Scientific Journal of Impact Factor (SJIF): 5.71
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406
International Journal of Advance Engineering and Research Development
Volume 7, Issue 06, June -2020

"Comparative Analysis of Axial shortening with Respect to Time in Reinforced Concrete building"

Vimal H. Jogi[1] and Akash Jivani[2]

[1]*Student, M.E. Structural Engineering, Darshan Institute of Engineering & Technology, Rajkot*
[2]*Assistant Professor, Department of Civil Engineering, Darshan Institute of Engineering & Technology, Rajkot*

Abstract – *Axial shortening of columns due to long term creep and shrinkage is unavoidable in reinforced concrete building. However, calculation of exact value of axial shortening is not an easy task since it depends on a number of parameters such as the type of concrete, dimension of member, volume to surface ratio, reinforcement ratio, and the rate of construction stage. All these parameters may or may not be available to the design engineer at the preliminary design stage of construction. Furthermore, long term Axial shortening of columns could affect the horizontal structural members such as beams and floors and hence could affect the plaster, cladding and partitions. This paper presents a set of guidelines so that the effect could be considered approximately, especially at the preliminary design stage and also during the construction phase. In this study it is assumed, construction stage analysis considers the creep and shrinkage effects of a 35-story building consist of an exterior concrete frame and interior shear walls. The displacements of vertical members are evaluated by CEB FIP MC2010 and ACI209R. Also, Axial shortening compare by both method at different concrete age (Time dependent effect).*

Keywords – *Axial shortening, Construction stage, Creep, Shrinkage, CEB FIP MC2010 and ACI 209R*

I. INTRODUCTION

In Reinforce concrete buildings, the axial deformations of columns cannot be ignored, and special considerations are required for design and construction. A vertical member undergoes both elastic and inelastic deformation. Inelastic deformation due to creep and shrinkage. The elastic deformation takes place suddenly due to dead loads of structure and live loads applied to the structure, while deformation due to creep and shrinkage occurs over many years. Most of the vertical deformations in a reinforce concrete building, take place during its construction.

Due to the difference in axial stiffness and load distribution areas on vertical members, differential shortening unavoidably develops. If this differential shortening in vertical members, which takes place during and after the construction, is not considered in analyses of high-rise buildings, structural safety will be compromised due to additional stresses in the horizontal members and, then, in the vertical members. The structural safety problem is also magnified when incorporating serviceability issues such as the curtain wall function, floor unevenness, excess stress in piping, etc. As such, total displacements of vertical members must be calculated at the design stage. Comparatively reasonable and accurate results can be predicted when construction stage analysis is carried out reflecting the creep and shrinkage behaviour of concrete.

Vertical members (columns and walls) in high-rise reinforced concrete buildings not only exhibit elastic shortening, but also have shrinkage and creep effects that develop from long-term compressive loading. In lower stories of a building, additional stresses in girders become very large due to differential shortening and undergo significant redistribution of the member forces. In order to analytically solve the problem described above, the construction stage analysis function of Midas Gen for ACI 209R and Etabs for CEB FIPMC 2010 considers shrinkage and creep during construction stages to simulate the construction process of a reinforced concrete building. Also, with input variables, such as the strength of concrete, construction duration of building components, casting condition, ambient condition, etc., the elastic shortening, shrinkage and creep of vertical members can be predicted with also consider concrete age effect.

II. BRIEF REVIEW OF THE LITRATURE

Mark Fintel, S. K. Ghosh, Hal Iyengar (1987) [1] The total shortening may be as high as 1 in. for every 80 ft of height. The differential Shortening may cause distortion of slabs leading to impaired serviceability. This procedure has been verified and found to be in reasonable agreement with a number of field measurement of column shortening in tall structure that extended over periods of up to 19 year. HN Praveen Moragaspitiya (2011) [2] Develop a numerical method incorporating time dependent parameter to predict during design the axial shortening of column and core shear wall components of concrete building that will occur during construction and service life. Develop a post construction monitoring procedure that incorporate time dependent behaviour to quantify axial shortening using ambient measurement of vibration characteristics. A.p. Waghmare, P.A. Dode, H.S.Chore(2015) [3] The proportion of the deformations due to creep and shrinkage that contribute to the total amount of deformations is 61.7~73.6% for the column, and 70.1~83.1% for the shear wall. Therefor for concrete buildings, deformations due to the creep and shrinkage must be considered. Diptesh Patil, M. N. Bajaj (2016) [4] Inelastic shortening (due to creep and shrinkage) is 1.75 times the elastic shortening for a column and 3.38 times for wall element. The proportion of the deformations due to creep and shrinkage that contribute to the total amount of deformations is 63.57% and 77.18% for the shear wall. Mohammad jalilzadeh Afshari, Ali Khelyroddin, Majid Gholhaki(2017) [5] The long term behavior of special reinforced concrete moment frame structure in form of time dependent shortening of column in 1000 day has been evaluated using different nonlinear staged analysis. Alaa Habrah, Adid I. Abu-Tair (2018) [6] Column Shortening estimation highly affected by the chosen method of prediction. Etabs analysis using CEB-FIP method was able to predict the settlement better than the theoretical approach of the ACI model. The average overestimation of the developed excel sheet based on the ACI 209R-93 model was 630% and also the average overestimate of Etabs analysis based on the CEB FIB 90 model was 258%. Mutlu Secer, Tolga Arslan (2019) [7] Time-dependent effects and Modelling construction sequence plays important role in determining realistic behavior of reinforced concrete building constructions. Numerical analyses of 15 story reinforced concrete building show that vertical displacement of columns have changed considerably when conventional analysis results and construction sequence analysis results are compared. This study shows that's it is necessary to consider the construction sequence and time dependent shows that it is necessary to consider the construction sequence and time dependent effects in reinforced concrete building modelling if more realistic design is desired. Santos panigrahi, Dr.Vikram patil, Somanagouda takkalaki(2019) [8] D.L. and L.L. including earthquake and wind force combination in CSA are higher than conventional method. Nikunj D., Banugariya and S.S.Solanke(2019) [9]As Construction of structure progress time dependent properties impact more stresses on structural components and thus recently constructed upper floor shows more variation as compared to lower floor.

III. MODEL SUMMERY

3.1 Structure system

The structural system, as shown in figure 1, is a 35-story building constructed with core walls and perimeter RC columns & RC girders. In order to evaluate the influence that gravity has on the displacements of a vertical member, and the member forces of horizontal members, the member sections are selected according to the dead load and the live load. The typical plan view of a story as shown in figure 1. Size of element of structure is column 1750mm X1750mm, beam 1250mmX 1250mm, thickness of slab and shear wall 300mm and using M30 grade concrete. Take 10day per floor stage construction. Using Etabs software for CEB FIP MC2010 and Midas Gen for ACI 209R.

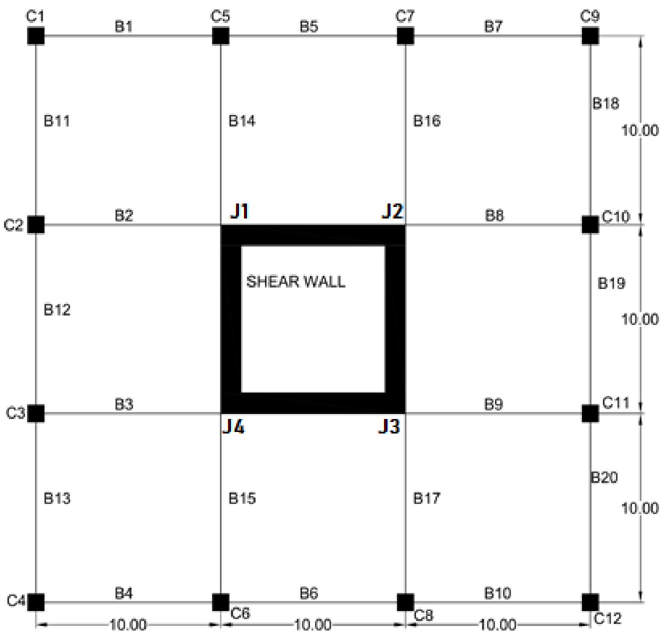

Figure 1 Typical story plan view

3.2 Design load

Dead loads are permanent loads which are acting on the structure. The unit weights of the materials that will help in calculations are as follow: Reinforced Concrete: 25.0 kN/m^3.However, this will be considered automatically in the software. As for super dead load to account for finishes cladding 2 kN/m^3 and wall load on beam 11 kN/m taken. Live load is the load that accounts for the intended use or occupancy. As per IS 875-part 2 and India practice, the value of live load shall be taken as 3 kN/m^2 and will be the same for all floors from top to bottom.

3.3 Material properties

In order to defined the properties of concrete creep and shrinkage, by using CEB FIP MC2010 and ACI209R are below,

Creep coefficient φ (t,t_0) By CEB FIP MC2010,
$\varphi(t,t_0) = \varphi_{0,bc}(t,t0).\beta_{bc}(t,t_0) + \varphi_{0,dc}.\beta_{dc}(t,t_0)$
Shrinkage strain by By CEB FIP MC2010,
$\varepsilon_{cs}(t,t_s) = \varepsilon_{cas}(t) + \varepsilon_{cds}(t,t_s)$
Where shrinkage is subdivided into the autogenous shrinkage $\varepsilon_{cas}(t)$:
$\varepsilon_{cas}(t) = \varepsilon_{cas0}(f_{cm})\cdot\beta_{as}(t)$
and the drying shrinkage $\varepsilon_{cds}(t,t_s)$:
$\varepsilon_{cds}(t,t_s) = \varepsilon_{ds0}(f_{cm})\cdot\beta_{RH}(t)\cdot\beta_{ds}(t-t_s)$
where,t = he concrete age in days
t_s = concrete age at the beginning of drying in days
$(t-t_s)$ = duration of drying in days

Creep coefficient V_t By ACI 209R,

$$V_t = \frac{t^{0.6}}{10 + t^{0.6}} * v_u$$

Shrinkage strain by ACI 209R-92,

$$\varepsilon_{sh} = \frac{t}{35 + t} X (\varepsilon_{sh})u$$

Where, t = age of concrete (days) at loading
v_u = final creep coefficient
$(\varepsilon_{sh})u$=final shrinkage stain in time infinity

Table 1 Concrete material properties

Column	Compressive Strength (N/mm^2)	Humidity (%)	Slump (mm)	Aggregate (%)	Air (%)	Cement (Kn/m^3)	V/S Ratio (mm)
C1	30	50	68.6	50	6	4.0726	437.5
C2	30	50	68.6	50	6	4.0726	437.5
Wall	30	50	68.6	50	6	4.0726	169

IV. RESULT AND DISCUSSION

The deformation of column due to creep and shrinkage on actual structure cannot be physically isolated; but, for the purpose of analysis, they are calculated. The observation points for the shortening of vertical member are selected at a column and a wall, highlighted in figure.
Here, observe effect of axial shortening at construction completed time, also after construction of 1 year, 5year, 15year after 25year. Take result out put from Etabs and Midas Gen which are described below.

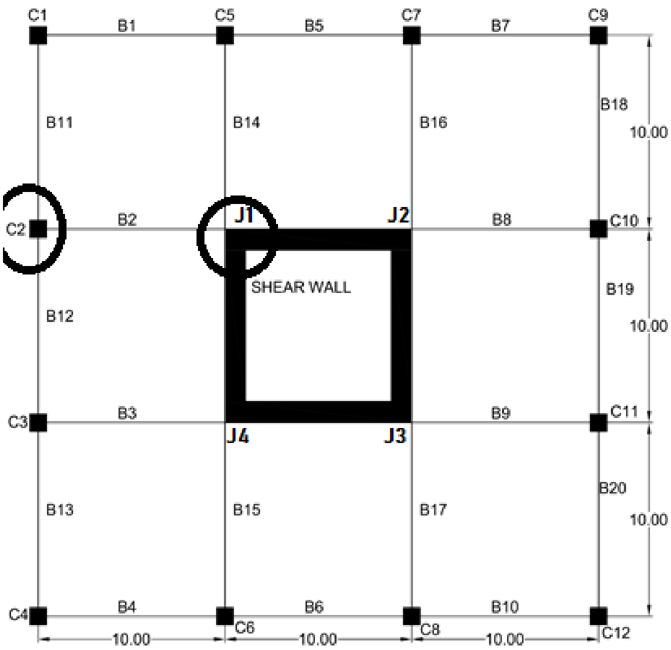

Figure 2 Observation points for shortening in vertical member

Axial shortening at end of construction period which means after 350day from construction started, its indicated in fig.3 for column and fig.4 for shear wall, maximum shortening due to CEB FIP MC2010 in column 23.995mm at 18th floor and shear wall 28.36mm at 17th floor, ACI 209R in column 25.77mm at 18th floor and 27.63mm at 19th floor.

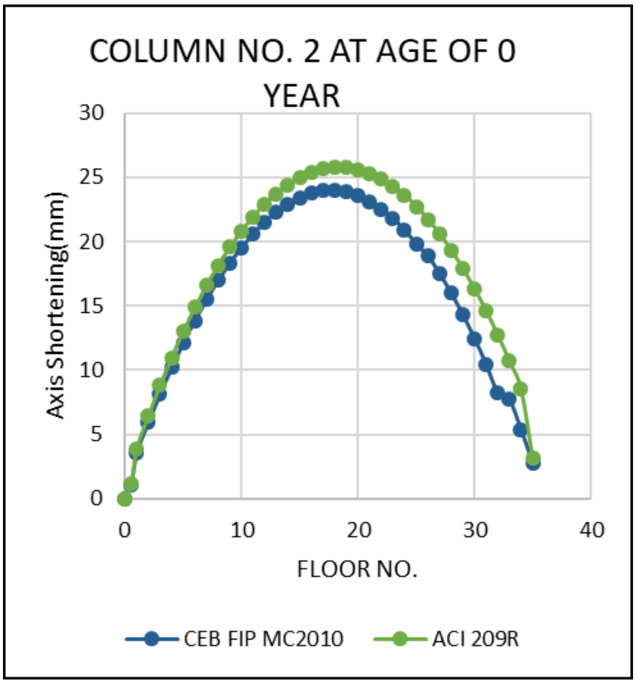

Figure 3 Axial shortening of column-0year

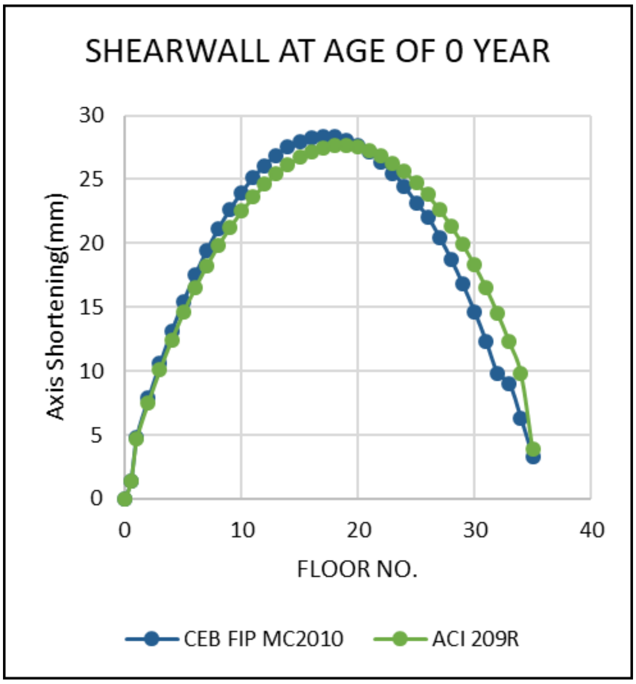

Figure 4 Axial shortening of shear wall-0year

Axial shortening at 1year which means time period of 1year after completion of construction work, its indicated in fig.5 for column and fig.6 for shear wall, maximum shortening due to CEB FIP MC2010 in column 32.80mm at 20th floor and shear wall 38.252mm at 20th floor, ACI 209R in column 31.35mm at 20th floor and 33.06mm at 21th floor.

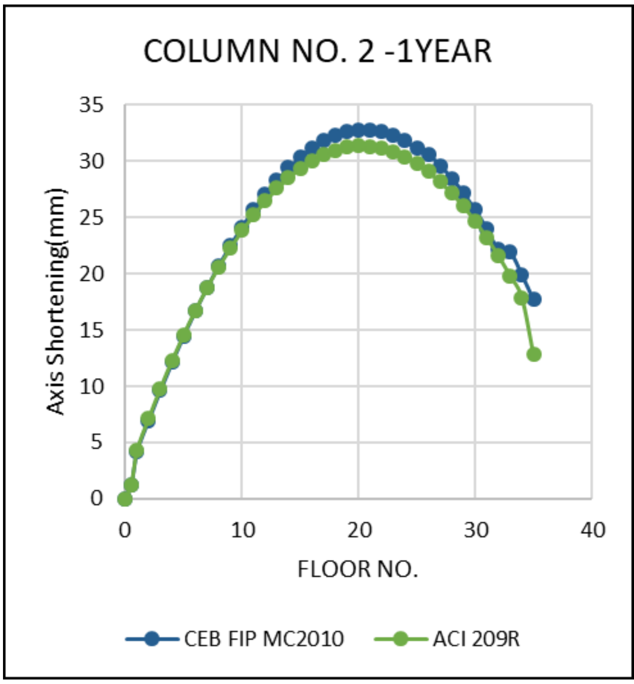

Figure 5 Axial shortening of column-1year

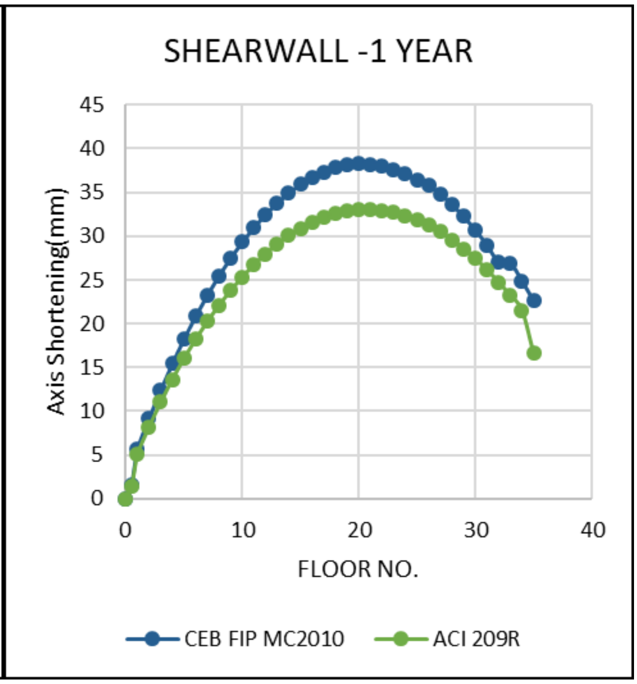

Figure 6 Axial shortening of shear wall-1year

Axial shortening at 5year which means time period of 5year after completion of construction work, its indicated in fig.7 for column and fig.8 for shear wall, maximum shortening due to CEB FIP MC2010 in column 45.82mm at 23th floor and shear wall 52.99mm at 24th floor, ACI 209R in column 34.44mm at 21th floor and 36.118mm at 22th floor.

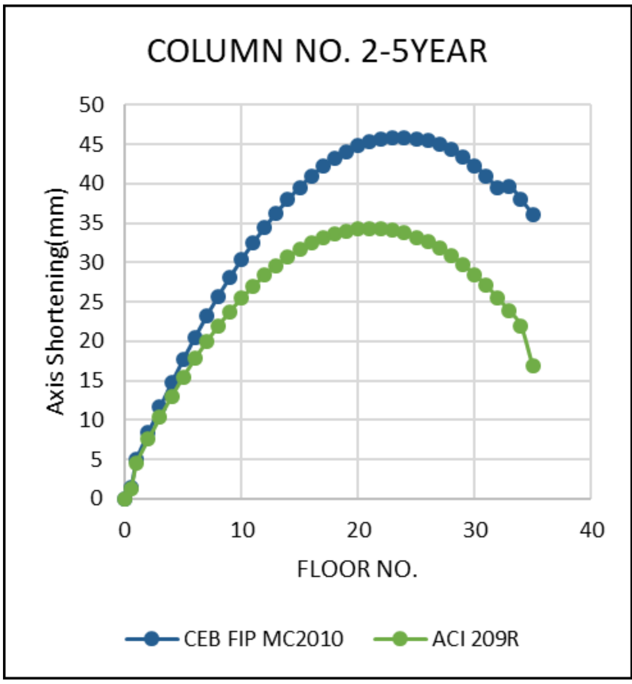

Figure 7 Axial shortening of column-5year

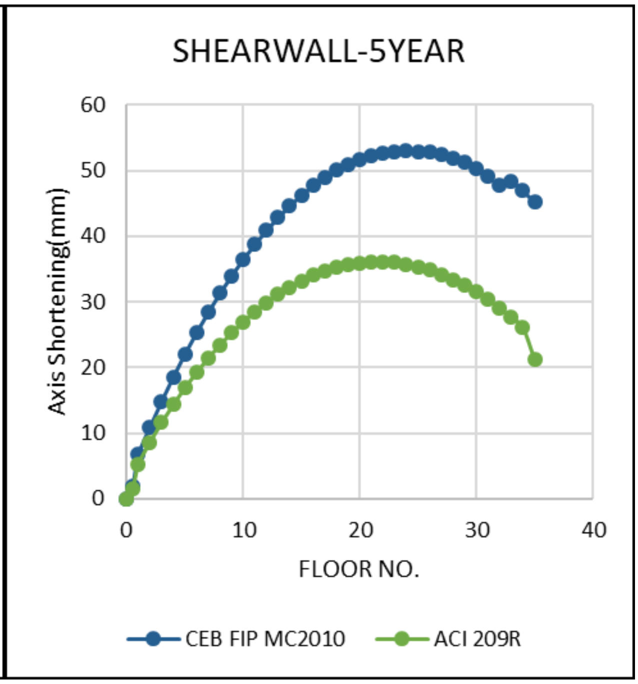

Figure 8 Axial shortening of shear wall-5year

Axial shortening at 15year which means time period of 15year after completion of construction work, its indicated in fig.9 for column and fig.10 for shear wall, maximum shortening du1e to CEB FIP MC2010 in column 58.70mm at 26th floor and shear wall 66.88mm at 27th floor, ACI 209R in column 35.498mm at 21th floor and 37.33mm at 22th floor.

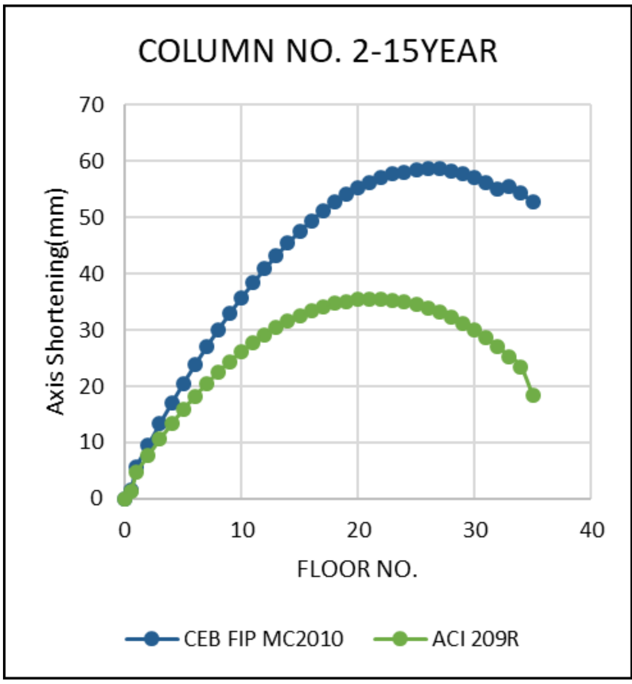

Figure 9 Axial shortening of column-15year

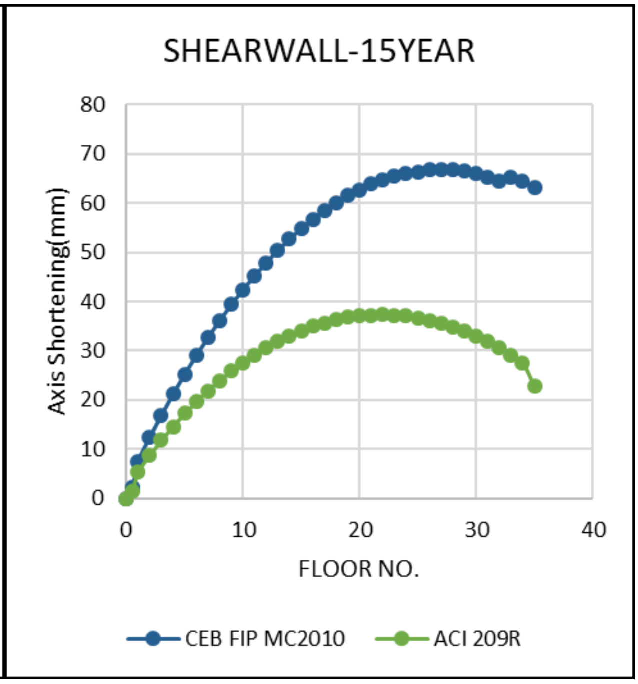

Figure 10 Axial shortening of shear wall-15year

Axial shortening at 25year which means time period of 25year after completion of construction work, its indicated in fig.11 for column and fig.12 for shear wall, maximum shortening due to CEB FIP MC2010 in column 65.33mm at 27th floor and shear wall 73.474mm at 28th floor, ACI 209R in column 35.803mm at 21th floor and 37.64mm at 22th floor.

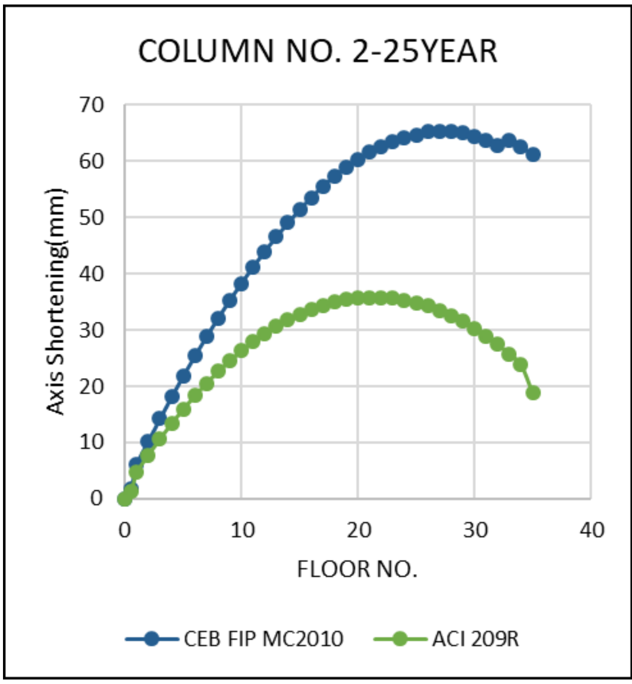

Figure 11 Axial shortening of column-25year

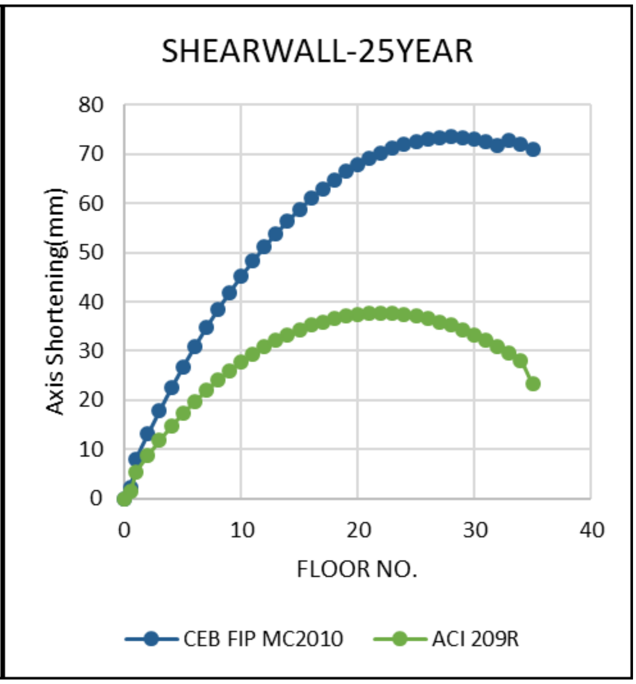

Figure 12 Axial shortening of shear wall-25year

Table 2 Comparison of maximum differential shortening

Year	Differential shortening Amount(mm)			
	CEB FIP MC2010		ACI 209R	
	Floor no.	Differential shortening(mm)	Floor no.	Differential shortening(mm)
0year	13	4.59	27	2.06
1year	15	5.55	35	3.78
5year	35	9.19	35	4.32
15year	35	10.409	35	4.432
25year	35	9.89	35	4.457

V. CONCLUSIONS

The construction stage analysis reflecting deformation due to creep and shrinkage of the 35-story reinforced concrete structure consisting of core wall and exterior frame shows the following effects:

- Comparative analysis shows that for above mentioned model, ACI 209R gives minimum value and CEB FIP MC2010 gives maximum value of Axial shortening.
- If maximum axial shortening considered among the all method, though this may produce addition forces, lead to fracture and failure of structure and non-structural members and overall. Huge maintenance required and the structure turns unserviceable before the expected life cycle.
- Hence to lower down maintenance cost and Infrastructure safety against failure, Axial shortening effects needs to be considered while planning.
- Since there are considerable amounts of deformations due to creep and shrinkage, their effects must be considered in analysis. This fact becomes more significant for high-rise construction or for structure with longer construction periods.

VI. REFERENCES

[1.] Fintel, M., Ghosh, S. K., & Iengar, H. (1987). "Column shortening in tall structures. Prediction and compensation " published in Portland cement association.
[2.] H. N. Praveen, Moragaspitiya, David. P. Thambiratnam, Nimalparera, Tommy H. T. Chen, "A Numerical Method to Quantify Differential Axial Shortening in Concrete Buildings", *Engineering Structures*, Vol. 32(8), pp. 2310– 2317, 2010.
[3.] Waghmare, A. P., Student, N., Dode, P. A., & Chore, H. S. (2007). Axial Shortening Effect on Vertical Element using Elastic and Inelastic Approach by ACI Code, International journal of computer application (0975-8887)

[4.] Diptesh patil & M.N.Bajad (2016). Predicting axial shortening of vertical elements in high rise building by using PCA method, International journal of innovation research in science engineering and technology, vol.5,issue 7
[5.] Afshari, M. J., Kheyroddin, A., & Gholhaki, M. (2018). Simplified time-dependent column shortening analysis in special reinforced concrete moment frames. *Periodica Polytechnica Civil Engineering*, *62*(1), 232–249. https://doi.org/10.3311/PPci.10679
[6.] Habrah, A., & Abu-Tair, A. I. (2018). The reliability of the ACI 209R-92 method in predicting column shortening in high-rise concrete buildings. Lecture Notes in Civil Engineering, 7(Isbs 2017), 396–412. https://doi.org/10.1007/978-3-319-64349-6_32
[7.] mutlu secer. (2019). Effects of construction sequence on reinforced concrete building analysis. Intenationa conference. https://doi.org/10.1007/978-981-2405_10
[8.] Panigrahi, S., Patil, V., Madan, S. H., & Takkalaki, S. (2019). Importance of Construction Sequence Analysis in design of High Rise Building. 6(4), 1–9. International journal of innovative science, engineering & technology.
[9.] Banugariya N.D., Solanke S.S. (2019) Analysis of Multi-storey Structures with Respect to Sequential Analysis. In: Kolhe M., Labhasetwar P., Suryawanshi H. (eds) Smart Technologies for Energy, Environment and Sustainable Development. Lecture Notes on Multidisciplinary Industrial Engineering. Springer, Singapore
[10.] ACI Committee 209(1992) Prediction of Creep, Shrinkage and temperature effects in concrete structure (ACI 209R-92). American Concrete institute, Farmington Hill
[11.] Comito Euro international Du beton (1993) CEB FIB model code Thomas telford, London

VII. BIOGRAPHIES

	❖ Vimal H. Jogi ❖ Post Graduate Student at Civil Engineering Department ❖ Darshan Institute of Engineering and Technology, Rajkot, -363650 & Gujrat Technological University, Gujrat, India.
	❖ Prof. Akash Jivani ❖ Assistant Professor, Civil Engineering Department ❖ Darshan Institute of Engineering and Technology, Rajkot, -363650 Gujrat Technological University, Gujrat, India.

