International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

EARTHQUAKE RESISTANT DESIGN OF MULTISTOREY BUILDING

Raja Gowhar[1], Nitin Mehta[2]

[1,2]*Department of civil engineering, Desh Bhagat University Mandi Gobindgarh, Fathegarh Sahib Punjab-147301, India*

Abstract - *The Aim of present study "Earth quake resistant design of multistory building'' by ETABS " is to define technique for stability of structure by taken regular Geometry ,proper cross sections for column and beam etc, developing specification and supports conditions, types of Loads and load combinations. In this study a G+25 storey high rise structure is analyzed for seismic load combination using ETABS and comparison is drawn by replacing of column into shear wall. The frame was found to be adequately designed for seismic loads in Zone IV. The building is designed as per IS 1893(Part 1):2016. The main objectives of the paper are to compare the variation of steel percentage, maximum shear force, maximum bending moment, and maximum deflection in seismic zone IV.*

Keywords: ETABS, Analysis, Storey forces, Maximum shear force, Maximum bending moment, Shell forces, drift.

1. INTRODUCTION

Earthquake-resistant structures are designed to protect building from earthquake. The main goal of earthquake resistant building is to design buildings that can sustain seismic activity of reasonable magnitude. According to building codes, earthquake resistant structures are intended to withstand the largest earthquakes, means loss of life should be minimized by preventing collapse of building while loss of functionality should be limited for more frequent ones. It is seen from past earthquakes many buildings have undergone damage despite of being properly designed, with in the race of growing population more integrated tools have been used for construction of Multistory building which can absorb surface phenomenon (waves).

Due to the asymmetry, dynamic analysis must be used for seismic analysis of the building. These methods are time history and response spectrum method. In the response spectrum method the data such as zone factor, type of soil etc. are applied from IS-1893. In time history method the actual record of accelerogram is applied on the building and analysis of the building is carried out in software. Time history method gives more realistic result compared to the response spectrum method because in time history the actual acceleration data of earthquakes are applied and response of building is studied. Construction of building depends on the shape of building (regular of irregular) and all the specific dimensions of a particular structure.

According to IS 13920:2016, grade of concrete M30 and steel Fe415 shall be used which give more durability to a structure and also show good performance for Dynamic loading as well as gravity loads, the soil beneath the structure shall be enough hard which uniformly distributed load to the structure while as deep foundation is preferred for loose soil. When Drift increase, lateral applied load increased gradually and at some point diagonal crack starts to develop within the joint. shear wall that are a part of lateral force resisting system of earthquake resistant building are also taken into consideration while design a Multistory earthquake resistant building. In RC frames buildings, lintel beams shall preferably not be integrated into the column I.e. to avoid short column effect. The structure designed for stability, strength and serviceability depends on Mass, material used, damping ratio, ductility and other factors. Structures should also resist minor earthquake (DBE), moderate earthquakes (DBE) and major earthquakes (MCE).

The above benefits help us decide to use SMRF as it fill the special detailing requirements for ductile behavior as per IS 13920 or IS 800 in areas of zone IV and V rather than OMRF.

2. Related works

Rajaram.P., Murugesan.A., et al. (2010) introduced an analysis on the structural behavior of RCC beam column joint interior analytically by utilizing STADD Pro. results carried out, critical parameters have been worked out, For example flexibility. The end goal to get the seismic conduct of the bar segment joint when earth quake comes

Ruichong .et all.(2011) In this study, an N-story building is modeled as a series of shear beams for columns/walls and lumped masses for floor in which one-dimensional shear wave propagation in vertical direction is investigated.

Raju K.R.,et al (2013),Reaction of tall building under wind and seismic loads are analyzed in this paper according to IS Codes of practice, STADD.Pro is used to display the building in 3D.Serviceability of the structure for storey drift ,base shear, acceleration and roof displacement is checked against allowable limits in code of practice.

Kameshwari. B., et al (2013), the effect of various configurations of shear wall on the structure is analyzed, due to which drift is examined in the structure by providing shear wall in diagonal, Zigzag. In controlling the seismic load .According to his paper Zigzag shear wall arrangement is superior.

Divya and Prasad. S.S (2015), Using STRUDS software for analysis of five storey building. The final report of STRUDS programming contains the design and comparing reinforcement details of slab, beam, column and footings.

Farqaleet A. (2016), in his study a Multi-storey was analyzed using Dynamic Analysis approach in SAP 2000 software. A 10 storey building has been analyzed using a Non-Linear Time History analysis, contemplating time history of EI Centro earthquake 1940.The response of building is then analyzed ,the parameters considered were base shear ,Storey drift , and Storey displacement. The permissible values for storey drift was determined from IS 1893:2002

Verma.S.K., et al (2017) a G+14 Multi-storey building was designed, in his paper comparison was drawn between Dynamic and static analysis for ground story with and without opening.Equilvent static and Response spectrum methods are compared using STADD.Pro as per IS 1893:2002.Seismic Response was performed for building with and without opening ground storey, the comparison was drawn using Displacement demand plot and Displacement-capacity curve.

3. METHODOLOGY

3.1 Model of RCC Frame

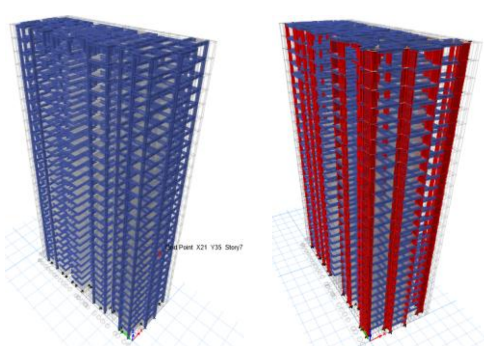

Fig-3.1: Comparsion 3-D Model of building with column and shear wall

3.2 Materials and Building Specification

A model of G+25 storey is developed and analysis using ETABS software, with building size plan 45.114m × 18.612m.The building is situated in Zone IV with following specifications given below

Table -1: Building Specifications

Building Description	
Length × Width	45.1m × 18.6m
No of story	25
Storey height	3m
Slab thickness	125mm
Thickness of main wall(External)	225mm
Thickness of partition wall	112.5mm
Height of parapet wall	.90m
Thickness of parapet wall	115m
Number of storey	G+25
Support conditions	Fixed

Table-2: Material specifications

Material Specifications	
Grade of concrete,M30 (F_{ck})	30N/mm^2
Grade of steel (F_y)	415 N/mm^2
Density of concrete (Y_y)	25N/mm^2
Density of brick wall considered(Y_c)	21 N/mm^2
Live load	.002 N/mm^2
Floor finish	.001 N/mm^2

These values are provided as an input to the ETABS software for drawing analysis and design purpose.

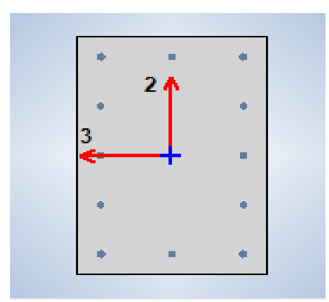

Fig- 3.2: Column reinforcement details

Table -3: Reinforcing Bar Sizes

Name	Diameter mm	Area mm^2
8	8	50
10	10	79
16	16	201
18	18	255

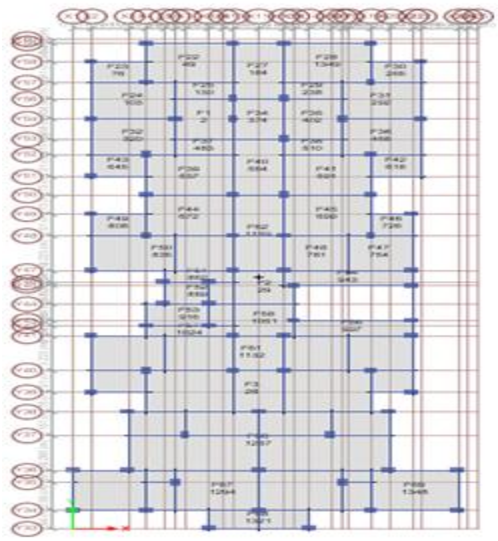

Fig- 3.3: Beam column layout

3.3 LOAD CALCULATION

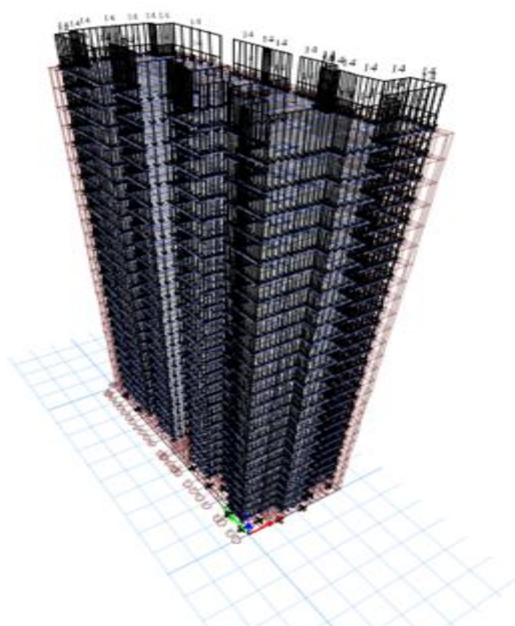

Fig-3.4: Loading

Gravity loads on the structure includes the self weight of beams, columns and slabs .The self weight of column, beams (Frame section) and slab (Area section) were automatically considered by the program itself. The imposed loads were provided as per IS: 875 (Part 2)-1987.Wall loads were provided as uniformly distributed load calculated as per IS: 875 (Part 1)-1987.Seismic loads for both lateral directions were taken from IS: 1893(Part-1):2016.13 load combinations were used for the design.

a. Live load

As per IS: 875 (Part 2) - 1987

All rooms and Kitchens 2 KN/m^2
Toilets and bathrooms 2KN/m^2
Balconies 3 KN/m^2
Staircase 3 KN/m^2

b. Dead load

As per IS: 875(Part 1)-1987

The self weight of beam, column and slab is included in dead load.

i. Dead load on brick wall (external wall):
Assume height of wall =3m
Assume wall thickness=230mm
Plaster inside =12mm
Plaster outside =15mm
Density of bricks =20 KN/m^3
Density of plaster=24 KN/m^3
Dead load of brick wall =15.74KN/m
~ 16 KN/m
ii. Dead load Partition wall=8.6 KN/m
~ 9 KN/m
iii. Dead load of slab:
Assume slab thickness =150mm
=.150m
Density of RCC =25 KN/m^3
Dead load =3.75 KN/m^2
IV .Floor finish=50mm
=.050m
Dead load = 1.05 KN/m^2
V. Dead load on parapet wall
Assume thickness=115mm
Height =.90m
Dead load=2.07 KN/m

c. Seismic load

Analysis of base shear
IS1893: 2002 Seismic Load Calculation in direction X

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2]
Response Reduction Factor, R [IS Table 7]
Importance Factor, I [IS Table 6]

Site Type [IS Table 1] = II

Spectral Acceleration Coefficient, S_a /g [IS 6.4.5]

S_a/g =1.36/T

= 1.044161

Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2]
A_h= (ZIS_a/g) ÷2R
Calculated Base Shear

V_B = A_hW

Table-4: Base shear in x-direction

Direction	Period	W (KN)	V_b (KN)
X	1.302	128343.4316	4824.405

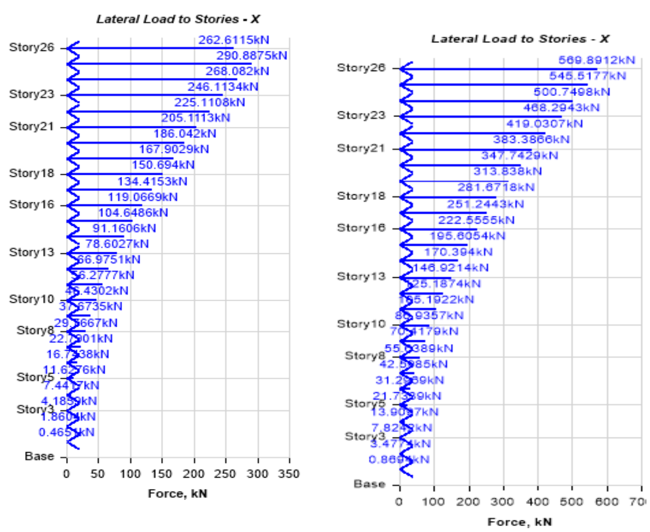

Fig-3.5: Story force in X-direction on replacement of column completely into shear wall

IS 1893: 2002 Seismic Load Calculation in direction Y

Z=0.24, R=5, I=1.5

S_a/g =1.36/T

= .626

Calculated Base Shear,

V_B = A_h W

Table- 5: Base shear in Y-direction

Direction	Period	W (KN)	V_b (KN)
y	2.07	137738.8044	3108.25

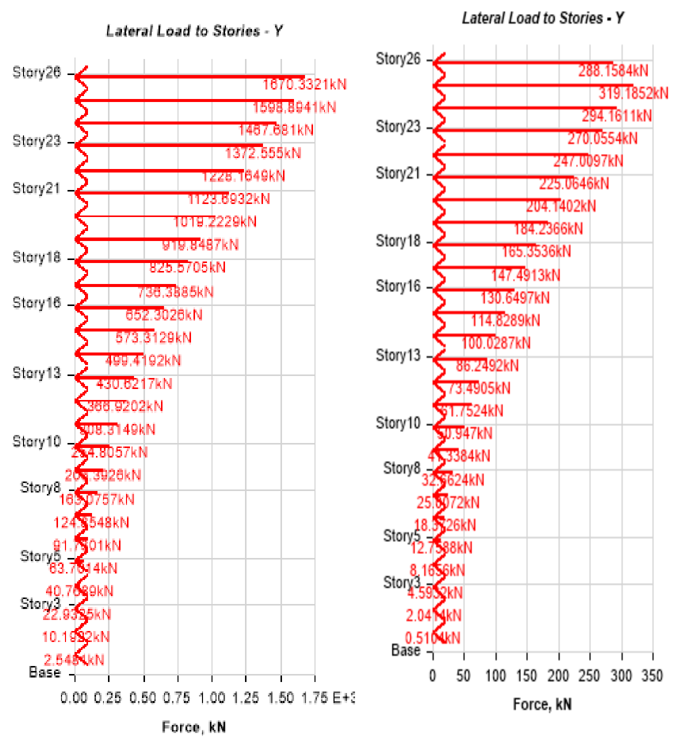

Fig-3.6: Story force in Y-direction on replacement of column completely into shear wall

4.5 Load combinations

The load combinations considered are specified in IS: 456-2000 and IS: 1893-2002 for analysis of building. The load combinations are taken in proper ratio .combinations of self –weight, dead load, live load and seismic load was taken into consideration.

Table -6: Load Combination

Sr.no	**Load combination**	**Primary load**	**Factor**
1	1.5 DL+1.5EQX	Dead load EQX (Along length)	1.5 1.5
2	1.5 DL-1.5EQX	Dead load EQX (Along length)	1.5 1.5

3	1.5 DL+1.5EQY	Dead load EQY (Along width)	1.5 1.5
4	1.5 DL-1.5EQY	Dead load EQY (Along width)	1.5 1.5
5	1.5DL	Dead load	1.5
6	1.5DL+1.5LL	Dead load Live load	1.5
7	1.2DL+1.2LL+1.2EQX	Dead load Live load EQX(Along length)	1.2 1.2 1.2
8	1.2DL+1.2LL-1.2EQX	Dead load Live load EQX(Along length)	1.2 1.2 1.2
9	1.2DL+1.2LL+1.2EQY	Dead load Live load EQY(Along Width)	1.2 1.2 1.2
10	1.2DL+1.2LL-1.2EQY	Dead load Live load EQY(Along Width)	1.2 1.2 1.2
11	.9DL+1.5EQX	Dead load EQX(Along length)	0.9 1.5
12	.9DL-1.5EQX	Dead load EQX(Along length)	0.9 1.5
13	.9DL+1.5EQY	Dead load EQY(Along width)	0.9 1.5
14	.9DL-1.5EQY	Dead load EQY(Along width)	0.9 1.5

4. RESULTS AND DISCUSSIONS

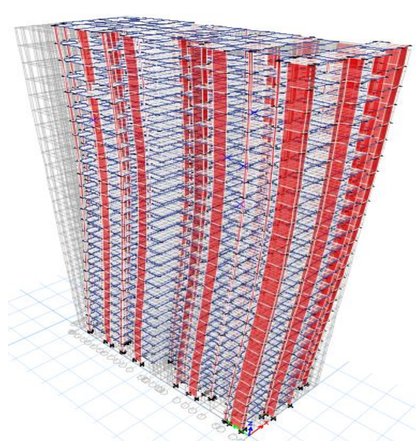

Fig-4.1: Deformed shape of building in X-direction

4.2 Bending moment

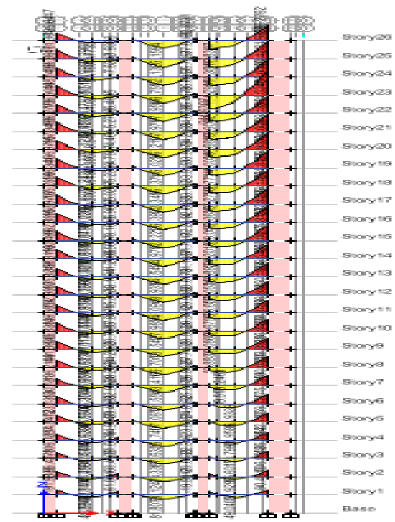

Fig- 4.2: Bending moment diagram

Table-7: Comparison of Moment results in Multi-storey Building

Structure	Mx (KN-m)	My(KN-m)
With column	867.693	-777.182
With shear wall	-635.112	173.276

4.3 Base reactions

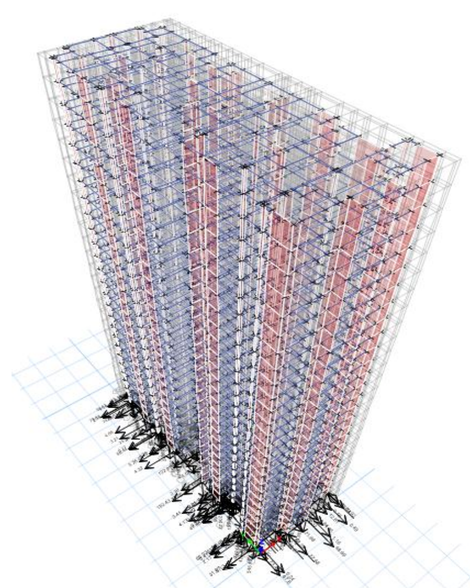

Fig- 4.3: Base reactions

4.4 Storey shear

Storey shear visualize the possible governing lateral load on certain floor at a given direction. In multistory building it varies gradually in each floor. In case of shear wall lateral drift is less as comparison to multistory building with column, so the storey shear incase is less. In case of shear wall centre of mass have rigidity also.

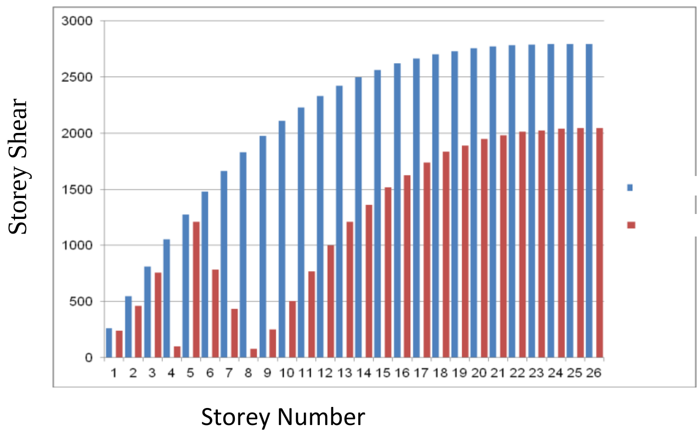

Fig- 4.4; Storey vs Storey shear

Table-8: Comparison of Story forces (Maximum) results in Multi-storey building

Structure	EQX (mm)	EQY (mm)
With column	1.3	0.0306
With shear wall	0.9	0.1

4.5 Storey drift

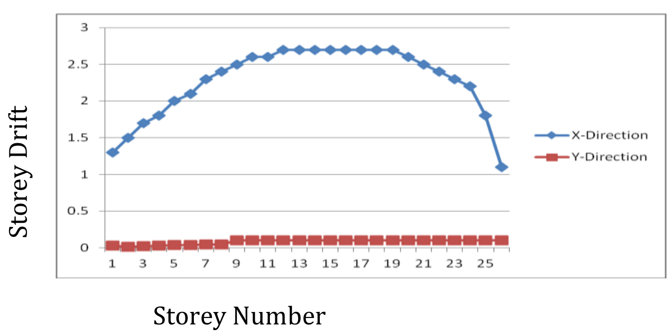

Fig-4.5: Storey Drift vs Storey Number (with column)

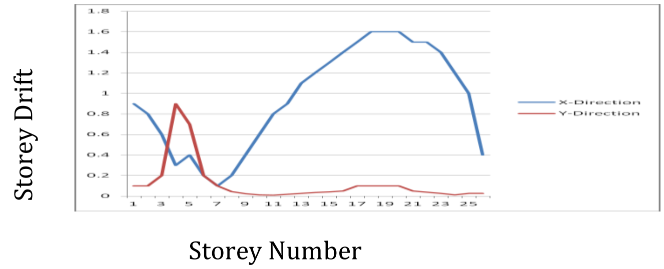

Fig- 4.6: Storey Drift vs Storey Number (with shear wall)

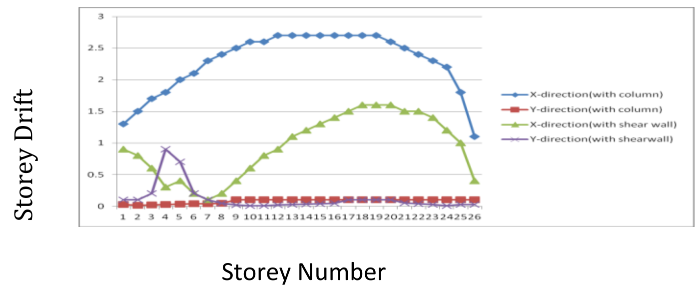

Fig-4.7: Comparison of Storey Drift vs Storey Number

Table-9: Storey drift

Structure	Vx (KN)	Vy (KN)
With column	-259.06	-289.2
With shear wall (Pier forces)	238.877	-229.252

4.6 Shell forces

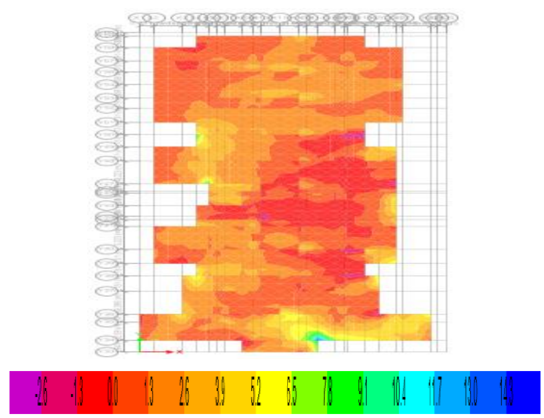

Fig-4.3: Shell forces

The shell element internal forces, like stresses act throughout the element. The contour above illustrated the maximum (14.3KN/m) and minimum (-2.6 KN/m) stresses at various points of a slab.

5. CONCLUSION AND FUTURE SCOPE

5.1 SUMMARY

The main aim of earthquake resistant building is to maintain ductility .In multistory RC building frames short column effect is avoided. Building with shear wall is preferred which can resist lateral forces.

CONCLUSIONS

1. The maximum storey drift is .0306 which is less than permissible drift 0.312 as specified in IS 1893-2016
2. The building is safe under seismic zone IV .The results vary with different seismic zones.
3. In open frame structures storey drift is large cause collapse in seismic activity.
4. The storey forces and BM are higher without the shear wall; presence of shear wall reduces the drift and base shear.
5 Reinforcement in frame structure is more than replacement of column into shear wall.
6. Due to floating column properties like drift, shear force, moment and displacement are inadequate.

FUTURE SCOPE

1. This present study considered seismic analysis by response spectrum method; same may be extended to Pushover and time history analysis method.
2. A Multistory building of higher storey has to be studied to check the effect of ground activities (Slope) for different seismic zones
3. However, in Seismic Zone III and IV it needs redesign of structure.

ACKNOWLEDGEMENT

This study would not have been possible without the able guidance of Assistant Professor Nitin Mehta, Professor Mohammad sharif and Mohammad irfan bakshi.I would like to thank my colleagues for their valuable comments and suggestions during this project.

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BIOGRAPHIES

Raja Gowhar
B.Tech
M.Tech(Structural),DBU,Punjab

Nitin Mehta
B.Tech
M.Tech(Structural),MRSPTU,Punjab

Mohammad irfan Bakshi
Ph.D,Jamia Milia Islamia