P-DELTA analysis on steel fiber reinforced concrete structure using ETABS

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***Abstract* — The intend of this research work is to introduce the application of SFRC (Steel Fiber Reinforced Concrete) as a structural material and the importance of P Delta analysis in highrise building, for this purpose first the previous research work was referred that have been done to obtain various important mechanical properties of SFRC which helps us to understand its behavior as a structural element. The material was simulated using software after the qualities were determined by experimental material testing study guidelines on SFRC. This study was conducted using ETABS 18.0.0. The P Delta study of a G+9 story RC frame structure was modified to use conventional M40 grade concrete, and the findings unmistakeably demonstrated that the SFRC building model had outperformed it under seismic stress.**

Keywords – Steel Fiber reinforced concrete, P-Delta effect, Linear Static Analysis, ETABs.

1.INTRODUCTION

Generally to calculate displacement, moments and design forces brought on by loads acting on a structure, structural designers employ linear static analysis, sometimes referred to as first order analysis. First order analysis is carried out by imagining minor deflection behavior, where the resulting forces, bending moments, and displacements do not account for the additional effect caused by the sudden changes in structure under vertical load before applying lateral loads. The structure experiences P-Delta effects when the structure elements are subjected to an axial load. In terms of deformation, it is one of the second order effects that correlates to the load applied to the structure. it is second order impact that is connected to the applied axial load and displacement. Every construction that has elements that are exposed to axial load experiences the nonlinear phenomenon known as P-Delta. Actually P-Delta is just one of several second-order effects. It is a “genuine effect” that is connected to a displacement (Delta) and the size of the applied axial load (P)

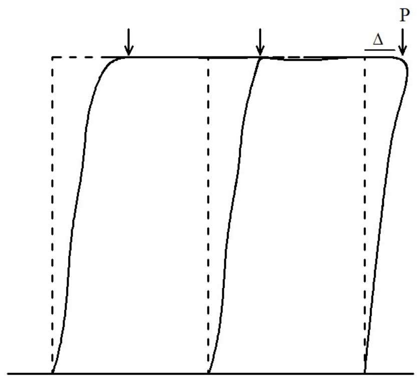

Fig 1: P- Delta

Steel fiber-reinforced concrete (SFRC) has become a practical way to provide ductility during both compressed post-peak softening behaviour and tensioned post-cracking behaviour. It has been discovered that using SFRC as a structural part also somewhat increases its ductility, which may make it a better material when subjected to seismic loads. Steel fiber reinforced concrete (SFRC) stands out for its high tensile strength, resilience to impact, resistance to fatigue, ductility under flexure, and capacity to stop cracks. Additionally, they lessen concrete's permeability, which reduces water leaking. It is true that such a building material has been investigated for the construction of pavement for more than 40 years. For the purpose of comparing the effectiveness of SFRC to conventional concrete, numerous experimental studies have been conducted in the past to gather information on the impact of steel fibre and its combination on workability, compressive strength, flexural strength, and non-destructive testing (NDT), such as rebound hammer. Steel Fiber comes in a wide variety of forms, although the most commonly used forms are conventionally straight, hooked, crimped, and coned. The modeling of SFRC in the current framework uses a variety of mechanical characteristics of steel fibres with hooked ends.

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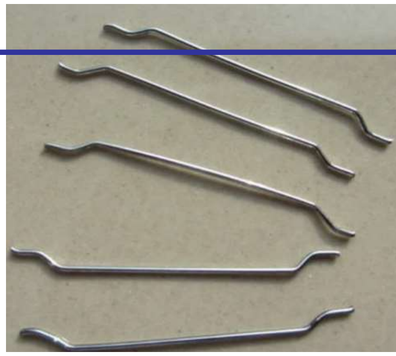

Fig 2: Hooked end steel fiber
https://5.imimg.com/data5/FS/CI/MY-4208505/hooked-steel-fiber-500x500.jpg

Fig 3: Steel fiber reinforced concrete
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According to experimental research investigations, concrete's compressive strength improves as the percentage of steel fibers exposed to the moment of hogging increases. According to earlier experimental research by [12], the strength-enhancing extremely high reinforced steel Fibre capacity Concrete strength (SFRC) has a volume of hooked-end steel Fibres in amounts of 0.5%, 0.75%, 1.0%, and 1.5%. In many different applications for wide blocks, such as heaw vibrating equipment frames, dolos shield systems, spillways, bridge overlays, etc., steel fibre reinforced concrete (SFRC) is used. The resistance, ductility, and durability of typical RC members under earthquake and blast stresses (dynamic loads) are also improved by the addition of steel fibres to concrete. Concrete cracks can be prevented from growing and enlarging by adding steel fibres; this may allow the use of high-strength steel bars without an excessive crack width or duty load deformation. The use of SRFC may help to some extent in reducing this issue by giving conventional RC members with better impact resistance, improving local damage and spreading resistance. Spalling of concrete is frequently encountered as a result of high loading and low confinement.

II. OBJECTIVE OF THE STUDY

- To evaluate construction using SFRC as a structural material both with and without with
- P-Delta effect using ETABS software
- To analyze building with Conventional RC structure with and without considering
- P-delta effect using ETABS software
- To determine the base shear, displacement, drift, and fundamental time period values' percentage changes.
- To compare the results of SFRC & RC framed structure
- To analyse the performance of the combined effect of suitable V bracing with FRP

III. MODELLING AND ANALYSIS

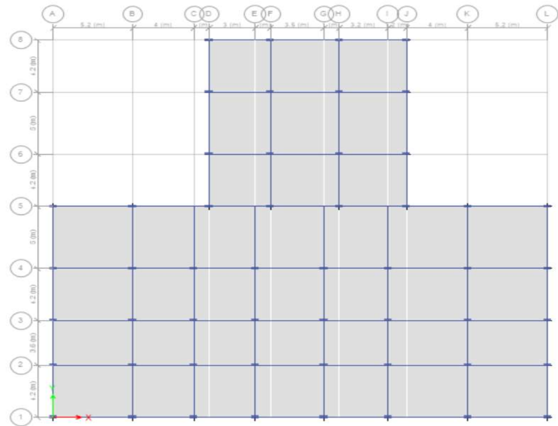

Fig 4: Plan of SFRC & RC Model

Geometry of the model:

No: of storey's	10
Storey height	Ground floor: 3m Typical floor: 3m
Live load	Typical floor: 3 kN/m Roof : 1.2 kN/m
Column	230mm x 500mm
Beam	230mm x 350mm
Slab thickness	150mm
Grade of concrete	M40
Grade of steel	Fe600

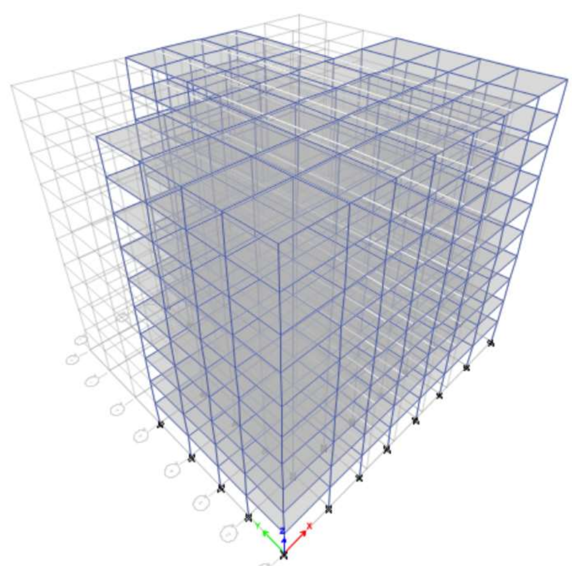

Fig 5: 3D – view

The steps for Modeling

1. Create a model
2. Enter storey details
3. Input material properties
4. Select frame section
5. Select section properties
6. Draw beam, column etc.
7. Define load patterns
8. Define load cases
9. Assign loads
10. Check model
11. Run analysis

Material properties of SFRC:

Properties	SFRC 3%
Unit weight	2660kg/m^3
Young's modulus	3751.6MPa
Poisson's ratio	0.2
Coefficient of thermal expansion	0.0000055
Shear Modulus	15631.94Mpa

The analysis of the SFRC structures is carried out using ETABS 2018 software. hooked end, steel fiber is used in the concrete. Here the linear and non-linear analysis of structures are done. The linear analysis is the dynamic analysis in order to perform the seismic analysis and design of the structures. Whereas the non-linear analysis is the P-Delta analysis of the structure to study the performance of the SFRC structures. The method involves the calculation of maximum values of the displacement and member forces in each mode of vibration. In this study the SFRC structures is analyzed considering with and without P-Delta effect. The models are analyzed for storey displacement, storey drift, base shear . The SFRC structures are analysed using the ETABS 2018 programme. Structures are analysed both linearly and nonlinearly here. In contrast, the P-Delta analysis of the structure is a non-linear analysis that is used to examine how well SFRC structures perform. The technique entails calculating the maximum displacement and member force values for each mode of vibration. The SFRC structures are examined in this work both with and without the P-Delta effect. Storey displacement, storey drift, base shear, and time period are all examined in the models.

The behaviour of the M 40 grade SFRC based G+9 storey model was studied using comparative seismic analysis. Only the beam and column materials were changed to 3% SFRC; the slab remained the same as standard M40 grade. The same model was compared to a traditional reinforced concrete model where all of the structural components, including the slab, columns, and beams, were made of standard M 40 Grade (0% SFRC). Following seismic examination of both models, a number of comparisons were made based on the different results outcomes.

Details of Loading:

The structure mainly undergone through four types of load cases in accordance with the Indian Standard code of practices for safety of the structure. They are given below.

1. Dead load [From IS:875-1987(Part I)]
2. Live load [From IS:875-1987(Part II)]
3. Seismic load [From IS:1893-2002
4. Wind load [From IS: 875-1987(Part III)]

Seismic Parameters

Seismic zone	V
Zone factor	0.36
Soil type	Medium
Damping percentage	5%
Response reduction factor	5
Importance factor	1
Zone factor	0.36

Wind Loading

Wind speed	39m/s
Category	2
Class	B
Risk factor	1

Linear static method:

With linear static analysis, we are unable to provide a response to the structure with regard to time. We may examine the minor deflections, bending moments, and shear forces of the applied load on the structure in this study. It is possible to integrate the outcomes of various load instances with those of other linear load situations, such as response spectrum analysis. Except for the P-Delta effect, geometric and material nonlinearity are not taken into account in a linear static analysis

Iterative based on mass:

A predetermined mixture of static load situations is used to calculate the load. The P-Delta load combination is what is meant by this. In this section, you select the single load combination that will be applied to the structure's first P-Delta analysis. The following load combinations must be taken into account during design, under the building code.

(1) 1.4 dead load

(2) 1.2 dead load + 1.6 live load

(3) 1.2 dead load + 0.5 live load + 1.3 wind load

(4) 1.2 dead load + 0.5 live load - 1.3 wind load

(5) 0.9 dead load + 1.3 wind load

(6) 0.9 dead load - 1.3 wind load

IV. RESULTS AND DISCUSSION

Each model has been analyzed and results are obtained. Results are compared on the basis of with considering and without considering P-Delta analysis. base shear, time period, and storey displacement are all completed. The modals are of steel fiber reinforced concrete structure and conventional reinforced concrete structures

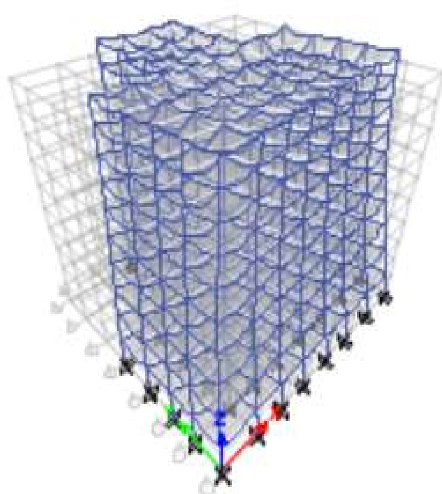

Fig 6: Deformation of structure after analysis

Maximum displacement of SFRC structure in mm

No: of storey's	Linear static analysis	P-delta Analysis
10	23.401	26.485
9	22.559	25.593
8	21.335	24.282
7	19.653	22.453
6	17.492	20.06
5	14.854	17.09
4	11.772	13.565
3	8.335	9.593
2	4.78	5.467
1	1.618	1.823

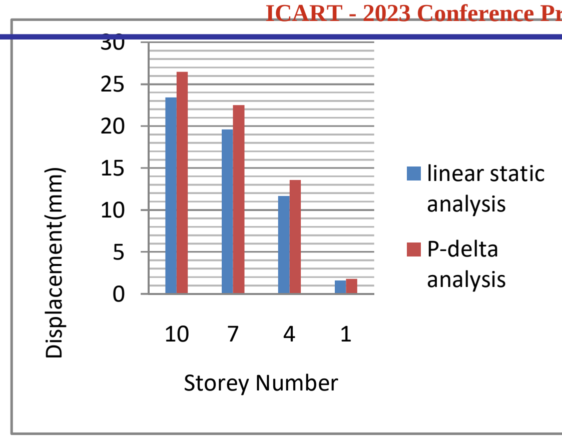

Fig 7: Displacement chart of SFRC model

Maximum displacement of RC structure in mm

No: of storey's	Linear static analysis	P-delta Analysis
10	27.775	32.137
9	26.774	31.068
8	25.32	29.493
7	23.324	27.290
6	20.759	24.399
5	17.628	20.78
4	13.970	16.514
3	9.891	11.676
2	5.672	6.647
1	1.92	2.211

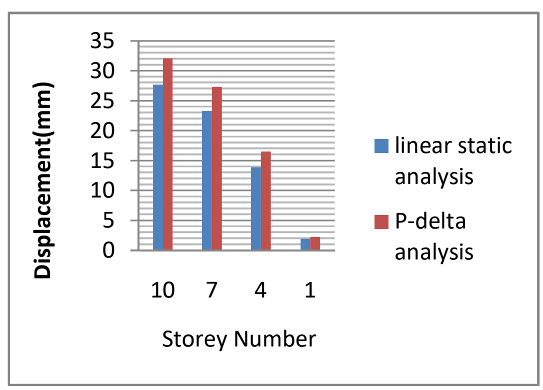

Fig 8: Displacement chart of RC model

Maximum displacement comparison of SFRC & RC structure in mm

No: of storey's	SFRC	RC
10	26.485	32.137
9	25.593	31.068
8	24.282	29.493
7	22.453	27.290
6	20.06	24.399
5	17.09	20.78
4	13.565	16.514
3	9.593	11.676
2	5.467	6.647
1	1.823	2.211

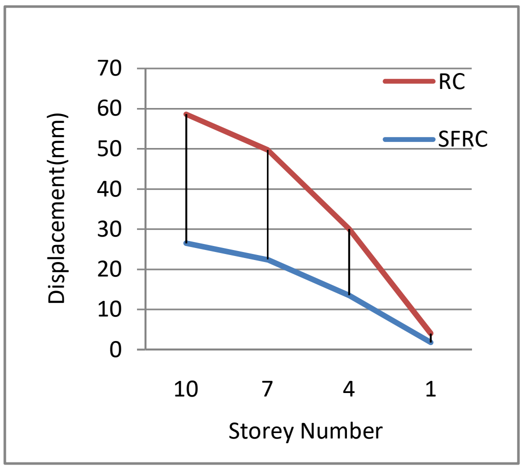

Fig 9: Displacement comparison of SFRC & RC

Storey drift of SFRC & RC structure without p delta

Storey no:	Storey drift SFRC	Storey drift RC
10	0.000428	0.000472
7	0.000856	0.001016
4	0.001307	0.001551
1	0.000614	0.000728

Storey drift of SFRC & RC structure with p delta

Storey no:	Storey drift SFRC	Storey drift RC
10	0.000417	0.000499
7	0.000952	0.001149
4	0.001534	0.001876
1	0.000711	0.000869

The above chart fig 5.3 is showing the comparison of maximum storey drift of Steel fibre reinforced concrete & conventional concrete structure. which indicate Maximum storey Drift at both top and 1st story of the building was found to be decreased in case of SFRC model

IX. CONCLUSION

Maximum storey displacement is decreased in case of SFRC Model also maximum storey Drift at both top and 1st story of the building was found to be decreased. The displacement effect of building models without p-delta is less when compare to building with P-Delta. Performance of the Steel Fiber Reinforced Concrete (SFRC) has shown a significant improvement in flexural strength and overall toughness compared against Conventional Reinforced Concrete. Behaviour of SFRC based model has shown significantly better performance under seismic loads, hence it can be opted as a seismic resistant material in future research work.

V. REFERENCE

[1] **Mohammed A. Mujalli; Samir Dirar, Emad Mushtaha,** “, Evaluation of the Tensile Characteristics and Bond Behaviour of Steel Fibre-Reinforced Concrete” MDPI Journal Issue 2 December 2022

[2] **Anurag Mishra, Kirti Chandraul, Manindra Kumar Singh., “**Experimental study on steel fiber reinforced concrete” IRJET journal of civil engineering, November 2017

[3] **Dharanedharan K S, Sivakumar C “**Significance Of P-Delta Effects In High Rise RC Structure In Various Seismic Zones. ”, International journal of aquatic science, February 2021.

[4] **NikunjMangukiya, Arpit Ravani, Yash Miyani**, “Study of P-Delta Analysis for RC Structure”, GRD, 2016.

[5] **Bhavani Shankar, Naveen Kumar**, “Study on Effects of P-Delta Analysis on RC Structures”, IRJET,2017.

[6] **Kumar,D.S. and Abraham,M.,(2019)**, “analysis of highrise building for p delta effect using e tabs”, Vol14, pg.176-179

[7] **Khan,M.A., Varshney,M.,Nagar,B.,(2019),** “analysis of p-delta effect on high rise building”, vol o6, pg.2060-2068

[8] **PhaniKumar.V, M.Deepthi, Saikiran K, R.B.N. Santhoshet.al,** “ Behavior of P-Delta effect in high- rise buildings with and without shear wall” IJRTE issued july 2019

[9] **Julian Carrillo, Julieth Ramirez, Juan Lizarazo-Marriaga**, “Modulus of elasticity and Poisson's ratio of fiber-reinforced concrete in Colombia from ultrasonic pulse velocities”, Journal of Building Engineering · May 2019,

[10] **Fang-Yuan Li , Cheng-Yuan Cao, Yun-Xuan Cui, and Pei-Feng Wu**, “Experimental Study of the Basic Mechanical Properties of Directionally Distributed Steel Fiber-Reinforced Concrete” Advances in Materials Science and Engineering, Volume 2018,

[11] IS:875(Part-I)-1987, IS:875(Part-II)-1987, IS:875(Part-III)-1987, IS 456 :2000 ,IS 800:2007, IS: IS:1893-2002

[12] ZHANG Ju, YAN Changwang, and JIA Jinqing, “Compressive Strength and Splitting Tensile Strength of Steel Fiber Reinforced Ultra High Strength Concrete (SFRC)”, Applied Mechanics and Materials Vols 34-35 (2010) pp 1441-1444 Online: 2010-10-25 © (2010) Trans Tech Publications, Switzerland doi:10.4028/www.scientific.net/AMM.34-35.1441

[13] **Mekala Prathap Reddy, Dr. K. Chandrasekhar Reddy** “Determination of Mechanical Properties of Steel Fiber Reinforced Concrete with Mineral Admixtures”, International Journal of Science and Research (IJSR), ISSN (Online): 2319-7064, Volume 4 Issue 5, May 2015

[14] **N.Anusha, AVS.Sai kumar**, “Experimental study of modulus of elasticity due to change in steel fiber reinforced concrete (SFRC) and size of aggregates” International Journal of Scientific & Engineering Research, Volume 6, Issue 7, July-2015, ISSN 2229-5518

[15] **Rao,M and Harsoor.R.S.,(2016)**, “Effect of P-delta in seismic analysis of multistory buildings”, Volume: 05