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Comparative Analysis of Conventional Structure and Diagrid Structure

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Abstract
In our day to day life we see there is increase in requirement of multistory building. For the growth of these buildings there are new and advanced construction technology, structural systems, analysis and design software's in terms of structural stability and architectural looks diagrid structure are best. In this work concrete diagrid structure is analysed and compared with conventional concrete building. Structural design of tall buildings is governed by lateral loads i.e wind or earthquake. Lateral loads in diagrid buildings are resisted by inclined members which are placed at exterior of building.In this paper G+16 storey RCC building with a plan dimension of 24mx16m is considered. For adverse effect seismic zone V is considered. ETABS 18 software is used for analysis of structural members. A conventional structure is compared with a diagrid structure of diagrid angle 40^0 and diagrid angle of 60^0. In this paper storey displacement, story drift, shear force, bending moment, axial load and reinforcement % of diagrid structures with different diagrid angles are compared with conventional structure.

Keywords: *Diagrid, storey displacement, storey drift, axial load, E-TABS*

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I. INTRODUCTION

Due to high land value and limited place everyone are looking out for high rise buildings. When high rise buildings comes into view the major factor comes into consideration is lateral forces. These lateral forces are resisted by different structural systems like shear wall, rigid frame, outrigger wall frame etc…now a day's diagrid system is used to resist the lateral loads.

Diagrid system is a system in which the periphery columns are inclined and inner columns are vertical. These inclined columns meet at a point diagonally where beam pass through that point forms triangular shape as shown in figure. This triangulated pattern can resist both lateral and gravity loads. In diagrid structures corner columns are not provided and lateral load is resisted by the exterior inclined columns. Diagrid system also provides good aesthetic looks to the tall structures. In tall structures this diagrid structure will save 20% to 30% of the steel as compared to conventional structure.

1.1.1 Scope of the study

Seismic analysis of high rise structure with diagonal inclined column is much more different from conventional vertical column. With different diagrid angle structure shows different behaviour. So first conventional structure behaviour is studied and later a diagrid angle of 40^0 and diagrid angle of 60^0 structure behaviour is studied and compared to know which structure is more efficient. To achieve this same plan dimensions are considered 24m x 16m with a storey height of G+16. Parameters like storey displacement, storey drift, shear force, bending moment, axial load is compared. And % of reinforcement is also compared among the structures.

1.1.2 Objectives of the study

i. To analyze the conventional building and diagrid building with variation in diagrid angle, both statically and dynamically.
ii. To check which structure is more efficient in resisting the seismic forces and which diagrid angle is more effective in resisting seismic forces

1.2 METHODOLOGY

A G+16 storey high rise building is considered for study. Both conventional building and diagrid building with variation in diagrid angle i.e. 40^0 and 60^0 is analyzed in E-TABS 2018 software. Analysis like Equivalent Static Analysis (ESA), Response Spectrum Analysis (RSA) is done.

Parameters considered for study

- Plan 24 m x 16 m
- (G+16) storey building
- Spacing between two bays:- 4m
- Storey height:- 3.35m
- Soil type:-II (Medium)
- Zone:- V
- Grade of concrete:- M30
- Grade of steel:-
  Longitudinal bars Fe500
  Confinement bars Fe415
- Response reduction factor:- 5
- Importance factor:- 1.0

Dimensions of building elements

Beam : 300mm X 450mm
Slab : 200mm thick
Column : 300mm x 650mm inner column
450mm x 450mm outer column
300mm x 300mm lift column

Loads cases considered for study

Dead load	Self-weight of building
Live load	3.5 kN/m^2
Parapet wall load	3 kN/m
Partition load	1.5 kN/m^2
Glass load	2 kN/m
Roof live load	1.5 kN/m^2
Wall load	7.83 KN/m
Staircase load	20 kN/m

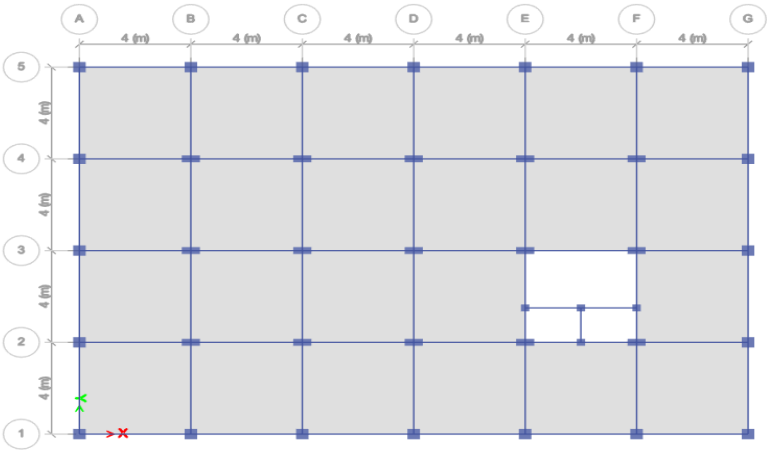
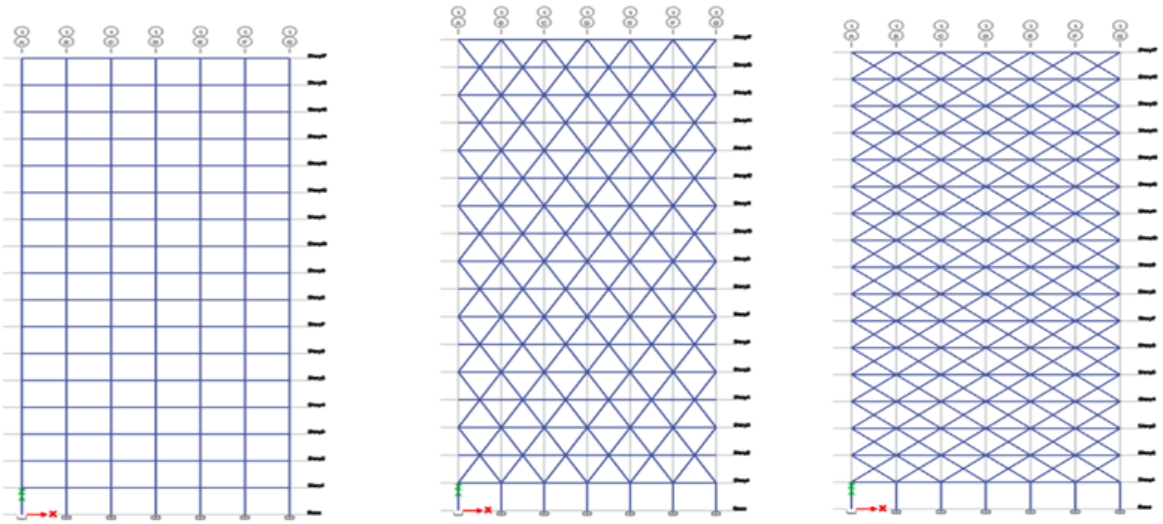


Fig 1: Plan of structure



Conventional (CON) 40^0 angled diagrid (D40) 60^0 angled diagrid (D60)

Fig 2: Elevation of 3 considered structures

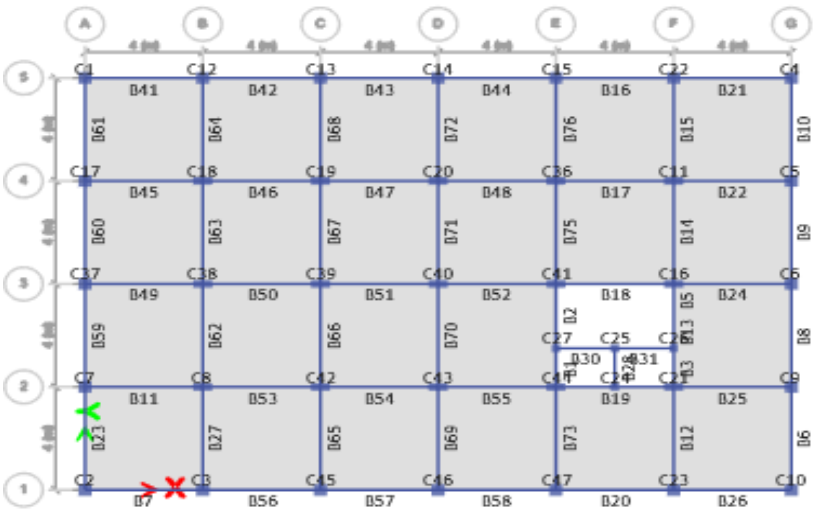


Fig 3: Beam and Column Labels

II. RESULT AND DISCUSSION

Overview

After the analysis from E-TABS, results of 3 structures are noted. Results like story displacement, story drift, axial load, reinforcement % and shear force and bending moments are noted and compared among 3 structures. The results obtained are as discussed below

STOREY DISPLACEMENT

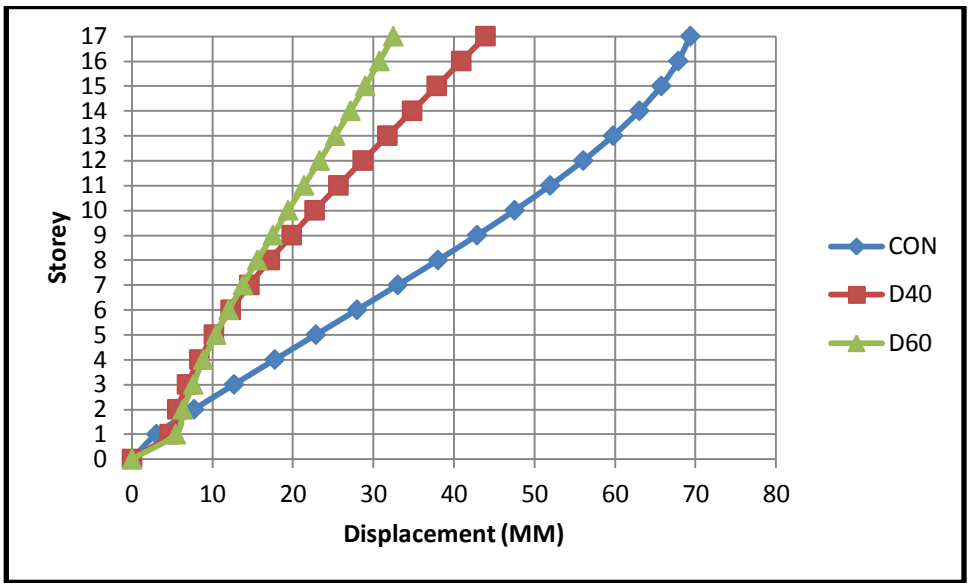


Fig 4: Storey displacement v/s storey for CON, D40, D60 (ESA)

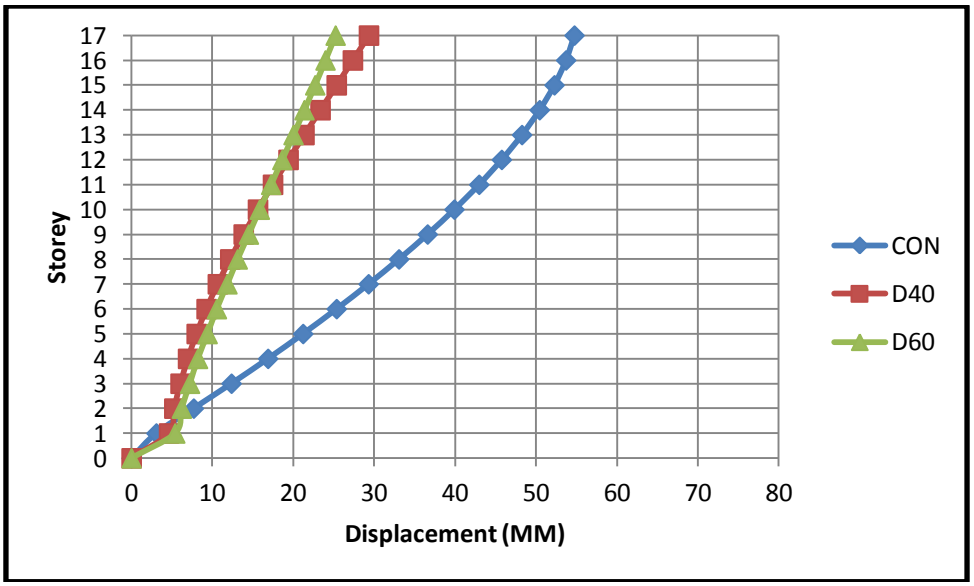


Fig 5: Storey displacement v/s storey for CON, D40, D60 (RSA)

➢ From ESA it is found that there is increase in storey displacement in conventional structure compared to diagrid structure with 60^0 diagrid angle by 53.21% and 36.69% compared to diagrid structure with 40^0 diagrid angle.

➢ From RSA it is found that there is increase in storey displacement in conventional structure compared to diagrid structure with 60^0 diagrid angle by 53.93% and 46.40% compared to diagrid structure with 40^0 diagrid angle.

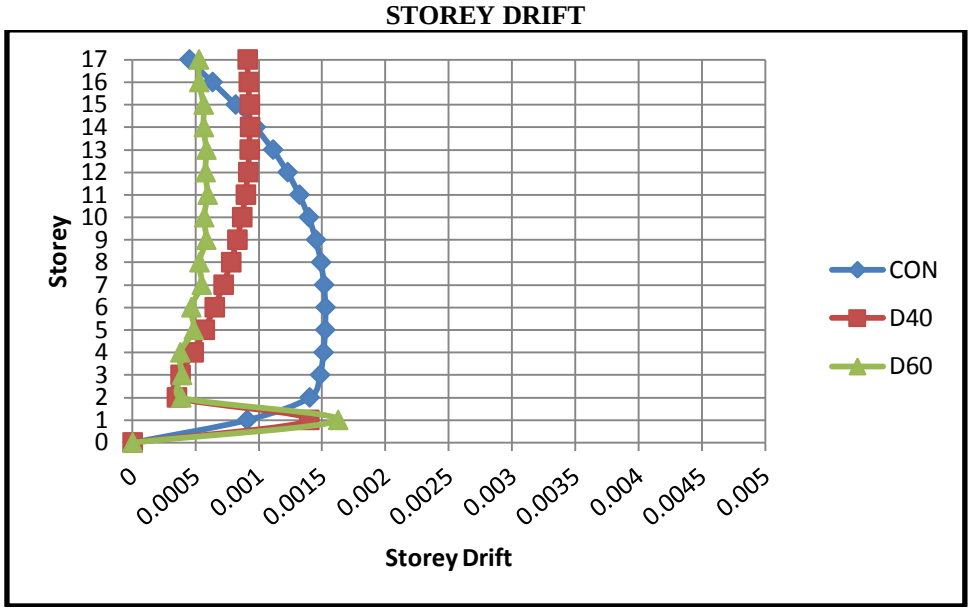


Fig 6: Storey drifts v/s storey for CON, D40, D60 (ESA)

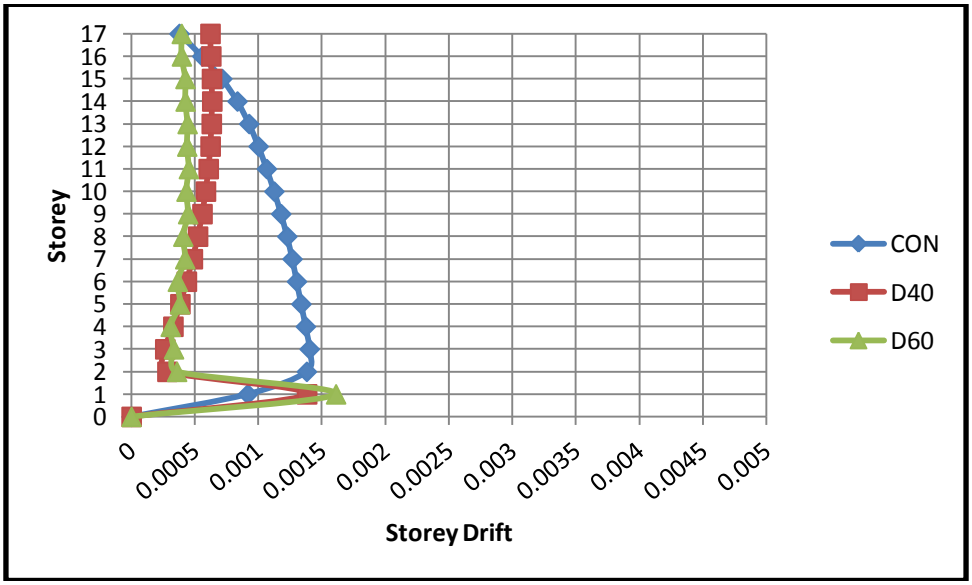


Fig 7: Storey drifts v/s storey for CON, D40, D60(RSA)

From ESA and RSA it is found that diagrid structure with 60^0 diagrid angle shows maximum story drift at story 1. Other than story 1, all other stories story drift values are less compared to conventional and 40^0 diagrid structure.

SHEAR FORCE

Shear force for some of the ground floor beams from all the 3 structures are noted and discussed below.

BEAM NO.	B9	B20	B42	B59	B66	B71		UNIT
CONV	140.57	82.69	83.22	147.57	120.18	120.46		KN
D40	63.42	59.4	55.58	61.71	77.87	73.02		KN
D60	73.61	66.33	65.42	73.36	79.11	79.71		KN

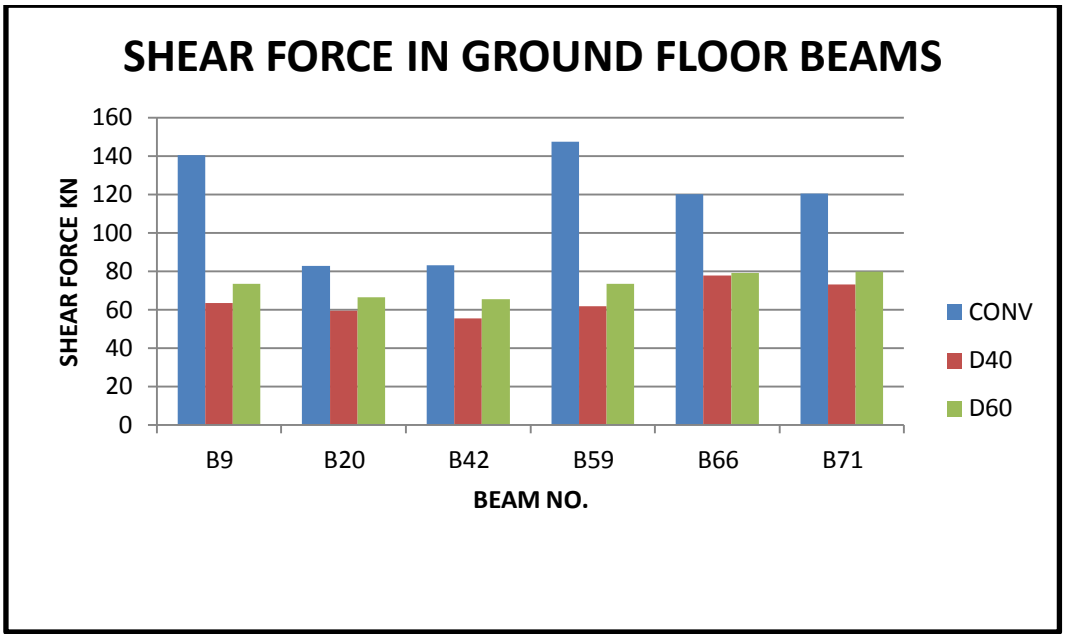


Fig 8: Beam No. v/s Shear force kN for CON, D40, D60

From the analysis it is found that conventional structure has more shear force in beams than diagrid structures. Among the diagrid structures, diagrid structure with 40^0 diagrid angle shows less shear force in beams.

BENDING MOMENT

Bending moment of some of the ground floor beams of all 3 structures are noted.

BEAM NO.	B9	B20	B42	B59	B66	B71		UNIT
CONV	178.73	75.54	78.71	192.63	118.72	117.73		KN-M
D40'	40.47	32.46	32.72	40.99	34.53	34.82		KN-M
D60'	59.51	46.23	46.56	60.19	38.6	38.78		KN-M

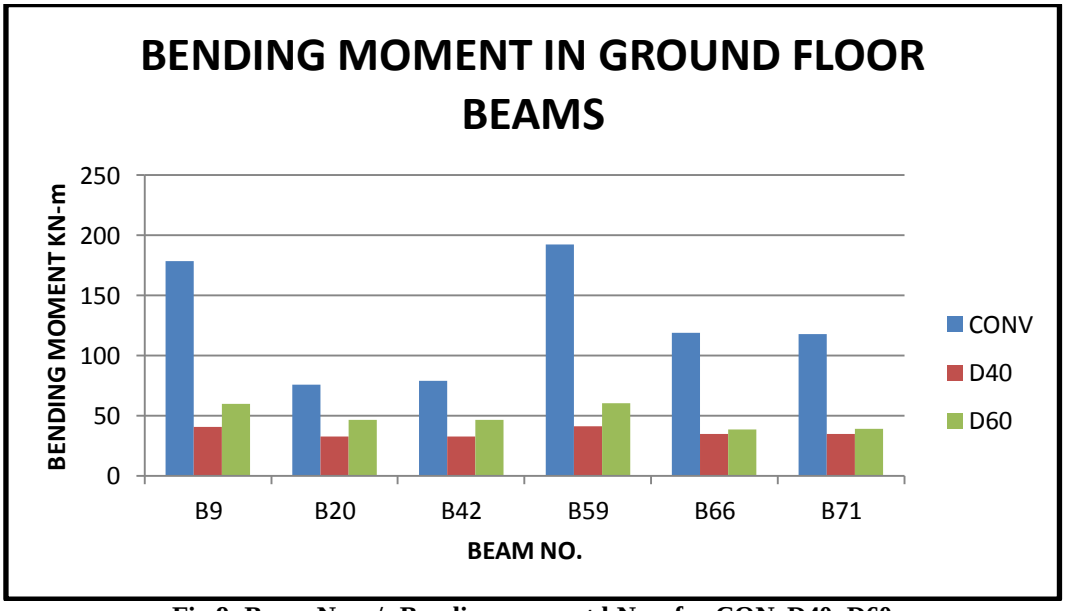


Fig 9: Beam No. v/s Bending moment kN-m for CON, D40, D60

From the analysis it is found that conventional structure has more bending moment in beams than diagrid structures. Among the diagrid structures, diagrid structure with 40^0 diagrid angle shows less bending moment in beams.

AXIAL LOAD

Axial load on inner column 18 for 3 structures are noted in below table. And graph is plotted axial force v/s structures.

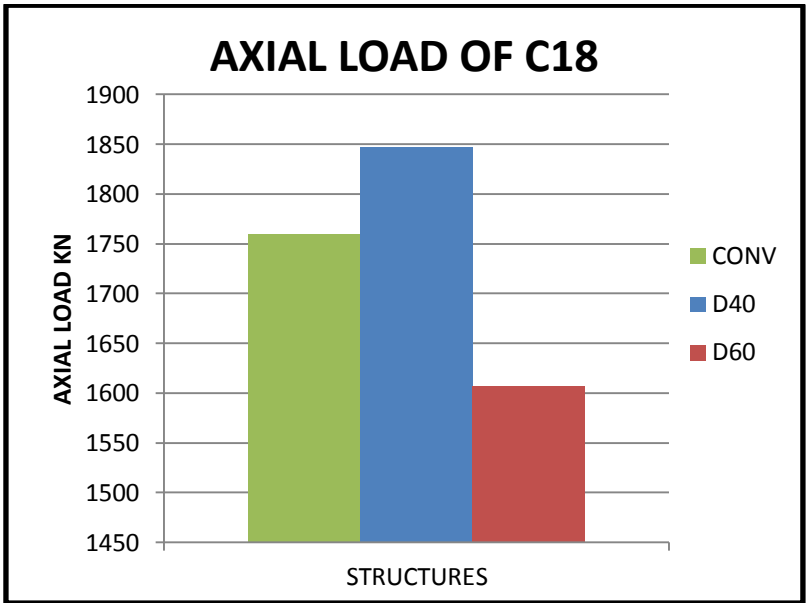


Fig 10: Structure v/s axial load kN-m for CON, D40, D60

From the analysis it is found that axial load on inner columns is less in case of diagrid structure with diagrid angle 60^0 as compared to conventional structure and diagrid structure with diagrid angle 40^0.

REINFORCEMENT

Reinforcement comparison for inner columns of 3 structures is done and noted below in table.

Inner column 300 X 650 mm	Conventional	D40	D60
Total Ast of inner columns	786810	686169	522657

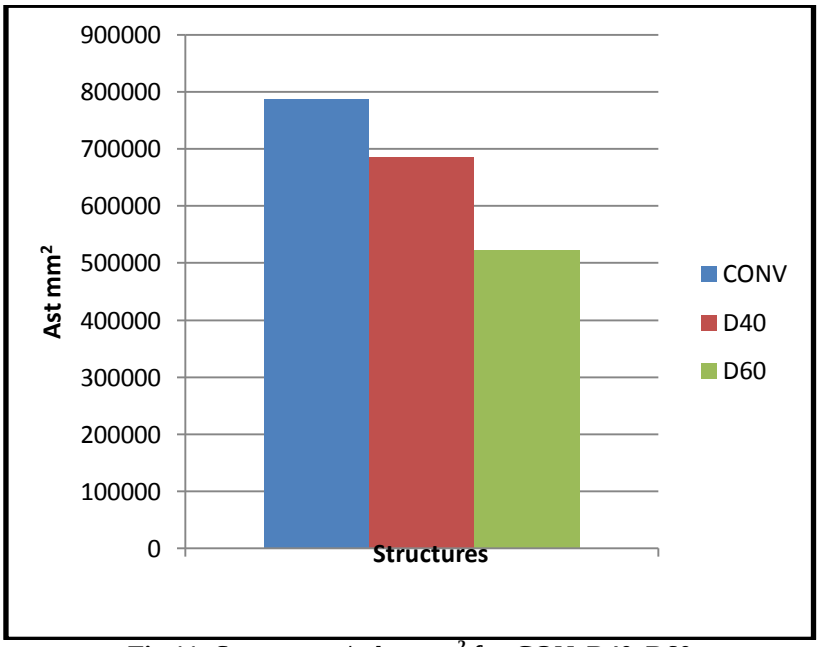


Fig 11: Structure v/s Ast mm^2 for CON, D40, D60

Reinforcement in inner columns are compared among conventional and diagrid structures. Conventional structure consumes more % of reinforcement as compared to diagrid structures. Among the 40^0 and 60^0 diagrid structures, structure with 60^0 diagrid angle consumes less % of reinforcement. Diagrid structure with 60^0 diagrid angle consumes 33.57% less reinforcement than conventional structures.

III. CONCLUSION

In this paper a study conducted on comparative analysis of conventional structure with diagrid structure. Two diagrid structure are considered with diagrid diagonal of 40^0 and 60^0 denoted with $D40^0$ and $D60^0$ respectively. Same floor plan of size 24m x 16m is considered. Modeled and analyzed in E-TABS 18. Analysis results like storey displacement, storey shear, shear force, bending moment, axial load and reinforcement % is compared among 3 considered models and presented.

- 60^0 angled Diagrid structure shows less storey displacement and storey drift as compared to conventional structure and 40^0 angled diagrid structure.
- 60^0 angled Diagrid structure shows less axial force in inner columns as compared to conventional structure and 40^0 angled diagrid structure.
- Reinforcement % in inner columns are compared among 3 modeled structures in which 60^0 angled diagrid structure showed less reinforcement %.
- Shear force in ground floor beams are compared among 3 modeled structures in which 40^0 angled diagrid structure showed little less shear force than 60^0 angled diagrid structure.
- Bending moment in ground floor beams are compared among 3 modeled structures in which 40^0 angled diagrid structure showed little less bending moment than 60^0 angled diagrid structure.
- This results and analysis shows that 60^0 angled diagrid structure is most economical and stable than conventional structure and 40^0 angled diagrid structure.

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