EVALUATION OF EXISTING BUILDING FOR PERFORMANCE CHECK IF ANOTHER FLOOR IS PROPOSED FOR CONSTRUCTION

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Abstract - *Existing buildings especially aging ones are currently in urgent need for upgrading to improve their performance and potentially achieve performance certification. Building owners often need to identify and implement building upgrades that maximizes the sustainability of their buildings for seismic resistivity. This paper presents the development of an optimization model that maximizes the performance for existing G+4building within specified upgrade budget to G+5building. Structural elements are used in structural analysis to split a complex structure into simple elements. The present model is expected to support decisions makers, building owners and operators, building managers, and contractors to optimize the use of their upgrade budgets and maximize the performance of their buildings.*

Key Words: *Storey, Loads, Beams, Columns, yield strength, Compressive strength, Deflection, Structure, Stress, moments, STAAD PRO.*

I. INTRODUCTION

In late 2005, Research Engineers International was bought by Bentley Systems. The commercial version, STAAD PRO, is one of the most widely used structural analysis and design software products worldwide. It supports several steel, concrete and timber design codes.Version-v8i (SELECT series-5). STAAD PRO is used to analyse the Super Structural elements like beams, Columns, Footings, Trusses, etc., as it is used to reduce the manual calculation and reduces the time.

A column or pillar in architecture and structural engineering is a structural element that transmits, through compression, the weight of the structure above to other structural elements below. In other words, a column is a compression member.

A beam is a structural element that primarily resists loads applied laterally to the beam's axis. Its mode of deflection is primarily by bending. The loads applied to the beam result in reaction forces at the beam's support points. The total effect of all the forces acting on the beam is to produce shear forces and bending moments within the beam, that in turn induce internal stresses, strains and deflections of the beam.

II. OBJECTIVES FOR THE STUDY

Following are some objectives of this Project work.
1. To design an extra storey on already existing structure by using STAAD PRO.

2. Whether it is in safe condition (or) unsafe condition for construction.

3. To check whether the existing structure is suitable for withstanding earthquake forces.

4. To design an extra storey on the existing structure withstanding the earthquake and wind forces.

5. To check the design whether it can withstand the combined earthquake and wind forces.

6. To design an optimal section with slight changes in the sectional dimensions.

7. To make the structure as a under reinforced section instead of designing as an over reinforced section.

III. RESEARCH METHODOLOGY

Inputting the job Information: Generating the 3D model geometry:

There are two methods of creating a structure data in STAAD PRO.

a. Using the command file also called "The STAAD PRO Editor method".

b. Using the graphical user interface (GUI).

We have done our whole of the programming with the help of GUI method because it is easier and much advance tool of STAAD PRO .The model of the framed structure is generated in STAAD PRO by Snap Node/Beam dialog box which appears when we select the grid from the top menu bar. Then the nodes and beams are created by this command at the suitable distances as per the dimensions of the existing building structure as shown in fig 1.

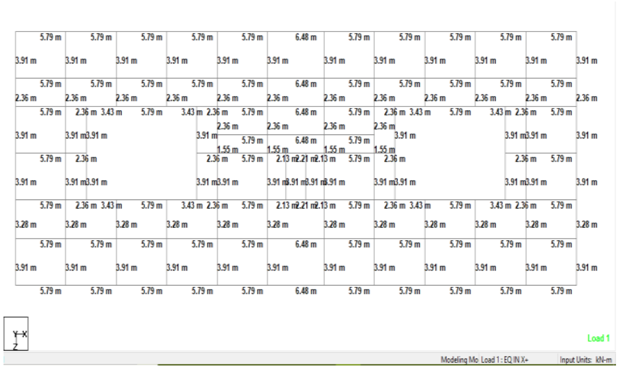

Fig 1 The model of structure with all the beams

Assigning the material:

As after creating the beams and columns we will assign material to them as we require. Our design is concrete design hence we have assigned the concrete material to the beams and columns as shown in fig 2.

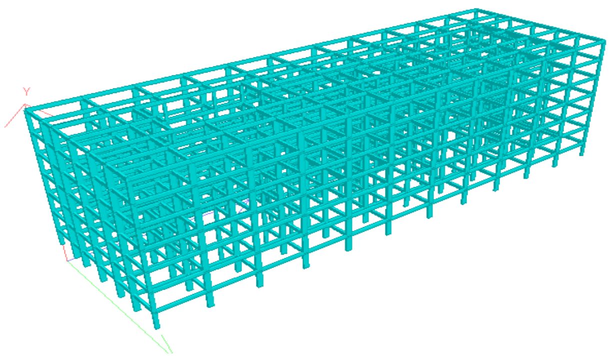

Fig 2 3D Rendered model

Specifying member properties:

The properties of the beams and columns is their size(width, depth of cross-section).So with the help of this command we have inputted the different properties (as circular, rectangular, square) and assign these properties to specified members as shown in fig 3.

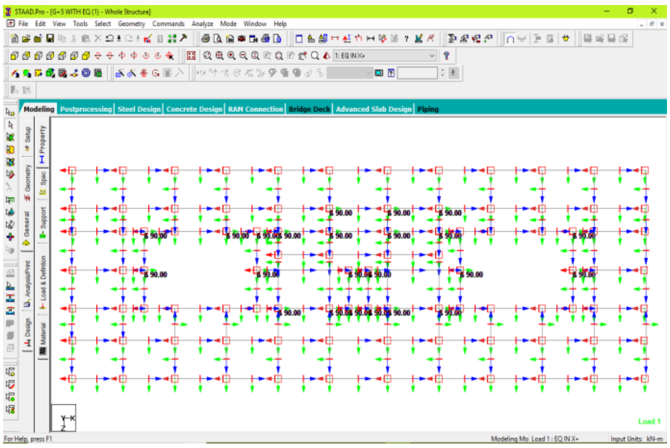

Fig 3 Figure showing its Assigned Properties and Orientation

Specifying material constants:

As we assigned the concrete material so by default we have the constants of concrete and we don't need to use this command separately. Or if we need to change the constants we can do so by this command as shown in fig 4.

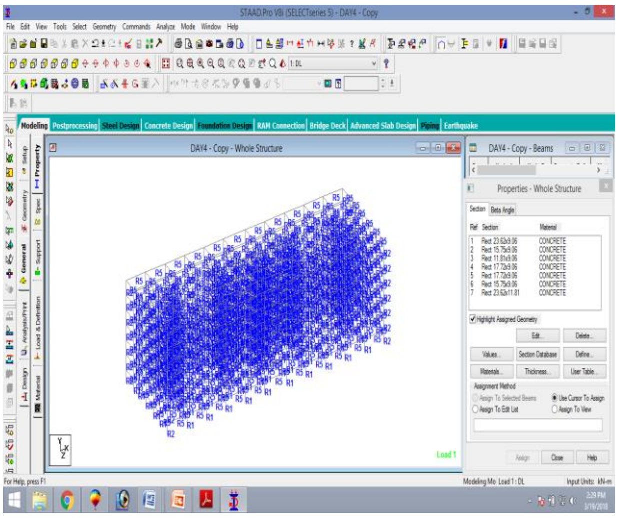

Fig 4 Figure showing its material constants assigned

Specifying Supports:

The supports are first created (as we created fixed supports) and then these are assigned to all the lowermost nodes of structure where we are going to design the foundation as shown in fig 5.

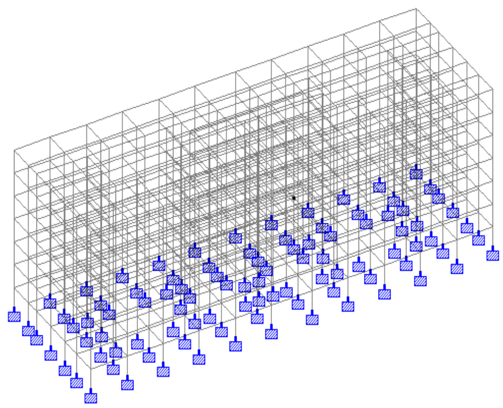

Fig 5 The model with the fixed supports.

Specifying Loads:

This is done in following two steps:

a. Firstly creating all the load cases according to IS 456:2000 & IS 1893:2002.

b. Then assigning them to respective members and nodes.

IS Codes considered for the Design:-

- IS RCC CODE 456-2000
- IS CODE OF DESIGN STRENGTH 1566
- IS CODE OF HYSD 1786-1985

The STAAD PRO program can produce all types of loads and can assign them to the structure. It also has the capability to apply the dead load on the structure. There are some definitions of loads which are firstly created according to IS codes before creating specific load cases (As Seismic or wind load). Here below are some types of loads as we have assigned.

Dead Load: The load coming on framed structure due to self-weight of beams, columns, slabs or walls. This load will act as uniformly distributed load over the supporting beams as shown in fig 6.

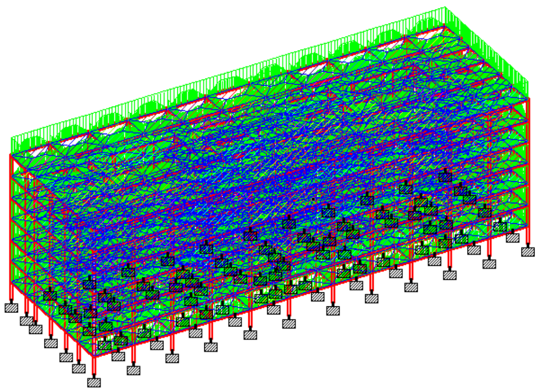

Fig 6 The dead load coming on beams

Live Load: The live load comes on structure due to extra necessary things in the house. There will be different Live Loads acting in the structure due to different uses of building. As here we have used various types of different live loads in our structure.

Dimensions & Loads Considered (fig 7 & fig 8):-

For Existed Building

Provided Column Size - 600 X 230 MM, 400 X 230 MM, 350 X 230 MM, 450 X 230 MM
Provided Beam Size - 450 X 230 MM
Steel Provided - HYSD Bars and
For beams - 8 bars of 10MM dia with 2 legged stirrups of 8MM dia
For columns - 25 bars of 8MM dia bars with 2 legged stirrups of 8MM dia
Beam - 265 to 1272
Column - 1 to 96 ,1605 to 1642 ,1647 to 1742 ,1747 to 1842 ,1847 to 1942 ,1947 to 2042 ,2047 to 2104
Mix grade of concrete - M30

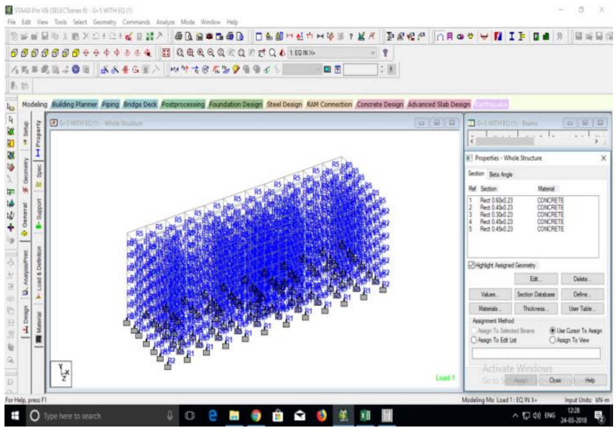

Fig 7 Figure showing its Specifying the Properties to the Assigned beams

Loads Assigned

Dead Load - -12 KN/M (for External walls)
Dead Load - -6 KN/M (for Internal walls)
Dead Load - -3 KN/M (for Open terrace walls)
Dead Load - -31 KN/M (for Steps Rising beam)
Dead Load - -16 KN/M (for Mid landing beam)
Live Load - -2 KN/M

Considered load definition (EQ & WIND) for redesign of the existing structure for wind & seismic resistivity:-

EQ & Wind Parameters considered for design:-

IS CODE - 1893: 2002
Type of structure - General Building, OMRF (Ordinary Moment Resisting Frame)
ZONE - II
Foundation depth - 2.5 M,
Damping Ratio - 5%
For wind - Type - I Structure
Exposure Factor - 1

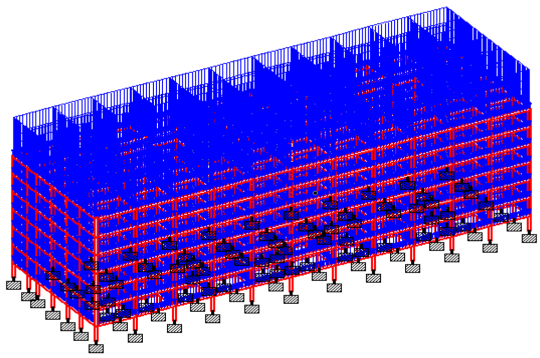

Fig 8 The Live load coming on beams

Load Combinations:

The load combinations have been created with the command of auto load combinations. By selecting the

Indian code we can generate loads according to that and then adding these loads. These combinations do not require to be assigned on members.

Hence all the loads are assigned on the structure we will move towards forward step.

Specifying the analysis type:

Before doing the analysis for the loads we require specifying analysis command which we need is linear static type. Choosing statics check, we will add this command.

Post-Analysis print command:

As we require obtaining member end forces and support reactions written in the output file. By clicking on post-analysis a dialog box will open then by clicking define command, we can add the commands which we need and can assign them to members for which these will be analyzed.

Run Analysis:

` The structure will be analyzed to the loads and this command will also show if there is any warning or error.

Post-Processing mode:

`We can see results in this mode. The deflection, bending moment, shear forces and reactions on supports can been on the structure with values. The figures shown below are under Dead Load. We can also see figures under Live Load or other which we want.

After doing all the structural analysis of our structure, we have designed it to find out the steel used for the reinforcement for the columns and beams.

By selecting the code IS: 456 2000 for the concrete design we will then define parameters for our design as:

After giving all these inputs we will now give commands as for the design of beams and columns. These are selected once added and then assigned to the structure to appropriate components. Then the structure is again analyzed for the generation of report.

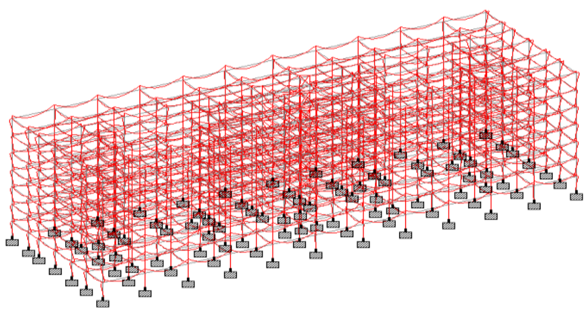

Fig 9 The Stresses on each beam and column.

IV. CONCLUSIONS

The IS code methods describing some sufficient guidelines about applying an extra floor on existing building. Software like STAAD PRO is used as a tool for analyzing and gives the results on designing details. To compare to manual calculations then the software should be gives on accurate results and it should be taken less time. Software shows the maximum deflection values and shear force and bending moments and reinforcement details.

The demonstrated capabilities of the present model can assist decisions makers, building owners and operators, building managers, and contractors who wish to improve building performance. Due to this difference in reaction load the above mentioned columns are failing for the reinforcement design as the section is undergoing for over reinforced section followed under IS 456:2000.hence the above columns section should be redesigned or should undergo for lateral supports or retrofitting of the structure for the failed column sections. So we should be increase the cross sectional area of failure columns by using Re jacketing process as a Redesign process. After increasing the cross sectional area then it should be shows the results on safe condition. The results had been done by the using of STAAD PRO software.

The results of the optimization model showed its capabilities to

(1) Identify replacements for building components of beams and columns including their detailed location at the building.

(2) Identify selected credit area alternatives that need to be implemented in the building.

(3) Model and calculate stability of buildings using STAAD PRO.

(4) Generate alternatives types of retrofitting like jacketing by increasing dimensions of the structural components.

4. RESULTS & DISCUSSION

The following below tables(1&2) shows the comparison of shear forces and bending moments for the Existing Column and Beam sizes with the general gravity load combination(3.Dead Load + Live Load) applied for the structure:-

Differences b/w G+4 & G+5:

BEAM FORCE DETAILING	SHEAR FORCE							
			G+4	G+5	G+4	G+5	G+4	G+5
Beam	L/C	Dist m	Fx kN	Fx kN	Fy kN	Fy kN	Fz kN	Fz kN
33	3 COMBINATION	0	1286.966	1506.785	-13.387	-13.498	3.089	3.366
34	3 COMBINATION	0	1293.996	1513.896	13.336	13.43	2.851	3.154
43	3 COMBINATION	0	1463.378	1716.899	-14.466	-14.624	-1.101	-1.468
44	3 COMBINATION	0	1455.389	1712.543	14.481	14.583	-0.935	-1.33
49	3 COMBINATION	0	1457.772	1715.311	-14.289	-14.359	-0.797	-1.214
50	3 COMBINATION	0	1463.606	1717.022	14.657	14.846	-1.011	-1.384
91	3 COMBINATION	0	1297.888	1568.898	6.805	6.609	-4.385	-4.382
92	3 COMBINATION	0	1279.476	1547.175	6.656	6.426	4.024	3.985
93	3 COMBINATION	0	2439.687	2959.679	-36.58	-36.683	17.166	17.395
94	3 COMBINATION	0	2421.369	2937.88	37.006	37.112	16.884	17.054
1631	3 COMBINATION	0	1071.924	1292.659	-19.678	-19.937	3.512	3.88
1632	3 COMBINATION	0	1060.794	1280.042	5.029	5.52	-13.759	-13.904
1637	3 COMBINATION	0	1055.764	1276.661	-19.401	-19.64	3.83	4.163
1638	3 COMBINATION	0	1062.279	1283.325	19.397	19.634	3.565	3.927
1657	3 COMBINATION	0	1197.217	1455.82	-21.052	-21.257	-0.876	-1.379
1658	3 COMBINATION	0	1203.885	1458.598	21.323	21.711	-1.123	-1.568
1700	3 COMBINATION	0	1060.272	1328.43	8.558	8.207	5.438	5.357
1701	3 COMBINATION	0	1994.81	2516.923	-48.297	-48.509	25.455	25.923
1702	3 COMBINATION	0	1978.355	2496.997	48.874	49.103	24.933	25.292
1751	3 COMBINATION	0	952.039	1209.132	-22.981	-23.622	-2.047	-2.635
1752	3 COMBINATION	0	944.044	1203.995	23.361	23.786	-1.847	-2.491
1757	3 COMBINATION	0	945.679	1206.055	-23.164	-23.56	-1.669	-2.336
1758	3 COMBINATION	0	952.151	1209.181	23.182	23.858	-1.95	-2.538

Table 1

BEAM FORCE DETAILING	BENDING MOMENT							
			G+4	G+5	G+4	G+5	G+4	G+5
Beam	L/C	Dist m	Mx kNm	Mx kNm	My kNm	My kNm	Mz kNm	Mz kNm
33	3 COMBINATION	0	-0.04	-0.062	-3.227	-3.575	-10.942	-11.039
34	3 COMBINATION	0	0.084	0.104	-2.909	-3.293	10.93	11.001
43	3 COMBINATION	0	0.087	0.119	1.371	1.828	-11.831	-11.959
44	3 COMBINATION	0	-0.105	-0.136	1.145	1.635	11.867	11.954
49	3 COMBINATION	0	0.104	0.134	0.953	1.472	-11.602	-11.644

50	3 COMBINATION	0	-0.076	-0.107	1.249	1.712	12.092	12.264
91	3 COMBINATION	0	0.047	0.058	3.642	3.642	5.727	5.5
92	3 COMBINATION	0	-0.055	-0.065	-3.281	-3.246	5.619	5.358
93	3 COMBINATION	0	-0.069	-0.078	-14.645	-14.829	-28.392	-28.476
94	3 COMBINATION	0	0.021	0.022	-14.475	-14.598	29.291	29.381
1631	3 COMBINATION	0	-0.03	-0.061	-4.719	-5.258	-29.129	-29.465
1632	3 COMBINATION	0	0.001	0.036	20.325	20.512	6.709	7.432
1637	3 COMBINATION	0	0.004	-0.03	-5.216	-5.699	-28.698	-29.009
1638	3 COMBINATION	0	0.039	0.069	-4.813	-5.342	28.747	29.052
1657	3 COMBINATION	0	0.062	0.102	0.811	1.531	-31.064	-31.324
1658	3 COMBINATION	0	0.002	-0.043	1.18	1.816	31.506	32.013
1700	3 COMBINATION	0	-0.049	-0.055	-8.26	-8.154	13.525	13.047
1701	3 COMBINATION	0	-0.027	-0.034	-37.419	-38.008	-73.484	-73.747
1702	3 COMBINATION	0	0	-0.001	-36.722	-37.163	74.56	74.862
1751	3 COMBINATION	0	-0.094	-0.046	2.669	3.518	-33.946	-34.83
1752	3 COMBINATION	0	0.064	0.02	2.377	3.309	34.495	35.085
1757	3 COMBINATION	0	-0.045	-0.004	2.105	3.071	-34.206	-34.752
1758	3 COMBINATION	0	0.106	0.057	2.524	3.373	34.241	35.177

Table 2

After considering the Earthquake Loads & Wind Loads and a Combination of Earthquake & Wind Load nodal displacements and beam displacements are obtained as the tables(3&4) specified below for G+4:-

			Horizontal	**Vertical**	**Horizontal**	**Resultant**	**Rotational**		
	Node	L/C	X MM	Y MM	Z MM	MM	rX rad	rY rad	rZ rad
Max X	691	1 EQ IN X+	36.564	0.185	-0.157	36.564	0	0	0
Min X	687	20 COMBINATION LOAD CASE	-54.765	-2.338	-0.363	54.816	0	0	0.001
Max Y	683	1 EQ IN X+	34.49	1.177	0.059	34.51	0	0	-0.001
Min Y	636	11 COMBINATION LOAD CASE	0.227	-11.82	-1.538	11.922	0.002	0	0.002
Max Z	650	3 EQ IN Z+	0.034	0.741	52.844	52.85	0	0	0
Min Z	650	18 COMBINATION LOAD CASE	-0.086	-8.03	-81.432	81.827	-0.001	-0.001	0.002
Max rX	247	3 EQ IN Z+	0.023	0.127	12.635	12.636	0.002	0	0
Min rX	247	18 COMBINATION LOAD CASE	0.004	-2.569	-19.323	19.493	-0.004	0	-0.001
Max rY	688	18 COMBINATION LOAD CASE	-0.013	-3.638	-65.591	65.692	-0.001	0.002	0
Min rY	681	18 COMBINATION LOAD CASE	0.063	-3.604	-67.957	68.052	-0.001	-0.002	0
Max rZ	252	16 COMBINATION LOAD CASE	-15.856	-0.778	0.015	15.875	0	0	0.004
Min rZ	233	1 EQ IN X+	10.264	0.618	0.004	10.282	0	0	-0.002
Max Rst	650	18 COMBINATION LOAD CASE	-0.086	-8.03	-81.432	81.827	-0.001	-0.001	0.002

Table 3

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	93	11 COMBINATION LOAD CASE	185	2439.687	-36.58	17.166	-0.069	-14.645	-28.392
Min Fx	18	3 EQ IN Z+	35	-322.132	-112.66	-0.084	-0.17	0.07	-206.98
Max Fy	764	16 COMBINATION LOAD CASE	293	0.235	228.351	0.602	0.621	-1.926	318.975
Min Fy	767	11 COMBINATION LOAD CASE	594	-24.902	-210.772	0.11	0.159	0.378	230.429
Max Fz	1801	18 COMBINATION LOAD CASE	293	1140.175	-48.755	90.065	0.195	-134.185	-72.616
Min Fz	1670	3 EQ IN Z+	124	-9.654	-0.197	-49.7	0.108	75.295	-0.277
Max Mx	830	16 COMBINATION LOAD CASE	294	-3.113	90.601	-3.958	36.784	2.134	67.353
Min Mx	801	18 COMBINATION LOAD CASE	392	-4.167	69.513	-1.433	-20.966	0.966	45.167
Max My	1801	18 COMBINATION LOAD CASE	393	1125.513	-48.755	90.065	0.195	135.942	73.613
Min My	1801	18 COMBINATION LOAD CASE	293	1140.175	-48.755	90.065	0.195	-134.185	-72.616
Max Mz	20	22 COMBINATION LOAD CASE	39	1113.409	172.33	-0.043	-0.45	0.04	324.947
Min Mz	93	16 COMBINATION LOAD CASE	185	2130.513	-144.455	15.353	0.512	-12.92	-254.98

Table 4

After considering the Earthquake Loads & Wind Loads and a Combination of Earthquake & Wind Load nodal displacements and beam displacements are obtained as the tables(5&6) & fig 10 specified below for G+5:-

			Horizontal	**Vertical**	**Horizontal**	**Resultant**	**Rotational**		
	Node	L/C	X MM	Y MM	Z MM	MM	rX rad	rY rad	rZ rad
Max X	778	17 COMBINATION LOAD CASE	92.999	-6.007	-0.083	93.193	0	0	-0.002
Min X	737	20 COMBINATION LOAD CASE	-92.707	-7.408	-1.105	93.009	0.001	0	-0.001
Max Y	777	2 EQ IN X-	-58.901	2.062	0.059	58.937	0	0	0.001
Min Y	736	11 COMBINATION LOAD CASE	0.275	-16.356	-0.763	16.376	0.002	0	0.002
Max Z	730	18 COMBINATION LOAD CASE	0.054	-11.172	131.146	131.621	0.002	0.001	0.002
Min Z	750	3 EQ IN Z+	-0.03	-1.351	-87.403	87.414	-0.001	0	0
Max rX	247	22 COMBINATION LOAD CASE	0.074	-1.516	27.834	27.875	0.005	0	0
Min rX	247	3 EQ IN Z+	-0.031	-0.197	-18.696	18.697	-0.004	0	0
Max rY	749	27 COMBINATION LOAD CASE	0.001	-10.034	-37.172	38.503	-0.001	0.002	-0.002
Min rY	686	18 COMBINATION LOAD CASE	0.151	-4.944	102.077	102.196	0.002	-0.002	0
Max rZ	340	16 COMBINATION LOAD CASE	-38.12	-1.858	-0.039	38.165	0	0	0.005
Min rZ	333	17 COMBINATION LOAD CASE	38.215	-1.743	-0.036	38.255	0	0	-0.005
Max Rst	730	18 COMBINATION LOAD CASE	0.054	-11.172	131.146	131.621	0.002	0.001	0.002

Table 5

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	93	18 COMBINATION LOAD CASE	185	3176.557	-37.223	-65.621	-0.431	92.724	-29.433
Min Fx	93	3 EQ IN Z+	185	-421.434	0.126	53.456	0.239	-70.099	0.419
Max Fy	768	16 COMBINATION LOAD CASE	693	-31.337	250.171	3.603	1.005	-11.654	326.994
Min Fy	692	18 COMBINATION LOAD CASE	226	-6.264	-323.545	-2.012	-0.316	-2.33	373.504
Max Fz	1755	16 COMBINATION LOAD CASE	247	1149.755	-20.095	70.529	-0.568	-106.099	-29.903
Min Fz	1627	18 COMBINATION LOAD CASE	46	1176.361	-2.543	-108.006	-0.083	163.156	-4.093
Max Mx	830	16 COMBINATION LOAD CASE	294	-3.266	83.219	-4.097	46.098	2.084	59.542
Min Mx	704	17 COMBINATION LOAD CASE	293	-3.599	84.543	4.103	-46.64	-2.045	63.357
Max My	1627	18 COMBINATION LOAD CASE	46	1176.361	-2.543	-108.006	-0.083	163.156	-4.093
Min My	1627	18 COMBINATION LOAD CASE	219	1161.699	-2.543	-108.006	-0.083	-160.781	3.534
Max Mz	692	18 COMBINATION LOAD CASE	226	-6.264	-323.545	-2.012	-0.316	-2.33	373.504
Min Mz	20	18 COMBINATION LOAD CASE	39	940.302	-258.917	0.466	0.439	-0.331	-470.059

Table 6

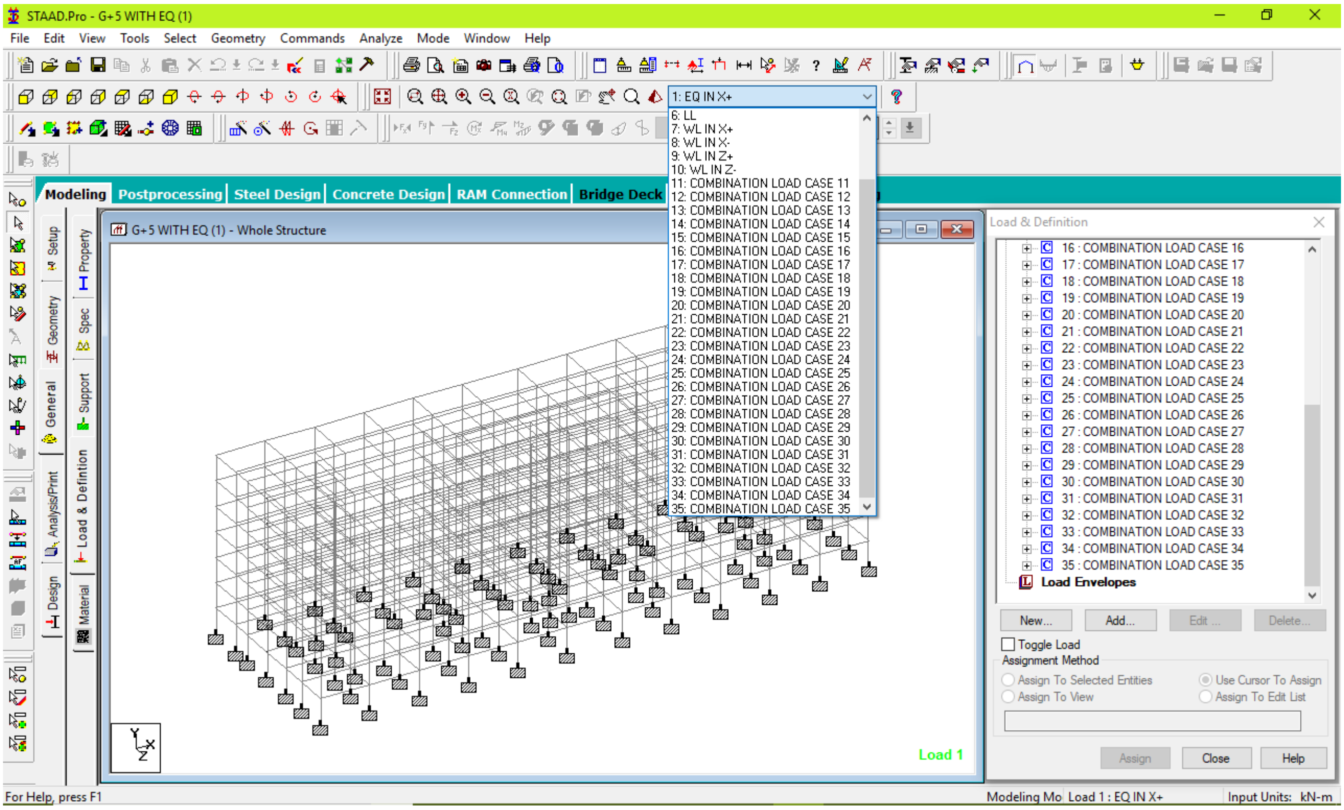

Fig 10 Load combinations applied to each beam and column for G+5

From the results shown in fig 11 obtained from the applied loads& load combinations the failed beams and columns displacements ,reaction loads, shear force and bending moments are considered .A redesign of the existing structural properties have been proposed to sustain the loads.

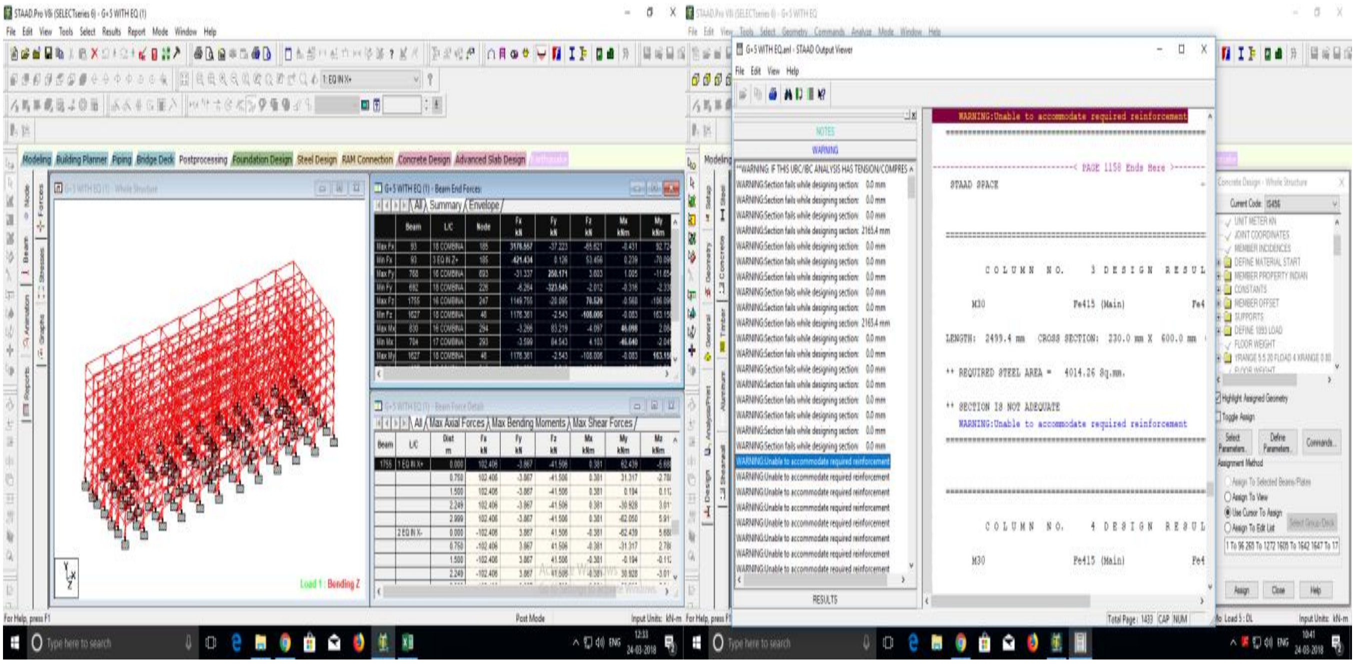

Fig 11 Results obtained after applying load combinations for G+5

For redesign of the existing structure (fig 12), the following sectional properties have been modified:-

Proposed Column Size - 600 X 300 MM, 600 X 300 MM, 400 X 300 MM, 350 X 300 MM, 450 X 300 MM
Proposed Beam Size - 500 X 230 MM, 450 X 300 MM

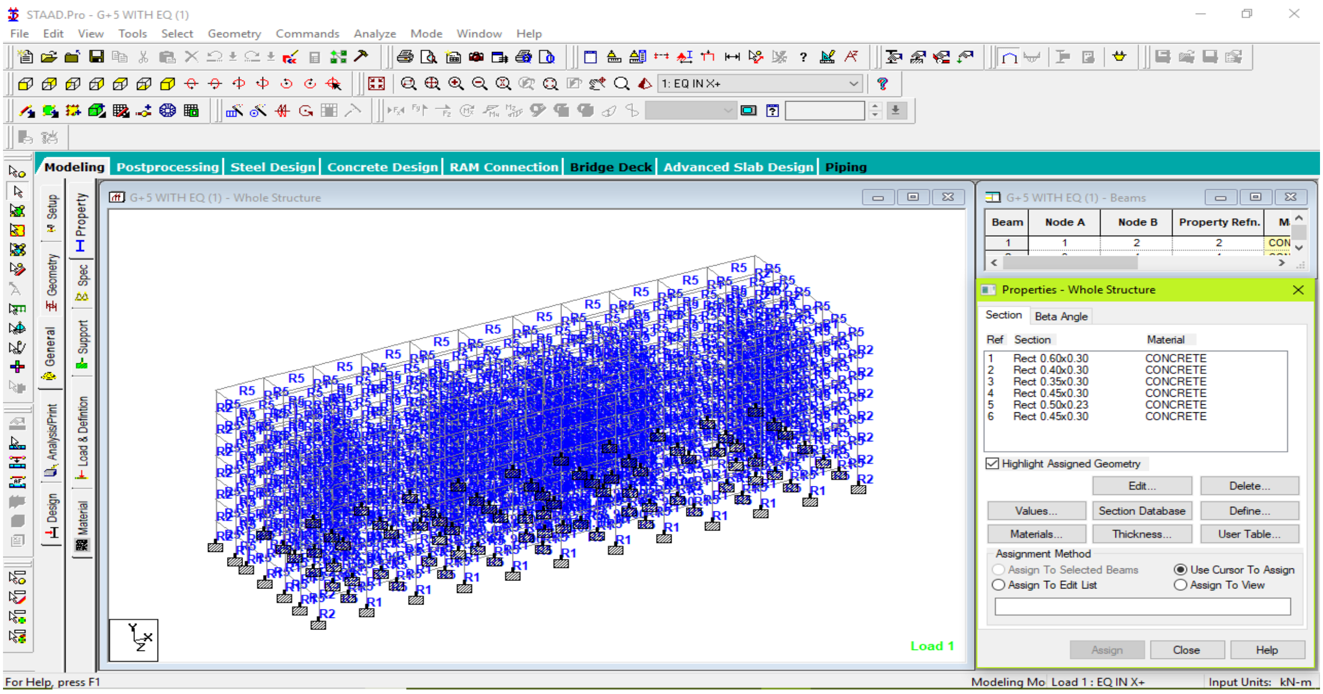

Fig 12 Redesigned sectional properties for each beam and column for G+ 5 proposals

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