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STUDY ON BEHAVIOUR OF DIAGRID STRUCTURE FOR DIFFERENT DIAGRID ANGLES WITH CONSTRUCTION SEQUENCE ANALYSIS

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Abstract - It is frame work of diagonally intersecting metal, concrete, or wooden beams i.e. used in the construction of building and roofs and its diagonal components can carry both gravity and lateral loads due to their trigulated design and axial actions. Construction sequence analysis is a non linear analysis approach in which the structures in analyzed at various stages corresponding to the construction sequence and partially required loads are applied sequentially at every stage. A plan of 20 m × 20m size was considered. ETABS 2016 was used in modeling and analysis of structural members and subjected to seismic loads for zone V as per IS1893-2016. In total 6 models with different diagrid angles (52^0 62^0 & 68^0) and column removal scenario at different floor levels. To study bending moment and shear force variation in transfer girder beams for with and without construction sequence and study axial force variation in columns for with and without construction sequence analysis & also study seismic response of diagrid structure with different diagrid angles i.e., storey displacement and storey drift. For response spectrum analysis when compared different diagrid models (62º and 68º), diagrid model 68º is less displacement as compared to other degrees implying that we take above 68º diagrid angle is best for tall buildings. A more realistic design than the standard design is produced by including sequential load case in the study of multistory RCC structure.

Key Words**:** Diagrid angle, construction sequence analysis,

1. INTRODUCTION

India is one of the countries where the majority of structures are low-rise, although industrialization has resulted in population growth in most of the cities. To accommodate those individuals in a small location, the building's height needs be increased from medium to high. Improper design and construction of all types of residential structures causes widespread structural deterioration throughout the world. As a result, we must emphasize structure safety over cost savings. From both a design and a safety standpoint, the structure should be created in such a way that it is both safe and inexpensive. Wind and earthquakes both have dynamic effects on structures; however wind force and earthquake design should be considered separately.

Diagrid has developed as a new tall-building design concept. The main distinction between diagrid structures and traditional outside braced frame constructions is that diagrid structures do not have any vertical columns. The diagrid system is possible because diagrid structures' component diagonals they are able to support lateral and gravitational stresses because of their triangular shape. When compared to typical framed tubular structures without diagonals, diagrid construction transfers load through axial action and lowers shear deformation, whereas traditional framed tubular structures transfer shear through vertical column bending

Construction sequence analysis is a non linear analysis approach in which the structures in analyzed at various stages corresponding to the construction sequence and partially required loads are applied sequentially at every stage. The purpose of this study is to investigate the change in values of numerous structural parameters namely axial force, shear force, and bending moment during and after construction.

Types of Diagrid Structural System

1. Steel diagrid structural system
2. Concrete diagrid structural system
3. Timber diagrid structural system

Concrete diagrid structural system in which the versatility of the precast concrete components may allow them to precisely suit the layout of the construction. It also offers fire suppression systems. Precast concrete, but in the other end, makes a greater contribution to the dead load of the building.

OBJECTIVES

1. To study the effect of construction sequence analysis on diagrid structure with different diagrid angles using etabs.
2. To study bending moment and shear force variation in transfer girder beams for with and without construction sequence.
3. To study axial force variation in columns for with and without construction sequence analysis.
4. To study seismic response of diagrid structure with different diagrid angles i.e., storey displacement and storey drift.

2. MODELLING AND ANALYSIS

In the present study, 6 models are considered, which are created using ETABS software, where in each model, 2 cases of column removal at ground floor and 12th floor locations are taken. The layout and elevation of a square building under consideration for study are both symmetric. The building to be modeled has a plan measurement of 20 m x 20 m.

TITTLE	Description
Structure	Concrete
Plan dimensions	20 m × 20 m
Number of stories	G + 25
Height of the structure	80 m
Floor height	3.2 m
Zone	Z-5
Concrete grade	M25 & M40
Steel grade	HYSD 500
Column size	750 × 750 mm
Beam size	300 × 600 mm 400 × 600 mm
Slab thickness	150 mm
Diagrid section	300 × 600 mm
Wall load (glass panels) 100mm	6.58 KN/m
Floor finish	1.5 kN/m²
Live load	3 kN/m²
Roof live load	1.5 kN/m²

The maximum values of transferred girder moments, shear force and axial force are tabulated for (DL+LL) combination and construction sequence analysis (AUTO SEQ) for different position of floating columns at different stories**.**

Step by step procedure for analysis

MODEL 1: DIAGRID ANGLE: 52°0'5"

In RCC 52° diagrid building, bending moment, shear force of transfer girder and axial force variations in columns after removing at the centre of ground floor and mid floor column in the seismic zone 5 analysing for normal (DL+LL) combination and applying AUTO SEQ method.

MODEL 2: DIAGRID ANGLE: 52°0'5"

In RCC 52° diagrid building, bending moment, shear force of transfer girder and axial force variations in columns after removing at the corner of ground floor and mid floor column in the seismic zone 5 analysing for normal (DL+LL) combination and applying AUTO SEQ method.

MODEL 3: DIAGRID ANGLE: 62°29'17"

In RCC 62° diagrid building, bending moment, shear force of transfer girder and axial force variations in columns after removing at the centre of ground floor and mid floor column in the seismic zone 5 analysing for normal (DL+LL) combination and applying AUTO SEQ method.

MODEL 4: DIAGRID ANGLE: 62°29'17"

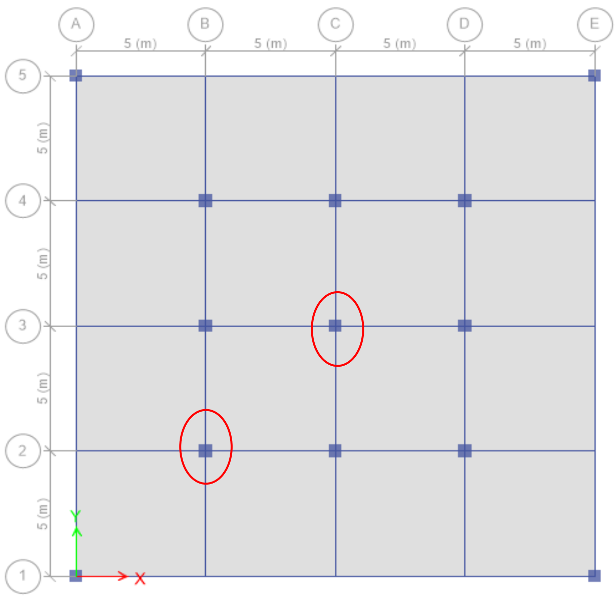
In RCC 62° diagrid building, bending moment, shear force of transfer girder and axial force variations in columns after removing at the corner of ground floor and mid floor column in the seismic zone 5 analysing for normal (DL+LL) combination and applying AUTO SEQ method

MODEL 5: DIAGRID ANGLE: 68°39'47"

In RCC 68° diagrid building, bending moment, shear force of transfer girder and axial force variations in columns after removing at the centre of ground floor and mid floor column in the seismic zone 5 analysing for normal (DL+LL) combination and applying AUTO SEQ method.

MODEL 6: DIAGRID ANGLE: 68°39'47"

In RCC 68° diagrid building, bending moment, shear force of transfer girder and axial force variations in columns after removing at the corner of ground floor and mid floor column in the seismic zone 5 analysing for normal (DL+LL) combination and applying AUTO SEQ method.



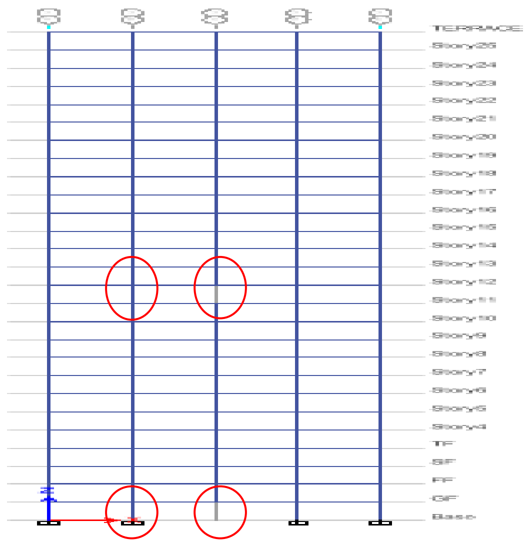
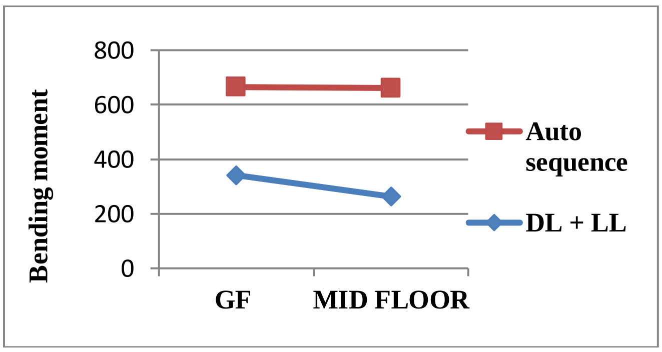


Fig 1. Elevation view of building with 4 locations where the columns are removed

BM FROM 52^0, 62^0 AND 68^0 DIAGRID ANGLE BY REMOVING COLUMN @ THE CENTRE OF GF AND MID FLOOR

Moment of transfer girder after removing at the centre of ground floor and mid floor column in the seismic zone 5 analyzing for normal (DL+LL) combination and applying AUTO SEQ method.

SL N0.	POSITION OF TRNSFER GIRDER	BM WITHOUT AUTO SEQUENCE	BM WITH AN AUTO SEQUENCE	% OF VARIATION
1	BM AT GROUND FLOOR TRANSFER GIRDER (KN-M)	347.07 339.67 337.62	688.88 660.68 644.42	98.47% 94.50% 90.87%
2	BM AT MID FLOOR TRANSFER GIRDER (KN-M)	266.32 262.25 260.90	683.49 654.27 646.10	156.6% 149.4% 147.6%

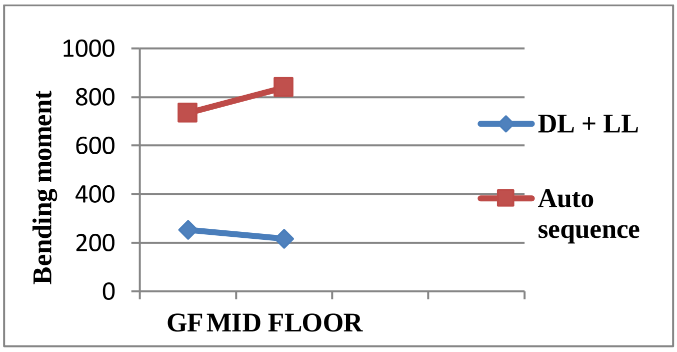


When compared to traditional analysis, auto sequence bending moment variation of ground floor level at the centre is 94.6% less as compared to auto sequence bending moment variation at mid floor level at the centre is 151.25%.

BM FROM 52^0, 62^0 AND 68^0 DIAGRID ANGLE BY REMOVING COLUMN @ THE CORNER OF GF AND MID FLOOR

Moment of transfer girder after removing at the corner of ground floor and mid floor column in the seismic zone 5 analysing for normal (DL+LL) combination and applying AUTO SEQ method.

SL N0.	POSITION OF TRNSFER GIRDER	BM WITHOUT AUTO SEQUENCE	BM WITH AN AUTO SEQUENCE	% OF VARIATION
1	BM AT GROUND FLOOR TRANSFER GIRDER (KN-M)	253.08 252.36 253.29	684.64 747.48 769.55	170.5% 196.1% 203%
2	BM AT MID FLOOR TRANSFER GIRDER (KN-M)	195.06 220.93 233.46	762.79 855.67 897.59	291% 287% 284.4%

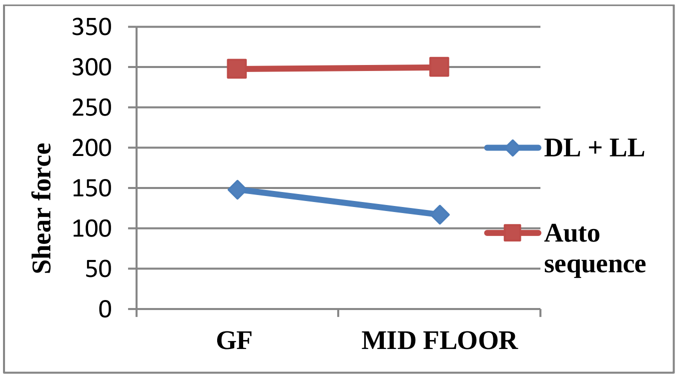


When compared to traditional analysis, auto sequence bending moment variation of ground floor level at the corner is 189.90% less as compared to auto sequence bending moment variation at mid floor level at the corner is 287.49%.

SF FROM 52º, 62º AND 68º DIAGRID ANGLE BY REMOVING COLUMN @ THE CENTRE OF GF AND MID FLOOR

Shear force of transfer girder after removing at the centre of ground floor and mid floor column in the seismic zone 5 analyzing for normal (DL+LL) combination and applying AUTO SEQ method.

SL N0.	POSITION OF TRNSFER GIRDER	SF WITHOUT AUTO SEQUENCE	SF WITH AN AUTO SEQUENCE	% OF VARIATION
1	SF AT GROUND FLOOR TRANSFER GIRDER (KN-M)	150.59 147.53 146.73	308.78 295.45 288.81	105% 100% 96.83%
2	SF AT MID FLOOR TRANSFER GIRDER (KN-M)	118.48 116.71 116.13	309.72 296.11 293.10	161% 153.7% 152.3%

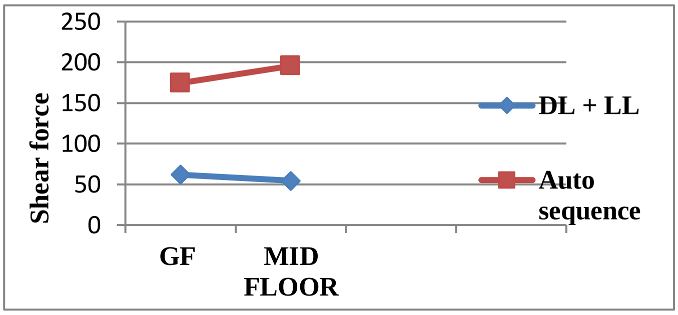


When compared to traditional analysis, auto sequence shear force variation of ground floor level at the centre is 100.61% less as compared to auto sequence shear force variation at mid floor level at the centre is 155.69%.

SF FROM 52º, 62º AND 68º DIAGRID ANGLE BY REMOVING COLUMN @ THE CORNER OF GF AND MID FLOOR

Shear force of transfer girder after removing at the corner of ground floor and mid floor column in the seismic zone 5 analyzing for normal (DL+LL) combination and applying AUTO SEQ method.

SL N0.	POSITION OF TRNSFER GIRDER	SF WITHOUT AUTO SEQUENCE	SF WITH AN AUTO SEQUENCE	% OF VARIATION
1	SF AT GROUND FLOOR TRANSFER GIRDER (KN-M)	61.86 61.72 61.91	164.63 177.20 181.62	166% 187% 193%
2	SF AT MID FLOOR TRANSFER GIRDER (KN-M)	50.26 55.43 57.94	180.26 198.84 207.23	258% 258% 257.6%



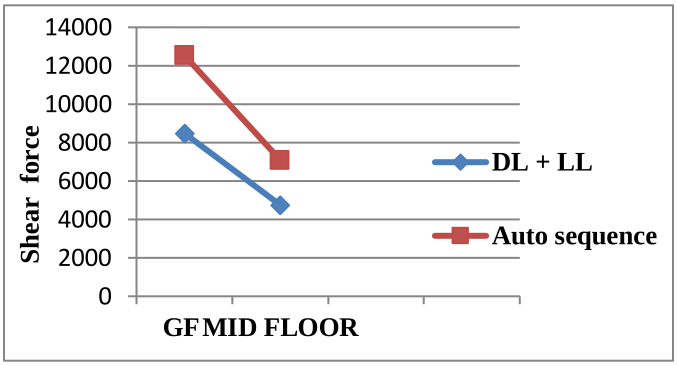
When compared to traditional analysis, auto sequence shear force variation of ground floor level at the corner is 182% less as compared to auto sequence shear force variation at mid floor level at the corner is 257.86%.

AF FROM 52º, 62º AND 68º DIAGRID ANGLE BY REMOVING COLUMN @ THE CENTRE OF GF AND MID FLOOR

Axial force of transfer girder after removing at the centre of ground floor and mid floor column in the seismic zone 5 analysing for normal (DL+LL) combination and applying AUTO SEQ method.

SL N0.	POSITION OF TRNSFER GIRDER	AF WITHOUT AUTO SEQUENCE	AF WITH AN AUTO SEQUENCE	% OF VARIATION
1	AF AT GROUND FLOOR TRANSFER GIRDER (KN-M)	8714 8415 8326	12268 12580 12769	40.78% 49.49% 53.3%

2	AF AT MID FLOOR TRANSFER GIRDER (KN-M)	4919 4703 4635	6925 7130 7231	40.78% 51.6% 56%

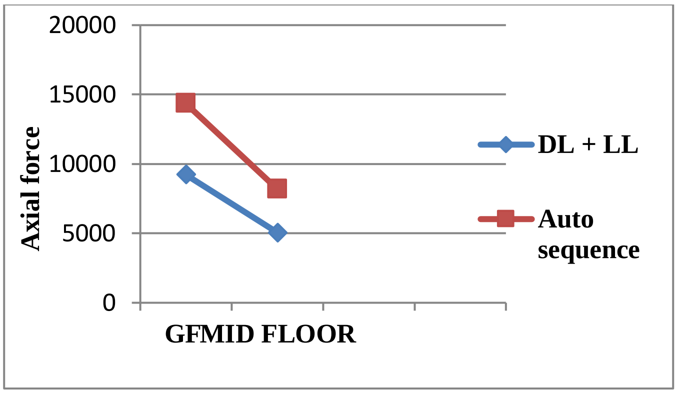


When compared to traditional analysis, auto sequence axial force variation of ground floor level at the centre is 47.85% less as compared to auto sequence axial force variation at mid floor level at the centre is 49.46%.

AF FROM 52º, 62º AND 68º DIAGRID ANGLE BY REMOVING COLUMN @ THE CORNER OF GF AND MID FLOOR

Axial force of transfer girder after removing at the corner of ground floor and mid floor column in the seismic zone 5 analyzing for normal (DL+LL) combination and applying AUTO SEQ method.

SL N0.	POSITION OF TRNSFER GIRDER	AF WITHOUT AUTO SEQUENCE	AF WITH AN AUTO SEQUENCE	% OF VARIATION
1	AF AT GROUND FLOOR TRANSFER GIRDER (KN-M)	9465 9129 9056	13842 14395 14788	46.24% 57.68% 63.2%
2	AF AT MID FLOOR TRANSFER GIRDER (KN-M)	5246 4995 4925	7871 8226 8457	50% 64.68% 71.71%



When compared to traditional analysis, auto sequence axial force variation of ground floor level at the corner is 55.70% less as compared to auto sequence axial force variation at mid floor level at the corner is 62.13%.

STOREY DISPLCAMENT (X) and (Y)

SL NO.	MAXIMUM DISPLACEMENT @ DIFFERENT DIAGRID ANGLES	EQX (mm)	SPECX (mm)	% OF VARIATION
1	52º0'5"	86.40	54.36	58.94%,
2	62º29'17"	84.72	59.10	43.35%
3	68º39'47"	91.94	66.08	39%

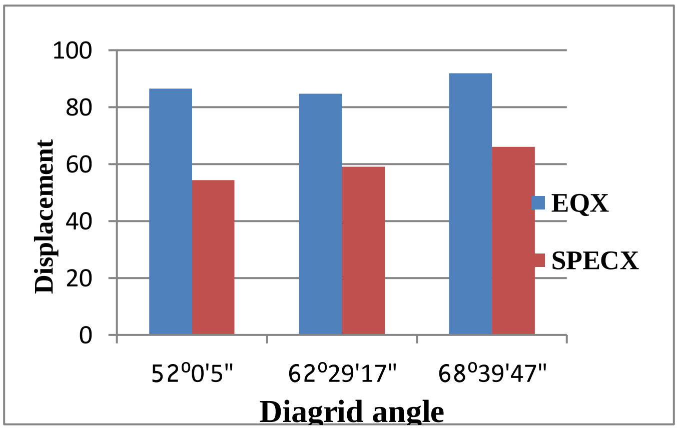
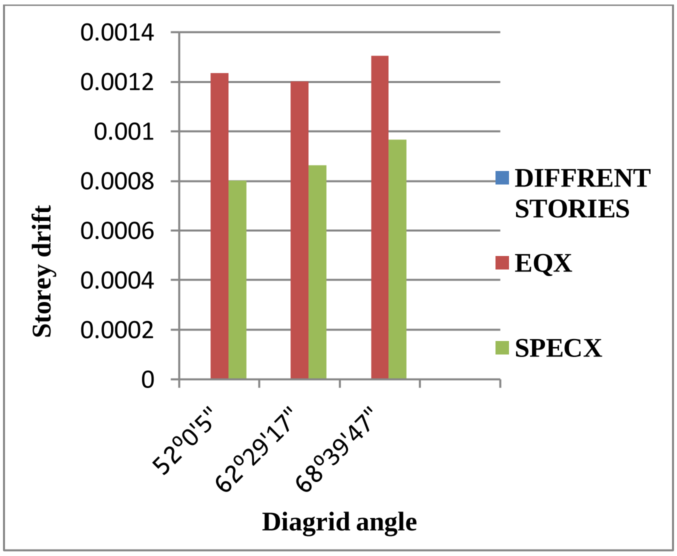


Fig Difference between storey displacements in different diagrid angle @ X and Y

The displacement in model with ZONE 5 along X & Y direction for response spectrum analysis when compared different diagrid models 52º, 62º and 68º. is (58.94%, 43.35% and 39%). Therefore 68º diagrid model is less displacement as compared to other degrees.

STOREY DRIFT (X) and (Y)

SL NO.	MAXIMUM DRIFT @ DIFFERENT DIAGRID ANGLES	DIFFERENT STORIES	EQX	SPECX	% OF VARIATION
1	52º0'5"	17th AND 17th STOREY	0.001234	0.000802	53%
2	62º29'17"	14th and 17th STOREY	0.001201	0.000864	39%
3	68º39'47"	15th and 15th STOREY	0.001304	0.000967	34%



The drift in model with ZONE 5 along X & Y direction for response spectrum analysis when compared different diagrid models 52º, 62º and 68º is (53.86%, 39% and 34.85%). Therefore 68º diagrid model is less storey drift as compared to other degrees.

CONCLUSIONS

1. When compared to traditional analysis, auto sequence bending moment, shear force and axial force variation of ground floor level at the centre is less as compared to auto sequence bending moment, shear force and axial force variation at mid floor level at the centre.
2. When compared to traditional analysis, auto sequence bending moment, shear force and axial force variation of ground floor level at the corner is less as compared to auto sequence bending moment, shear force and axial force variation at mid floor level at the corner.
3. The displacement in model with zone 5 along X & Y direction for response spectrum analysis when compared different diagrid models 52º, 62º and 68º. Therefore 68º diagrid model is less displacement as compared to other degrees
4. The drift in model with zone 5 along X & Y direction for response spectrum analysis when compared different diagrid models 52º, 62º and 68º. Therefore 68º diagrid model is less storey drift as compared to other degrees.
5. Building sequence analysis is required for RCC structures in order to increase the analysis & accuracy for displacement, axial, moment, and shear forces in nearby supporting beams and columns as well as for the entire structure.
6. A more realistic design than the standard design is produced by including sequential load case in the study of multistory RCC structure.

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