A Contemporary Study of Multi-Storey Building with Shear Wall using the Bonded & Unbonded PT System in Beam

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Abstract **- The benefits of Post-Tensioning method are still to be accepted in a developed world like India. Because of it uses the post-tensioning approach is now commonly used a day. The most affordable and secure structure for industrial as well as residential buildings can be achieved by using the post-tensioning techniques. There are two different approaches of post tensioning procedure, such as bonded & un-bonded. In this technique can achieve the most economical and safe design for residential as well as commercial tower to adding shear wall component. For lateral load like wind, earthquake load, the shear wall used in the PT system that supported the more strength, stability and hardening to the structural members.**

In present study, a commercial G+5 storey building has been selected to perform a parametric study. Various 9 Location of shear wall model made for Bonded and Un-bonded PT Beam have been studied to compare their performance by applying PT Steel, Non-PT Steel, Stress (top and bottom), Deflection (Long term, total load, sustain load), Displacement etc. have been selected for the present study to arrive at best suitable for location of shear wall model. The design was analyzed using ADAPT Builder 2015 software for Bonded and Un-bonded PT Beam.

Index Terms **- Bonded System, Un-bonded System, ADAPT-PT Builder 2015, Pre-stressed concrete, Shear wall, Post-tensioning system.**

I.INTRODUCTION

Usually, Un-bonded tendons consist of single threads or threaded bars that remain Un-bonded to the underlying concrete throughout their service period-allowing them to shift locally relative to the structural component. In one continuous process, the strands in Un-bonded mono-strand systems are coated with specially formulated grease with an exterior layer of smooth plastic sculpted to provide corrosion security. The anchorages of Un-bonded mono-strand devices can also be summarized, depending on the requirement and the degree of protection required. Light and versatile, Un-bonded mono-strand can be mounted easily and quickly offering an inexpensive alternative Bonded post-tensioning system consist of tendons from one to several strands or bars. The pre-stressing steel is enclosed in a corrugated metal or plastic duct for bonded systems. Forward to stress on the tendon, cementations grout is injected into the duct to bind it to the concrete surrounding it. Additionally, the grout creates an alkaline environment that protects the pre-stressing steel against corrosion.

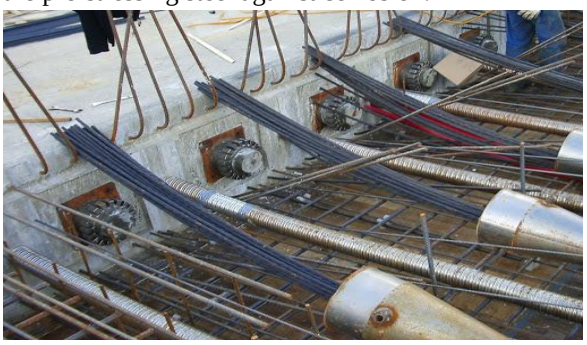


Figure 1: Bonded PT system

Figure 2: Un-bonded PT system

II. REVIEW OF LITERATURE

The tensioning device blends concrete or other structural components with strings or wires constructed from high-resistance steel, also called tendons. Plan includes buildings for offices and apartments, car parks, slabs, bridge, sports stadium, storage tanks, stone and surface anchors. The Post-Tension Program. Several scholars have already addressed the post-tension, Load balance principle for PT beam buildings, shear and deflection requirements for post-tension buildings.

P. Kalpana et. Al., [15] (2016) presented analytical study of different height structural shear walls for many models which take combination load as per IS:1893(PART-1)-2002. Authors find axial force, lateral displacement, and moment of bending in shear wall. Compare for diff with varying height. Project homes. Author also analysis this model in diff. Zone like zone 3 & zone 5. Author make 5 storey building in STAAD Pro software. P. Kalpana et. Al. Gave result That less displacement in shear wall construction relative to without shear wall building. With the construction of the shear wall, there is more seismic strength than to the construction of the shear wall. The author has claimed that the node deformation is more associated with zone 3 for zone 5.

Padhiar Kamal et. Al., [13] (2010) conducted that the flat wall with drop panel and square slab on the two separate post-tensioning floor systems were considered. Author changing the concrete grade from M35 to M50 with increasing concrete grade, the punching shear ratio, the mid-span factor and finding out after tension rating as well. The author has also found a flat plate with a maximum length of 8 m and a flat plate with a maximum drop panel length of 13 m. Kamal Padhiar, et. Aim was to increase the amount of non-PT steel by rising the concrete scale to 5-10 per-cent.

Dobariya Nishant M. et. Al., [11] (2017) studied stress, Bending moment, Shear force, deflection. Author provide extra bars in both systems. Author used ADAPT PT builder software for base work & use IS:1343-1980 and ACI-318 code for theory-based work. Author analyzed long span T-Beam which length is 10-20m span in bonded & unbonded beam with maximum tension zone cable profile. Author give result up to 20m span unbonded T-Beam is good compared to bonded T-Beam is great result compared to unbonded in bonded T-Beam. In bonded T-Beam laborer cost is very high & reinforcement quantity is low that the opposite condition in case of unbonded beam author also observe unbonded beam take less time for the casting work.

Kikani Rahul et. Al., [17] (2018) studied and analyzed on the commercial office building was chosen to conduct the parametric study. Author took specific slab devices such as Flat slab with Concrete beams, RC slab with RC plate, post tensioning flat slab with drop panel and Post tensioning plain slab with Post stiffeners voided flat slab, and contrasted their result using time history. The author gave different parameters such as slab thickness, concrete grade, shear punching, column size etc. In this study author used to ADAPT BUILDER Vs. 2015 Software. The tendons are less needed for controlling deflection and stress compared to solid flat slab after examination of all parameters author concluded in voided slab. Author also said the punching shear is a huge problem in the flat slab, but in this system that provides voided flat slab, the punching shear reduces by up to 23 %.

III. OBJECTIVE OF STUDY

The motto of the present study is to the analysis and design of the G+5 storey building with post-tension beam and these beam systems are compared to bonded and un-bonded PT system by using ADAPT Builder 2015.To analysis the post-tensioning beam using ADAPT Builder 2015 along with different location wise shear wall models.

To take 20% of total shear wall outer length periphery of multi-storey buildings for all models.

IV. EXPERIMENT AND RESULT

4.1 Problem statement

To analysis and design G+5 storey building with post-tension beam and different location of shear wall and then compare different PT system like, Bonded and Un-bonded post-tensioning system along with different parameter like, Loss due to Stressing, Number of PT cable, Numbers of Non-PT cables, Deflection (Sustain load, Service load, Long term), Non-PT steel, Stress (Top stress, Bottom stress), Displacement (Zone-3) by using ADAPT Builder 2015.

4.2 Problem Formulation:
X-axis: 6 bays (10m length)
Y-axis: 5 bays (10m length)
Building Dimension: 60 m X 50 m X 18 m
Column Size: 750 mm X 750 mm
Beam Size: 600 mm X 525 mm
Slab Size: 200 mm
Dead Load (D.L):1.5 kN/m2 (Floor finish)
Live Load (L.L): 4 kN/m2
RC wall thickness:230 mm
Grade of concrete: M35
Grade of steel: Fe500
Total shear wall length:44 m (20% of building periphery)

4.3 Analysis and Design for different locations –
The models are arranged in various groups according to location of shear wall. With each location of shear wall there are three models.
M1 = Shear wall placed only in X-direction
M2 = Shear wall placed only in Y-direction
M3 = Shear wall placed in both X & Y direction
In this study using 20% shear wall of length of building outer periphery shown in table.

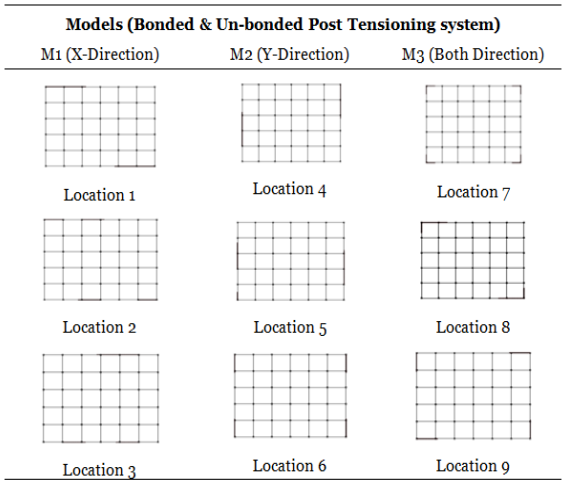


Fig. 3. Location wise models (Provision of Shear Wall in building at 20% of periphery).

V. RESULTS AND DISCUSSION

The study findings are as follows. The distinction for bonded and Un-bonded post tensioning device is made on the basis of the following parameters.

- Long term deflection, Displacement (Zone-3), Stressing, Number of PT cable, Numbers of Non-PT cables, Non-PT steel, PT steel.
- Used IS-1343:1980, ACI-318 code and Pre-stressed Concrete Analysis and Design (Dr. Y. M. Rao) (Textbook) including all parameter.

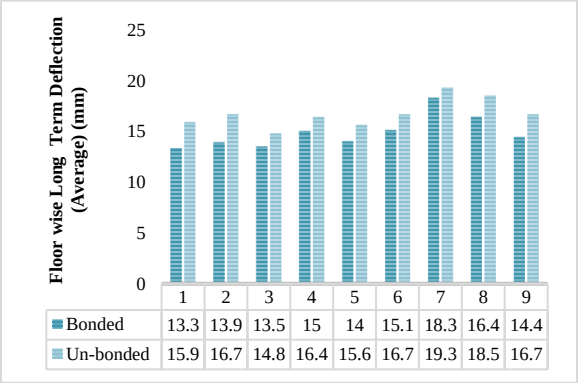


Figure 4: Long term Deflection (Floor wise) Vs Location of Shear wall

On the bases of floor for both the system Bonded and Un-bonded at Location 3 minimum Long-term deflection and at Location 7 maximum Long-term deflection is there.

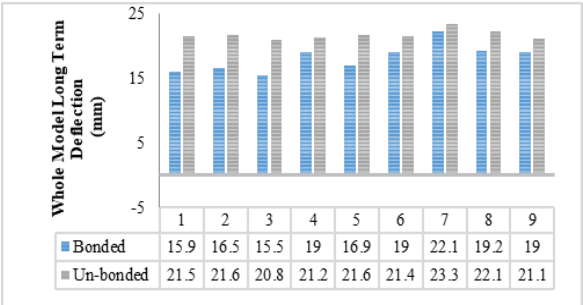


Figure 5: Long term Deflection (G+5 storey building) Vs Location of Shear wall

As for whole building with G+5 storey the same scenario will be there.

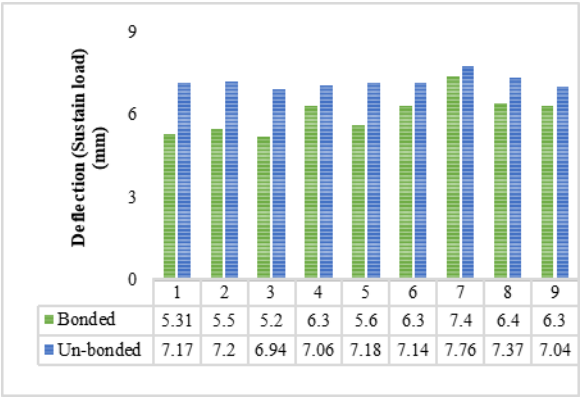
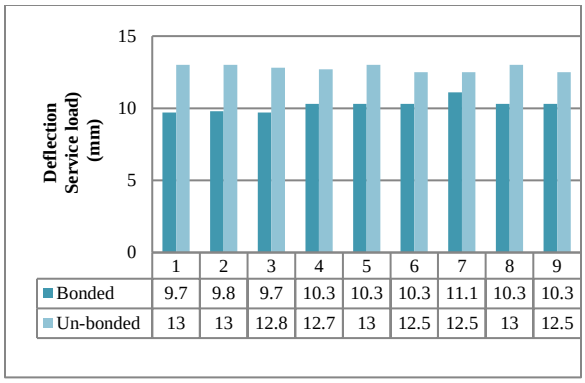


Fig. 6. Deflection (Sustain load) mm Vs Location of Shear wall

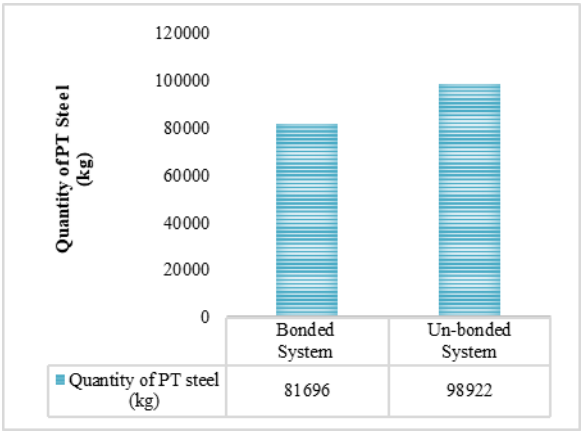
For both the system Bonded and Un-bonded maximum Sustain deflation load is there at Location 7



	1	2	3	4	5	6	7	8	9
Bonded	9.7	9.8	9.7	10.3	10.3	10.3	11.1	10.3	10.3
Un-bonded	13	13	12.8	12.7	13	12.5	12.5	13	12.5

Fig. 7. Deflection (Service load) mm Vs Location of Shear wall

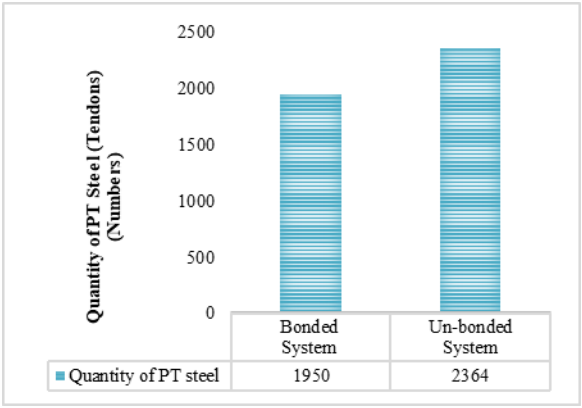
For the Bonded system maximum Service deflation load is there at Location 7 and minimum at Location 3 and opposite for Un-bonded system.



	Bonded System	Un-bonded System
Quantity of PT steel (kg)	81696	98922

Fig. 8. Quantity of PT Steel (kg) Vs Different PT System

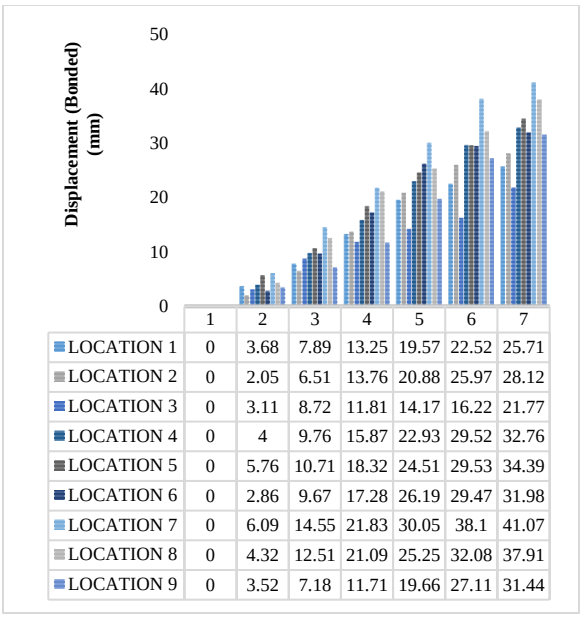
Bonded system is used less PT steel in weight as compare to Un-bonded system.



	Bonded System	Un-bonded System
Quantity of PT steel	1950	2364

Fig. 9. Quantity of PT Steel (Number tendons) Vs Different PT System

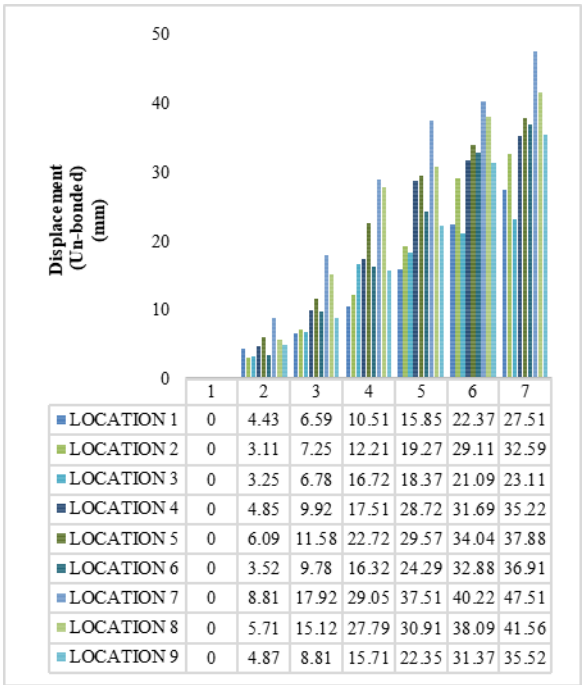
Bonded system is also used less PT steel in Numbers as compare to Un-bonded system.



	1	2	3	4	5	6	7
LOCATION 1	0	3.68	7.89	13.25	19.57	22.52	25.71
LOCATION 2	0	2.05	6.51	13.76	20.88	25.97	28.12
LOCATION 3	0	3.11	8.72	11.81	14.17	16.22	21.77
LOCATION 4	0	4	9.76	15.87	22.93	29.52	32.76
LOCATION 5	0	5.76	10.71	18.32	24.51	29.53	34.39
LOCATION 6	0	2.86	9.67	17.28	26.19	29.47	31.98
LOCATION 7	0	6.09	14.55	21.83	30.05	38.1	41.07
LOCATION 8	0	4.32	12.51	21.09	25.25	32.08	37.91
LOCATION 9	0	3.52	7.18	11.71	19.66	27.11	31.44

Fig. 10. Displacement (mm) Vs Different floor system in zone-3 for Bonded model

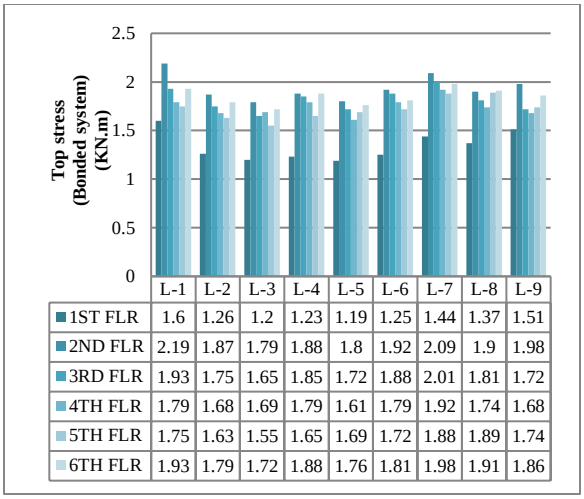
Maximum displacement value got at Location 7 for Bonded system.



	1	2	3	4	5	6	7
LOCATION 1	0	4.43	6.59	10.51	15.85	22.37	27.51
LOCATION 2	0	3.11	7.25	12.21	19.27	29.11	32.59
LOCATION 3	0	3.25	6.78	16.72	18.37	21.09	23.11
LOCATION 4	0	4.85	9.92	17.51	28.72	31.69	35.22
LOCATION 5	0	6.09	11.58	22.72	29.57	34.04	37.88
LOCATION 6	0	3.52	9.78	16.32	24.29	32.88	36.91
LOCATION 7	0	8.81	17.92	29.05	37.51	40.22	47.51
LOCATION 8	0	5.71	15.12	27.79	30.91	38.09	41.56
LOCATION 9	0	4.87	8.81	15.71	22.35	31.37	35.52

Fig. 11. Displacement (mm) Vs Different floor system in zone-3 for Un-bonded model

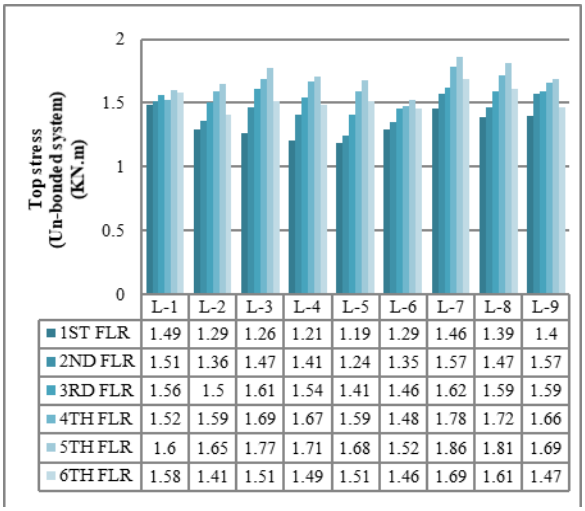
- Constantly got minimum displacement value at Location 3 at compare other Location for bonded and Un-bonded system.
- Maximum displacement value got at Location 7 for Un-bonded system that is a same scenario like Displacement for Bonded PT system.



	L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8	L-9
1ST FLR	1.6	1.26	1.2	1.23	1.19	1.25	1.44	1.37	1.51
2ND FLR	2.19	1.87	1.79	1.88	1.8	1.92	2.09	1.9	1.98
3RD FLR	1.93	1.75	1.65	1.85	1.72	1.88	2.01	1.81	1.72
4TH FLR	1.79	1.68	1.69	1.79	1.61	1.79	1.92	1.74	1.68
5TH FLR	1.75	1.63	1.55	1.65	1.69	1.72	1.88	1.89	1.74
6TH FLR	1.93	1.79	1.72	1.88	1.76	1.81	1.98	1.91	1.86

Fig. 12. Top stress in bonded system Vs Different floor wise building

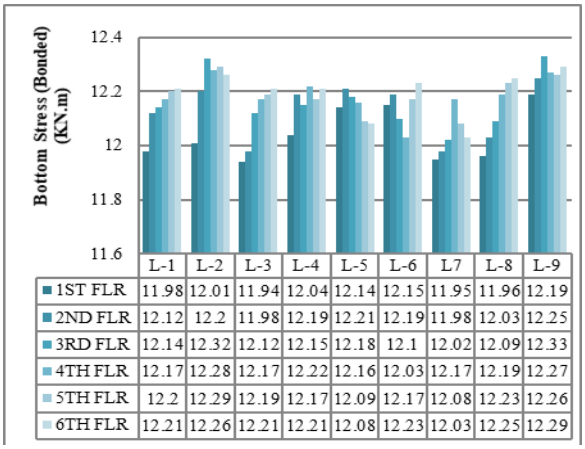
At Location 7 the maximum Top stress level where as minimum is at Location 3 in Bonded system



	L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8	L-9
1ST FLR	1.49	1.29	1.26	1.21	1.19	1.29	1.46	1.39	1.4
2ND FLR	1.51	1.36	1.47	1.41	1.24	1.35	1.57	1.47	1.57
3RD FLR	1.56	1.5	1.61	1.54	1.41	1.46	1.62	1.59	1.59
4TH FLR	1.52	1.59	1.69	1.67	1.59	1.48	1.78	1.72	1.66
5TH FLR	1.6	1.65	1.77	1.71	1.68	1.52	1.86	1.81	1.69
6TH FLR	1.58	1.41	1.51	1.49	1.51	1.46	1.69	1.61	1.47

Fig. 13. Top stress in Un-bonded system Vs Different floor wise building

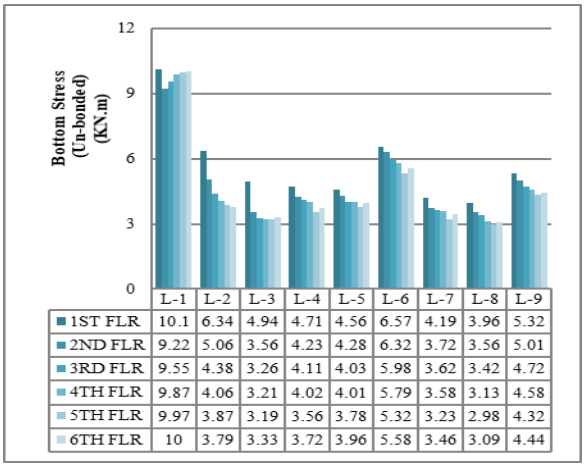
The Top stress level in order to Un-bonded system is highest at Location 7 and lowest at Location 6.



	L-1	L-2	L-3	L-4	L-5	L-6	L7	L-8	L-9
1ST FLR	11.98	12.01	11.94	12.04	12.14	12.15	11.95	11.96	12.19
2ND FLR	12.12	12.2	11.98	12.19	12.21	12.19	11.98	12.03	12.25
3RD FLR	12.14	12.32	12.12	12.15	12.18	12.1	12.02	12.09	12.33
4TH FLR	12.17	12.28	12.17	12.22	12.16	12.03	12.17	12.19	12.27
5TH FLR	12.2	12.29	12.19	12.17	12.09	12.17	12.08	12.23	12.26
6TH FLR	12.21	12.26	12.21	12.21	12.08	12.23	12.03	12.25	12.29

Fig. 14. Bottom stress in bonded system Vs Different floor wise building

- In Bonded system maximum bottom stress is at Location 9 whereas minimum is at Location 7
- In Un-bonded system lower top stress is there at floor 5 and in Bonded system at floor 2



	L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8	L-9
1ST FLR	10.1	6.34	4.94	4.71	4.56	6.57	4.19	3.96	5.32
2ND FLR	9.22	5.06	3.56	4.23	4.28	6.32	3.72	3.56	5.01
3RD FLR	9.55	4.38	3.26	4.11	4.03	5.98	3.62	3.42	4.72
4TH FLR	9.87	4.06	3.21	4.02	4.01	5.79	3.58	3.13	4.58
5TH FLR	9.97	3.87	3.19	3.56	3.78	5.32	3.23	2.98	4.32
6TH FLR	10	3.79	3.33	3.72	3.96	5.58	3.46	3.09	4.44

Fig. 15. Bottom stress in Un-bonded system Vs Different floor wise building

VI. CONCLUSION

The following conclusion has been derived based on comparative study done for the different two methods (Bonded and Un-bonded) of post tensioning different type of geometries having different location of shear wall.

- As compared to Un-bonded system 18% of lower PT steel is applied in the Bonded System on the bases of Tendons. (Number and Kilograms)
- 46% less Non-PT steel is used in Bonded system by weight (kg) compared to Un-bonded System.
- After modeling observed that the displacement value constant increased with floor system increased.
- When we take Dominating as deflation considering floor than for both the system like bonded and un-bonded location 3 is best and location 7 is not so good as well as the same is true for G+5 storey building
- After modeling observed that the displacement value constant increase with floor system increase, Maximum displacement value got at Location 7 for Bonded and Un-bonded system and opposite for Location 3.

- If we have found deflection as the most appropriate factor than location 3 is most suitable and location 7 is inappropriate.
- According to economy system Bonded system is preferred more than Un-bonded system for these building.
- In account of economic, stability Location 3 is preferred more whereas Location 7 is uneconomic, unstable.

VII.ACKNOWLEDGMENT

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REFERENCES

[1] Atilla puskas, Iosiftorok, Jacintvirag. Post tensioned flat slab with unbonded tendons for public buildings. technical university of napoca,400027 Romania.)

[2] Anusha. I. Koti, Dr. S. B. Vanakudre.2018 Analysis of PT flat slab with Drop- Considering Seismic Effect. International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 06 | June-2018

[3] Bijan Aalami, StiveWoaks, JemsPhill. 2018.Bonded and Unbonded system of post tensioning -A design and performance review, IJSRD - International Journal for Scientific Research & Development, ISSN (online): 2921-0848.

[4] Cullington D.W., Macnei D. L, Paulson P., Elliott J. Continuous Acoustic Monitoring of Grouted Post-Tensioned Concrete Bridges, NDT&E International volume 34, pp 95–105.

[5] Ehab Ellobody, ColinG.Bailey, 2008. Modeling of un-bonded post-tensioned concrete slabs under fire conditions.

[6] Garlock Maria M, Ricles James M., Sause Richard, 2007. Influence of Design Parameters on Seismic Response of Post-Tensioned Steel MRF Systems, Journal of Engineering Structures.

[7] Julie E. Mills Reza Hassanli, Mohamed A. El Gawad, 2015. Force-displacement behavior of unbonded post tension concrete wall, University of South Australia, Adelaide, Australia.

[8] Medini Deshpande, Dr. M.G.Kalyanshetti and Dr. S.A.Halkude. Performance of multi-storey building for various location of shear wall, International Journal of Latest Trends in Engineering and Technology Vol. (8), Issue (3), pp.029-039.

[9] Mohammed Kohail, Hany Elshafie, Ahmed Rashad, Hussein Okail, 2018. Behavior of post tensioned dry stack interlocking masonry shear wall under cyclic in plan loading, Structural Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

[10] Nishant M. Dobariya, Ankit Agrawal, Jignesh Patel, 2017. Comparative Study of Bonded & Un-bonded Post-Tensioning for Long Span Beam in Building, International Journal of Advance Engineering and Research Development Volume 4, Issue 4.

[11] Nishant M. Dobariya, Ankit Agrawal, Jignesh Patel, 2017. Parametric Study between Bonded & Un-bonded Post-Tensioning for Long Span T-Beam in Building, IJSRD - International Journal for Scientific Research & Development, Vol. 5, Issue 03, ISSN (online): 2321-0613.

[12] O.F.Hussien, T.H.K.Elafandy, A.Abdelrahman, S.A AbdelBaky, E.A. Nasar, 2012. Behavior of bonded and unbonded prestressed normal and high strength concrete beams, HBRC Journal (2012) 8, 239–251.

[13] Kamal Padhiar, Dr. C. D. Modhera, Dr. A. K. Desai, 2010.Comparative parametric study for post-tension flat slab with drop system, International journal of civil engineering.)

[14] Priyanka Soni, Mr. Purshottam Lal Tmarakar, Vikky Kumar, 2016, Structural Analysis of Multistory Building of Different shear Walls Location and Heights, International Journal of Engineering Trends and Technology (IJETT) – Volume 32 Number 1.

[15] P. Kalpana, R.D. Prasad, B.Kranthi Kumar, 2016, Analysis of building with and without shear wall at various height and variation of zone 3 & zone 5,Int. Journal of Engineering Research and Application www.ijera.com ISSN: 2248-9622, Vol. 6, Issue 12, pp.05-11.

[16] Rahul P. Kikani, Kishan N. Davara, Yati R.Tank, Palak V.Trivedi, Bhavin Sheladiya.2017. A Comparative Review on Behavioral Aspect of Post- Tensioning Voided Flat Slab with Other Slab Systems, International Journal of Advance Engineering and Research Development. Volume 4, Issue 11, November -2017.

[17] Rahul P. Kikani, Kishan N, Davara, Yati R.Tank, Palak V.Trivedi, Bhavin Sheladiya, 2018.Comparative Study of a Post Tensioning Voided Flat Slab with Different Slab Systems, International Conference on Advances in Construction Materials and Structures (ACMS-2018) IIT Roorkee, Roorkee, Uttarakhand, India.

[18] Rajeh Z. Ai-Zaid. Analysis of Bonded Post-tensioned Partially Pre-stressed Concrete Beams under Sustained Loads, Department of Civil Engineering, College of Engineering King Saud University, P.O. Box 800, Riyadh 11421, Saudi Arabia.

[19] Shanmathi Sridhar, A. Leema Rose, 2019. Performance Evaluation of Post-Tensioned Concrete Beams with Bonded System, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-7.

[20] Tatar J, Tofik L, TorokAmbros. The simplified finite element modeling of post tensioning concrete member with mixed Bonded & Un bonded tendons, Int. Journal of Engineering Research and Application.

[21] T.Nagae.Seismic performance & modeling of post-tension precast concrete shear wall, National Research Institute for Earth Science and Disaster Prevention, Miki City, Japan.

[22] Thapa Axay, Sajal Sarkar, 2017.Comparative study of multi-storey building with & without shear wall. International Journal of Civil Engineering (IJCE)ISSN(P): 2278-9987; ISSN(E): 2278-9995Vol. 6, Issue 2, Feb - Mar 2017; 11-20.

[23] Webster Norman R., Rogowsky David M,2015. Strength Evaluation of Unbonded Post-Tensioned Structures with Severe Tendon Breakage" ISSN: 2278-3075, Volume-8 Issue-7 May, 2015.