Retrofitting of Beams in a RCC Structure Subjected to Modified Forces in the Form of an Additional Storey

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.*Abstract*-**Retrofitting of constructions subjected to additional loads is a problem of social significance. Usually people construct the structure to achieve their present needs but with the passage of time they realize that their demands have increased and there is a need for the addition/alteration of the current structure. This demand can be fulfilled by constructing a new storey. However, provision for additional load due to the new construction over existing structure was not made in the structural design of the old structure. Therefore, the construction of new storey requires the strengthening of the old structure. In this paper the structural behaviour of an RC frame under the additional load in the form of a new storey is studied. The analysis of the structure is performed by using structural analysis software i.e. STAAD Pro. The analysis results of existing and proposed structure are compared to evaluate the increase in structural forces due to the construction of a new storey. The results indicates that the significant increase is found in the shear force and bending moment in beams. The weak and deficient beams are identified and strengthened for the additional loads and additional moments. The strengthening of beams is done by placing the steel plates at top and bottom of the beams, connected with the help of shear connectors.**

Keywords- Concrete; Steel; Jacketing; Strengthening.

I. INTRODUCTION

Retrofitting is the process of modifying something after it has been manufactured. This is done with the probability of improving the performance of the building. Concrete is one of the most common building materials and is used both for buildings, bridges and other heavyweight structures. Normally, structures of concrete are very durable, but sometimes they need to be strengthened. The reason for it may be cracking due to environmental properties that a bridge is to be used for heavier traffic, new building codes, or damage as a resultant of earthquakes.

The need for retrofitting in existing building can arise due to any of the following reasons:

- Building not designed to code
- Subsequent updating of code and design practice
- Subsequent upgrading of seismic zone
- Deterioration of strength and aging
- Modification of existing structure
- Additional loads
- Change in use of the building, etc.

Fig.1 Steel plates

Fig.2 Steel plates glued to reinforced concrete beam

II. LITERETUREREVIEW

Dr. Khair Al-DeenIsamBsisu conducted the study of 20 square reinforced concrete columns to examine retrofitting with steel jackets method and design procedures to provide theoretical and experimental confirmation of the method. Compressive strength of these columns as more than double the strength of the original column can be achieved by retrofitting the square reinforced concrete columns with full steel jackets. The confined strength of concrete is almost 1.5 times the unconfined strength. Confinement of reinforced concrete columns with steel jackets can improve the ductility of the column, and retrofitting with full steel jacket can increase ductility as well as the ultimate strength of the column exposed to eccentrically axial loading.

Ghobarahet tested three 1/3-scale columns to examine the effectiveness of corrugated steel jacketing in the retrofitting of reinforced concrete columns. The jackets were constructed from commercially presented corrugated steel sheets and the gaps between the concrete and the steel jacket was filled with grout to provide continuity between the two components. Further, the undulated shape exhibits an out-of-plane stiffness which increases its efficiency in providing external passive confinement to the renewed members. These showed a significant increase in deformation capacity, without any major change in the initial stiffness.

Slobodan Rankovicet.al. reviews the important analytic expressions for determination of strength of shear connectors in steel concrete composite beams. The mechanism of possible failure and basic criteria used for defining of the shear connector strength at composite slabs and composite slabs with profiled sheet. Special analysis has been done in the expressions and approvals given by the Euro code 4 in the area of shear connector strength, both elastic and rigid. For all the regulations, a comparative analysis with our standing standard addressing this area is given. Along with the relative review of the regulations, a commentary on the strength of the shear connectors in composite beams was given.

III. PROPOSED WORK

In this paper the structural behaviour of an RC frame under the additional load in the form of a new storey is investigated. The analysis of existing structure (two storey) and proposed structure (one additional storey constructed over existing two storey structure) is performed by using structural analysis software i.e. STAAD Pro. The analysis results of existing and proposed structure are compared to evaluate the increase in structural forces due to the construction of a new storey. The results indicates that the significant increase is found in the shear force and bending moment in beams.

Methodology

The following sequence is adopted for strengthening the structure:

1. Analysis of the existing structure
2. Analysis of the new structure
3. Comparative study to evaluate the increase in beam forces and identifying the weak zones
4. Strengthening of weak members

Pictorial representation of the structure

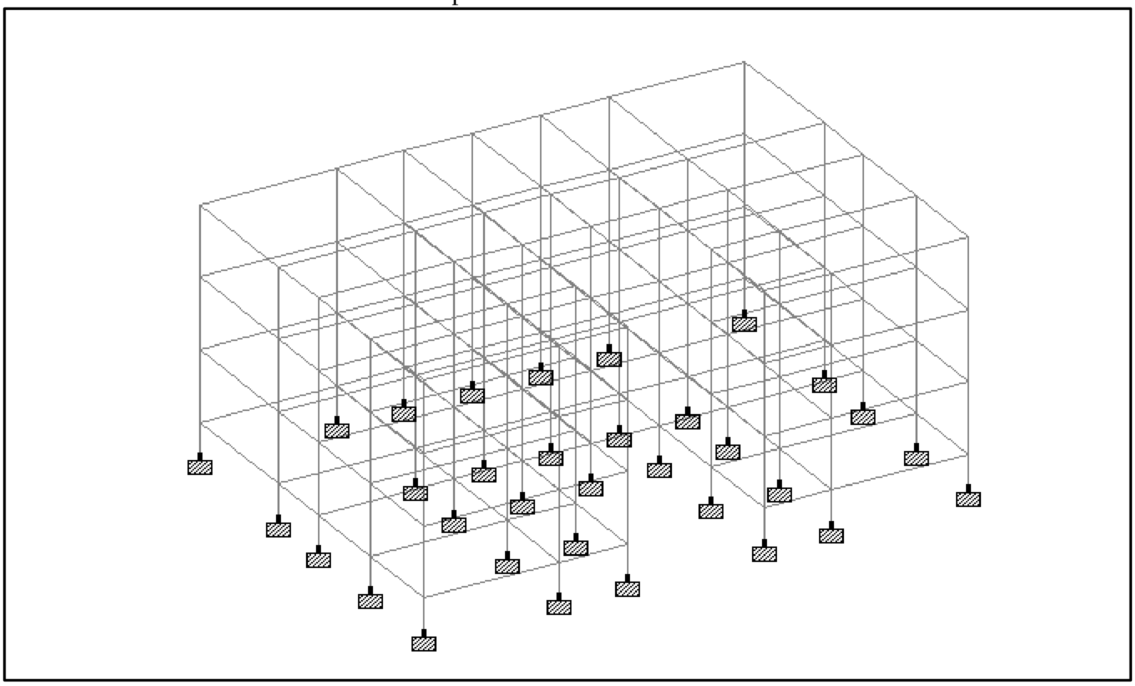

Fig.3 Isometric view of the proposed structure

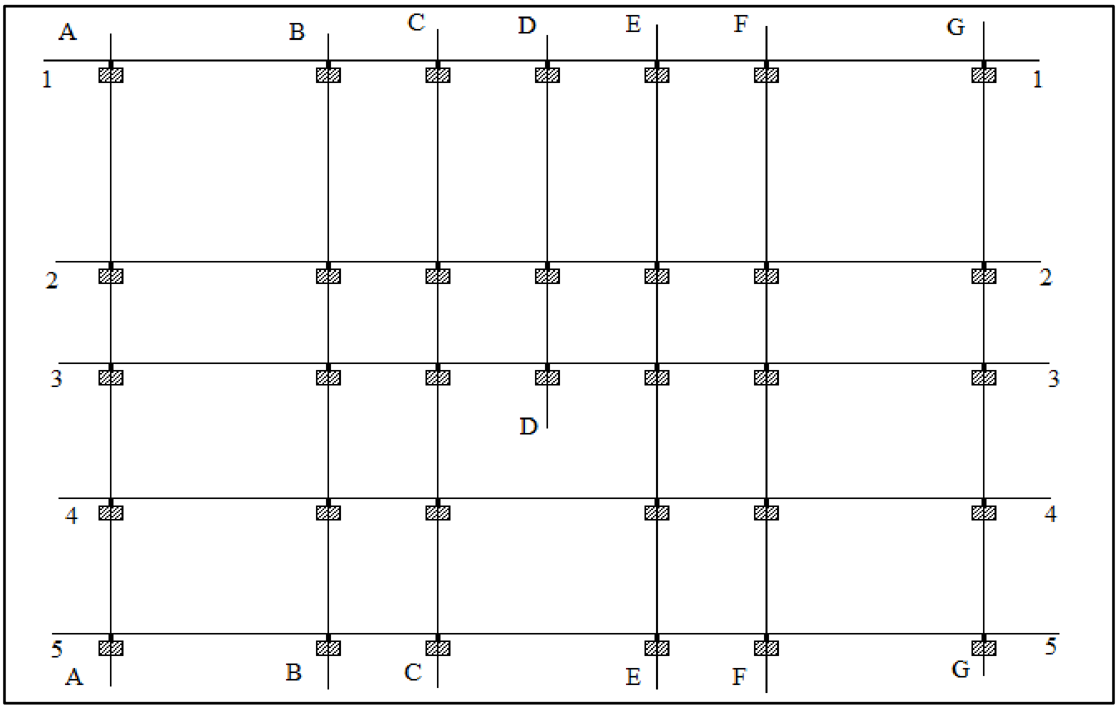

Fig.4 Plan of the structure

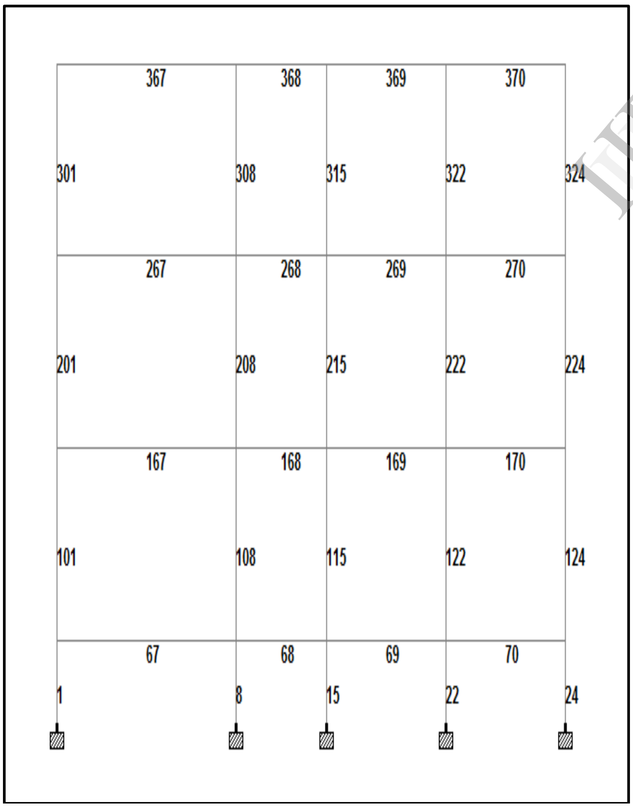

Fig.5 Member numbering at section A-A

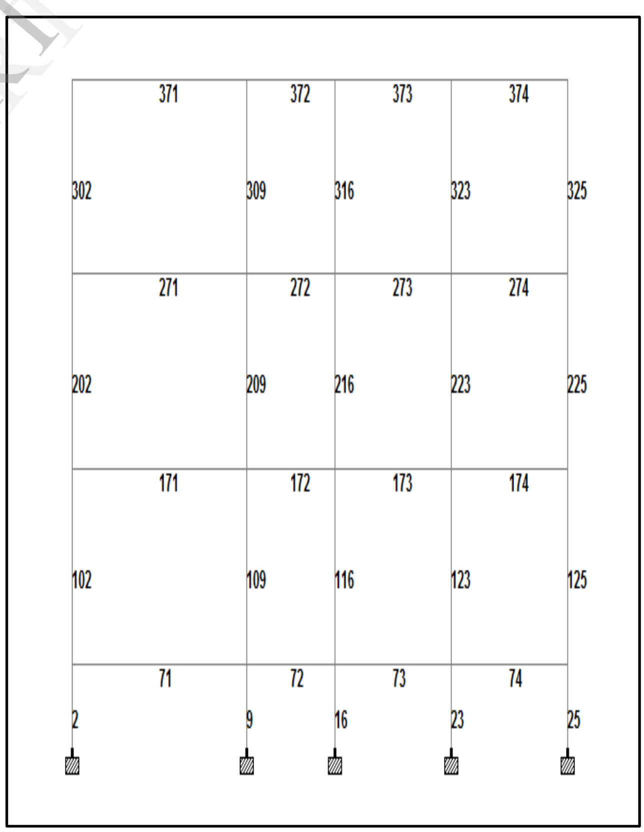

Fig.6 Member numbering at section B-B

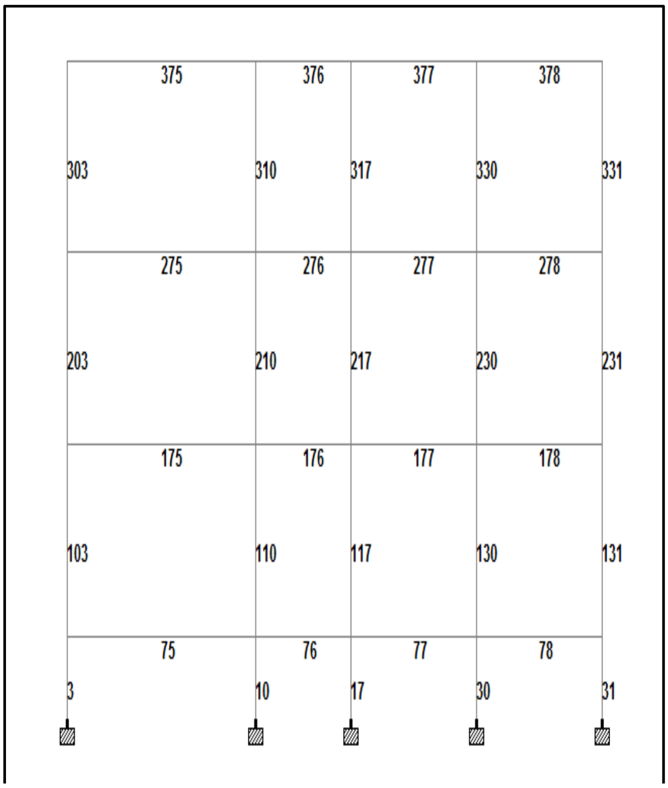

Fig.7 Member numbering at section C-C

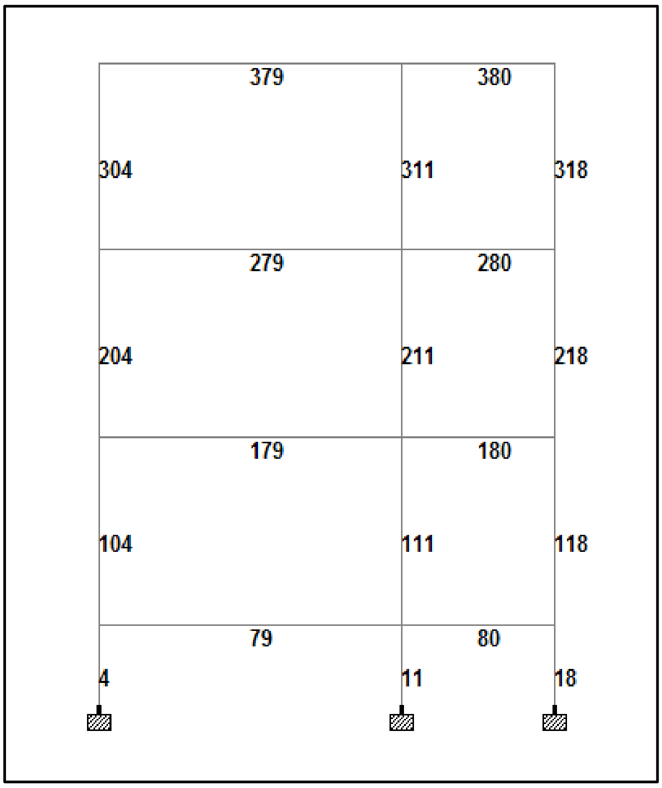

Fig.8 Member numbering at section D-D

DETAILS OF STRUCTURE

This paper presents the analysis and design of an existing structure (two storey) and proposed structure (additional storey constructed over existing two storey structure) RCC framed structure. The details of which are given below.

TABLE-1: Geometry of the Structure

S. No.	Description	Value
1	Area of building	408 m^2
2	Length	24 m
3	Breadth	17 m
4	Storey height	3.5 m
5	Height of the column below plinth level	1.5 m
6	Size of the column	300 mm x 300 mm
7 (a)	Size of beam for 6m span	200 mm x 500 mm
7 (b)	Size of beam for 4m span	200 mm x 400 mm
8	Thickness of slab	150 mm
9	Thickness of outer walls	200 mm
10	Thickness of inner walls	100 mm
11	Support condition	Fixed

Material properties

Grade of concrete = M20

Grade of Steel = Fe415

Elasticity constant = 2.17 X 10^7kN/m^2

Dead load
Unit weight of concrete = 25 kN/m^3
Unit weight of masonry wall = 20 kN/m^3
Dead load of slab = 3.75 kN/m^2
Floor finish = 0.75 kN/m^2
Load of parapet wall = 2.6 kN/m
Load of inner wall = 8.06 kN/m
Load of outer wall = 14.26 kN/m
Live load
Live load on floor = 4 kN/m^2
Live load on roof = 1.5 kN/m^2

Parameters for seismic load

TABLE-2: Parameters for seismic load

S. No.	Parameter	Value
1	Location (ZONE II)	Zone Factor = 0.10
2	Response reduction factor (Ordinary RC Moment Resisting Frame)	RF = 3
3	Importance factor (All General Building)	I = 1
4	Rock and soil site factor (Medium soil)	SS = 2
5	Type of structure (RC Frame Building)	ST = 1
6	Damping ratio	DM = 0.05

IV. FORCES IN BEAMS

Analysis results of shear force Fy and bending moment Mz in beams obtained from STAADPro are presented below.

a) First floorbeams

The increase in shear force and bending moment in first floor beams due to construction of additional storey is depicted in Table 3 and 4 respectively.

TABLE-3: Comparison of shear force Fy in first floor beams due to additional storey

Beam No.	Shear Force Fy (kN)		Increase in Shear Force Fy (kN)	% Increase
	Case 1 (Existing Structure)	Case2 (Proposed Structure)		
141	137.70	147.01	9.31	6.76
142	74.22	87.80	13.58	18.29
143	64.61	79.24	14.62	22.64
147	152.31	153.99	0.32	0.21
148	71.42	81.94	10.51	14.72
149	58.65	73.36	14.71	25.08
153	145.35	146.61	0.73	0.50
154	55.65	64.01	8.36	15.02
155	38.81	52.94	14.13	36.40
159	154.33	154.84	0.51	0.33
160	57.32	68.62	11.30	19.71
163	131.08	130.47	-0.61	-0.46
164	40.49	60.68	20.19	49.88
167	139.21	137.19	-2.02	-1.45
168	48.82	87.39	38.56	78.98
169	63.30	88.57	25.26	39.90
170	67.01	95.43	28.42	42.41
171	155.89	116.05	-39.84	-25.55
172	62.51	75.65	13.14	21.02
173	108.13	84.52	-23.61	-21.83
174	104.18	89.95	-14.23	-13.66
175	135.41	137.85	2.44	1.80
176	54.94	61.19	6.25	11.37
177	35.90	48.86	12.96	36.10
178	37.01	54.15	17.13	46.29
179	136.41	137.93	1.52	1.11
180	86.65	66.83	-19.82	-22.87

TABLE-4: Comparison of bending moment Mz in first floor beams due to additional storey

Beam No.	Bending moment Mz (kN-m)		Increase in Bending moment Mz (kN-m)	% Increase
	Case 1 (Existing Structure)	Case 2 (Proposed Structure)		
141	135.96	161.15	25.19	18.53
142	78.03	97.74	19.71	25.25
143	49.44	72.56	23.12	46.76
147	126.55	168.92	42.37	33.48
148	81.91	96.72	14.81	18.08
149	50.22	73.33	23.11	46.01
153	141.22	157.46	16.24	11.50
154	72.05	83.66	11.61	16.12
155	36.00	62.25	26.07	72.05
159	151.13	163.36	12.23	8.09
160	71.91	85.79	13.87	19.29
163	-121.73	-144.06	22.32	18.33
164	57.22	77.33	20.10	35.14
167	-137.26	-165.29	28.03	20.42
168	84.41	97.96	13.54	16.04
169	-65.23	-94.99	29.75	45.60
170	104.01	131.28	27.27	26.22

171	-159.71	-143.67	16.04	-10.04
172	99.42	85.55	13.87	-13.95
173	-98.37	-89.95	8.42	-8.56
174	85.95	96.71	10.75	12.51
175	-141.72	-149.44	7.72	5.44
176	72.29	79.07	6.78	9.37
177	-42.34	-63.95	21.61	51.05
178	-45.95	-71.78	25.81	56.14
179	-145.63	-147.41	1.78	1.22
180	84.87	82.19	2.68	-3.15

Negative values in the difference of case 1 and case 2 indicate that there is a decrease in the value.

Table 3 and 4 indicates that there is an increase in shear force Fy and bending moment Mz in all the beams. The maximum increase in shear force is found in beam no168 with an increase of 79%.The maximum increase in bending moment Mz is found in beam no 155 with an increase 72%.

b) Second floor beams

The increase in shear force and bending moment in second floor beams due to construction of additional storey is depicted in Table 5 and 6 respectively.

TABLE-5: Comparison of shear force Fy in second floor beams due to additional storey

Beam No.	Shear Force Fy (kN)		Increase in Shear Force Fy (kN)	% Increase
	Case 1 (Existing Structure)	Case 2 (Proposed Structure)		
241	65.85	136.17	70.32	106.78
242	32.20	76.67	44.47	138.09
243	26.34	68.70	42.36	160.77
247	85.44	151.48	66.04	77.28
248	36.75	70.45	33.69	91.66
249	28.45	63.43	34.98	122.95
253	80.69	144.03	63.33	78.48
254	34.89	53.28	18.39	52.70
255	26.28	43.60	17.31	65.88
259	86.78	152.46	65.68	75.68
260	36.76	55.29	18.53	50.40
263	61.74	129.26	67.51	109.34
264	31.32	48.28	16.96	54.17
267	67.11	136.22	69.11	102.98
268	28.25	75.17	46.85	165.81
269	27.63	81.37	53.73	194.42
270	29.65	85.46	55.81	188.18
271	87.50	114.32	26.81	30.64
272	39.48	64.34	24.85	62.93
273	52.47	81.14	28.67	54.63
274	51.03	81.93	30.90	60.55
275	72.80	136.48	63.67	87.46
276	34.80	51.39	16.59	47.67
277	25.67	43.92	18.25	71.12
278	27.00	46.04	19.03	70.49
279	73.09	136.45	63.36	86.68
280	43.87	54.63	10.76	24.53

TABLE-6: Comparison of bending moment Mz in second floor beams due to additional storey

Beam No.	Bending moment Mz (kN-m)		Increase in Bending moment Mz (kN-m)	% Increase
	Case 1 (Existing Structure)	Case 2 (Proposed Structure)		
241	66.32	143.44	77.12	116.27
242	38.59	80.94	42.34	109.72
243	21.15	59.21	38.06	179.93
247	-82.54	-154.60	-72.06	87.30
248	46.99	78.74	31.74	67.56
249	24.24	59.25	35.01	144.40
253	76.44	143.46	67.01	87.67
254	42.96	66.64	23.68	55.12
255	22.72	48.93	26.20	115.29
259	-83.45	-150.64	-67.19	80.51
260	42.67	66.23	23.56	55.22
263	-60.66	-129.54	-68.87	113.52
264	32.60	60.74	28.13	86.27
267	-67.84	-146.49	-78.64	115.92
268	44.08	79.77	35.68	80.95
269	-28.71	-80.87	-52.15	181.63
270	27.98	83.18	55.20	197.27
271	-90.88	-130.59	-39.71	43.69
272	59.05	68.19	9.14	15.47
273	-49.65	-77.62	-27.96	56.31
274	43.81	79.90	36.09	82.37
275	-77.82	-136.90	-59.11	75.96
276	43.45	63.71	20.26	46.63
277	-28.43	-52.80	-24.37	85.73
278	27.83	57.63	29.79	107.03
279	-78.52	-135.34	-56.81	72.34
280	47.55	63.90	16.34	34.37

Table 5 and 6 indicates that there is an increase and decrease in shear force Fy and bending moment Mz in all the beams. The maximum increase in shear force is found in beam no 269 with an increase of 194%. The maximum increase in bending moment Mz is found in beam no 270 with an increase of 197%.

Comparison of maximum values of shear force Fy in beams at different floors.

The maximum values of shear force Fy is compared for the beams of plinth level, first floor and second floor due to additional storey.

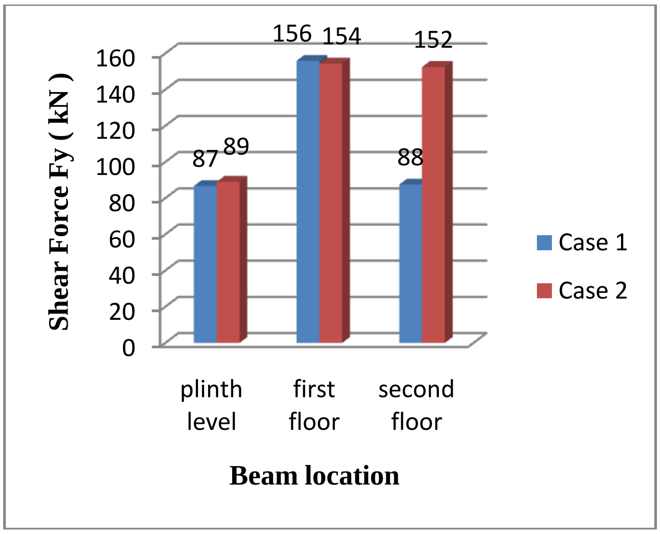

Fig.9 Comparison of maximum shear force Fy in beams at different locations

Comparison of maximum values of bending moment Mz in beams at different floors.

The maximum values of bending moment Mz is compared for the beams of plinth level, first floor and second floor due to additional storey.

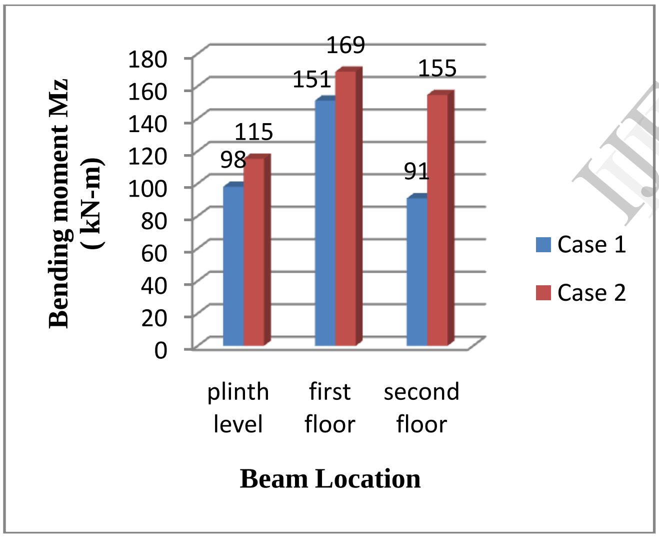

Fig.10 Comparison of maximum bending moment Mz in beams at different locations

V. REINFORCEMENT IN BEAMS

The difference in the reinforcement in beams of plinth level, first floor and second floor are estimated for case 1 (existing structure) and case 2 (proposed structure) and are presented below.

a)Reinforcement in first floor beams

The increase in top and bottom reinforcement in first floor beams due to construction of additional storey is depicted in Table 7 and 8 respectively.

TABLE-7: Comparison of top reinforcement in first floor beams due to additional storey

Beam No	Top Reinforcement (mm^2)		Increase in reinforcement (mm^2)	% Increase
	Case 1 (Existing Structure)	Case 2 (Proposed Structure)		
141	1004.80	1256.00	251.20	25.00
142	785.00	942.00	157.00	20.00
143	452.16	678.24	226.08	50.00
147	1004.80	1205.76	200.96	20.00
148	785.00	942.00	157.00	20.00
149	452.16	678.24	226.08	50.00
153	1004.80	1205.76	200.96	20.00
154	678.24	904.32	226.08	33.33
155	339.12	565.20	226.08	66.67
159	1004.80	1256.00	251.20	25.00
160	678.24	791.28	113.04	16.67
163	791.28	1004.80	213.52	26.98
164	549.50	791.28	241.78	44.00
167	803.84	1256.00	452.16	56.25
168	565.20	942.00	376.80	66.67
169	339.12	942.00	602.88	177.78
170	452.16	981.25	529.09	117.01
171	1004.80	1004.80	0.00	0.00
172	706.50	791.28	84.78	12.00
173	565.20	791.28	226.08	40.00
174	803.84	942.00	138.16	17.19
175	1205.76	1205.76	0.00	0.00
176	678.24	791.28	113.04	16.67
177	314.00	565.20	251.20	80.00
178	392.50	678.24	285.74	72.80
179	1205.76	1205.76	0.00	0.00
180	565.20	791.28	226.08	40.00

Table 7 indicates that there is an increase in top reinforcement in first floor beams due to the construction of an additional storey. The maximum increase in the top reinforcement is observed in beam no 169 with an increase of 177.78%.

TABLE-8: Comparison of bottom reinforcement in first floor beams due to additional storey

Beam No	Bottom Reinforcement (mm^2)		Increase in reinforcement (mm^2)	% Increase
	Case 1 (Existing Structure)	Case 2 (Proposed Structure)		
141	791.28	803.84	12.56	1.56
142	157.00	339.12	182.12	116.00
143	226.08	339.12	113.04	50.00
147	942.00	942.00	0.00	0.00
148	226.08	942.00	715.92	316.67
149	226.08	401.92	175.84	77.78
153	904.32	904.32	0.00	0.00
154	226.08	904.32	678.24	300.00
155	226.08	401.92	175.84	77.78
159	981.25	981.25	0.00	0.00
160	314.00	565.20	251.20	80.00
163	785.00	791.28	6.28	0.80
164	314.00	565.20	251.20	80.00
167	803.84	803.84	0.00	0.00
168	226.08	401.92	175.84	77.78
169	226.08	339.12	113.04	50.00
170	226.08	401.92	175.84	77.78
171	942.00	791.28	-150.72	-16.00
172	226.08	339.12	113.04	50.00
173	314.00	339.12	25.12	8.00

174	401.92	401.92	0.00	0.00
175	942.00	791.28	-150.72	-16.00
176	226.08	401.92	175.84	77.78
177	157.00	339.12	182.12	116.00
178	226.08	452.16	226.08	100.00
179	942.00	791.28	-150.72	-16.00
180	235.50	565.20	329.70	140.00

Negative values in the difference of case 1 and case 2 indicate that there is a decrease in the value.

Table 8 indicates that there is an increase in bottom reinforcement in first floor beams due to the construction of an additional storey. The maximum increase in the bottom reinforcement is observed in beam no 148 with an increase of 361%.

b) Reinforcement in second floor beams

The increase in top and bottom reinforcement in second floor beams due to construction of additional storey is depicted in Table 9 and 10 respectively.

TABLE-9: Comparison of top reinforcement in second floor beams due to additional storey

Beam No	Top Reinforcement (mm^2)		Increase in reinforcement (mm^2)	% Increase
	Case 1 (Existing Structure)	Case 2 (Proposed Structure)		
241	452.16	1004.80	552.64	122.22
242	339.12	791.28	452.16	133.33
243	226.08	565.20	339.12	150.00
247	452.16	1205.76	753.60	166.67
248	471.00	791.28	320.28	68.00
249	226.08	565.20	339.12	150.00
253	392.50	1004.80	612.30	156.00
254	392.50	602.88	210.38	53.60
255	226.08	452.16	226.08	100.00
259	452.16	1205.76	753.60	166.67
260	392.50	602.88	210.38	53.60
263	401.92	942.00	540.08	134.38
264	314.00	565.20	251.20	80.00
267	339.12	1004.80	665.68	196.30
268	314.00	791.28	477.28	152.00
269	226.08	678.24	452.16	200.00
270	226.08	678.24	452.16	200.00
271	628.00	942.00	314.00	50.00
272	392.50	602.88	210.38	53.60
273	314.00	678.24	364.24	116.00
274	392.50	791.28	398.78	101.60
275	549.50	1004.80	455.30	82.86
276	392.50	565.20	172.70	44.00
277	235.50	452.16	216.66	92.00
278	226.08	565.20	339.12	150.00
279	471.00	1004.80	533.80	113.33
280	401.92	565.20	163.28	40.63

Table 9 indicates that there is an increase in top reinforcement in second floor beams due to the construction of an additional storey. The maximum increase in the top reinforcement is observed in beam no 247 with an increase of 166.67%.

TABLE-10: Comparison of bottom reinforcement in second floor beams due to additional storey

Beam No	Bottom Reinforcement (mm^2)		Increase in reinforcement (mm^2)	% Increase
	Case 1 (Existing Structure)	Case 2 (Proposed Structure)		
241	401.92	791.28	389.36	96.88
242	157.00	226.08	69.08	44.00
243	157.00	226.08	69.08	44.00
247	565.20	942.00	376.80	66.67
248	157.00	226.08	69.08	44.00
249	157.00	226.08	69.08	44.00
253	549.50	904.32	354.82	64.57
254	157.00	339.12	182.12	116.00
255	157.00	339.12	182.12	116.00
259	565.20	942.00	376.80	66.67
260	157.00	339.12	182.12	116.00
263	392.50	791.28	398.78	101.60
264	157.00	339.12	182.12	116.00
267	401.92	791.28	389.36	96.88
268	226.08	226.08	0.00	0.00
269	226.08	339.12	113.04	50.00
270	226.08	339.12	113.04	50.00
271	549.50	791.28	241.78	44.00
272	226.08	226.08	0.00	0.00
273	226.08	339.12	113.04	50.00
274	226.08	339.12	113.04	50.00
275	549.50	791.28	241.78	44.00
276	157.00	226.08	69.08	44.00
277	157.00	226.08	69.08	44.00
278	157.00	339.12	182.12	116.00
279	549.50	791.28	241.78	44.00
280	157.00	339.12	182.12	116.00

Table 10 indicates that there is an increase in bottom reinforcement in second floor beams due to the construction of an additional storey. The maximum increase in the bottom reinforcement is observed in beam no 263 with an increase of 101%.

VI. STRENGTHENING OF BEAMS

The beams of first floor and second floor are strengthened for the additional load and moment estimated from the above tables.

a)Strengthening of first floor beams

Beams are strengthened for additional reinforcement requirement at top and bottom obtained from the Table 7 and 8 respectively.

Design of top plate

Additional reinforcement area (Fe-415) required for critical beam at first floor = 602.88mm^2

Equivalent area of mild steel plate (Fe-250)

$= \frac{415}{250}$ x 602.88 =1000.78mm^2

Assuming width of mild steel plate = 150 mm

Required thickness of plate = $\frac{1000.78}{150}$ = 6.67≅8mm

Area of steel plate provided = 150 x 8 = 1200mm^2

Therefore provide a steel plate of 150 mm wide and 8mm thick at top of the first floor beam to resist hogging moment.

Design of bottom plate

Additional reinforcement area (Fe-415) required for critical beam at second floor = 715.92mm^2

Equivalent area of mild steel plate (Fe-250) = $\frac{415}{250}$ x 715.92 = 1188.42mm^2

Assuming width of mild steel plate = 150 mm

Required thickness of plate = $\frac{1188.42}{150}$ = 7.92≅ 8 mm

Area of steel plate provided = 1200mm^2

Therefore provide a steel plate of 150 mm wide and 8mm thick at bottom of the plinth beam to resist sagging moment.

TABLE-11: Size of mild steel plate provided at top and bottom of beam

S.No.	Additional reinforcement area required	Equivalent reinforcement area of mild steel plate	Size of steel plate provided
1	up to 361 mm^2	600 mm^2	150 mm x 4 mm
2	362 mm^2– 450 mm^2	700 mm^2	150 mm x 5 mm
3	450 mm^2 – 630 mm^2	1050 mm^2	150 mm x 7 mm
4	631 mm^2 – 720 mm^2	1200 mm^2	150 mm x 8 mm
5	721 mm^2 – 900 mm^2	1500 mm^2	150 mm x 10 mm

VII.DESIGN OF SHEAR CONNECTORS

a)First storey

We know that,

Moment, M = 0.36 f_{ck} x b x_u x (d-0.42x_u)

Finding x_u for maximum of sagging and hogging moment

Max sagging moment = 34.19 kN-m

Therefore we have,

34.19 x 10^6 = 0.36 x 25 x 200 x_u x (367 – 0.42x_u)

34.19 x 10^6 = 660600x_u-756${x_u}^2$

∴ x_u = 55.23 mm

Lever arm (a) = (d-0.42x_u)

a = 367 – 0.42 x 55.23 = 343.79 mm

Now additional force to be carried by stud

F = $\frac{M}{a}$ = $\frac{34.19 \ x \ 10^6}{343.80}$

Therefore, F = 99.45 kN

Now designing the shear connector for the above force using IS 11384:1985 code

From Table 1, we have

20 mm diameter of stud, 100 mm height and for M25 concrete

Strength of shear connector F = 63 kN

So for the above required force, provide 2# shear connectors at a spacing of 50 mm c/c.

b) Similarly, at second storey

For moment = 77.7 kN-m and force = 183 kN

From Table 1, we have

25 mm diameter of stud, 100 mm height and for M25 concrete

Strength of shear connector F = 94 kN

So for the above required force, provide 2# shear connectors at a spacing of 50 mm c/c.

VIII. CONCLUSIONS

In present work the effect of additional forces due to construction of new storey on existing structure is studied. The shear force and bending moment in beams are compared to investigate the need of strengthening of beams. Comparison of beam forces due to construction of an additional storey over existing structure is presented in Table-12.

TABLE-12: Comparison of beam forces due to construction of additional storey over existing structure.

Structural component	Variation of forces in existing structure	Variation of forces in structure with additional storey	% Variation in forces due to additional storey
A) Beams			
i) Shear force Fy (kN)			
a) Plinth level (Member no.)	15.11 – 86.53 (78)* - (67)	21.06 – 89.01 (77) - (67)	39.37 – 2.86
b) First floor (Member no.)	35.90 – 155.89 (177) - (171)	48.86 – 154.84 (177) - (159)	36.10 – (-0.67)**
c) Second floor (Member no.)	26.28 – 87.50 (255) - (271)	43.60 – 152.46 (255) - (259)	65.90 – 74.24
ii) Bending moment Mz (kN-m)			
a) Plinth level (Member no.)	24.36 – 98.03 (77) - (41)	34.54 – 115.24 (77) - (67)	41.78 – 17.55
b) First floor (Member no.)	36.00 – 159.71 (155) - (171)	62.25 – 168.92 (155) - (147)	72.91 – 5.76
c) Second floor (Member no.)	21.15 – 90.88 (243) - (271)	48.93 – 154.60 (255) - (247)	131.34 – 70.11

Note:
* Value within the bracket indicates member no.
** Negative sign indicates decrease in the value.
# Indicates insignificant value.

The main findings of this study are mentioned below:

1. The effect of construction of additional storey on critical value of shear force and bending moment in beams of plinth level and first floor shows a minor increment
2. There is a significant increase in the critical value of shear force and bending moment in second floor beams with an increment of 74.24% and 70.11% respectively due to construction of an additional storey.

REFERENCES

[1]. ACI Committee 437, (1991), "Strength Evaluation of Existing Concrete Buildings", American Concrete 15 Institute.

[2]. ASCE-41 (2007), "Seismic Rehabilitation of Existing Buildings", American Society of Civil Engineers, Reston, Va.

[3]. Broderick, B. M. and Ehashai, A. S. (1994) "Seismic Resistance of Composite Beam-Columns in Multi-Storey Structures. Part 2: Analytical model and discussion of results," J. Construct. Steel Res. 3O(3), 23 1-258

[4]. Calvi, G. M., Moratti, M., and Pampanin, S. (2002), "Relevance of beam-column damage and collapse in RC frame assessment", Journal of Earthquake Engineering, 6(1), 75-100.

[5]. El-Amoury, T., and Ghobarah, A., (2005) "Retrofit of RC Frames Using FRP Jacketing or Steel Bracing" JSEE: Vol. 7, No. 2 / 83.

[6]. Elnashai, A. S. and Pinho, R. (1998), "Repair And Retrofitting Of RC Walls Using Selective Techniques", Journal of Earthquake Engineering, 2: 4, 525 — 568.

[7]. Ghobarah, A., Ashraf Biddah and Mahgoub, M. (1997), "Rehabilitation Of Reinforced Concrete Columns Using Corrugated Steel Jacketing," J. Earthquake. Engineering. 1(4), 65 1-673.

[8]. Guide for Evaluation of Concrete Structures Prior to Rehabilitation (ACI 364. 1R-94(99)), By ACI Committee 364, Rehabilitation.

[9]. Mohd Irfan, Dr. Abhay Sharma, Dr. Vivek Garg, (August, 2014) "Strengthening Demand of Columns in A RCC Structure Due To Construction of An Additional Storey", International Journal of Engineering Research & Technology:
E-ISSN: 2278-0181 Vol. 3 - Issue 8.

[10]. Johnson R. P., 1975."Composite Structures of Steel and Concrete". Volume 1, Applications in Buildings. London.

[11]. Kenji, S., and Yuping, S., (2000), "Steel Jacketing For Improvement of Column Strength and Ductility" 12WCEE.

[12]. Millar, D., Scott, P., and Clenin, R. (2004) "Bridge Strengthening with Prestressed CFRP Plate System", Proc. 2nd International Conference on FRP Composites in Civil Engineering, 463-469, Taylor and Francis, Adelaide, Australia.

[13]. Mirmiran, A., and Shahawy, M. (1997) "Behavior of concrete columns confined by fiber composites", ASCE-Journal of Structural Engineering, 123(5), 583-590

[14]. Plizzari, G.A., Meda, Z., A., Rinaldi, Martinola Concretum, G., and Zurich, (2009) "Concrete Repair, Rehabilitation and Retrofitting II", Taylor & Francis Group, London, ISBN 978-0-415-46850-3.

[15]. Reddy, G., R., Akanshu, S., Dubey, P., N., Parulekar, Y., M. (2010) "Seismic Retrofitting Of Lifeline Structures And Systems", Proceedings for WSRR 09, IIT Bombay, ASTR.

[16]. Reza Mousavi M.M., Khaloo A.R., April 26-27, (2011) "Effect of Steel Plate Jacketing of Columns in Seismic Behavior of Concrete Beam-Column Connections", 6th National Congress on Civil Engineering, Semnan University, Semnan, Iran.