Retrofitting of an Existing Building for Increased Imposed Load with the Help of Bracing Members (A Software Approach)

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Abstract- Repair, retrofitting and rehabilitation of existing structures have become a large part of the construction activity in India. By some estimates, the money spent on retrofitting of existing structures in recent years has exceeded that spent on newstructures. In order to strengthening the existing structures against the seismic forces retrofitting is one of the useful solutions. Retrofitting procedures might be explored for a range of constructions and potential flaws. RCC Jacketing and the bracing system are one of the retrofitting techniques. A bracing system is a good way to reinforce and stiffen an existing structure for lateral loading. Another possible benefit of this approach is the very little mass increase involved with the retrofitting strategy, because this is a major concern for many retrofitting systems.

The Endeavour of our present study is to observe the effect of two additionalfloors on the existing structure which has to resist the additional forces arises due tothe addition of two extra floors. The main purpose of this study is to select the idealsystem to retrofit the existing structure. To achieve the economy in the design.

Keywords — Bracing, Existing Structure, Retrofitting.

I. INTRODUCTION

Among the most important concerns in civil engineering is the preservation, repair, and improvement of structural components. As per the new design rules, a huge number of buildings built in the past utilizing the previous design standards in various regions of the globe are unsafe. In spite of the increasing cost and time involved in completely replacing such structurally defective components, strengthening has emerged as a viable option for enhancing load capacity and prolonging the useful life of existing buildings. Premature degradation of building structures has prompted research into a number of methods for mending or improving the structure. The choice of a strengthening technique that improves the structure's durability and workability while also addressing constraints.

Such as build ability, construction operations, and finance is a difficulty in reinforcing concrete structures. Structural strengthening may be necessary in a variety of circumstances.

- It may be necessary to add more strength to the structure in order to handle increased loads. A larger load bearing capacity is often desired whenever the structure's intended usage changes. This may also happen if a building is being expanded with new mechanical components, filing systems, planters, and so on.
- Allowing for unexpected loads may necessitate the need for additional structural support. When structural strengthening is needed to withstand wind and seismic pressures, or to increase the resistance to blast loading, this may be a potential problem.

II. MODELLING AND ANALYSIS OF BUILDING

The analysis of G+19 floors is carried out using STAAD V8i software for special moment resisting frame situated in zone 4.The RCC G+19 structure is analysed with the help of STAAD V8i.

1. Existing Building,

2. Additional Two Storey without Cross Bracing,

3. Additional Two Storey with Cross Bracing structural system.

Area of Steel for Columns, storey shears, Deflections are compared for both type of structural systems i.e. braced and

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unbraced structural system. Step by step procedure will as follow:-

I. Data of Column sizes and Available **Ast** will be prepared.

II. Afterward, Staad model will be prepared with Additional Two Storey and Required Ast will be calculated keeping the column sizes same as existing.

III. Then, Difference in existing and required **Ast will** be analyzed.

IV. Deflection and Story Shear will be compared.

V. After this, Bracings (x bracing , K Bracing, etc.) will be added on periphery of structure and try to achieve the required result

VI. Each and every column will be analyzed and it will be checked if this bracing is sufficient to strengthen the structure or else, need jacketing of few columns.

VII. Main concentration is on columns and deflection of building.

1. Model Analysis of Existing Building-

Structure	SMRF
No. of Stories	G+19
Type of Building Use	Residential
Young`s modulus, E	$2.17x10^6$ kN/m^2
Grade of Concrete	M30
Density of RCC	30 kN/m^3
Beam Size	0.3 X 0.5
Column Size	0.5 X 0.5
Dead Load Intensity	5.0 kN/m^2
Live Load Intensity	3.0 kN/m^2
Seismic Zone, Z	Medium
Importance Factor, I	1
Response Reduction Factor, RF	5

Table 1. Modelling Data for Existing Building

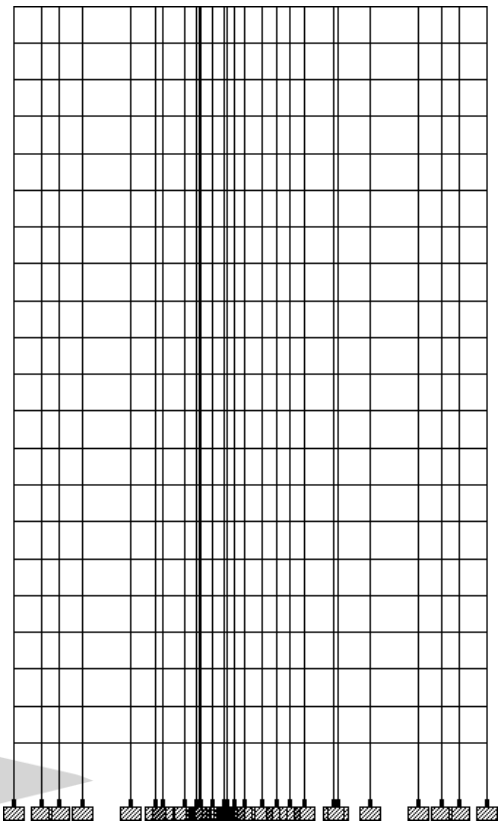

Fig.1 Elevation of Existing Building

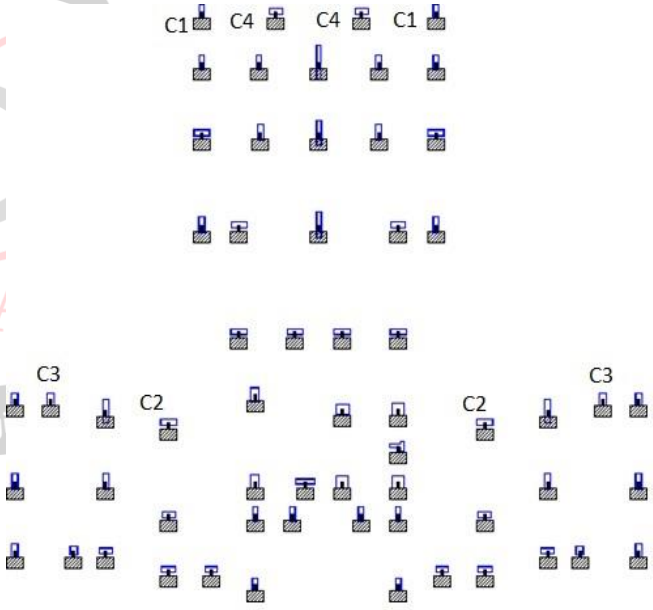

Fig. 2 Plan of Existing Building with Column Numbers

2. Model Analysis of Existing Building with additional Two Stories

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Structure	SMRF
No. of Stories	G+21
Type of Building Use	Residential
Young`s modulus, E	$2.17x10^6$ kN/m^2
Grade of Concrete	M30
Density of RCC	30 kN/m^3
Beam Size	0.3 X 0.5
Column Size	0.5 X 0.5
Dead Load Intensity	5.0 kN/m^2
Live Load Intensity	3.0 kN/m^2
Seismic Zone, Z	Medium
Importance Factor, I	1
Response Reduction Factor, RF	5

Table 2. Modelling Data for Existing Building with Additional Two Stories

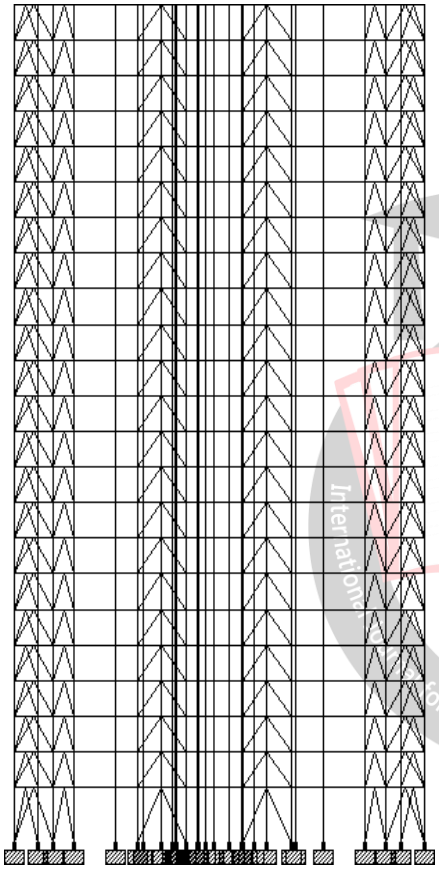

Fig. 4 Elevation of Existing Building with Additional Two Stories with X-Bracing

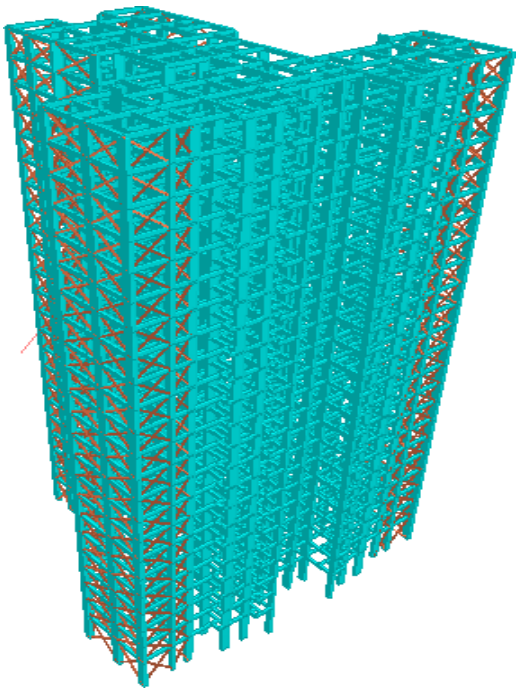

FIG. 5 3D View of Existing Building with Additional Two Stories with X-Bracing

III. RESULTS

Storey Shear for Exiting Building:-

Storey	Storey Shear (kN)
Terrace	520
19	1091
18	1475
117	1739
16	1942
15	2109
14	2262
13	2410
12	2548
11	2679
10	2806
9	2926
8	3041
7	3156
6	3262
5	3363
4	3476
3	3600
2	3734
1	3889
Ground	4208
Base	4208

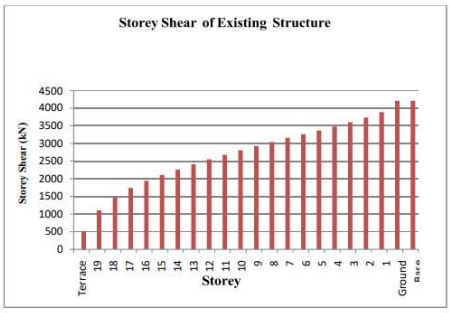

TABLE 3. Storey Shear for Existing Building

Lateral Displacement for Exiting Building in X direction:-

Levels	Displacement (mm)	Percentage Reduction
Ground	2.7	14.8
1st	5.9	20.3
2nd	9.6	20.8
3rd	13.5	21.5
4th	17.6	21
5th	21.8	20.6
6th	26.1	20.3
7th	30.3	19.5
8th	34.5	18.6
9th	38.8	18.3
10th	43	17.4
11th	47.1	17
12th	51	16.3
13th	54.7	15.5
14th	58.3	15.1
15th	61.6	14.5
16th	64.6	13.8
17th	67.3	13.1
18th	69.6	12.2
19th	71.6	11.6
Terrace	73.2	10.7

TABLE 4. Lateral Displacement in X-Direction

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Lateral Displacement For Exiting Building in Z direction:-

Floor	Displacement (mm)	Percentage Reduction
Ground	2.2	13.64
1st	4.9	18.37
2nd	8.2	23.17
3rd	11.8	23.73
4th	15.6	25.64
5th	19.5	26.15
6th	23.4	26.07
7th	27.4	26.28
8th	31.3	25.88
9th	35.2	25.85
10th	39.1	25.58
11th	43	25.58
12th	46.5	25.16
13th	50	25
14th	53.1	24.48
15th	56.1	24.06
16th	59	23.9
17th	61.3	23.33
18th	63.4	22.87
19th	65.1	22.43
Terrace	66.6	21.77

TABLE 5. Lateral Displacement in Z- Direction

Storey Shear for Building with Additional Two Stories:-

Storey	Storey Shear (kN)
Terrace	500
21	1055
20	1434
19	1694
18	1889
17	2054
16	2205
15	2350
14	2488
13	2615
12	2730
11	2841
10	2951
9	3058
8	3167
7	3275
6	3373
5	3468
4	3572
3	3687
2	3815
1	3968
Ground	4289
Base	4289

TABLE 6. Storey Shear for Existing Building with Additional Two Stories

Lateral displacement in X direction For Additional Two Stories with and without X- Bracing:-

Levels	Displacement (mm)			Percentage Reduction		
	Without Bracings	With X Bracings	With Chevron Bracings	Without Bracing	With X-Bracings	With Chevron Bracings
Ground	2.7	1.99	2.21	26.3	18.15	11.1
1st	5.8	4.1	4.4	29.31	24.14	7.32
2nd	9.5	6.6	7.7	30.53	18.95	16.7
3rd	13.4	9.3	9.8	30.6	26.87	5.38
4th	17.5	12.3	12.9	29.71	26.29	4.88
5th	21.7	15.5	16.2	28.57	25.35	4.52
6th	26	18.9	19.5	27.31	25	3.17
7th	30.1	22.4	23.1	25.58	23.26	3.13
8th	34.6	26	26.7	24.86	22.83	2.69
9th	39	29.7	30.3	23.85	22.31	2.02
10th	43.2	33.4	34	22.69	21.3	1.8
11th	47.5	37.1	37.9	21.89	20.21	2.16
12th	51.6	40.9	41.5	20.74	19.57	1.47
13th	55.7	44.6	45.1	19.93	19.03	1.12
14th	59.6	48.2	48.7	19.13	18.29	1.04
15th	63.4	51.8	52.2	18.3	17.67	0.77
16th	66.9	55.2	55.5	17.49	17.04	0.54
17th	70.2	58.5	58.8	16.67	16.24	0.51
18th	73.2	61.7	61.7	15.71	15.71	0
19th	75.9	64.7	64.6	14.76	14.89	0.15
20th	78.2	67.4	67.2	13.81	14.07	0.3
21st	80.2	70	69.6	12.72	13.22	0.57
Terrace	81.9	72.5	71.9	11.48	12.21	0.83

TABLE 4. Lateral Displacement in X-Direction

Lateral displacement in Z direction For Additional Two Stories with and without X- Bracing:-

Levels	Displacement (mm)			Percentage Reduction		
	Without Bracings	With X Bracings	With Chevron Bracings	Without Bracing	With X-Bracings	With Chevron Bracings
Ground	2.1	1.6	1.8	23.81	14.29	12.5
1st	4.8	3.3	3.7	31.25	22.92	12.12
2nd	8.1	5.3	5.8	34.57	28.4	9.43
3rd	11.6	7.5	8.2	35.34	29.31	9.33
4th	15.4	9.8	10.6	36.36	31.17	8.16
5th	19.3	12.2	13.2	36.79	31.61	8.2
6th	23.3	14.7	15.9	36.91	31.76	8.16
7th	27.2	17.3	18.6	36.4	31.62	7.51
8th	31.3	20	21.4	36.1	31.63	7
9th	35.3	22.7	24.2	35.69	31.44	6.61
10th	39.3	25.5	27.1	35.11	31.04	6.27
11th	43.2	28.2	29.9	34.72	30.79	6.03
12th	47	31	32.8	34.04	30.21	5.81
13th	50.7	33.7	35.6	33.53	29.78	5.64
14th	54.3	36.4	38.3	32.97	29.47	5.22
15th	57.7	39.1	40.9	32.24	29.12	4.6
16th	60.9	41.6	43.5	31.69	28.57	4.57
17th	63.8	44.1	45.9	30.88	28.06	4.08
18th	66.5	46.4	48.3	30.23	27.37	4.09
19th	68.9	48.6	50.4	29.46	26.85	3.7
20th	71.1	50.7	52.4	28.69	26.3	3.35
21st	72.8	52.7	54.2	27.61	25.55	2.85
Terrace	74.4	54.4	55.9	26.88	24.87	2.76

TABLE 5. Lateral Displacement in Z- Direction

Storey vs. Lateral Displacement in X direction for the Structure with Two Additional Floors:-

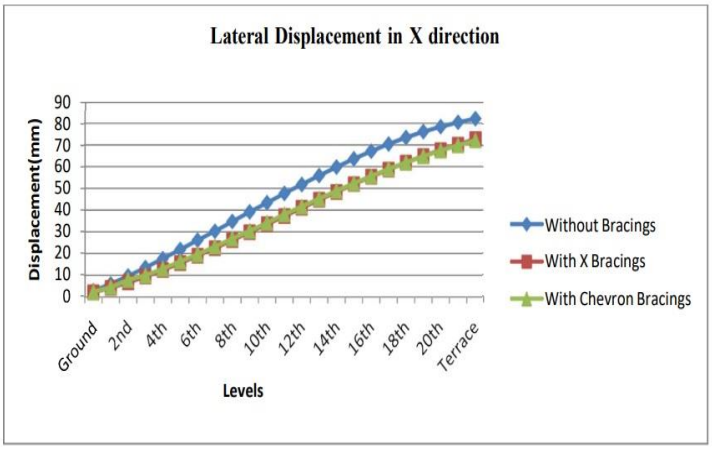

FIG. 6 Graph Showing Comparison of Later Displacement in X- Direction

Storey vs. Lateral Displacement in Z direction for the Structure with Two Additional Floors:-

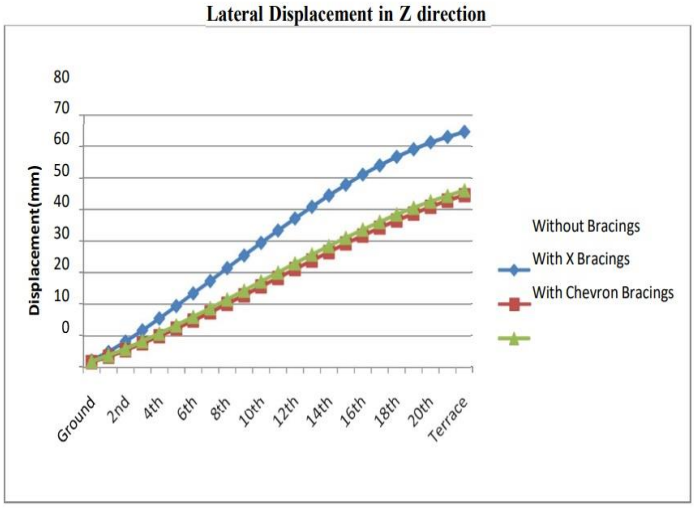

FIG. 7 Graph Showing Comparison of Later Displacement in Z- Direction

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Ast Results for Existing Building:-

Level	Size(mm)	R/F Required(cm^2)	Available R/F (cm^2)
Foundation to Ground	400x1000	119	132
Ground to 1st	300x900	95	100
1st to 2nd	300x900	85	90
2nd to 3rd	300x900	77	90
3rd to 4th	300x900	59	74
4th to 5th	300x900	63	66
5th to 6th	300x900	50	54
6th to 7th	300x900	45	50
7th to 8th	300x900	40	46
8th to 9th	300x900	33	42
9th to 10th	300x900	30	36
10th to 11th	300x900	31	32
11th to 12th	300x900	20	28
12th to 13th	300x900	14	24
13th to 14th	300x900	Nominal	18
14th to 15th	300x900	Nominal	18
15th to 16th	300x900	Nominal	18
16th to 17th	300x900	Nominal	18
17th to 18th	300x900	Nominal	18
18th to 19th	300x900	Nominal	18
19th to Terrace	300x900	Nominal	18

TABLE 8. Ast Results for Column C1 & C4

Level	Size(mm)	R/F Required(cm^2)	Available R/F (cm^2)
Foundation to Ground	400X900	67	100
Ground to 1st	300X900	82	90
1st to 2nd	300X900	71	82
2nd to 3rd	300X900	58	74
3rd to 4th	300X900	46	66
4th to 5th	300X900	50	54
5th to 6th	300X900	37	50
6th to 7th	300X900	26	46
7th to 8th	300X900	20	42
8th to 9th	300X900	19	36
9th to 10th	300X900	20	32
10th to 11th	300X900	Nominal	28
11th to 12th	300X900	Nominal	24
12th to 13th	300X900	Nominal	24
13th to 14th	300X900	Nominal	24
14th to 15th	300X900	Nominal	24
15th to 16th	300X900	Nominal	24
16th to 17th	300X900	Nominal	24
17th to 18th	300X900	Nominal	24
18th to 19th	300X900	Nominal	24
19th to Terrace	300X900	Nominal	24

TABLE 9. Ast Results for Column C2 & C3

Ast Results for Existing Building with Additional Two Stories with & Without X-Bracing:-

Level	Size(mm)	Available R/F(cm^2)	Without X-Bracing		with X-Bracing	
			R/F Required(cm^2)	Retrofitting Required	R/F Required(cm^2)	Retrofitting Required
Foundation to Ground	400x1000	132	135	Yes	51	No
Ground to 1st	300x900	100	FAIL	Yes	82	No
1st to 2nd	300x900	90	FAIL	Yes	68	No
2nd to 3rd	300x900	90	96	Yes	58	No
3rd to 4th	300x900	74	79	Yes	48	No
4th to 5th	300x900	66	94	Yes	52	No
5th to 6th	300x900	54	72	Yes	41	No
6th to 7th	300x900	50	64	Yes	30	No
7th to 8th	300x900	46	56	Yes	Nominal	No
8th to 9th	300x900	42	48	Yes	Nominal	No
9th to 10th	300x900	36	53	Yes	Nominal	No
10th to 11th	300x900	32	45	Yes	Nominal	No
11th to 12th	300x900	28	37	Yes	Nominal	No
12th to 13th	300x900	24	30	Yes	Nominal	No
13th to 14th	300x900	18	25	Yes	Nominal	No
14th to 15th	300x900	18	30	Yes	Nominal	No
15th to 16th	300x900	18	24	Yes	Nominal	No
16th to 17th	300x900	18	20	Yes	Nominal	No
17th to 18th	300x900	18	20	Yes	Nominal	No
18th to 19th	300x900	18	20	Yes	Nominal	No
19th to 20th	300x900	18	20	Yes	Nominal	No
20th to 21st	300x900	--------	20	--------	Nominal	--------
21st to Terrace	300x900	--------	20	--------	Nominal	--------

TABLE 10. Ast Results for Column 1 & 4

Level	Size(mm)	Available R/F(cm^2)	Without X-Bracing		with X-Bracing	
			R/F Required(cm^2)	Retrofitting Required	R/F Required(cm^2)	Retrofitting Required
Foundation to Ground	400X900	100	85	No	85	No
Ground to 1st	300X900	90	104	Yes	75	No
1st to 2nd	300X900	82	90	Yes	65	No
2nd to 3rd	300X900	74	79	Yes	70	No
3rd to 4th	300X900	66	75	Yes	64	No
4th to 5th	300X900	54	71	Yes	52	No
5th to 6th	300X900	50	58	Yes	50	No
6th to 7th	300X900	46	46	No	48	No
7th to 8th	300X900	42	34	No	38	No
8th to 9th	300X900	36	30	No	28	No
9th to 10th	300X900	32	30	No	32	No
10th to 11th	300X900	28	21	No	Nominal	No
11th to 12th	300X900	24	Nominal	No	Nominal	No
12th to 13th	300X900	24	Nominal	No	Nominal	No
13th to 14th	300X900	24	Nominal	No	Nominal	No
14th to 15th	300X900	24	Nominal	No	Nominal	No
15th to 16th	300X900	24	Nominal	No	Nominal	No
16th to 17th	300X900	24	Nominal	No	Nominal	No
17th to 18th	300X900	24	Nominal	No	Nominal	No
18th to 19th	300X900	24	Nominal	No	Nominal	No
19th to 20th	300X900	24	Nominal	No	Nominal	No
20th to 21st	300X900	--------	Nominal	---------	Nominal	--------
21st to Terrace	300X900	--------	Nominal	---------	Nominal	--------

TABLE 11. Ast Results for Column 2 & 3

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IV. DISCUSSION OF RESULTS

The storey shear of the existing structure starting from terrace @20th storey up to the base. The values of shear are increasing from 520kN to 4208kN corresponding to the terrace & ground floor level respectively. The value of shear is increasing from 500kN to 4289kN corresponding to the terrace & ground level respectively with addition of two Stories. It clearly shows that the base shear corresponding to the foundation level is maximum due to the addition of storey shear of above levels.

The max displacement of 73.3 mm is recoded at terrace level for an unbraced existing structure, whereas, The maximum displacement of 81.9 mm is noticed at the terrace level for an unbraced structure with additional two stories. This value is reduced to 72.5 mm & 71.9 mm for cross & chevron braced structure respectively. A reduction of 11.48% & 12.21 % corresponding to terrace level is achieved with cross & chevron braced structure respectively.

Similarly, on comparison for the lateral displacement in Z direction for the structure for two additional floors, the reduction in displacement in Z direction at terrace level is observed as 26.88% & 24.87% for cross & chevron braced structure respectively.

The graphical curves shows the comparison of lateral displacement inX & Z direction for the structural with two additional floors. Both the figures consist of 3 curves corresponding to cross bracing, chevron bracing & unbraced structure. In all the cases maximum displacement is noticed corresponding to the terrace level while it is almost 0 corresponding to the ground floor level.

Table 8 & 9, 10 & 11, Shows the Area of Steel required for the column no. C1, C4 & C2, C3 for the Existing Structure is 95 & 82 cm^2 respectively at Ground to 1st Floor level. Whereas, the same columns are need to be retrofit for the Additional Two Stories in the building. After, Introducing Cross Braced Structural System, the Ast for C1, C4 & C2, C3 reduced to 82 & 75 cm^2 respectively.

V. CONCLUSION

After the analysis of the structure with both types of structural systems i.e. unbraced & cross braced structural systems, it has been concluded that the lateral displacement is reduced after introduction of cross bracing system. Cross bracing system reduces the Area of Steel Required for the columns.

Bracing system provides an excellent approach for strengthening and stiffening of existing structure for lateral forces. Another potential advantage of bracing system is the comparatively small increase in mass associated with the retrofitting scheme since this is a greatproblem for several retrofitting techniques.

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