

Comparative study of results of static and dynamic method for beams given blow in tabular form. It contains design loads which includes moment at different distances of beam for different load combinations. And gives designed required steel for different moments.

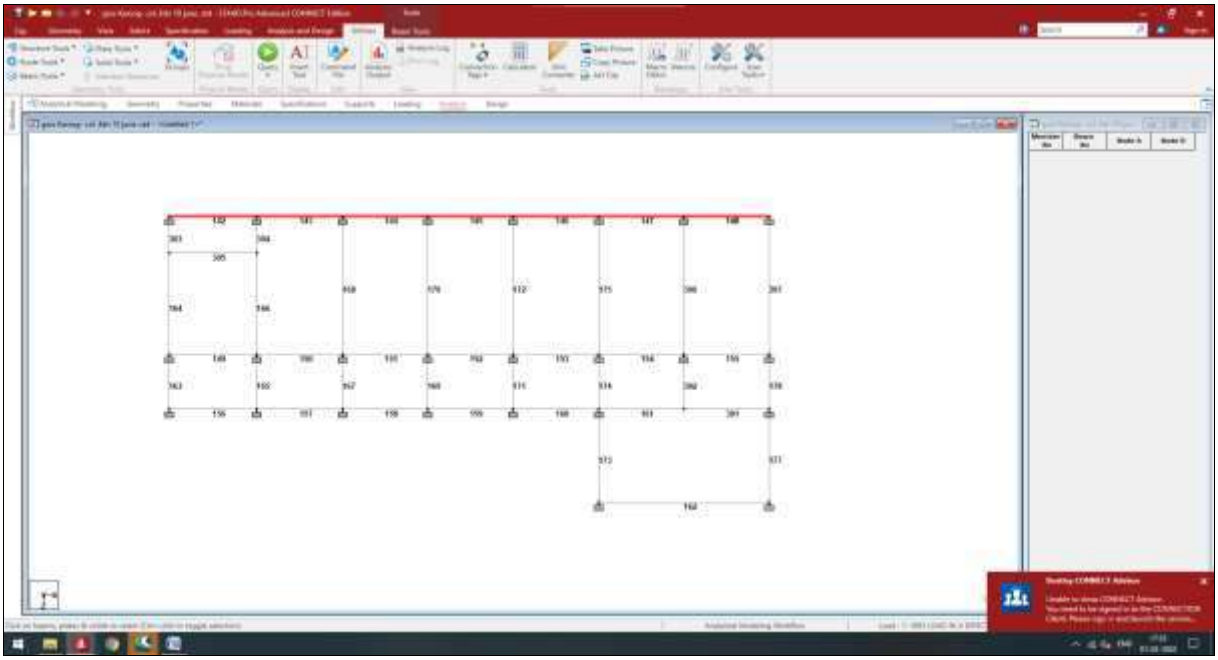


Fig 12: Shows the first floor beams 142 to 148 from left end to right end

Design load for beams for is code 456

Table 13: Design Load of beam 142 For Is Code 456

Beam no.- 142	Static Method			Dynamic Method		
Mz(kn-m)	192.84	-243.99	-243.41	167.91	-228.99	-231.25
Distance(m)	0	0	3.4	0	0	3.4
load	14	11	10	19	12	12

Design load for beams for is code 456

Table 14: Design load of beam 143 For Is Code 456

Beam no.- 143	Static Method			Dynamic Method		
Mz(kn-m)	169.02	-230.99	-220.65	156.24	-219.45	-209.76
Distance(m)	0	0	3.3	0	0	3.3
load	14	11	10	19	12	12

Design load for beams for is code 456

Table 15: Design load of beam 144 For Is Code 456

Beam no.- 144	Static Method			Dynamic Method		
Mz(kn-m)	151.99	-209.25	-207.58	146.52	-203.99	-203.14
Distance(m)	3.3	0	3.3	3.3	0	3.3
load	15	11	10	19	12	12

Design load for beams for is code 456

Table 16: Design load of beam 145 For Is Code 456

Beam no.- 145	Static Method			Dynamic Method		
Mz(kn-m)	152.89	-207.08	-214.24	147.21	-202.7	-207.06
Distance(m)	0	0	3.3	0	0	3.3
load	14	11	10	19	12	12

Design load for beams for is code 456

Table 17: Design load of beam 146 For Is Code 456

Beam no.- 146	Static Method			Dynamic Method		
Mz(kn-m)	146.49	-223.29	-217.63	139.73	-217.93	-215.24
Distance(m)	3.3	0	3.3	3.3	0	3.3
load	15	11	10	19	12	12

Design load for beams for is code 456

Table 18: Design load of beam 147 For Is Code 456

Beam no.- 147	Static Method			Dynamic Method		
Mz(kn-m)	152.57	-205.61	-213.69	145.83	-202.23	-205.25
Distance(m)	0	0	3.3	0	0	3.3
load	14	11	10	19	12	12

Design load for beams for is code 456

Table 19: Design load of beam 148 For Is Code 456

Beam no.- 148	Static Method			Dynamic Method		
Mz(kn-m)	192.58	-235.13	-255.07	168.51	-227.76	-237.53
Distance(m)	3.3	0	3.3	3.3	0	3.3
load	15	11	10	19	12	12

Conclusions

The results obtained from STAAD. PRO ADVANCED CONNECT EDITION for the static and dynamic analysis are different for code IS 1893-2002 and IS 1893-2016 respectively.

In Columns

1) The loads come from static and dynamic method varies according to the geometry of building. Mostly loads comes from static method are on higher side.
2) Mostly Moments comes from dynamic method are on higher side.
3) Steel requirement in columns from static method is on lower side by 25 to 30 percent.

In Beams

1) Area of steel in beams comes from both methods are approximately same. From static method it's on higher side by 5 to 10 percent.
2) Moments comes from static is on higher side as compare to dynamic method.
3) When we cracked members in STAAD.PRO by 70 and 35 percent in columns and beams respectively. Then steel requirement is on higher side on both methods.

Future Scope of Study

The comparative study of static and dynamic design analysis on STAAD.PRO software on building has also includes following points in future scope.

1) We can also study for zone 4 in somewhere India according to IS 456.
2) In residential building where importance factor (ST) is 1.
3) For multi-storey building where importance factor is 1 and soil stabilization is 2 can be studied.
4) For multi-storey building where importance factor is 1.5 and soil stabilization is 2 and IS code 1893-2016 used.

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