PROPOSED RETROFITTING STRATEGIES FOR EXISTING MULTISTORIED RC FRAMED HOSPITAL BUILDING

A Dissertation Submitted in Partial Fulfillment of the
Requirement for award of the Degree of

MASTER OF ENGINEERING IN
CIVIL ENGINEERING (STRUCTURE)

BY

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UNDER THE GUIDANCE OF

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DELHI COLLEGE OF ENGINEERING

UNIVERSITY OF DELHI, DELHI

2003-2006

"CERTIFICATE"

This is to declare that the major project on the topic of "Proposed Retrofitting Strategies for Existing Multistoried RC framed Hospital Building" is a bonafide record of work done by Saloni Priyadarshini for the partial fulfillment of the requirement of the degree of M.E., Civil Engg. (Structures) from Delhi College of Engineering, Delhi.

This project has been carried out under the supervision of Dr. (Mrs.) P. R. Bose, Prof. & Head and Shri Alok Vema, Lecturer, Civil Engg. Dept., Delhi College of Engineering.

I hereby state that I have not submitted the matter embodied in the report for award of any other degree.

NAME : SALONI PRIYADARSHINI
ROLL NO : 9134

Certificate

This is to certify that the above statement made by the candidate is correct to best of our knowledge.

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ACKNOWLEDGEMENT

It is a matter of great pleasure to acknowledge a debt of gratitude to **Dr. (Mrs.) P.R. Bose, Professor and Head Department of Civil Engineering,** Delhi College of Engineering & **Shri Alok Verma, Lecturer, Department of Civil Engineering, Delhi College of Engineering,** Delhi for their invaluable guidance and generous assistance. Their help, Coordination & patience with which they attended my problems and solved them have lead to the completion of the project.

I am also thankful for the Cooperation extended by the faculty members of the Civil Engineering Department.

I sincerely express my gratefulness to Mr. Sanjeev Wason (Munish Verma & Associates) for his extended help in AUTOCADD & compilation during the execution of project.

In the end, I would like to thank all my friends for their Cooperation.

(SALONI PRIYADARSHINI)

TABLE OF CONTENTS

INTRODUCTION

1. INTRODUCTION

This Report comprises of **Proposed retrofitting measures for Ward Block** of a Hospital Located in North East District of Delhi. This is a study of existing RC framed building as per latest prevailing codes, i.e. IS:456-2000, IS:1893-2002, IS:875:1987, IS:13920-1993, IS:4326-1990 etc (since it was designed on the basis of 1975 code of practices) and proposing various types of retrofitting The purpose of this study is to have seismic evaluation of existing building and a model program for retrofit. For analysis of building response spectrum method (with 5% damping for RC framed buildings) has been adopted.

Although IS: 1893-2002 has been used to evaluate seismic forces, peak ground acceleration and spectral values, do not necessarily account for seismic sources or site conditions in rigorous way. There are significant knowledge gaps about local seismic sources and site conditions. Local seismic sources need to be defined, including location, fault mechanism, distance to sites, maximum magnitude and response spectra. A significant amount of work is needed to rigorously address ground shaking potential in India and to develop probabilistic maps or charts so that sufficient data is available at the time of design.

Liquefaction potential is one of the areas to be considered while designing (or checking in this case) of foundation. But since this study mainly reflects seismic safety of superstructure, liquefaction potential of soil and other soil parameters have been assumed to be well within safe limit.

The **Hospital Block** is 8 - storied and it was constructed in the year 1980. The building was designed as per 1975 prevailing code of practice. Two revisions of Indian code (IS: 1893) have taken place since then in 1984 and 2002, each after some damage-causing earthquake. The building is resting on raft foundation of 750mm thickness at a depth of 2.0 m below ground level. Soil bearing capacity was reported to be 150 KN/M^2.

OBJECTIVE

2. OBJECTIVE

To propose suitable retrofitting measure for existing Hospital building as per the latest code of practice to meet Maximum Considered Earthquake guidelines.

PROPOSED METHODOLOGY
&
PROJECT DESCRIPTION

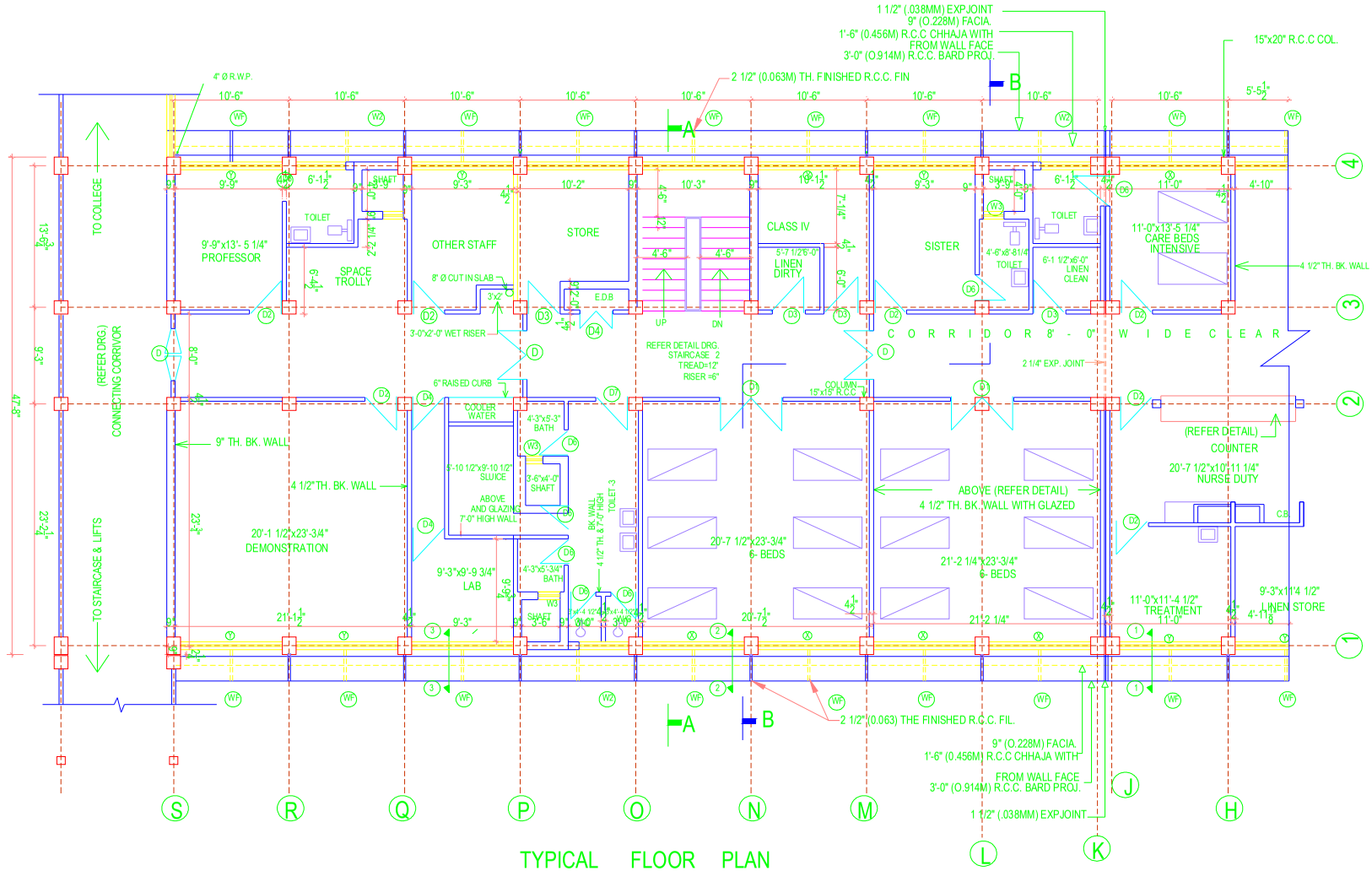
3. PROPOSED METHODOLOGY

a. Analysis to be carried out for a various number of options suggested by Peer Review Panel, India & Peer Review Panel (USA) for existing building as per latest prevailing codes(IS:456-2000, IS:1893-2002, IS:13920-1993, IS:4326-1993, IS:875-1987).
b. Results to be compared with existing structural drawings.
c. Carry out various retrofitting analysis based on its feasibility.
d. Select an appropriate retrofitting strategy after looking at the options available.

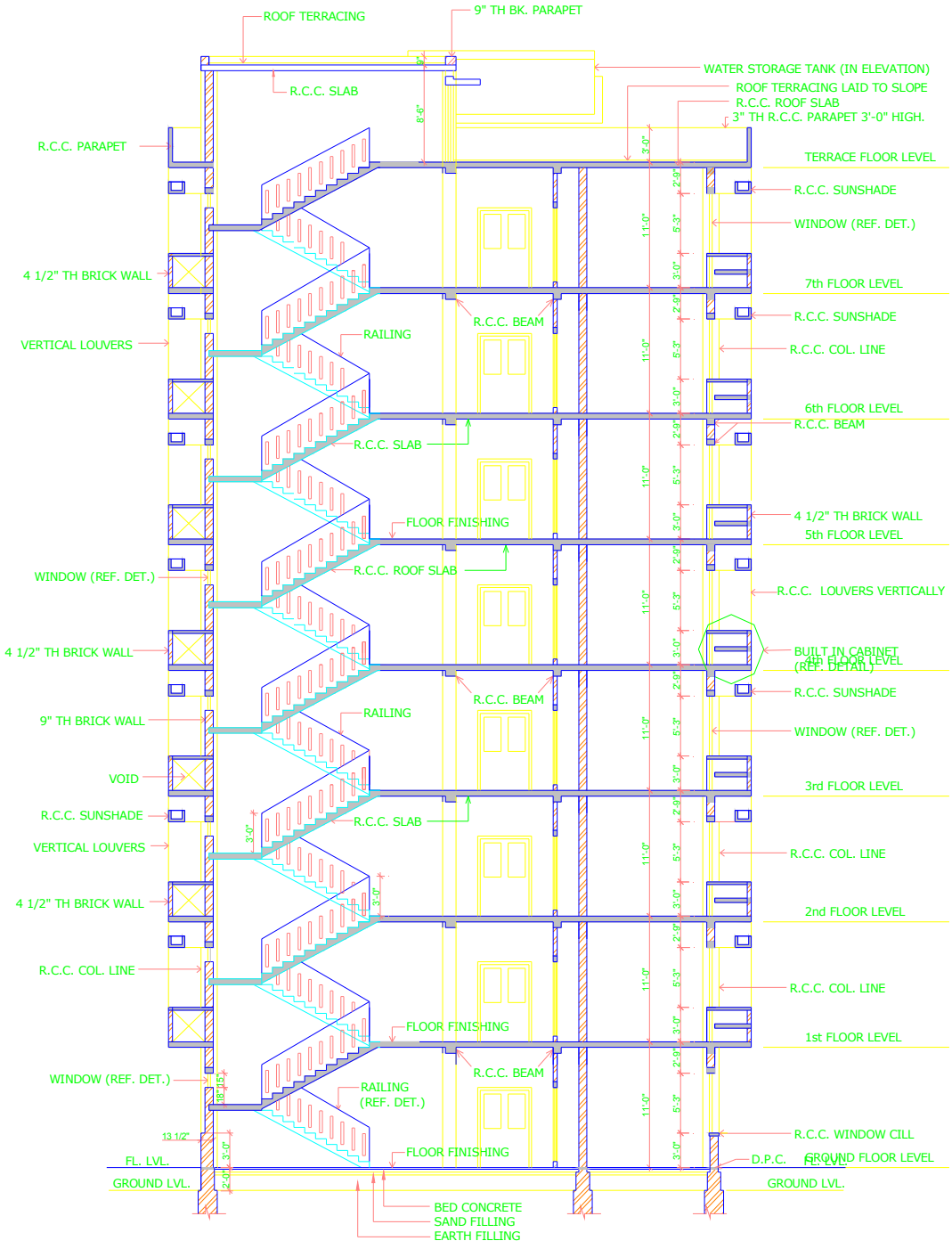
4. PROJECT DESCRIPTION

4.1. ARCHITECTURAL DRAWINGS - (TYPICAL FLOOR PLAN)

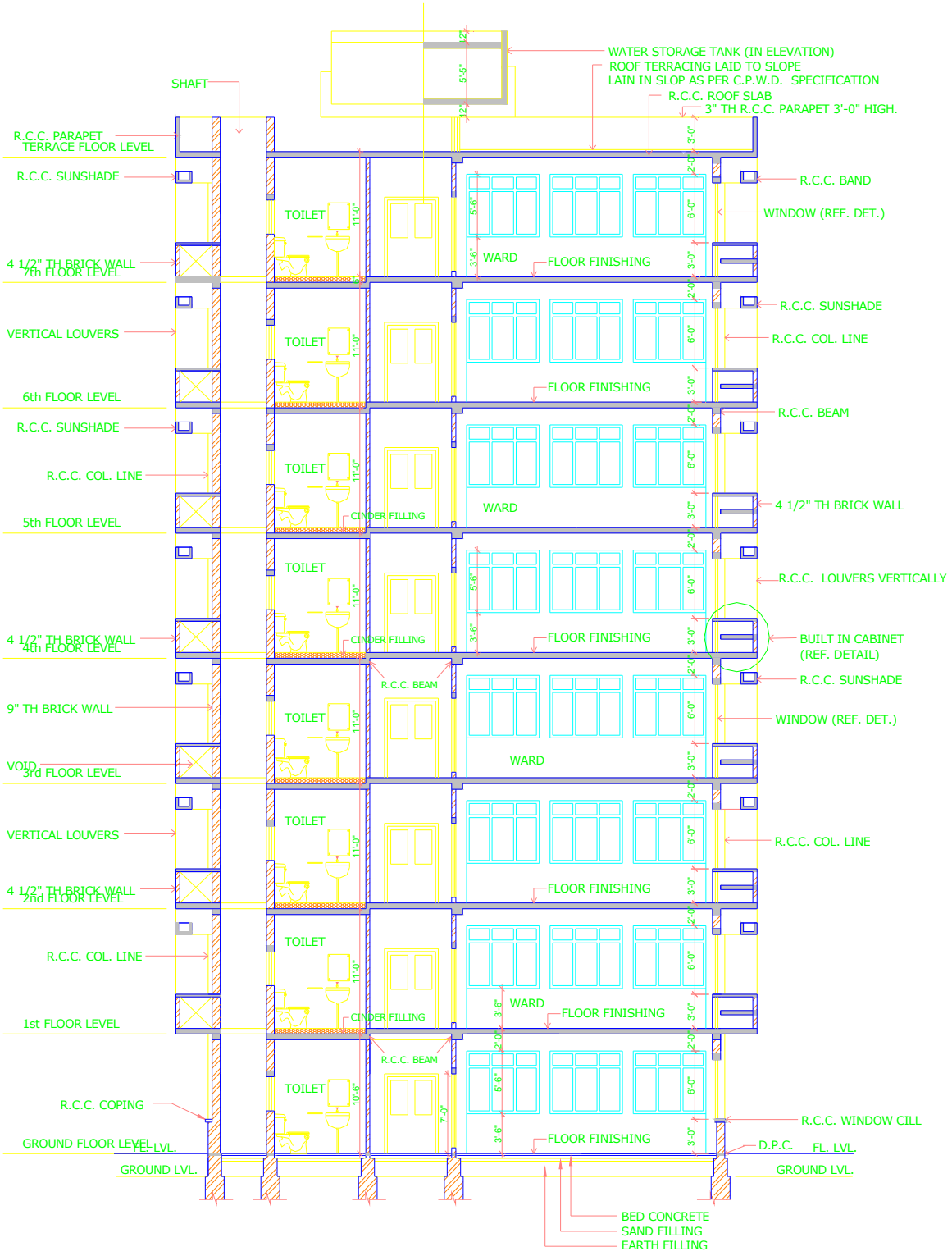
Floor plans & elevations of building are shown as below. The structural arrangement of building (framing plans and column locations) are based on these architectural drawings. Electrical & plumbing services are also indicated on these drawings only.



TYPICAL FLOOR PLAN



SECTION AT A-A



SECTION AT B-B

CONDITION ASSESSMENT
&
ASSUMPTIONS

5. CONDITION ASSESSMENT

- There was no major visible deterioration found in most of the structural members such as columns, beams and slabs.
- Three-four external columns were found to have noticeable cracks. Rusting of steel is found to be approximately 10%.
- These types of columns are only three / four columns in the building.
- Machine room columns above terrace have large deterioration.

6. ASSUMPTIONS

- Building idealized as a 3-D Space Frame structure on STAADPro-2005.
- Analysis has been carried out for MCE and I=2 and R=4 since ductile detailing has not been provided. A static Coefficient method analysis as well as a Response Spectrum Analysis has been carried out
- Building has been analyzed twice –first with Bare walls as per 7.6.1 of IS 1893:2002.Next the analysis has been carried out with Infill Panels by modeling them as diagonal struts and using the time period as per 7.6.2 of IS1893.
- Two options for retrofitting have been considered, one with enlarged column sizes at periphery of building and another with introducing shear walls as book ends.

DATA AVAILABLE OF EXISTING BUILDING

7. DATA AVAILABLE OF EXISTING BUILDING

- Ward Block-A - 8 storied RCC framed structure , 28.8 m x 13.94 m in plan & 27.43m high
- Columns - 400 x 600 mm and 400 x 750 mm in size & beams as follows-
    1. 300 x 400 mm in size(outer beams)
    2. 400 x 400 mm (internal beam on grids B)
    3. 400 x 600 mm (all main beams between C and D)
    4. 300 x 600 mm (between D 17 to D 19)
    5. 400 x 500 (between grid A and C on all grids from 1 to 10
- By soil investigation report - medium soil with a low water table & Allowable Bearing pressure of 11.5t/sq.m and a K value of 2 kg/cu.cm.
- Walls made of Burnt Clay bricks of Class 75, all outer walls 9” thick and inner walls 4.5” thick mostly.
- RCC water tank placed on terrace of 5.04m x 14.8m x 1.7m in size.

MATERIALS USED
&
DATA ASSUMED FOR ANALYSIS

8. MATERIAL USED

- Material properties as listed in the structural drawings have been utilized for analysis while the Condition Assessment is being carried out in the meantime to confirm these values.
- For the present analysis, a concrete mix of M25 (based on 1:1:2 recorded in the structural drawings) and steel reinforcement of Fe 415 has been adopted.

9. DATA ASSUMED FOR ANALYSIS (FOR RETROFITTING STRATEGIES):

9.1. PROPOSAL-I

- Columns - 400 x 600 mm and 400 x 750 mm in size is assumed as 400 x 1600 mm at base, gradually tapered to 400 x 800mm at top.
- Internal columns as well as beams are assumed to have same properties as of the existing building.
- Infill panels are taken into account while analyzing.

9.2. PROPOSAL-II

- Shear wall are introduced in buildings at book ends.
- All columns as well as beams are assumed to have same properties as of the existing building.
- Internal Infill panels are taken into account while analyzing.

9.3. PROPOSAL-III

- Steel bracing has been introduced in end frames (extreme sides).
- Properties of all other structural members remains the same as that in existing structure.
- ISMB250 has been adopted as x-bracings in frame, assuming to take only in plane shear. Shear out of plane and all moments were released at the time of analysis.
- Effect of infill panels have not been taken into account.

9.4. PROPOSAL-IV

- RCC wall of 100mm thickness has been introduced in end frames, at the same location where bracings were considered (brick wall is removed).
- Properties of all other structural members remains the same as that in existing structure.
- Effect of infill panels have not been taken into account.

ANALYSIS

10. ANALYSIS

The analysis for both the retrofitting options has been carried out on STAADPRO-2005 as per static coefficient method as well as response spectrum method.

Proposal – I consists of enlargement of column sizes from 400 x 600mm to 400 x 1600mm. (Only at periphery). The STAAD model consists of beams and columns (as members) and slabs (as elements or plates). However these slabs are modeled only to take into account diaphragm action and assumed to have zero density so as to avoid repetition of loading.

Proposal – II consists of book ends type of shear wall. Reinforced concrete wall has been modeled (elements or plates) as book ends with 230mm thickness. Again these walls are assumed to have zero density to avoid double loading.

Proposal – III consists of bracings in end (side) frames. ISMB250 has been modeled as x-bracings to study the behavior of building. These bracings were not taken below plinth beam level so as to avoid touching foundations while retrofitting. Although this option was applied only in side frames, we can have a no. of arrangement (locations) of these for further study.

Proposal – IV consists of RCC walls in same bay where bracings were placed (extreme side) frames. Thickness of wall is assumed as 100mm. this to be noted that

we cannot have too thick wall as it will add on to the dead weight of building since we are not taking it upto foundation level.

Building Time Period as per IS 1893-2002

(Bare frame-without Brick in fills)

- T_a = .075 x h 0.75 seconds

  = .075 x 27.430.75 = 0.889 seconds

  Sa/g value=1.5

  RF = 4, I=2, Z = 0.24

- Base Shear as per IS 1893= 0.24/2 x 2/4 x 1.5 = 0.09, i.e. 9%

(Frame-With Brick infill)

- T_a = .09 x h/√d seconds

  = .09 x 27.43/√28.8 = 0.49 seconds

  Sa/g value = 2.5

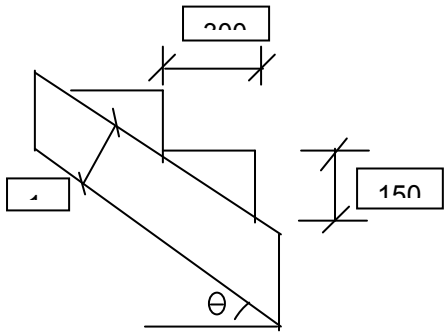
  RF = 4, I=2, Z = 0.24

- Base Shear = 0.24/2 x2/4x 2.5 = 0.15, i.e. 15% (Ref 1893:2002)
- Time period used = 0.5 sec., & corresponding Sa/g value of 2.5 sec. thus giving a Base Shear of 15%.

GTB HOSPITAL

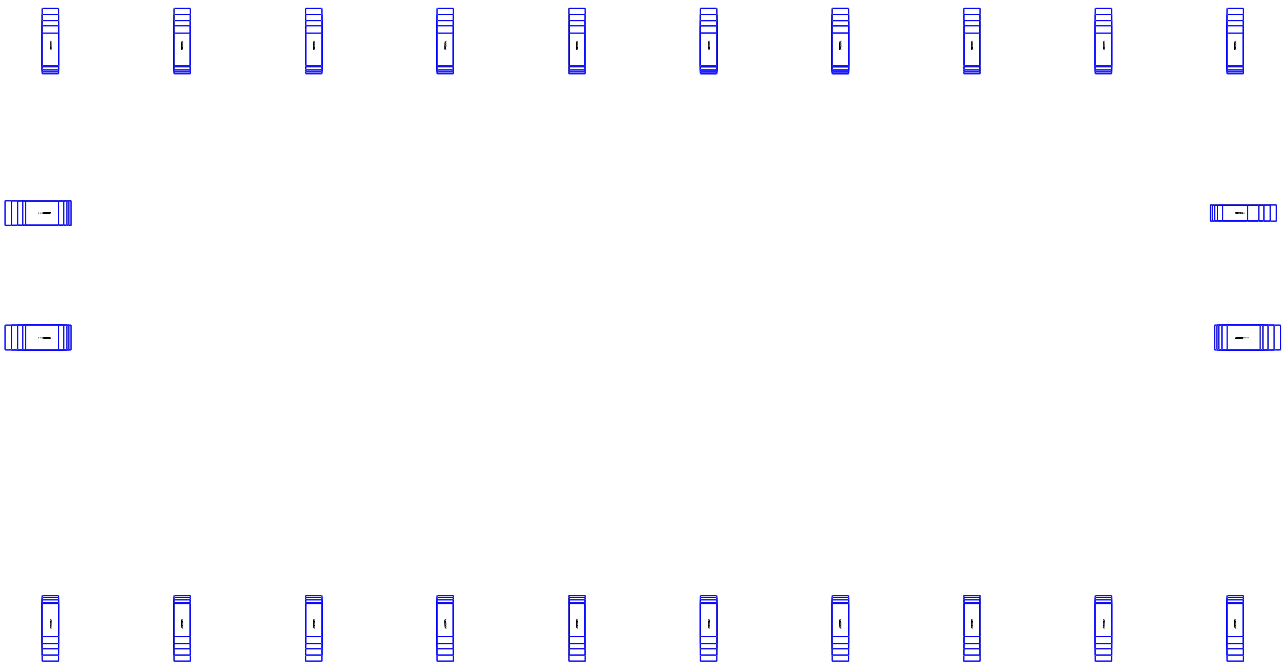
	DESCRIPTION	VALUES	REMARKS
LOAD CASE 1 & 2 EARTHQUAKE LOAD.			
	Zone Factor ,Z =	0.24	Zone refer IS 1893:2002 appendix-E
	Impotance Factor ,I =	1.5	Imp. Factor refer IS1893:2002,Table-6
	SS(hard=3 ,medium=2, soft =1)	2	Perf. Factor refer IS1893:2002,Table-5
	ST(Ty = 0.09 x h / sqrt(d)) , h=17.57 , Ly =10.67	0.484	
	ST(Tx = 0.09 x h / sqrt(d)) , h=17.57 , Lx =18.83	0.364	
	ST =	3	table-7
	RF =	5	
LOAD CASE-3 DEAD LOAD			
1	**DEAD LOAD INTENSITY ON GENERAL FLOORS**		
a	Selfweight of slab		Selfweight of the superstructure
	100mm thick slab =(0.10 X 25) KN/M2	3.75	floor dead load
	50 mm thk Floor Finish	1	Density of finish is 20 N/M^3
	6mm ceiling plaster (0.006 X 22)	0.132	Density of Plaster is 20 N/M^3
	TOTAL	4.88	**Say 5 KN/M^2**
2	**DEAD LOAD INTENSITY ON POARCH**		
a	Selfweight of slab		Selfweight of the superstructure
	150mm thick slab =(0.15 X 25) KN/M2	3.75	floor dead load
	50 mm thk Floor Finish	1	Density of finish is 20 N/M^3
	6mm ceiling plaster (0.006 X 22)	0.132	Density of Plaster is 20 N/M^3
	TOTAL	4.88	**Say 5 KN/M^2**
2	**DEAD LOAD INTENSITY ON TERRACE FLOOR**		

	Selfweight of slab		
a	150mm thick slab =(0.15 X 25) KN/M2	3.75	
	150mm thick terracing =(0.150 X 20)	3	
	6mm ceiling plaster (0.006 X 22)	0.132	
		6.88	**Say 7.0 KN/M^2**
	DEAD LOAD INTENSITY ON TOILET FLOOR		
3			
	Selfweight of slab		
a	150mm thick slab =(0.15 X 25) KN/M2	3.75	
	350mm thk filling and finishing =(0.350 X 20)	7	
	6mm ceiling plaster (0.006 X 22)	0.132	
		10.88	**Say 11.0 KN/M^2**
b	LOAD OF PARTITION WALL B/W TOILETS TOTAL LENGTH OF WALL IN M = 10X0.115X18X2.8	57.96	
	LOAD PER SQ M AREA =58/(3.9X5.4)	2.75	
	TOTAL		**Say 2.75 KN/M^2**
4	**DEAD LOAD CANTILEVER LANDING SLAB**		
a	Self weight of slab 175mm thk		
	0.175x25 = 4.375	4.38	
	finish load = 0.05x20 = 1 KN/M^2	1.00	
	total	5.38	
	load/m run = 5.38x1.6	8.61	
	LOAD OF CANTILEVER PER M RUN ON BEAM	**9**	**SAY KN/M^2**
5	**Water Tank load =**		
a	Capacity = 5000 Ltrs	**25**	**KN per column (Lumpsum)**
6	**230mm THK. EXTERNAL WALL**		
a	Self wt. of 230 thk. External Wall ={0.23X(3.81-0.15)X18}	15.15	
	12mm plaster on inner face =(0.012X22X3.66)	0.97	
	15mm finish on exterior face =0.015X22X3.66	1.21	
	TOTAL	17.33	**SAY 17.5 KN/M**
7	**230mm THK. EXTERNAL WALL WITH MURAL/EMBLEM**		

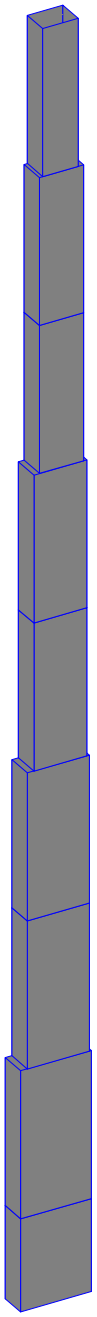
a	Self wt. of 230 thk. External Wall ={0.23X(3.5-0.15)X18}	13.87	
	12mm plaster on inner face =(0.012X22X3.66)	0.97	
	230mm finish on exterior face as mural emblem =0.23X20X3.66	16.84	
	TOTAL	31.67	**SAY 33 KN/M**
	FIRST,SECOND AND THIRD FLOOR		
	F/F Height of wall	3.5	m
8	**<u>230mm THK. EXTERNAL WALL</u>**		
a	Self wt. of 230 thk. External Wall ={0.23X(3.5-0.15)X18}	13.87	
	12mm plaster on inner face =(0.012X22X3.35)	0.88	
	15mm finish on exterior face =0.015X22X3.35	1.11	
	TOTAL	15.86	**SAY 17.5 KN/M**
9	**<u>230mm THK. INTERNAL WALL</u>**		
	GROUND FLOOR		
a	Self wt. of 230 thk. Internal Wall ={0.23X(3.81-0.15)X18}	15.15	
	12mm plaster on inner face =(0.012X22X3.66)	0.97	
	15mm plaster finish on wall facing corridor =0.015X22X3.66	1.21	
		17.33	**SAY 17.5 KN/M**
10	**<u>230mm THK.PARAPET WALL</u>**		
a	(0.23X1X18)	4.14	**SAY 4.5 KN/M**
11	**<u>STAIRCASE LOAD (Dog Legged staircase)</u>**		
			θ $=Tan^{-1}(150/300)$.=26.56 degrees

	Stair flight length =	3.65	M
	Area of cross section of step section		
	.=0.15x0.3/2	0.0225	M^2
	Area of cross section of inclined slab		
	.=0.175x0.3/cos35.75	0.065	M^2
	Area of cross section of finishing		
	.=(0.15+0.3)x0.04	0.018	M^2
	Total =	0.105	M^2
	DL = 0.105x25 =	2.625	KN/ M^2
	Dead Load per M^2 On plan = (2.625 x 1000/300) =	8.75	KN/ M^2
a	L0AD ON SHOTER BEAM = 8.75X3.75/2	15.97	**SAY 16 KN/M^2**
12	**PROECTED BOX LOAD (0.55 M PROJECTED CHAJJA)**		
a	Self wt. Of slab(100 mm thk) =0.1x0.555x25 =	1.375	
	brick wall of box weight with 3' height		
	0.115x18x0.9	1.863	
	TOTAL	3.238	**Say 3.3 KN/M**
LOAD CASE-4 LIVE LOAD			
a	LL in on floor =		
b	Class room load	**3**	**KN/M2**
c	Toilet	**2**	**KN/M3**
d	Stairs	**4**	**KN/M4**
LOAD CASE-5 LIVE LOAD ON ROOF			
a	LL on roof slab (LL intensity @ 1.5KN/M^2)	**1.5**	**KN/M**
LOAD CASE-6 LIVE LOAD GREATER THAN 3KN/M^2 (STAIRCASE L.L.)			
a	LL intensity =	**4**	**KN/M2**
b	LL on Stair beams(on shorter side)= (4x3.65x3.9)/2	**7.3**	**Say 7.5 KN/M**
c	Live load passage	**5**	**KN/m2**

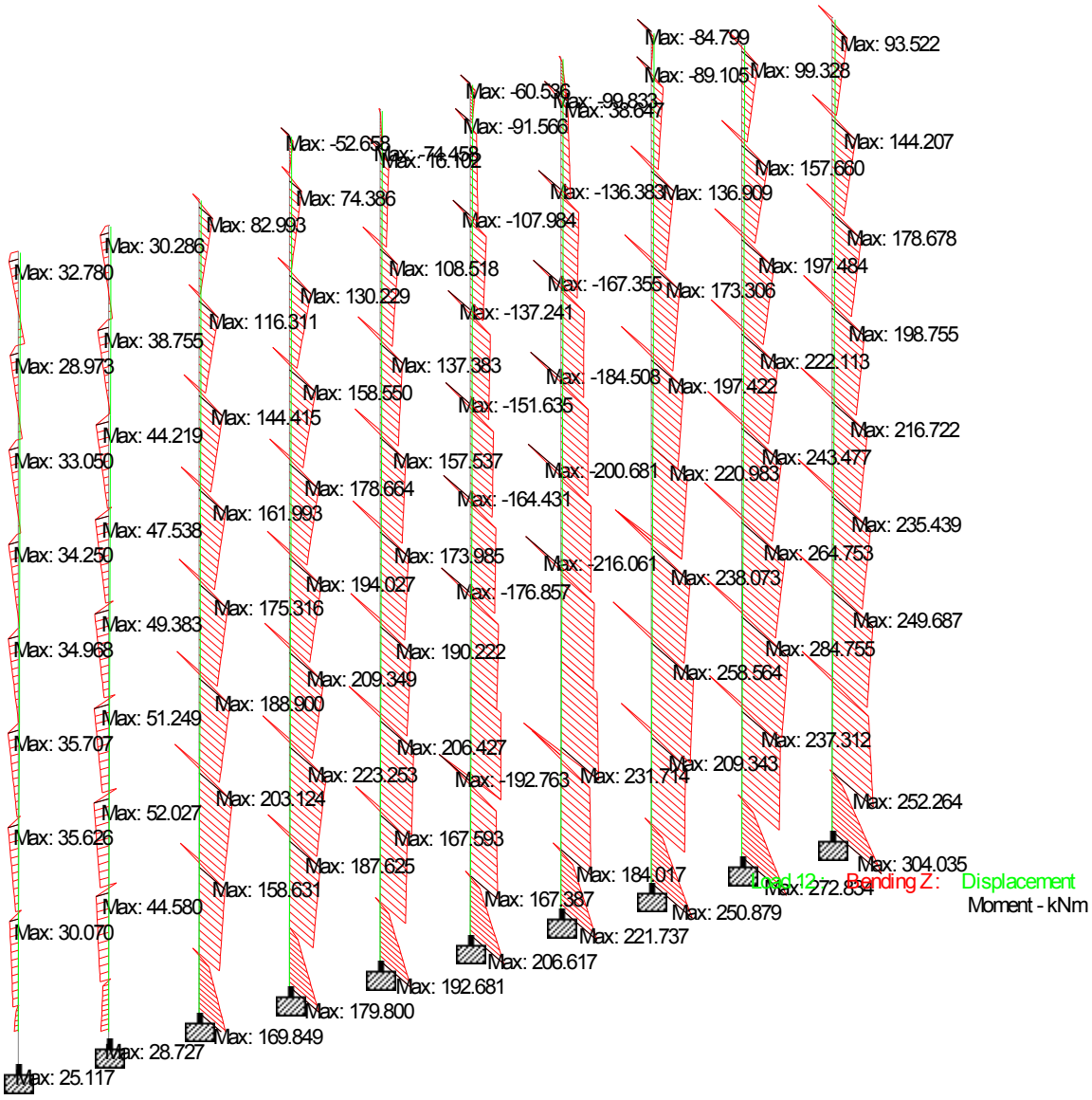
PROPOSAL - I



ENLARGED COLUMNS (PERIPHERAL) IN PLAN

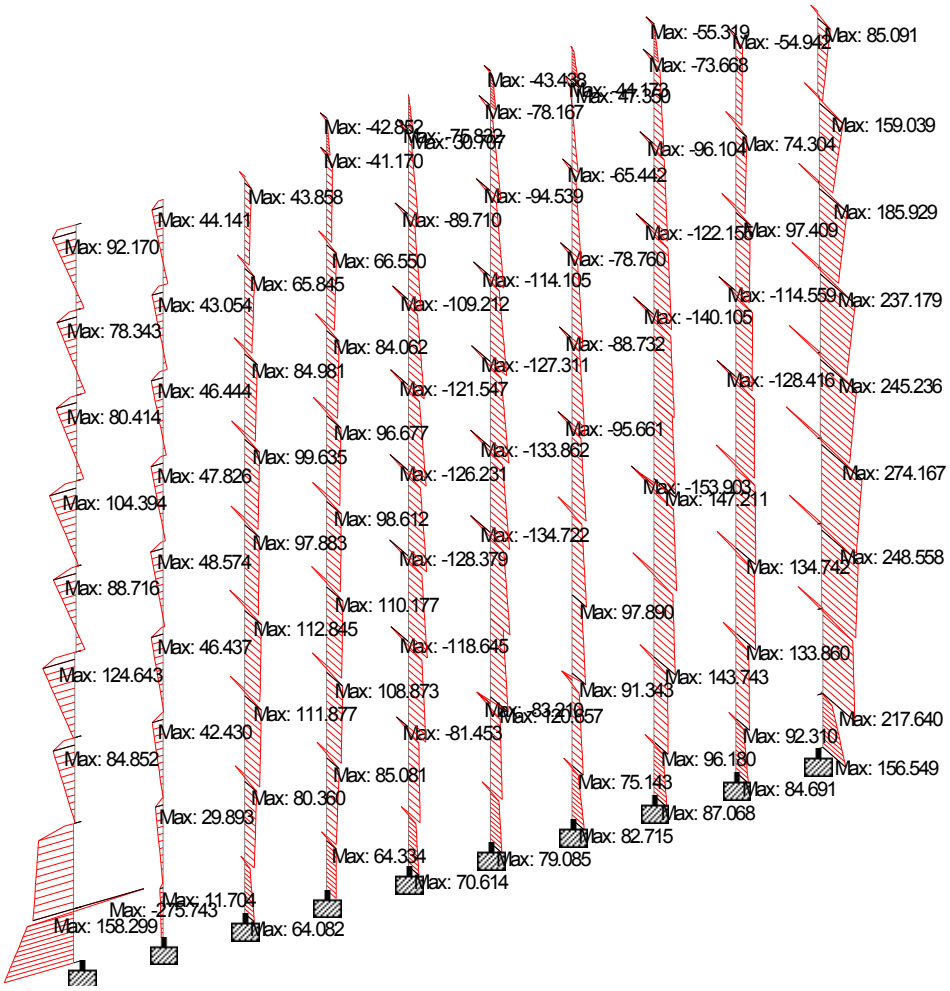


ENLARGED COLUMNS (PERIPHERAL) IN ELEVATION



MAX. BM IN Z-DIR

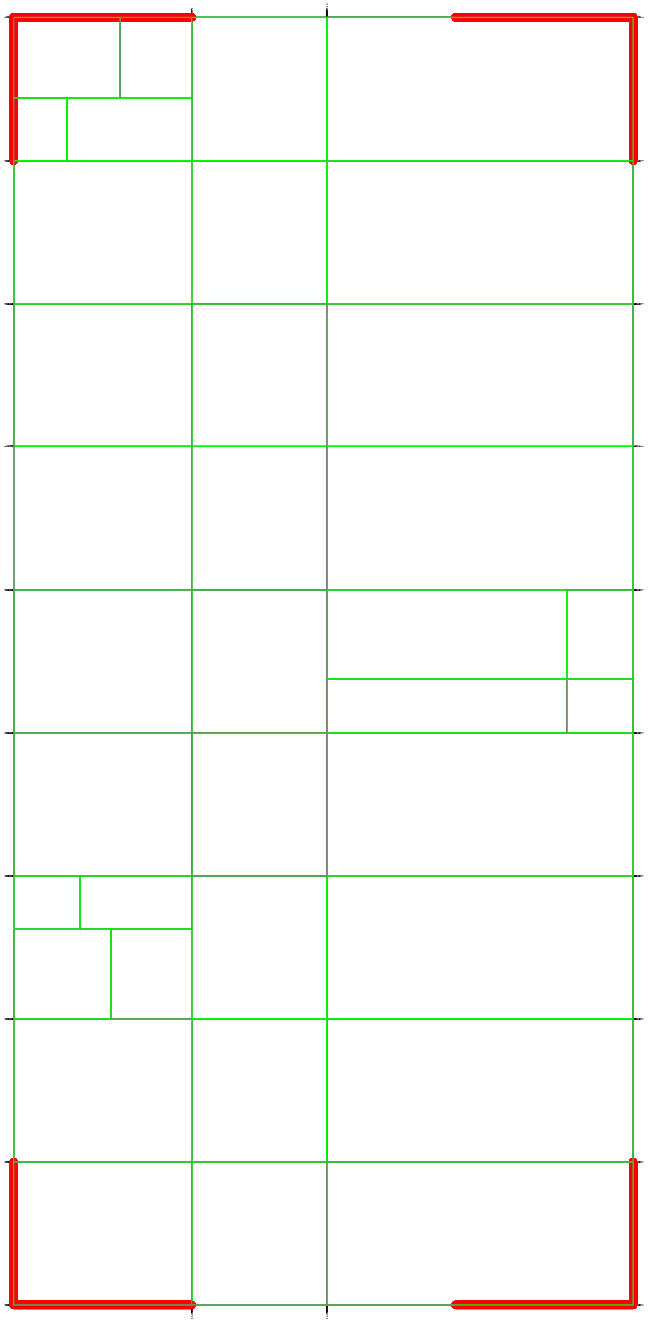
EXISTING BUILDING WITHIOUT (INFILL EFFECT)



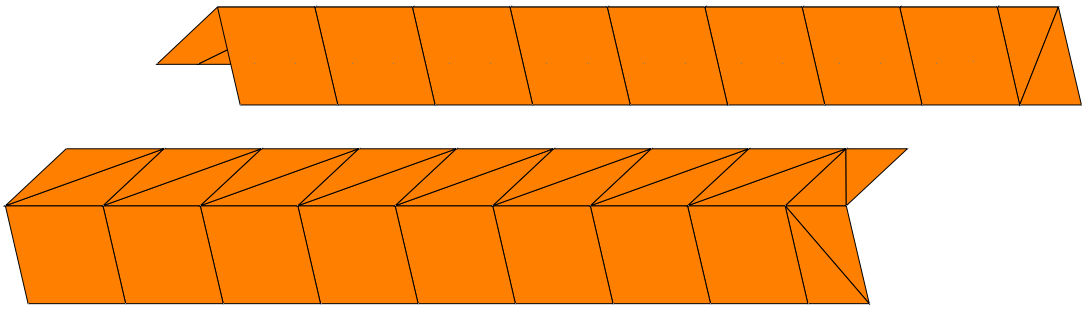
MAX. BM IN Z DIR

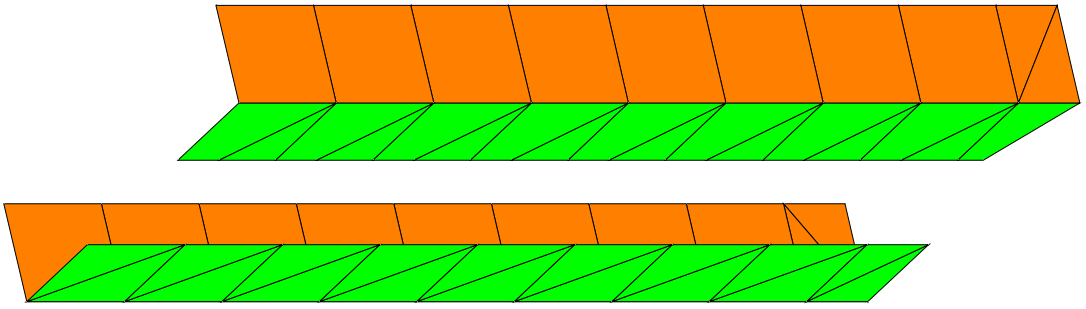
(PROPOSAL-I, ENLARGED COLUMN - BUTTRESS)

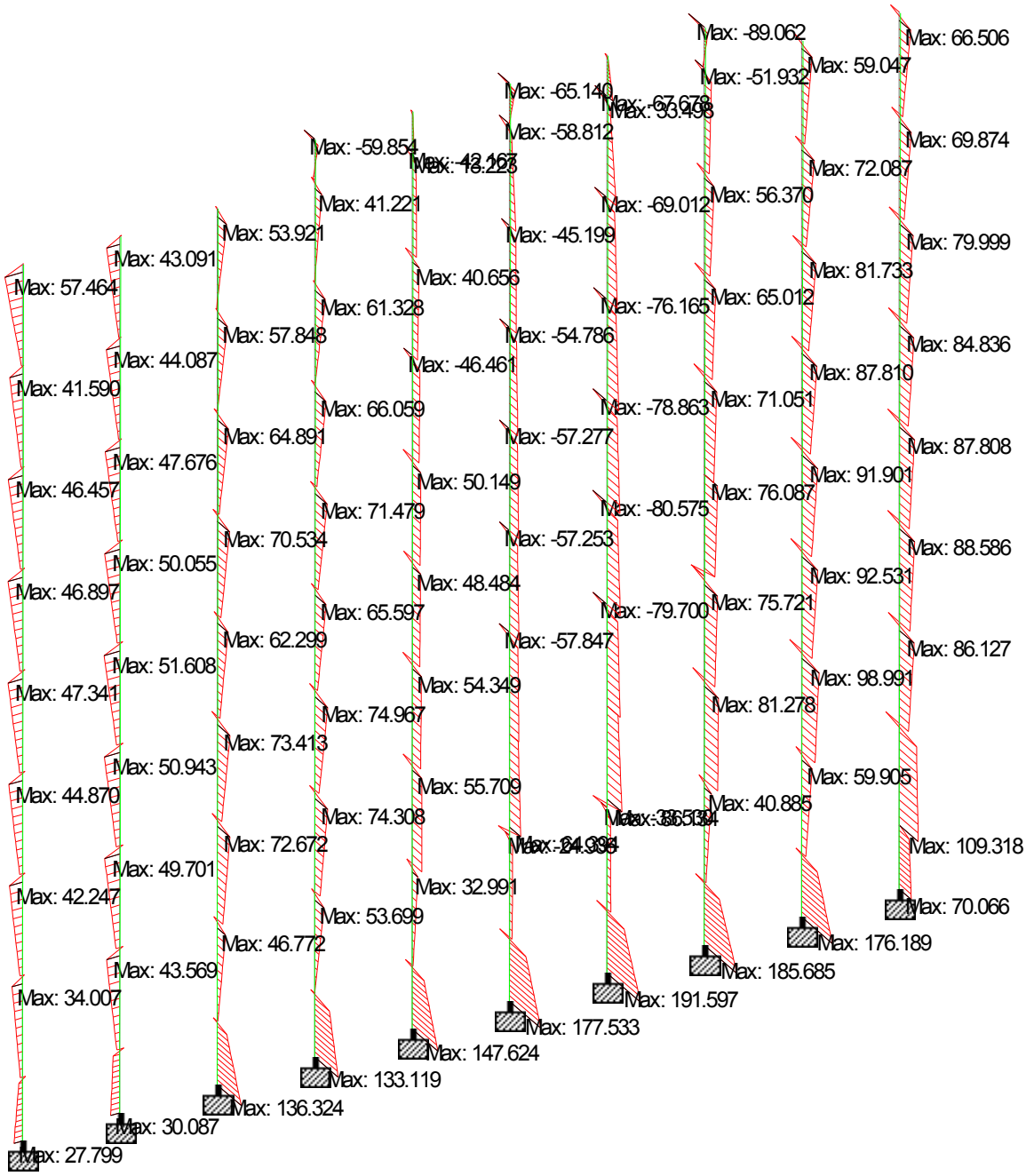
PROPOSAL - II



EXISTING BUILDING WITH RCC WALLS AT BOOK ENDS (230MM THICK) AT

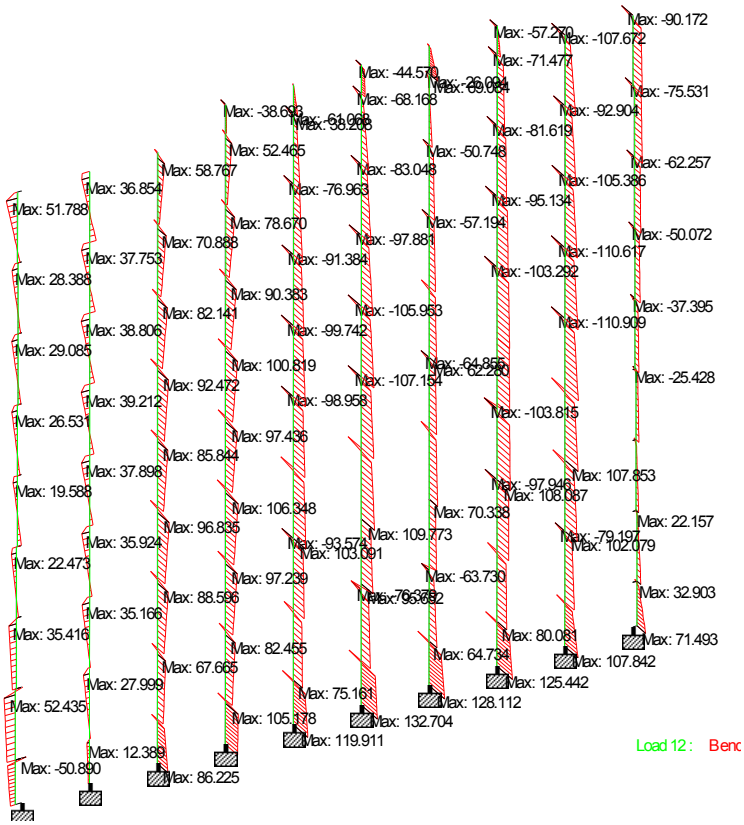






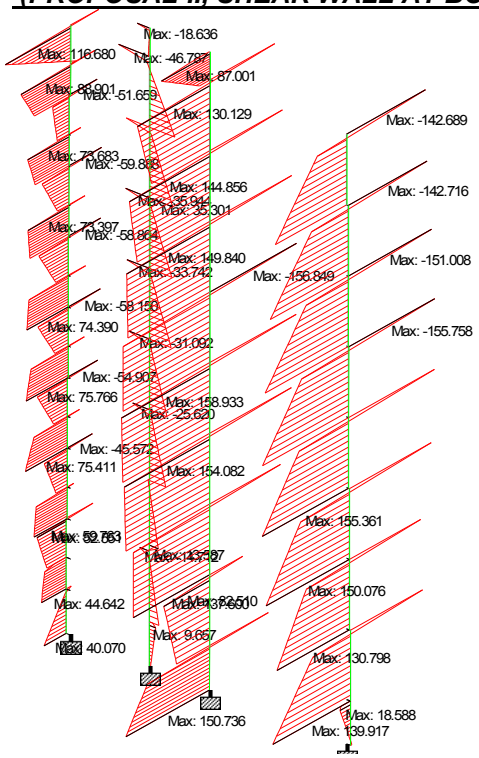
MAX. BM IN Z-DIR

(EXISTING BUILDING WITH INFILL EFFECT)



MAX. BM IN Z DIR

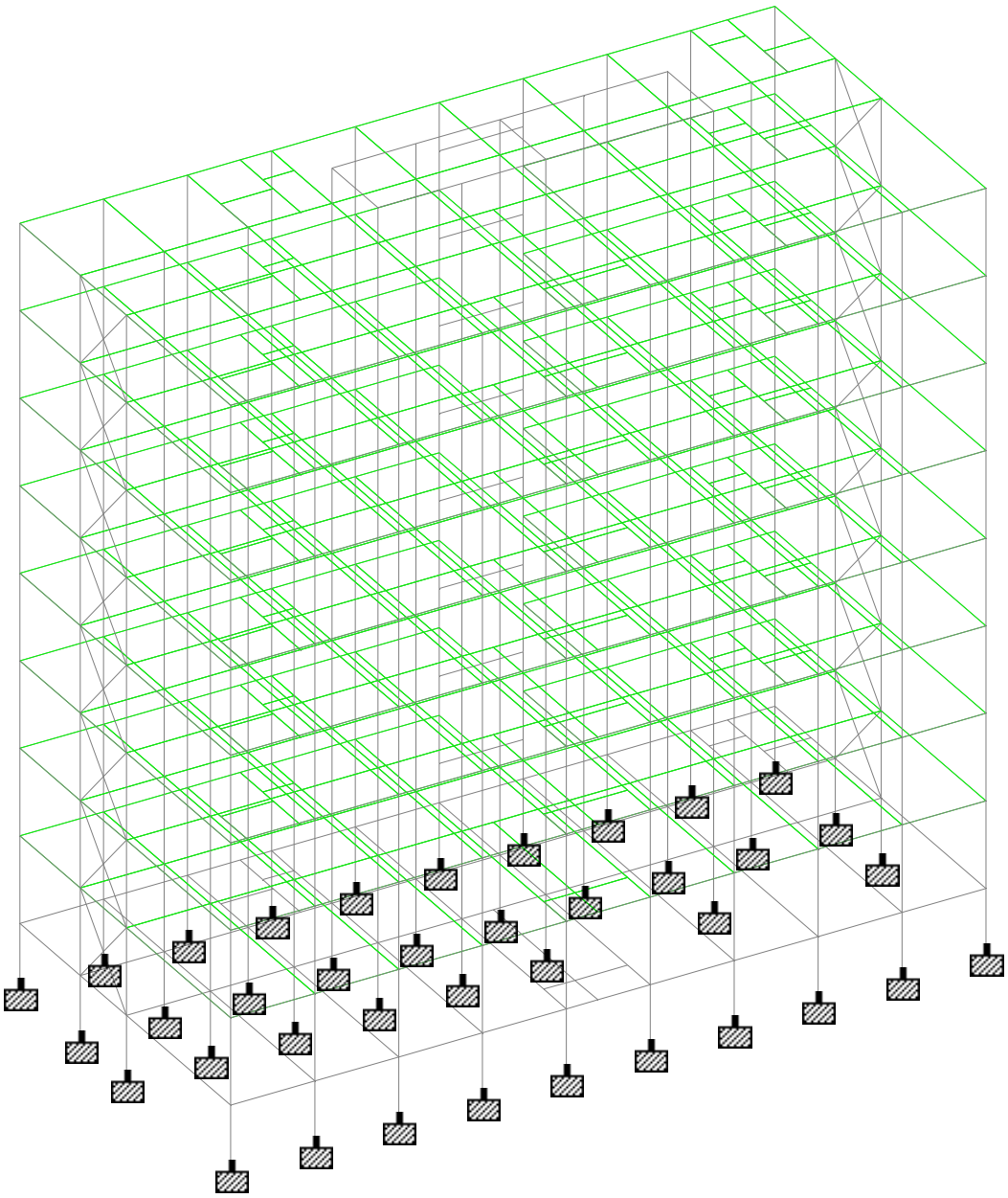
(PROPOSAL-II, SHEAR WALL AT BOOK ENDS.)



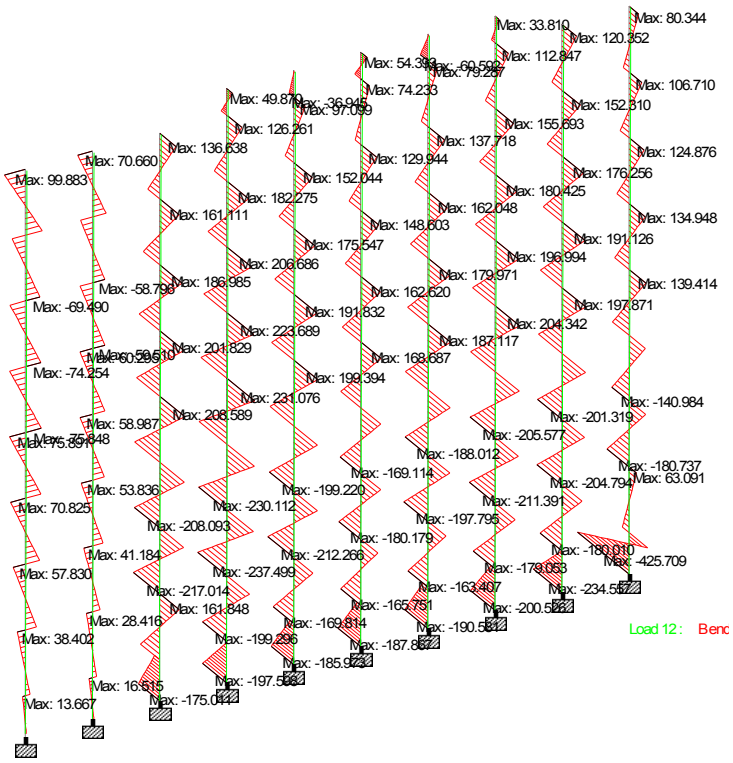
MAX. BM IN X DIR

(PROPOSAL-II, SHEAR WALL AT BOOK ENDS.)

PROPOSAL - III

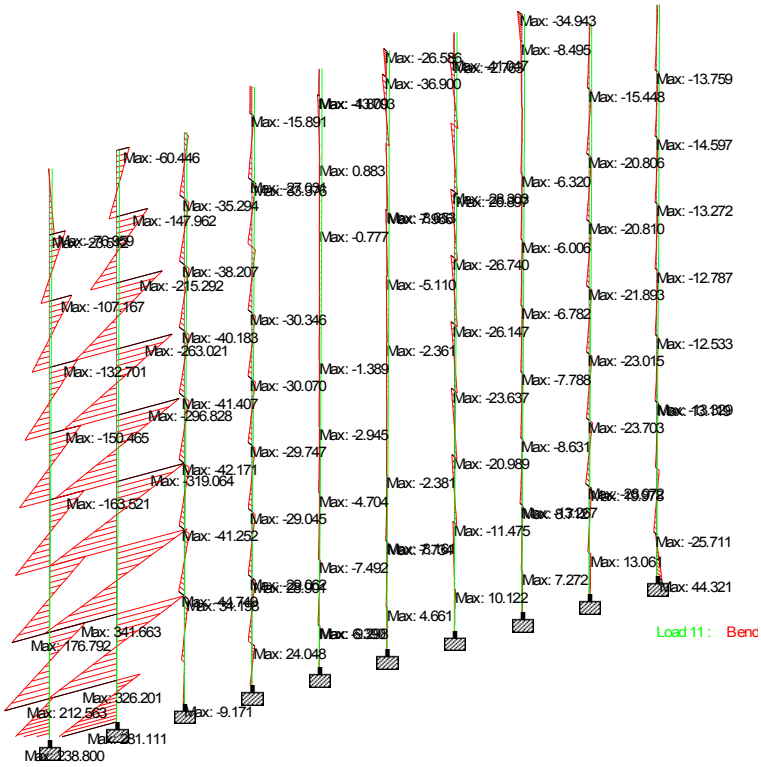


STEEL BRACINGS IN END BAY



MAX. BM IN Z DIR

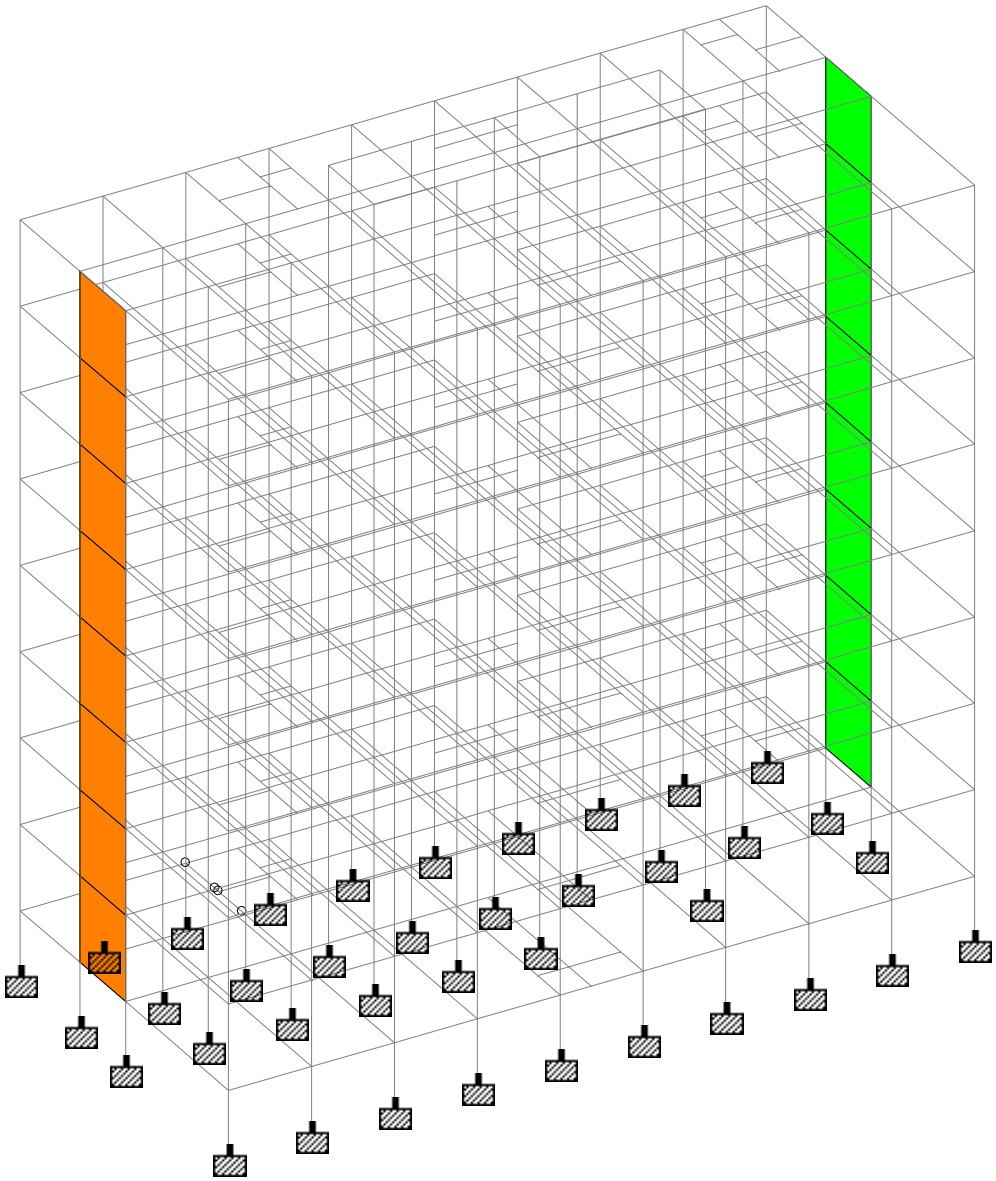
(PROPOSAL-III, STEEL BRACING)



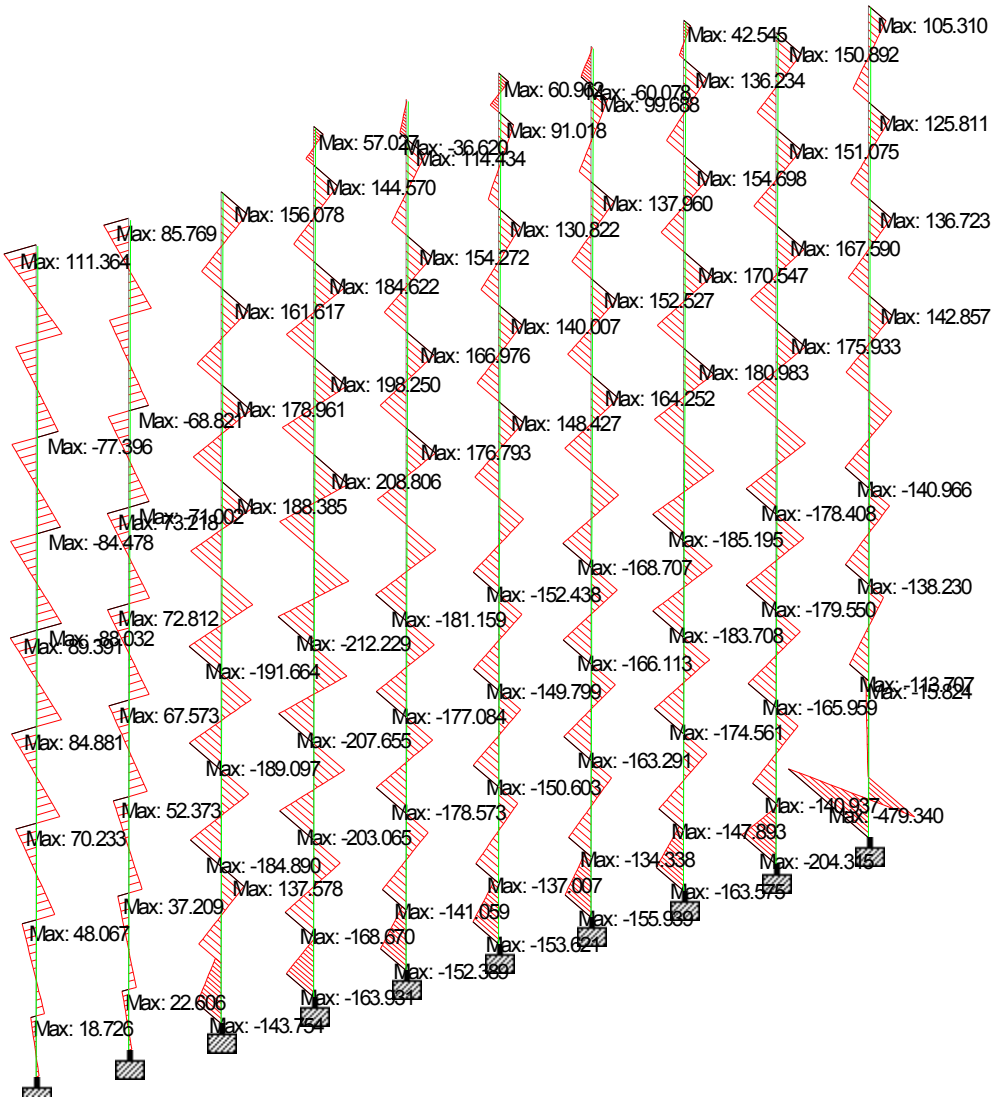
MAX. BM IN X- DIR

(PROPOSAL-III, STEEL BRACING)

PROPOSAL - IV

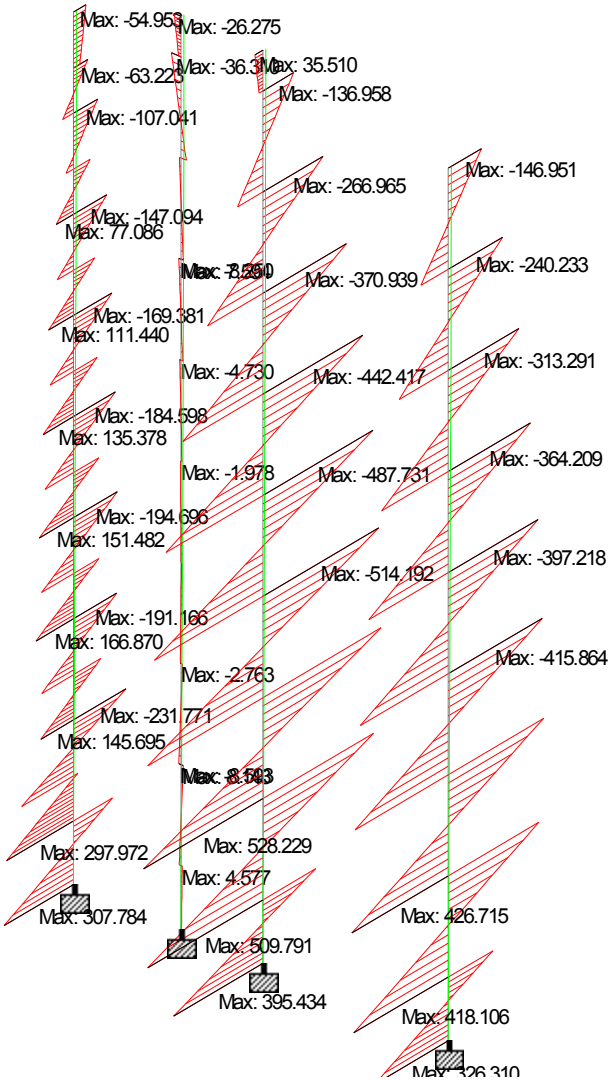


EXISTING BUILDING WITH RCC WALLS (100MM THICK) AT END FRAMES



MAX. BM IN Z DIR

(PROPOSAL-IV, RCC WALL 100 THK.)



MAX. BM IN X- DIR

(PROPOSAL-IV, RCC WALL 100 THK.)