ISSN NO: 2770-4491
Date of Publication:28-06-2022

Comparative study between using rigid diaphragm and flexible diaphragm slabs in multi-story buildings (solid slab system) under earthquake loads

Mohammed A.Hassan
University of Samarra /college of engineering/Civil department , Iraq,
mohammed.a.hassan@uosamarra.edu.iq

Abstract
The aim of this study is to inspect the variation between the flexible floor and the rigid floor analyses for the buildings. The method of finite-element is going to be implied for analyzing the buildings with the engineering software of Autodesk Robot Structural Analysis Professional 2020, the analysis was executed for the structure that having two different diaphragm for floor, and they are flexible floor and rigid floor diaphragms. In this paper the seismic analysis for10,15 and20 stories structures with reinforced concrete that has been executed by taking two kinds of floor diaphragms. The horizontal loads include seismic and wind loads that have been applied by using Autodesk Robot Structural Analysis Professional2020 for the model of multistoried buildings along all directions for the used building, by using (ASCE 7-10 / IBC 2012)for seismic loadings and (ASCE7-5) for wind loads. According to the result data for the modeling, current study provides a great resource of information on the horizontal displacement parameters like, drift of storey, shear of storey, moments of column, axial forces and time period.

***Keywords**: Flat slab, story shear, Story drift, Edge beams, Time period, Autodesk Robot Structural Analysis Professional2020.*

I. Introduction

Diaphragm denotes the interaction of the horizontal load with the resisting of vertical components for the lateral force has been accomplished by utilizing the frameworks of the floor for the most fraction that have the essential in-plane stiffness. therefore, the aggregate lateral resistance for load contains the resisting components of the vertical load in addition to their individual stiffness. Floors could be represented as diaphragm as an effect from its big in-plane stiffness. conveying the inertial forces that has been produced by the ground movement for the floor mass at the level that has been presented to the vertical components of lateral force resisting that produced by the ground movement is the major amplitude of the floor diaphragm. At minimizing the story, a big horizontal load should be reciprocated beginning with one ingredient then onto the following ingredient that generating noticeable shear forces and bending moments through the diaphragm.

2. Different Types Of Diaphragm:

2.1 Rigid Diaphragm: as long as the diaphragm is at mid-point displacement we can consider it as Rigid under horizontal load and it is smaller than the twice average of the displacements at its both ends. also It can split the horizontal forces to the vertical components in the main ratio to the relative rigidities. According to the hypothesis that each vertical will produce a little distortion quantity and diaphragm would not distort itself. Also it is going to convey the torsional and shear distortions also forces that are based on the hypothesis, for the diaphragm that will generate extra shear force at the shear wall that ruled by the rotation of rigid body.

2.2 Semi-Rigid Diaphragm: The hypothesis For the analysis that have been made the semi-rigid diaphragm that could be generated as the diaphragm's rigidity or the flexibility according to the diaphragm that is not perfectly rigid or perfectly flexible, but in a few situations the diaphragm distortion and the vertical component of horizontal load-resisting that can the same amount only in the semi-rigid diaphragm.

2.3 Flexible Diaphragm: The Diaphragms that are taken as flexible at the displacement mid-point, subjected to horizontal load, it will overtakes double the rate displacement at the both end supports and also

ISSN NO: 2770-4491
Date of Publication:28-06-2022

as long as the maximum horizontal distortion of the diaphragm is bigger than twice as the rate of the storey drift for the related storey. It could be specified by matching the calculated mid-point of the deflection for the diaphragm itself that subjected to horizontal load with the drift of the neighboring vertical components beneath tributary horizontal load

II. Modeling Approach

In our paper the 10, 15 and 20 storeys of the commercial Reinforced Concrete structures that have been figured and analyzed by using the Autodesk software Robot Structural Analysis. The elevation of each floor is around 3.6m and all the storeys that have been taken as a representative floors. The area of the plan for the building is around 15x20m with the spacing between the columns at 5 m from c/c in the main direction at 5 m from c/c in the minor direction. The view of the structure's plan is as shown in Figure (1)

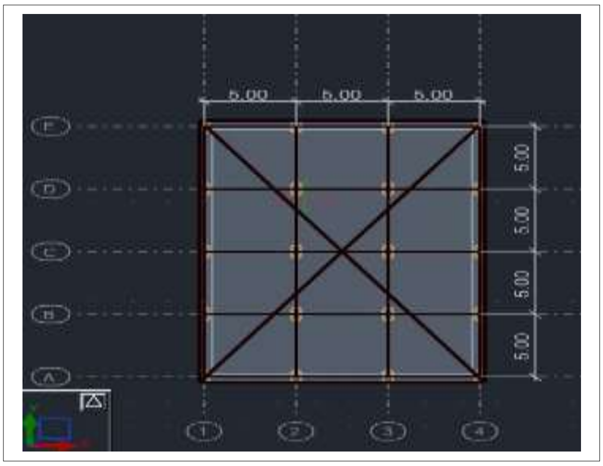

Figure 1: *The layout Plan of building with solid slab (rigid diaphragm).*

The building's location has been supposed to be at California in U.S.A. In designing the properties of materials and geometric that have been taken for the given structure in Table 1 and 2 respectively.

Table 1: Material properties that have been used in the Flat slab RC buildings

Type of Material	**Properties**	**Unit**	**Value**
Concrete	Modulus of elasticity	MPa	29725
	Density	kN/m^3	24
	Poisson's ratio	----	0.17
	Damping ratio	----	5%
	Compressive Strength f_c'	MPa	40
Steel	Yield strength	MPa	414

ISSN NO: 2770-4491
Date of Publication:28-06-2022

Table 2: Geometric properties of the buildings

Name of parameter	Value	Value	Value	Unit
Number of stories	10	15	20	---
Each Storey height	3.6	3.6	3.6	M
Total height of the structure above base	36	54	72	M
Length in long direction	20	20	20	M
Length in short direction	15	15	15	M
Thickness of Slab	200	200	200	mm
Column size	500x900 500×500	500x900 500×500	500x900 500×500	mm
Beam size	400 × 700	400 × 700	400 × 700	mm

The next two cases that have been taken for this paper:
Case I: Solid slab system (rigid diaphragm).
Case II: Solid slab system (flexible diaphragm).
those cases have been taken for comparing according to the elevation of the building. differentiation have been made with horizontal displacement, drift of the storey, shear of the storey, axial forces of the column, bending moments and time period. Every solid slab of the structure is completely meshed with size closer to the aspect ratio of 1 . 3D view for the solid slab (rigid diaphragm) structure for the 10, 15 and 20 storeys that has been showed in figure 2,3 and 4 respectively. designing plan for the solid slab (flexible diaphragm) structure that has been showed in figure 5 . 3D view for the solid slab (flexible diaphragm) structure for the 10, 15 and 20 storeys that have been showed in the figures 6,7 and 8 respectively .

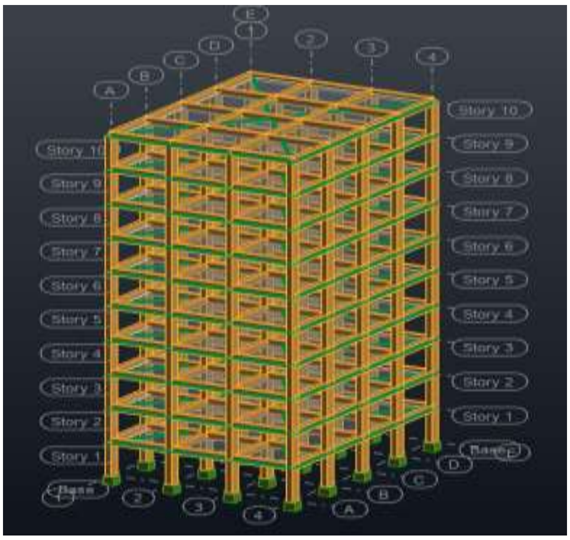

Figure 2: 3D view for10 storeys building with solid slab(rigid diaphragm).

ISSN NO: 2770-4491
Date of Publication:28-06-2022

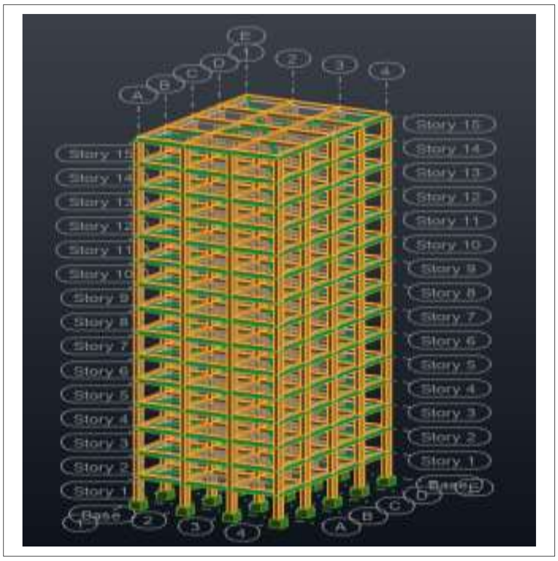

Figure 3: 3D view for15 storey building with solid slab(rigid diaphragm)

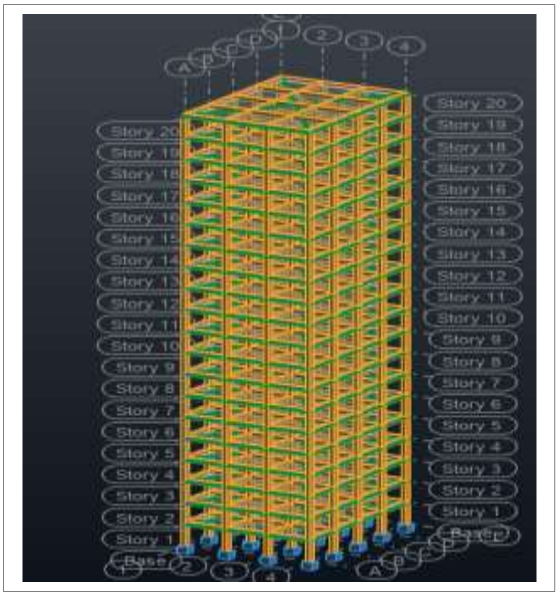

Figure 4: 3D view for 20 storey building with solid slab(rigid diaphragm)

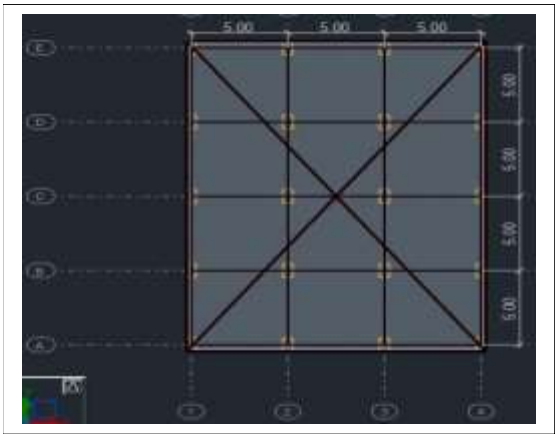

Figure 5: Layout Plan of the building with solid slab(flexible diaphragm).

ISSN NO: 2770-4491
Date of Publication:28-06-2022

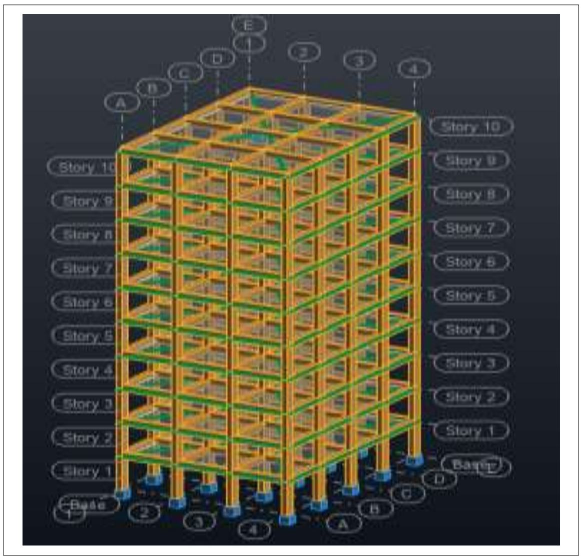

Figure 6: 3D view for 10 storeys
building with solid slab(flexible diaphragm)

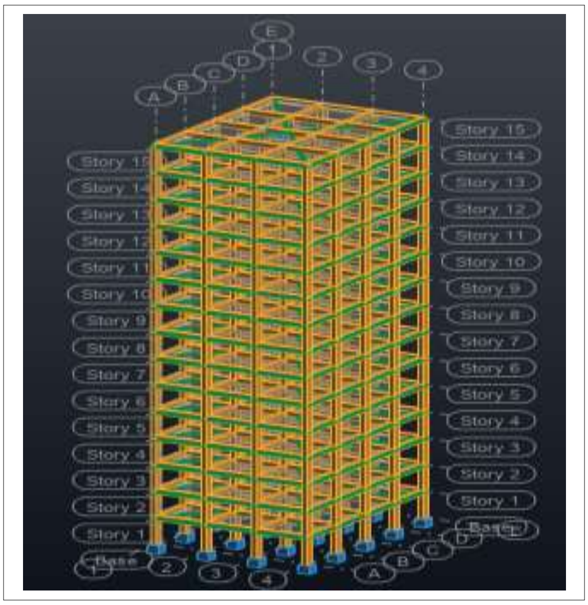

Figure 7: 3D view for 15storey building solid slab(flexible diaphragm)

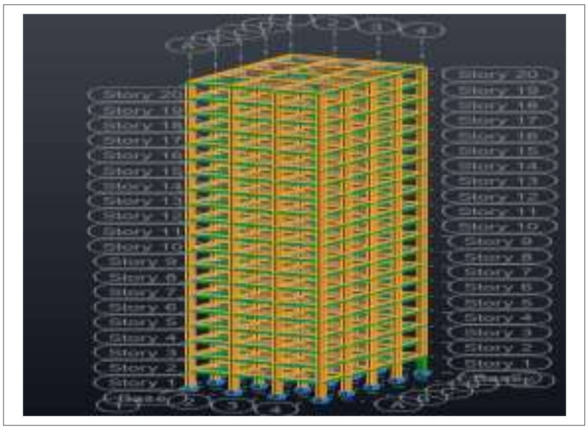

Figure 8: 3D view for 20 storey building with solid slab(flexible diaphragm)

ISSN NO: 2770-4491
Date of Publication:28-06-2022

III. Loading Approach

III.1 Applying loads on the structures

Various loads that are projected on the floor of the given structure in the following Table 3.

Table 3: Applied loading on the slab

Type of load	Name of Load	Value	Unit
Dead Load (D)	Self weight	-	kN/m
	Floor finish (include wall load)	4.0	kN/m^2
Live load (LL)	Live load	5.0	kN/m^2
Live load (L_r)	Roof live load	2.0	kN/m^2

Wind and earthquake loadings were computed For analysis, as in ASCE7-5 and ASCE 7-10 / IBC 2012 building codes . Different parameters and coefficients that have been taken for wind (W) and earthquake (Eq) loadings that projected to the buildings, According to the following Tables 4 and 5,.

Table 4: Different coefficients that have been taken in consideration for the calculation of seismic loads

Name	Symbol	Value	Description
Spectral response accelerations	S_s , S_1	1.4620, 0.5160	Short period (0.2 sec.), long period (1.0 sec.)
Seismic Design Category	SDC	IV	Zone D
Structural Importance Coefficient	*I*	1.250	Standard occupancy Structure (Commercial-Office)
Site Class	sc	Zone D	Stiff clay soil (N=15to50)
Response Modification Coefficient	*R*	8.0	Special Moment Resisting frame

Table 5: Coefficients or parameters coefficients that have been taken in consideration for the calculation of wind loads.

Name	Symbol	Value	Description
Terrain Exposure Category	A	---	Urban and sub-urban areas
Basic	Vb	100	Dhaka city

ISSN NO: 2770-4491
Date of Publication:28-06-2022

wind speed		km/hr	
Structural Importance Coefficient	CI	1.25	Standard occupancy Structure (Commercial)

III.2 Load Combinations Considered

The Following combinations that have been considered for the analysis which are 27 combinations as per mentioned ASCE 7-10.

U1:1.40D
U2:1.20D+1.60L
U3:D+L
U4:1.20D+0.2SDS+LL+1.25EX1
U5:1.20D+0.2SDS+LL-1.25EX1
U6:1.20D+0.2SDS+LL+1.25EY1
U7:1.20D+0.2SDS+LL-1.25EY1
U8:1.20D+0.2SDS+LL+1.25EX2
U9:1.20D+0.2SDS+LL-1.25EX2
U10:1.20D+0.2SDS+LL+1.25EY2
U11:1.20D+0.2SDS+LL-1.25EY2
U12:0.90D-0.2SDS+EX1
U13:0.90D-0.2SDS-EX1
U14:.0.90D-0.2SDS+EY1
U15:0.90D-0.2SDS-EY1
U16:.0.90D-0.2SDS+EX2
U17:.090D-0.2SDS-EX2
U18:0.90D-0.2SDS+EY2
U19:.0.90D-0.2SDS-EY2
U20=1.20D+LL+WX
U21=1.20D+LL+WY
U22=1.20D+LL-WX
U23=1.20D+LL-WY
U24=0.90D+WX
U25=0.90D+WY
U26=0.90D-WX
U27=0.90D-WY

IV. Results and Discussion

Displacements and forces that have been developed for each member in the structure are obtained from our analysis. Those obtained results from our analysis that have been debated in details through this chapter. Outer most for the obtained results that have been taken for the comprehending the behavior of the structure among the buildings that having system of solid slabs (rigid diaphragm) and system of solid slabs (flexible diaphragm) beneath the earthquake loads effects.

1. Moment and axial force of Columns

The critical columns at corner of the buildings have been chosen for the study. figures 9-14 show the details of the column moments and axial force obtained for columns. figures 9-14 represents the column results obtained for the structures which have been applied to in-plane loads. The analysis of in-plane load for the system of solid slabs (rigid diaphragm) and system of solid slabs (flexible diaphragm). From the results of in-plane load analysis it could noticed that in building with 10 storey the moments (Mz)is going to be

ISSN NO: 2770-4491
Date of Publication:28-06-2022

maximum at the ground level (storey 1) and first level (storey2) for the corner column. Therefore the column at the ground and first level that uses a maximum steel ratio comparing to the other situations. We can notice from the analysis' results that the moments of the column for the system of solid slabs (rigid diaphragm) is bigger than the moments of the column at the system of solid slabs (flexible diaphragm).The variation between those two disparity from 12 to 19% . We can notice from the results of the in-plane load analysis that in the building with 15 storey the moment (Mz) is going to be fullest at the ground level (storey1) and the first level (storey2) for the columns at corners. therefore the column at the ground level solicits a maximum steel ratio comparing to the other situations. We can notice from the analysis' results that the moments of the column for the system of solid slabs (rigid diaphragm) is bigger than the moments of the column at the system of solid slabs (flexible diaphragm). The variation between those two disparity from 8 to 21%. We can notice from the results of the in-plane load analysis that in the building with 20 storey the moment (Mz) is going to be fullest at the ground level (storey1) and the first level (storey2) for the columns at corners. After the second level we can notice that the moments are going to declines and increments as long as the building's height increments. therefore the column at the ground level solicits a maximum steel ratio comparing to the other situations. We can notice from the analysis' results that the moments of the column for the system of solid slabs (rigid diaphragm) is less than the moments of the column at the system of solid slabs (flexible diaphragm). The variation between those two disparity from 6 to 24%. We can notice from the analysis' results that the axial loads for the system of solid slabs (rigid diaphragm) is bigger than the axial loads at the system of solid slabs (flexible diaphragm). The variation between those two disparity up to 20.6%. For all the columns that have been determined for the in-plane combo of the dead ,live and earthquake loads show us that the earthquake combo is the worst giving combo to most of the critical sections. Earthquake is the most dominant load among others. The behavior of the moments of the column varies as the building's height increments.

1- Height of the Building

The effect of building's height has been studied by taking buildings with 10, 15 and 20 storeys. our paper has been created for the system of solid slabs (rigid diaphragm) and system of solid slabs (flexible diaphragm). The obtained results have been shown in the figures 9-14. We can notice from the Charts that the moments at the ground level (story1) and the first level (story2) are the fullest in the most critical column. Furthermore after level 2 as long as the height increments the moments of the column criticality declines and increments at the upper storey. The base shear, displacement, time period and storey drift increments directly as the height increments.

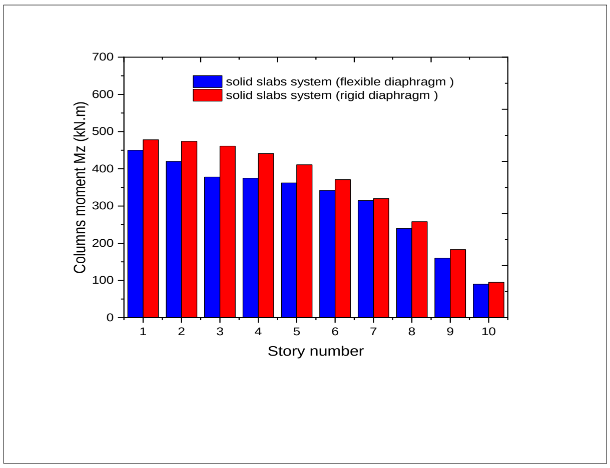

Figure -9: Design moments, for 10 storey building that Subjected to in-plane loads

ISSN NO: 2770-4491
Date of Publication:28-06-2022

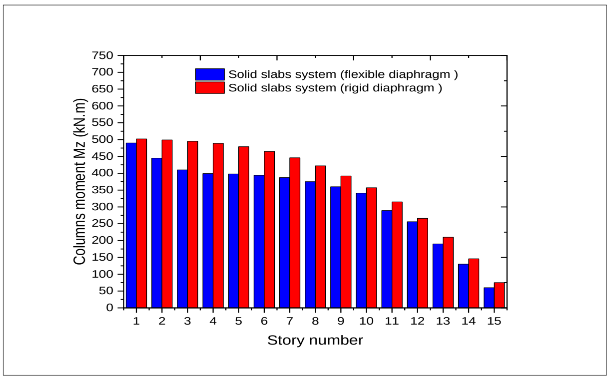

Figure -10: Design moments, for 15 storey building that Subjected to in-plane loads

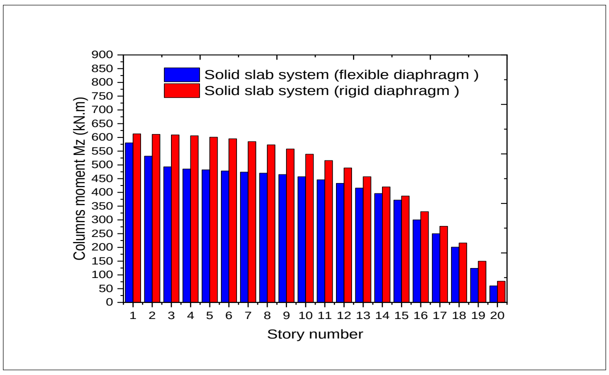

Figure -11: Design moments, for 20 storey building that Subjected to in-plane loads

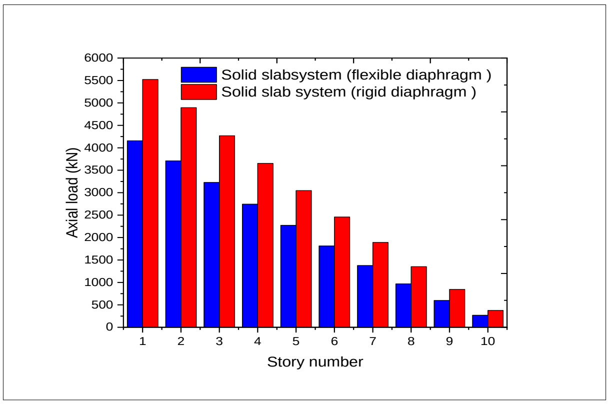

Figure -12: Axial force, for 10 storey building that Subjected to in-plane loads

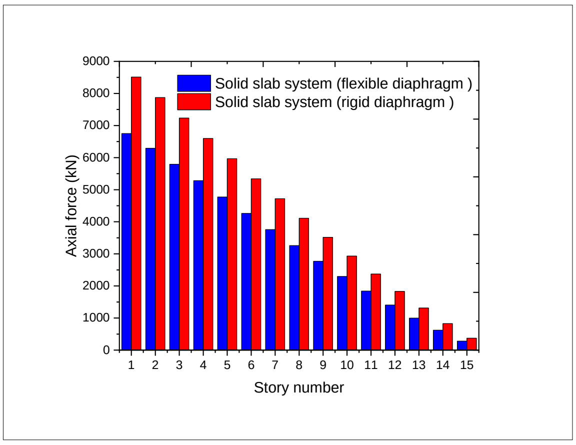

Figure -13: Axial force, for 15 storey building that Subjected to in-plane loads

ISSN NO: 2770-4491
Date of Publication:28-06-2022

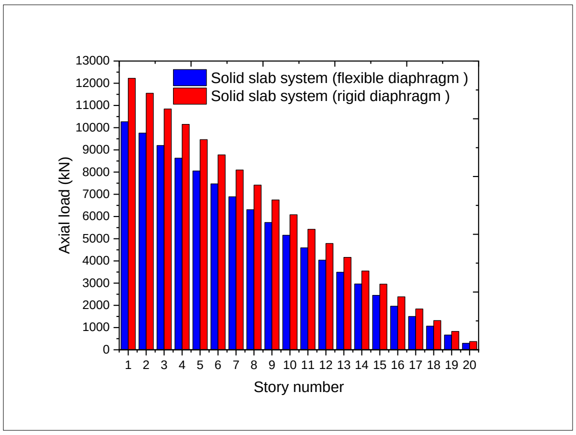

Figure -14: Axial force, for 20 storey building that Subjected to in-plane loads

2. Storey Shear

The represented results that have been shown in the figures (15-17). We can notice from the Charts that the base shear is going to be fullest at the ground level (storey1) for all buildings' storeys. The base shear is going to be declined as long as the building's height increasing. According to the building's symmetry, the base shear will be the same in both major directions (Vx and Vy). We can notice in the Figures 15-17 that the base shear in the system of solid slabs (rigid diaphragm) building is the same in the system of solid slabs (flexible diaphragm).

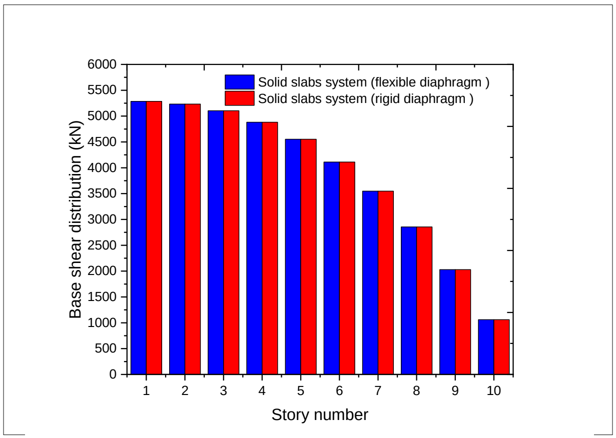

Figure-15: Base shear distribution for 10 storey building

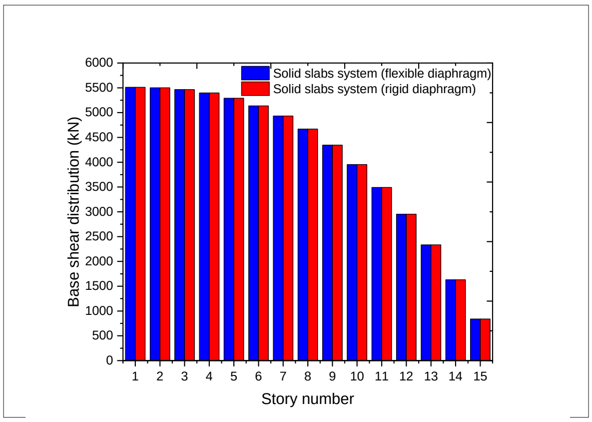

Figure -16: Base shear distribution for 15 storey building.

ISSN NO: 2770-4491
Date of Publication:28-06-2022

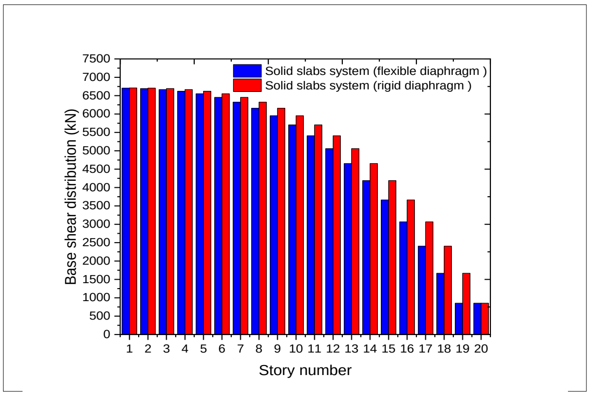

Figure -17: Base shear distribution for 20 storey building.

3. Lateral Displacement

The results that have been showed in the figure 18-23. We can notice in the figures that the horizontal displacement (both components Ux and Uy) is going to be fullest at the terrace level for all buildings' types. The horizontal displacement increments as long as the storey height increments. The horizontal displacement is going to be the least at the ground level (story1) and will be fullest at the terrace level. We can notice in the figures that, the horizontal displacement is going to be increments drastically as long as the building's height increments (No. of the stories). The horizontal displacement of building at the system of solid slabs (rigid diaphragm) is going to be smaller than the building at the system of solid slabs (flexible diaphragm). The variation between those two diverges from 65 to 69(%)

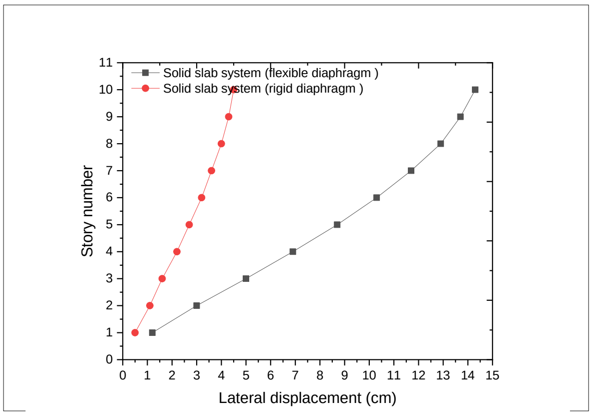

Figure -18: Lateral displacement in x-direction (Ux) for10 storey building.

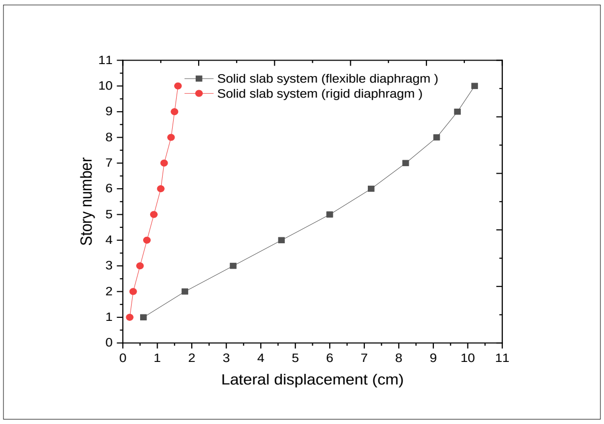

Figure -19: Lateral displacement in y-direction (Uy) for10 storey building

ISSN NO: 2770-4491
Date of Publication:28-06-2022

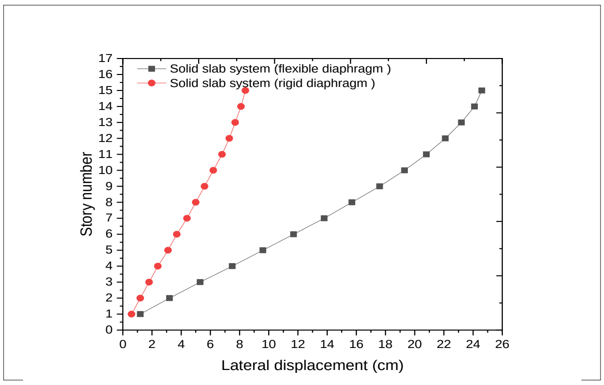

Figure -20: Lateral displacement in x-direction (Ux) for15 storey building.

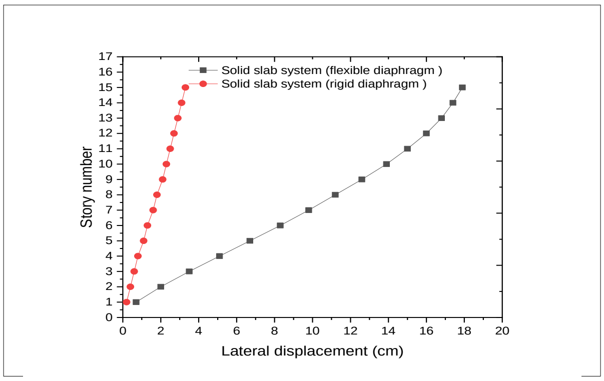

Figure -21: Lateral displacement in y-direction (Uy) for15 storey building.

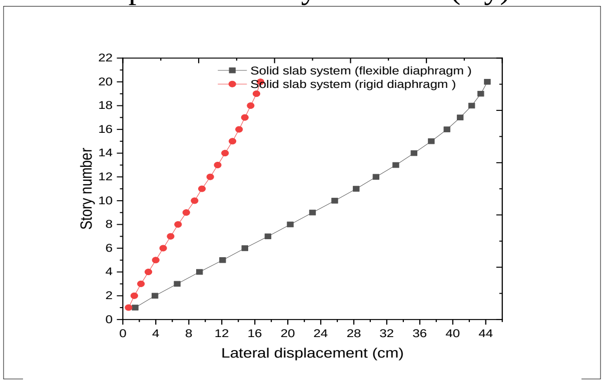

Figure -22: Lateral displacement in X-direction (Ux) for20storey building

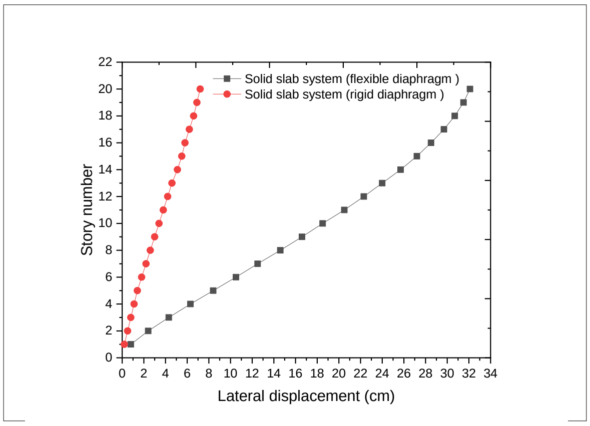

Figure -23: Lateral displacement in Y-direction (Uy) for20 storey building.

ISSN NO: 2770-4491
Date of Publication:28-06-2022

4. Time Period

The represented results that have been shown in the figures 24-26. We can notice in the figures that the time period is going to be fullest at the modes 1, 2 and 3. The natural time period is going to be incrementing as long as the building's height incrementing (No of the stories). We can notice in the figures 24-26 that, the time period is going to be incrementing drastically as long as the building's height incrementing. Comparing the systems of the building's with solid slabs (rigid diaphragm) and the building's with solid slabs (flexible diaphragm), the time period of the building's system with solid slabs (rigid diaphragm) is smaller than the building's system with solid slabs (flexible diaphragm). The variation between the two systems diverges from 50 to 52(%).

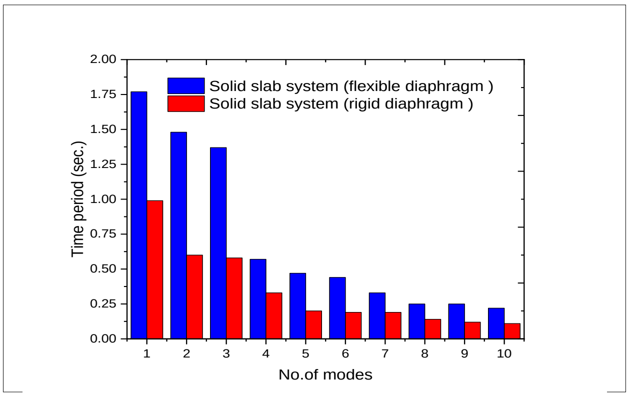

Figure -24: Effect of time period on behaviour of modes shapes on 10 storey building

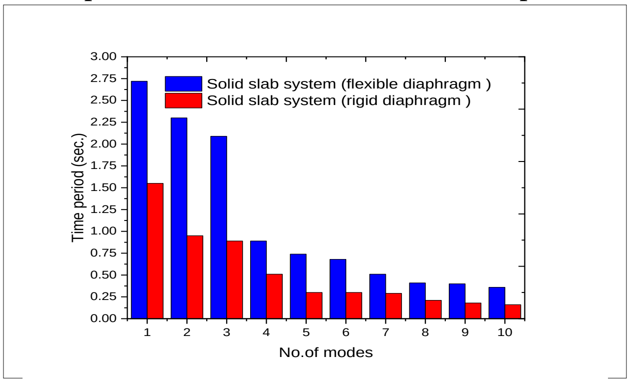

Figure -25: Effect of time period on the behaviour of modes shapes on 15 storey building

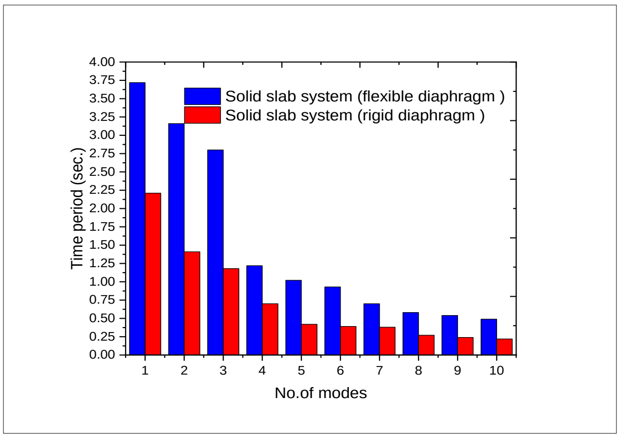

Figure -26: Effect of time period on the behaviour of modes shapes on 20 storey building

5 .Storey Drift

The represented results in the figure 27-32. We can notice in the figures the storey drift, for building with 10 storeys, the storey drift (dr Ux) is going to be fullest at the fourth level for the system of solid slabs (rigid diaphragm) and for the system of solid slabs (rigid diaphragm), storey drift (dr Uy) is going to be fullest at

 ISSN NO: 2770-4491
Date of Publication:28-06-2022

the fourth level for the system of solid slabs (rigid diaphragm) and for the system of solid slabs (rigid diaphragm). For building with 15 storeys, the storey drift (dr Ux) is going to be fullest at sixth level for the system of solid slabs (rigid diaphragm) and for the system of solid slabs (rigid diaphragm), storey drift (dr Uy)
is going to be fullest at the fifth level for the system of solid slabs (rigid diaphragm) and for the system of solid slabs (rigid diaphragm). For building with 20 storeys, the storey drift (dr Ux) is going to be fullest at seventh level for the system of solid slabs (rigid diaphragm) and for the system of solid slabs (rigid diaphragm), storey drift (dr Uy) is going to be fullest at the sixth level for the system of solid slabs (rigid diaphragm) and for the system of solid slabs (rigid diaphragm). After the fourth ,fifth ,sixth and seventh levels the storey drift declines as long as the building's height increments. We can notice in the figures that, the storey drift in the buildings' system with solid slabs (rigid diaphragm) the construction is significantly smaller comparing to the buildings' system with solid slabs (flexible diaphragm). The average variation between the two systems diverges from 55-72(%).

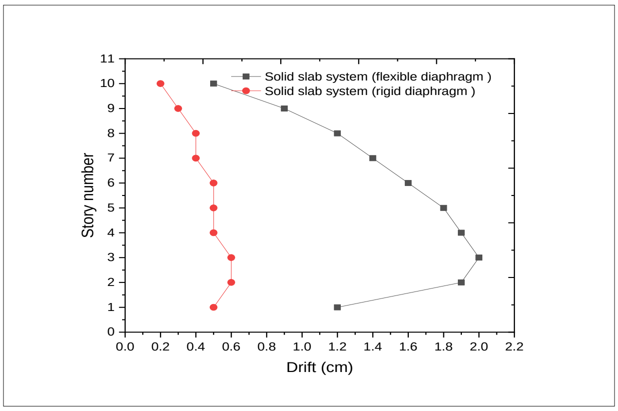

Figure -27: Story drift in X-direction (dr Ux) for10storey building

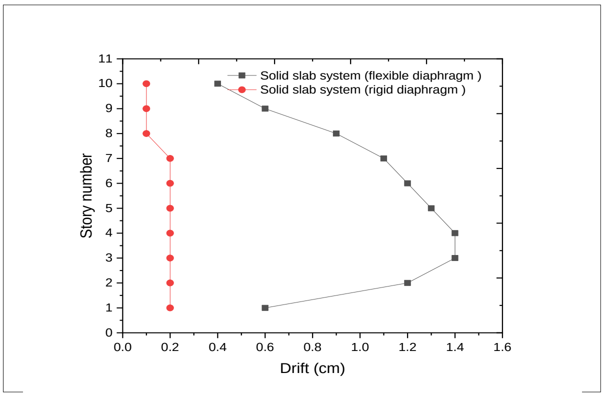

Figure -28: Story drift in Y-direction (dr Uy) for10storey building.

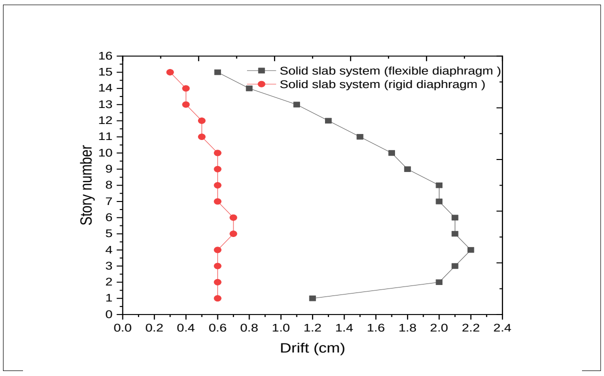

Figure -29: Story drift in X-direction (dr Ux) for15storey building.

ISSN NO: 2770-4491
Date of Publication:28-06-2022

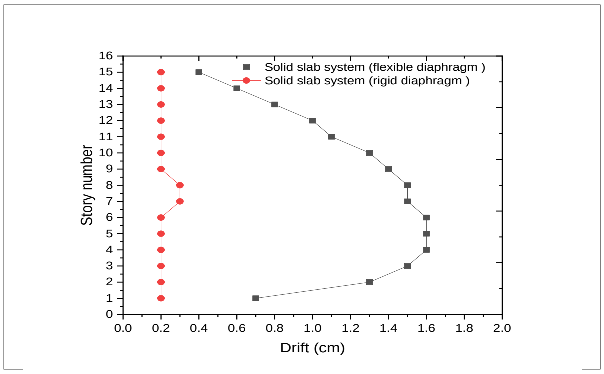

Figure -30: Story drift in Y-direction (dr Uy) for15storey building.

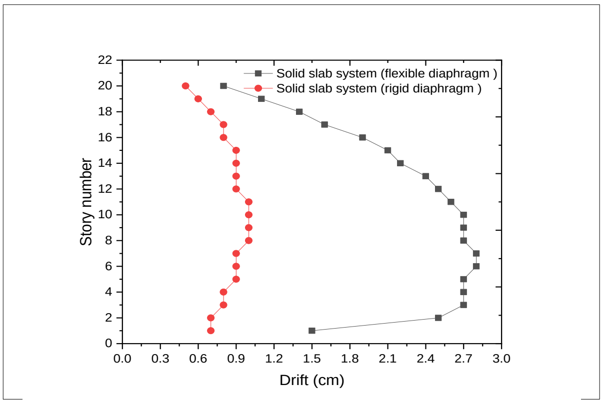

Figure -31: Story drift in X-direction (dr Ux) for20storey building

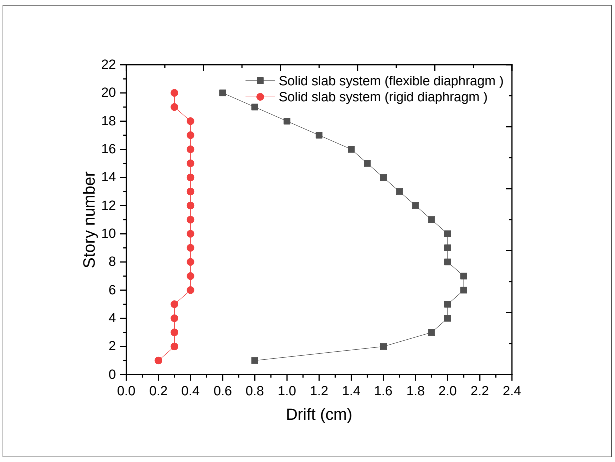

Figure -32: Story drift in Y-direction (dr Uy) for20storey building

V. Conclusions

This paper is going to present a synopsis for the work of this project, for the system with solid slabs (rigid diaphragm) and the system with solid slabs (flexible diaphragm) buildings for the different heights of the floor in the seismic areas. The seismic load effect that has been elaborated for those building's types with variation of the height. According to the results' basis the conclusions that have been drawn as following:

1. The moment is fullest at the ground level (storey 1) and the first level (storey 2). Moments after the first level are declining and incrementing at the upper storey.
2. The behavior of the column varies as the building's height increments.
3. The designed columns for the in-plane combo of the dead, live and earthquake loads, for all the situations and the in-plane load combo is being generality critical.

ISSN NO: 2770-4491
Date of Publication:28-06-2022

4. The moments of the columns are extra in system of solid slabs (flexible diaphragm) comparing with system of solid slabs (rigid diaphragm) buildings.
5. The moments of the Column in the system of solid slabs (flexible diaphragm) diverge from 6 to 24% in comparing with the system of solid slabs (rigid diaphragm) relying on the storey.
6. From the results of in-plane load analysis we can notice the axial load is bigger in the system of solid slabs (rigid diaphragm) as comparing with the system of solid slabs (flexible diaphragm). The variation between those two systems diverges up to 20.6%.
7. For all kinds of buildings the base shear is going to be fullest at the ground level (story1). After the ground level the base shear declines as long as the building's height increments. Drastically the base shear is going to increments as long as the building's height increments.
8.the base shear of the system with solid slabs (flexible diaphragm) building is going to be as same as the value of the system with solid slabs (rigid diaphragm) building.
9. The horizontal displacements (both Ux and Uy) is going to be fullest at the terrace level for all kinds of buildings. The horizontal displacement increments as long as the level of the storey increments.
10.The horizontal displacement is going to be incrementing as long as the building's height incrementing. The horizontal displacement of the system with solid slabs (rigid diaphragm) building is going to be smaller than the system with solid slabs (flexible diaphragm) building. The variation between the two systems diverges from 65 to 69(%).
11. The natural time period is going to be incrementing as long as the building's height incrementing (No of stories).
12. In differentiation of the system of solid slabs (flexible diaphragm) building and the system of solid slabs (flexible diaphragm) building, the time period is extra more for the system of solid slabs (flexible diaphragm) building than the system solid slabs (rigid diaphragm) building. The variation between those two systems diverges from 50 to 52(%).
13. The time period is going to be at phase 1, 2 and 3. After the phase 3, time period is going to be declining drastically.
14. The storey drift in both directions (dr Ux, dr Ux) is going to be fullest at the fourth level for the system of solid slabs (flexible diaphragm) and for the system of solid slabs (flexible diaphragm), the storey drift (dr Uy) is going to be fullest at the fourth level for the system of solid slabs (flexible diaphragm) and the system of solid slabs (flexible diaphragm). For the building with 15 storeys, the storey drift (dr Ux) is going to be fullest at the sixth level for the system of solid slabs (flexible diaphragm) and for the system of solid slabs (flexible diaphragm), the storey drift (dr Uy) is going to be fullest at the fifth level for the system of solid slabs (flexible diaphragm) and the system of solid slabs (flexible diaphragm). For the building with 20 storey, the storey drift (dr Ux) is going to be fullest at the seventh level for the system of solid slabs (flexible diaphragm) and for the system of solid slabs (flexible diaphragm), the storey drift (dr Uy) is going to be fullest at the sixth level for the system of solid slabs (flexible diaphragm) and the system of solid slabs (flexible diaphragm).
15. After the fourth ,fifth ,sixth and seventh levels the storey drift would be declined as long as the building's height incremented.
16. The storey drift in the building's system with of solid slabs (flexible diaphragm) is clearly extra more as we are comparing with the system of solid slabs (rigid diaphragm) building. The variation between the two systems diverges from 55-72(%).

References

1. Autodesk Robot Structural Analysis Professional 2020 © 2019 Autodesk, Inc.
2. Amar Singh Thaku, they studied about Response Spectrum Analysis of RC Buildings with and without Rigid Slab Modeling, IJSRD - International Journal for Scientific Research & Development
3. Dr. S. N. Tande & S.A.Devarshi, Diaphragm Flexibility in Buildings with Shear Walls (2014).

ISSN NO: 2770-4491
Date of Publication:28-06-2022

4. Jadhav Anupriya Pramod, S.A. Karale, U.S. Ansar, Analysis of Floor Diaphragm in Multi – Storied Reinforced Concrete Building, International Advanced Research Journal in Science, Engineering and Technology (IARJEST).
5. Kehila, Zerzour and Remki, Deformability of floors under the effect of seismic actions.
6. Kehila Fouad ,Zerzour Ali &Remki Mustapha, Structural Analyses with Flexibility Effect of the Floor slab.
7. Khajedehi and Panahshashi, Non-linear Finite Element analysis of RC structure floor diaphragms with openings.
8. Viswanathan, T.S, Ganesh, G.M., Santhi, A.S. (2012), Shear stress distribution of flat-plate using Finite Element Analysis, International Journal of Civil and Structural Engineering, Vol. 2, Issue 3, pp. 914-923.
9. Agarwal. P. and Shirkhande.M, “Earthquake resistant Design of Structures” Printice- Hall of India Private Ltd. New Delhi, India.
10. Alpa Sheth“Effect of perimeter frames in seismic performance of tall concrete buildings with shear wall core and flat slab system” The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China.
11. Apostolska1 R.P and Necevska-Cvetanovska G. S, “Seismic performance of flat-slab building structural systems” The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China.
12. Bhavikatti S.S, “Advance R.C.C. Design” , New Age International (p) Limited, Publishers, New Delhi, India.
13. Ema COELHO, Paulo CANDEIAS, Raul ZAHARIAand Artur V. PINTO, “Assessment of the seismic behavior of R C flat slab building structures”, 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004 Paper No. 2630
14. Prof. K S Sable, Er. V A Ghodechor, Prof. S B Kandekar,“ Comparative Study of Seismic Behavior of Multistorey Flat Slab and Conventional Reinforced Concrete Framed Structures”, Volume 2, Issue 3, June 2012
15. Lan N .Robertson, “Analysis flat slab structures subjected to combined lateral and gravity load”, ACI Structural Journal.
16. Garg c.s, Yogendrasingh, Pradeep Bhargava and Bhandari N.M, “Seismic performance of flat slab shear wall system”, Journal of structural Engineering, Vol.37, No.3, August-September2010, PP.203-207.
17. Shyh-jiann Hwang and Jack p. moehle, “Models for laterally loaded slab-column frames”, ACI Structural Journal, March-April 2000
18. Mohammed A.Hassan[1], MOHAMMED F. HASAN [2], Osamah I. Mahmood[3],Dr.Ali A. Habeeb[4]., Investigate the Effect of using the Edge Beams in Flat slab system on the Structural Behavior of Multistoried Building subjected to seismic loads, REVISTA AUS 25,pp144-154.

.19