Study of Nonlinear Analysis ONE-WAY Ribbed Reinforced Concrete Slab of The Tall Building Subjected to Seismic Load

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Abstract— Study is aimed to investigate of stresses nonlinear analysis one way ribbed reinforced concrete slab of the tall building (10 stories) subjected to seismic load. Although structures are often designed to resist seismic loading using elastic analysis, nearly all experience considerable inelastic deformations when subjected to great earthquakes. Current performance- based design techniques have need of traditions to resolve the practical performance of buildings subjected to such circumstances. Facilitated by innovation in technology along with accessible experiment facts, nonlinear analysis presents the methods for calculating structural reaction outside the elastic range, together with stiffness and strength weakening connected with inelastic behavior of material and huge displacements. Therefore, nonlinear analysis is capable of playing a significant position in the analysis of design of present and upcoming buildings. SAP2000 program is used to conduct the nonlinear direct integration analysis and estimation of stress and maximum displacement of the tall building. The reinforcement of layered shell element is assumed as a smeared bar. The results showed that the stress and maximum displacement for one way ribbed slab are less when compared with those solid slab in tall buildings and this reduced start to decreasing with increase in number of stories In addition, It can be noted that the maximum response displacement in case of ribbed slab subject to seismic loading is reduced by 34% than displacement of solid slab and this reduced start to decreasing with increase in number of stories. Stresses value in ribbed slab are smaller about 23% than stresses in solid slab.

Index Terms— SAP2000, finite element, displacement, Solid slab, ribbed slab

1 INTRODUCTION

The Display execution based seismic tremor configuration includes finding presentation positions and reviewing endorsement definitive components for that a structure is to be outlined. Presentation positions in unequivocal quality of earth convulsing should be affirmed by method for appropriate claim components and endorsement criteria. The presentation endorsement apportions might be spelled for the general coordination, establishment, or constituents of the structure. In support of a predetermined structure as well as groups of interest constraints, the construction is required to be displayed plus dissected in order for estimations of the request constraints are ascertained by way of adequate exactness in favor of configuration uses. The execution is verified by looking at the computed estimations of interest constraints (that is to say "requests") to the acknowledgment standards ("limits") intended for the craved execution stage. Thus, ascertained requests and acknowledgment measures are regularly looked at by use of "request limit" proportions.

This acknowledgment standards intended for seismic execution may possibly fluctuate contingent upon if static before element nonlinear investigations are utilized and for which instabilities connected by way of the requests as well as acknowledgment measures are taken care of. To give an example, the part representations, request factors, along with acknowledgment standards utilized as a part of nonlinear static methods need to verifiably represent cyclic debasement impacts that are not displayed in the static examination. Then again, some dynamic examination models may specifically join debasement because of cyclic stacking, and therefore diverse models and acknowledgment criteria might be utilized.

Acknowledgment standard applied in basic segments by and large recognized "misshapening controlled" (pliable segments which are capable of enduring inelastic disfigurements) as well as "constraint restricted" (rigid segments for which limits are represented through quality). As a general rule, most parts show some measure of inelastic twisting, and the refinement amongst compel and misshapening controlled segments is not outright. By and by, the refinement gives a reasonable way to deal with buildup prerequisites for the investigation and plan. Disfigurement controlled parts must be displayed as inelastic, though compel controlled segments might be demonstrated as versatile, gave that the drive requests don't suggest huge yielding in the segments. American Society of Civil Engineers 41 characterizes twisting and quality acknowledgment standard for instant tenancy, safety of lives, and prevention of collapses execution stages, and gives direction on criteria to the onset of auxiliary harm and critical quality/firmness debasement [1].

Relocations, speeds, and increasing velocities are extra request parameters that can give bits of knowledge towards the general structure reaction along with harm to non-structural segments as well as substance. The racking of storeys distortions (that are capable of regularly being estimated by storey float proportions) give the decent quantify of general basic reaction, counting the perpendicular dispersion of disfigurements and worldwide rotation of the structure, in addition to requests inside twisting touchy segments, for example, the building façade, inside parcels, or adaptable channeling frameworks. Crest floor increasing speeds and speeds are usually used to plan and survey execution of firm quickening touchy building segments, for example, unbendingly moored gear, raised floor

frameworks, supported roof frameworks, and inflexible channeling frameworks.

2 LITERATURE REVIEW

The factors of non-linear dynamic analysis

2.1 The foundation designed for the Analysis

Within static methodology, the auxiliary representation is focused on an increased parallel weight for which the conveyance speaks to inactivity powers anticipated amid earth quaking. The sidelong weight are connected awaiting forced relocations to achieve supposed "goal removal," that speaks to such uprooting requests that the seismic tremor earth movements can force on top of the building. When stacked to objective relocation, the request standard intended for the auxiliary segments is contrasted and separate acknowledgment measure in support of the wanted execution shape. Framework request standards, for example, story floats and foundation cut off, can likewise be evaluated. This non-linear static system is relevant to relatively small-ascent consistent structures, in which the reaction is commanded by means of central influence method of shaking. This is not appropriate for high, thin, and otherwise sporadic structures, in which different shaking styles influence the conduct. [2].

2.2 The analysis techniques, representation, and result

This non-linear firmness as well as quality intended for parts is demonstrated in view of a cyclic envelope bend, which certainly represents debasement because of cyclic stacking that is normal under seismic tremors. Burdens are connected at hubs where dynamic idleness strengths would create and they get expanded devoid of weight inversions. A power position is characterized in support of the objective uprooting, for the most part on the pinnacle (rooftop height) of the structure. This design intended for the subsequent foundation shear compel because the component of the power summit (rooftop) dislodging is frequently perceived to be the "sucker bend" of the building. The sucker bend is capable of being disentangled through glorified slanting stems of flexible, solidifying and reduce (corrupting) conduct, and used to inspect general building execution. FEMA 440 and 440A portray how the glorified sucker bend has been utilized as a part of streamlined nonlinear element investigations to build up least quality criteria for sidelong element precariousness. FEMA 440A additionally gives direction on the most proficient method to lead improved nonlinear element examinations on a structure-particular premise to decrease the instability in the ascertained target uprooting, in respect to the default strategy in American Society of Civil Engineers 41. [3].

2.3 Computation of seismic claims

This aggregate magnitude weight ought to get connected in order to begin with, preceding the incremental horizontal load, to catch the impacts of gravity-initiated powers and P-Δ consequences for part yielding and the post-crest reaction. The sidelong load appropriation ought to mirror the normal dormancy powers at each storey height, typically corresponding to each storey weights as well as the modular state of each key mode. The rest of the parallel compel circulations might be utilized to additionally investigate the reaction. Notwithstanding, contemplates have demonstrated they do not enhance the precision of a non-linear system [4]. The examination is directed until the uprooting at the control point achieves the objective dislodging. A few techniques are accessible for figuring the objective removal, the two most common being the purported "coefficient strategy" and the "limit range technique" (FEMA 2005). In American Society of Civil Engineers 41, the objective relocation is resolved utilizing the coefficient strategy as the result of the flexible ghastly dislodging and three change variables. The flexible ghostly uprooting is communicated as an element of the versatile otherworldly speeding up and the compelling time frame. The three alteration coefficient degree of the ghostly relocation to the pinnacle removal, ordinarily located where rooftop level is; modify for non-elastic impacts as part of an element inside the proportion of flexible compel requests to the auxiliary quality, along with (3) change for solidness plus quality corruption, in addition to squeezing. This option limit range technique utilizes the ideas of identical linearization whereby a compelling time of vibration and proportionate thick damping are resolved from the weakling bend. The convergence of the weakling bend with the limit range bend characterizes the objective removal (or execution point) [2].

2.4 Acceptability Criteria and Performance Evaluation

At a given target uprooting, the nonlinear static methodology characterizes drive, disfigurement, or pliability requests in the basic parts. American Society of Civil Engineers 41 characterizes two adequacy criteria, one managing neighborhood segment measures to drive restricted and otherwise disfigurement restricted parts, and a following test for general solidness. These nearby tests are characterized by means of contrasting each figured requests each the segment acknowledgment standard. Sections 4-8 of American Society of Civil Engineers 41 indicate part demonstrating. [3].

3 THE FINITE ELEMENT METHOD

An ordinary exertion effort of the coordination incorporates separating the space of the matter at hand into a collection of junior-field, each junior field addressed by a course of action of segment conditions to the principal matter, trailed by deliberately putting together all plans of segment conditions into an overall game plan for conditions in the final check. The overall game plan of conditions has known course of action frameworks, and can be learned from the basic evaluation of the main problem to get a mathematical answer. [5].

In the underlying stride over, the segment conditions are clear conditions that privately derived the primary complex conditions that can be considered, in which the principal conditions are routinely inadequate differential conditions (Partial Differential Equations). To illuminate the figure in this system, FEM is ordinarily exhibited in an outstanding case of Gale family technique. The methodology, in logical lingo, is to fabricate a crucial of the inner aftereffect of the remaining and the weight

limits and set the fundamental to zero. In direct expression, it is a technique that reduces the screw up of estimation by using experiment restrictions in the Partial Differential Equations. The extra is the mix-up realized by the examination limits, and the influence limits are polynomial calculated approximately that wander the waiting. The methodology takes out all the spatial auxiliaries from the Partial Differential Equations, subsequently estimating the Partial Differential Equations locally with an arrangement of arithmetical conditions for continuing condition matters and an arrangement of typical differential conditions for temporary matters [6].

The condition positions are the segment conditions. They are immediate to each major Partial Differential Equations are straight, and a different way. Arithmetical condition positions that develop in the constant situation issues are handled using mathematical direct factor based arithmetic methodologies, while regular degree of difference condition sets that rise in the temporary issues are fathomed by arithmetical mix using typical strategies e.g. Euler's system or Runge-Kuttas technique. [5].

As stated above, an overall course of action of conditions is made from the part conditions through a change of headings from the sub-fields neighborhood center points to the region's overall centers. This change joins reasonable presentation alteration as associated in association with the proposition encourage structure. The technique is frequently finished by Finite Element Method programming using coordinate data made from the sub-fields. [6].

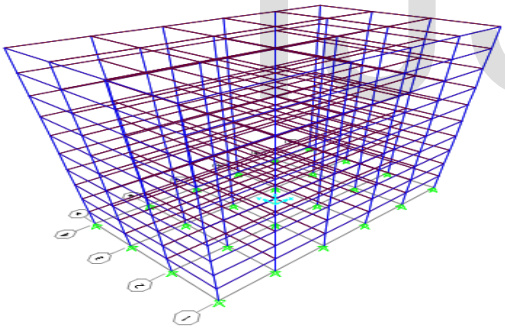

Figure 1: An SAP model of the Building

4 ANALYSIS OF THE ONE-WAY RIBBED SLAB

The ribbed piece is broke down in the customary strategy as indicated by the Egyptian code as strong piece. In this strategy "customary' the basic arrangement of the ribs is considered as bars upheld on fundamental cross bars which are considered as inflexible backings. The supporting pillars are thought to be straightforward if there is one narrows piece and proceeds supporting pillars if there are more than one inlet. On this rule, which is said already the twisting minutes, are resolved. As suggested in this technique, strong parts must be utilized at the association of the ribs with the upheld bar. These strong parts oppose the interior powers, which are higher than the stacking limit of the ribs with no impact on the interior strengths. In the restricted ribbed piece where the ribs are in one bearing, it is expected that the heaps are circulated toward the ribs just .so the heap which is exchanged through every rib is as per the following :-

w=W*s … . (1)
Where: w = the heap of every rib/m`
W = the heap followed up on section/m2
s = the separation between the ribs

From the past investigation of the ribbed section in the conventional techniques, it is noticed that the accompanying presumptions are mulled over-

i. The stack totally exchanges from the section to the ribs in any case the solidness of the section and ribs.
ii. Ribs are bolstered on the shaft which considering as unbending backing.
iii. Both the width and the thickness of strong parts have no impact on the conduct of the rib.

As a consequence of the past talk about the customary technique, there is need to concentrate different techniques for examination considering these elements utilizing the limited component hypothesis through sap 2000 program. The proposed display gives the conduct for ribbed chunk by investigating the structure as one-join in two measurements. In this strategy, the structure is isolated to edge components and shell components. Hardens network for these components are resolved. This technique contemplates the misshapenings happened in all components, for example, vertical removals and pivots in the two headings x, y, and finding the inside powers delivered in these components. The section has been partitioned to edge components to speak to ribs and pillars, and shell components to speak to the section and strong part. Edge and shell depict the cross-area of at least one component. Every edge component has its own neighborhood facilitate framework used to characterize area properties and burdens. The tomahawks of this neighborhood framework are signified 1, 2 and 3.

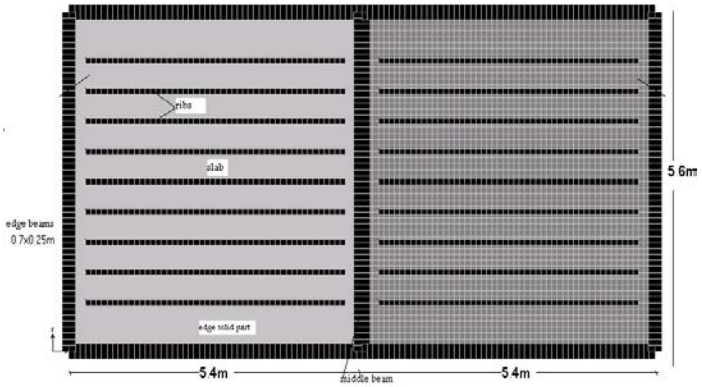

Figure 2: An SAP model of the slab

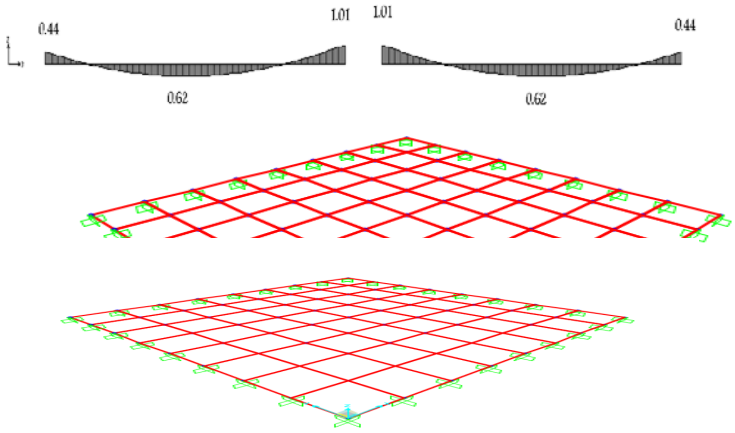

Figure 4: Shell analysis from present study

The principal pivot is coordinated along the length of the component; the staying two tomahawks lie in the plane opposite to the component with determined introduction. Additionally every shell component has its own neighborhood organize framework used to characterize material properties and burdens. The tomahawks of this neighborhood framework are indicated 1, 2 and 3. The initial two tomahawks lie in the plane of the component with determined introduction; the third hub is typical to the plane. Two inlets one way ribbed section is investigated by both customary and limited component strategies to decide the prompted snapshots of the rib. The measurements of every cove are 5.6x5.4m. The ribs have cross segment 0.1x 0.25m and the space between ribs is 0.5m. The thickness of top piece equivalents to 0.05m. The cross-area of edge pillars is 0.25x0.7m and the cross segment of center pillar is 0.3x0.9 m. the width of strong part in both bearing equivalents to 0.3m. The Slab is subjected to uniform load 1 t/m2 and as appeared in Figure 2.

5 METHODOLOGY

The finite element dynamic analysis was applied through using SAP2000 software and the results are as shown below:

SAP2000 Analysis on Building Case 1

SAP2000 v18.2.0 Ultimate 64-bit (Analysis Build 9503/64)
File:
D:\Attachment\2015\Raghvani\Apartments\Architectural\23-09-15\Sap2000.LOG

Begin analysis 2016/12/08, 09:39:32
Running analysis within the gui process
Using the advanced solver (provides limited instability information)
Number of joints = 1154
Number of frame/cable/tendon elements = 922
Number of link/support elements = 31
Number of load patterns = 1
Number of acceleration loads = 9
Number of load cases = 2
Addressable physical memory (ram) = 3.803 gb
Parallelization of analysis operations:
(env. Variable sapfire_num_threads = 0)
Number of threads: state (automatic) = 2
Number of threads: stiffness (automatic) = 2
Number of threads: event (automatic) = 2
Number of threads: move (automatic) = 2
Number of threads: response (automatic) = 2
Number of threads: solve (automatic) = 2
Element formation 09:39:32
Linear equation solution 09:39:32
Forming stiffness at zero (unstressed) initial conditions
Total number of equilibrium equations = 6924
Number of non-zero stiffness terms = 57858
warning
The structure is unstable or ill-conditioned!!
Check the structure carefully for:
- Inadequate support conditions, or
- One or more internal mechanisms, or
- Zero or negative stiffness properties, or
- Extremely large stiffness properties, or
- buckling due to p-delta or geometric nonlinearity, or
- A frequency shift (if any) onto a natural frequency

To obtain further information:
- use the standard solver, or
- run an eigen analysis using auto frequency shifting (with Additional mass if needed) and investigate the mode shapes

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Basic stability check for linear load cases:
Number of negative stiffness eigenvalues should be zero for stability.
(Note: further checks should be considered as deemed necessary,
Such as reviewing eigen modes for mechanisms and rigid-body motion)
Number of negative eigenvalues = 309
warning
The structure is unstable or ill conditioned!
Linear static cases 09:39:33
Using stiffness at zero (unstressed) initial conditions
Total number of cases to solve = 1
Number of cases to solve per block = 1
Linear static cases to be solved:
Case: dead
Eigen modal analysis 09:39:33
Case: modal
Using stiffness at zero (unstressed) initial conditions
Number of stiffness degrees of freedom = 6924
Number of mass degrees of freedom = 3306
Maximum number of eigen modes sought = 12
Minimum number of eigen modes sought = 1
Number of residual-mass modes sought = 0
Number of subspace vectors used = 24
Relative convergence tolerance = 1.00e-09
Frequency shift (center) (cyc/time) = .000000
Frequency cutoff (radius) (cyc/time) = -infinity-
Allow automatic frequency shifting = yes
Original stiffness at shift : ev= 0.0000000e+00, f= .000000, t= -infinity-
Number of eigenvalues below shift = 309
Number of eigen modes found = 0
Number of iterations performed = 13910

Number of stiffness shifts = 0
Sap2000 v18.2.0 ultimate 64-bit (analysis build 9503/64)
File:
d:\attachment\2015\raghvani\apartments\architectural\23-09-15\sap2000.log
B e g i n a n a l y s i s 2016/12/08 10:10:33
Running analysis as a separate process
Using the advanced solver (provides limited instability information)
Number of joints = 1154
Number of frame/cable/tendon elements = 922
Number of link/support elements = 31
Number of load patterns = 1
Number of acceleration loads = 9
Number of load cases = 2
Addressable physical memory (ram) = 3.803 gb
Parallelization of analysis operations:
(env. Variable sapfire_num_threads = 0)
Number of threads: state (automatic) = 2
Number of threads: stiffness (automatic) = 2
Number of threads: event (automatic) = 2
Number of threads: move (automatic) = 2
Number of threads: response (automatic) = 2
Number of threads: solve (automatic) = 2
E l e m e n t f o r m a t i o n 10:10:33
L i n e a r e q u a t i o n s o l u t i o n 10:10:33
Forming stiffness at zero (unstressed) initial conditions
Total number of equilibrium equations = 6924
Number of non-zero stiffness terms = 57858
* * * w a r n i n g * * *
The structure is unstable or ill-conditioned!!

6 DISCUSSION

It can be noted that the maximum response displacement in case of ribbed slab subject to seismic loading is reduced by 34% than displacement of solid slab and this reduced start to decreasing with increase in number of stories as table (1). Stresses value in ribbed slab are smaller about 23% than stresses in solid slab as table (2). This can be justified due to the higher stiffens of the ribbed slab and its lighter weight compared to the solid slab. Since it is stated that the inalienable inconstancy for reaction of buildings to tremor earth movements as well as numerous streamlining suppositions stated for examination, the consequences of whichever straight and otherwise non-linear investigation intended for seismic tremor execution ought to be translated through great concern. Although non-linear element investigations are, given principle, giving additional practical measures of reaction compared to different techniques, this dependability on non-linear element examinations is capable of being touchy for displaying presumptions and measures. Hence, the initial stride earlier than a few translations of consequences ought to set up trust for the unwavering quality of the representation by means of systems, for example, depicted in Moreover, non-linear investigations are capable of being utilized to expand the non-linear element examination for questioning basic conduct and the impact of configuration changes on the requests.

TABLE (1)
Maximum displacement of solid and one way ribbed slab

STOREY	Maximum displacement in Solid slab	Maximum displacement in one way Ribbed slab
Story 1-9	**0.009783**	**0.009002**
Story 1-8	**0.009268**	**0.00848**
Story 1-7	**0.008645**	**0.007872**
Story 1-6	**0.007909**	**0.007173**
Story 1-5	**0.007057**	**0.006379**
Story 1-4	**0.006086**	**0.005487**
Story 1-3	**0.004993**	**0.004491**
Story 1-2	**0.003781**	**0.003187**
Story 1-1	**0.002435**	**0.002069**
Story 1	**0.001021**	**0.000674**

TABLE (2)
Maximum compression and tension stress of one way ribbed slab and solid slab

	Stress in Solid slab		Stress in one way Ribbed slab	
Floor No.	σ_x (Mpa)	σ_y (Mpa)	σ_x (Mpa)	σ_y (Mpa)
Story 1-9	2.324	1.354	2.275	1.293
	-21.874	-2.989	-21.678	-2.874
Story 1-8	2.844	1.672	2.658	1.586
	-22.494	-3.483	-22.122	-3.248
Story 1-7	3.225	1.911	3.098	1.877
	-23.084	-3.968	-22.791	-3.545
Story 1-6	3.966	2.325	3.966	2.123
	-23.734	-4.453	-23.145	-4.089
Story 1-5	4.491	2.733	4.045	2.498
	-24.283	-4.913	-23.635	-4.734
Story 1-4	5.102	3.192	4.798	2.975
	-25.086	-5.564	-24.143	-5.174
Story 1-3	5.635	3.673	5.201	3.369
	-26.534	-6.045	-24.935	-5.894
Story 1-2	6.331	4.130	6.331	4.130
	-27.95	-6.976	-25.633	-6.474
Story 1-1	6.971	4.879	5.161	4.282
	-29.31	-7.802	-26.753	-7.014
Story 1	7.58	5.434	5.824	4.654
	-30.41	-8.962	-27.486	-7.648

7. CONCLUSION

The outcomes appeared here of the request parameters that

would should be checked at proper seismic tremor power stages. For examination functions, the storey float proportions in element investigations are plotted at relating ground movement forces. In this case, the distinctions in middle float proportions from these two techniques are somewhat unobtrusive, particularly in contrast with the vast inconstancy among individual ground movement. The results showed that the stress and maximum displacement for one way ribbed slab are less when compared with those solid slab and this reduced start to decreasing with increase in number of stories. In addition, the Stresses value in ribbed slab are smaller than the stresses in solid slab .

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