Effect of Differential Settlement on Forces and Moments of Beam of RCC frame Structure using Staad Pro V8i Software

K.B.Jaiswal[1] A.C.Saoji[2]
[1]ME Student [2]Associate Professor
[1,2]Department of Civil Engineering
[1,2]BNCOE, Pusad, Maharashtra, India

Abstract— The structural Frames are normally analyzed by assuming frames with fixed base, and role of foundation and soil properties on member action is neglected. In this paper effect of differential settlement on Beams of RCC frame structure building of G+9 is carried out considering Beams at corners and centers respectively. A settlement of 25mm, 50mm, 75mm and 100 mm respectively is applied to supports and effect in terms of Axial force, shear force and Bending moments at Ground floor, Fifth floor and Ninth floor Beams are compared with Fixed support and Spring Support. It was concluded from the comparison of results that when settlement increases the value of Axial forces, Shear Forces and Bending Moments Increases accordingly. The Research work can be helpful to know the realistic response of structural members when differential settlement occur and design can be modified considering Forces & moments when differential settlement occur in the building this will help in economical and safe design of RCC structures under Gravity load, Wind load and Seismic Loading.

Key words: Differential Settlement, Comparison of Forces, STAAD Pro Software, Structural Response, Beam Comparison, Indian Standard Code

I. INTRODUCTION

In most instances of construction the subsoil is not homogeneous and the load carried by various shallow foundations of a given structures can vary widely, The Differential settlement of the parts of building can lead to damage of the superstructures. Hence it is important to define certain parameters that quantify Differential settlement and to develop limiting value for those parameters in order that resulting structures be safe. Usually the most settlement sensitive building is those having low bearing capacity of soil versus maximum loading on the structure without considering the effect of forces and moments increases due to settlement. A good understanding of mechanisms and factors producing differential settlement will result in a better understanding of the behavior of the structure and will therefore allow for a more optimal design. Beams are the most predominant in the structure and may affect most due to differential settlement. In this paper an attempt made to see that which beams in the structure is effected more due to settlement and comparison of forces and moments changes in the beams before settlement and after settlement of 25 mm, 500mm, 75mm and 100mm.are carried out and results are discussed. To study the effect of forces and moments on Beams Staad Pro V8i Software is used. loading is kept same for G+9 RCC building with 16x16 meter. 36 Beams are considered for study, 12 on Ground floor,12 on 5th floor and 12 on 9th floor.

II. LITERATURE REVIEW

It is important to know the damage that structure suffer due to differential settlement of foundation, because sometime differential settlement may tend to damage building which may not be reparable and may cost high to repair. Many studies have been done in the past to define value of settlement, factors affect the settlement, loading, which to be taken into consideration while designing structures. Burland et.al 1977 studied that total settlement on clay are generally greater than those on sand owing to the consolidation process. But differential settlements, which are the most dangerous for building, tend to be greater on sand because sand deposits are more heterogeneous. Bjerrum 1963; Horn and lambe 1964 studied the relation between foundation displacement and superstructure damages, and defined several parameters i.e. absolute settlement, differential settlement, downward vertical movement, rotation and tilt. From 1950s until the prsenet day many attempts made to define real values for these parameters (Brinch Hansen 1964, feld 1964, golder 1971, Meyerhof 1977 boone 1996). Skempton and Mcdonald (1956) supplies important indication regarding allowable settlement. In this paper comparison made between the values of Axial forces, Shear forces, Bending moments of beams of Ground floor,5th floor and 9th floors due to settlement of 25mm, 50mm, 75mm and 100 mm respectively keeping other factors such as loading, sizes of columns and beams same

A. *Method used to Predict the Settlement*

One of the first methods to predict the settlements of foundations on granular soils was proposed by Terzaghi and Peck (1948). They used results from load tests with 300-mm square plates on sand. The sand had a wide range in standard penetration test (SPT) blow count (N60). They related the observed settlements from the load tests to the expected settlements on actual foundations. Meyerhof (1965) proposed a method where the settlements were predicted based on SPT blow count, N60. Schmertmann (1970) proposed a semi-empirical method which has become one of the most widely used methods today. He used elastic theory, model lo loads tests, and field cone penetration tests (CPT) and finite element analyses to develop the approach. He modified the method to assess strip footings and square footings separately by changing strain influence factors (Schmertmann et al., 1978)

B. *Building Description*

A Nine storied building shown in figure 1 is taken having dimension 16m*16m and total height of building is 30m (depth of foundation -3 Meter).Settlement of 25mm, 50mm, 75mm 100mm is provided to all supports to two rows only to make effect of differential settlement.

Sr. No.	Floor	Beam Numbers
1	Ground Floor	1,46,4,50,65,40,37,61,53,21,58,20
2	5th floor	626,371,329,375,390,365,362, 386,378,346,383,345
3	9th floor	586,631,589,635,650,625,622, 646,638,606,643,605

Table 1: Showing Numbering of Beams

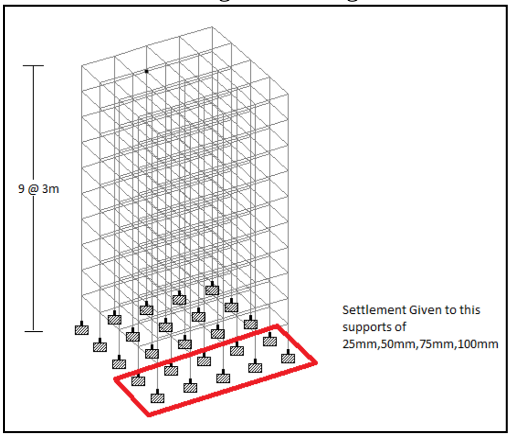

Fig. 1: Geometrical Configuration of Building

III. Modeling

Modeling is done using analysis & design software Staad-proV8i. In this total 36 Beams are considered of corners & centers. 12 Beams each for Ground floor, 5th floor & 9th floor. As given in table 1.

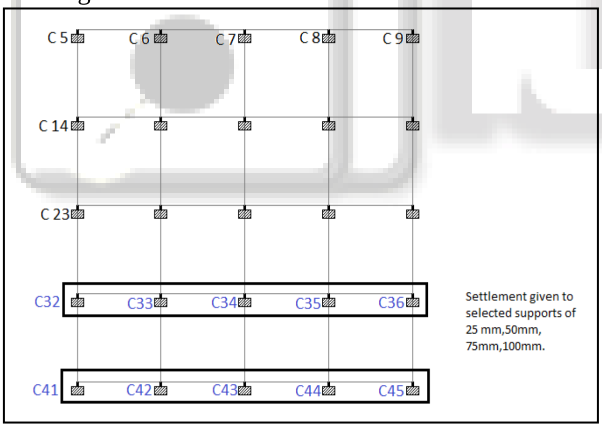

Fig. 2: Plan Showing Supports where settlement applied

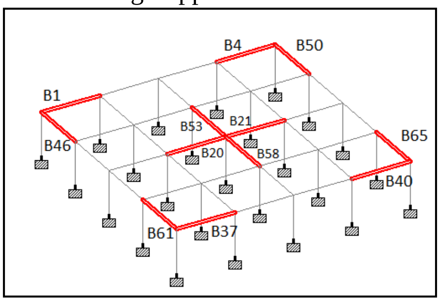

Fig. 3: Isometric View showing Beams selected for results of diff. settlement of Ground floor, 5th floor & 9th floor

Differential settlements of 25mm, 50mm, 75mm &100 mm respectively are applied to Supports. Support 32-support 36 & support 41- support 45 with keeping rest configurations same only settlement are provided as shown in Fig-2. It was important to apply settlement to any one side of building to see the effect of differential settlement. So in this paper two rows along with X-Axis is considered as shown in figure 1. Settlement is provided to dead load only and 41 related standard cases taken by software as per standard code. Loading such as Dead load, live load, Wind load & seismic load kept same for all condition i.e. for fixed support, spring support & when differential settlement are applied Only.

IV. Results and Discussion

In the following section, the effect of Differential settlement on selected Beams i.e. corners & centers are mentioned. In first case fixed supports are considered and axial forces, shear forces and bending moments are note down. Then in second case one by one differential settlement of 25mm, 50mm, 75mm, 100mm respectively applied to selected Beams as shown in figure 3. to the same building and reactions noted down. And lastly in third case spring supports are applied instead of fixed support by considering modulus of subgrade reaction as K=40000.and results are note down and comparison between three cases presented.

Note: In this paper results + ve values of axial force, shear force and bending moments are shown only Ground floor Beams.5th floor and 9th floor results are not shown in this case.

A. Effect of differential settlement on fx on ground floor corner & center beams

It is found that FX is increased in the Beam no. 46,50,53,58, when settlement increased from 00 mm to 100 mm and there is no change in FX value of other beams. And on comparison of 00 mm settlement and spring support FX increased in all beams as shown in table 2 and Fig.4.

B.N.	00 mm	25 mm	50 mm	75 mm	100 mm	Spring
1	3.45	3.45	3.45	3.45	3.45	7.31
46	3.39	21.21	43.53	65.84	88.16	7.20
4	3.45	3.45	3.452	3.45	3.45	7.31
50	3.39	21.21	43.53	65.84	88.16	7.20
65	3.39	3.39	3.39	3.39	3.39	7.20
40	3.45	3.45	3.45	3.45	3.45	7.31
37	3.45	3.42	3.45	3.45	3.45	7.31
61	3.39	3.39	3.39	3.39	3.39	7.20
53	3.67	66.48	133.5	200.6	267.7	5.67
21	3.66	3.66	3.664	3.66	3.66	5.82
58	3.67	19.19	38.98	58.78	78.57	5.67
20	3.66	3.66	3.66	3.66	3.66	5.82

Table 2: Variation of FX in Ground floor Beams due to differential settlement

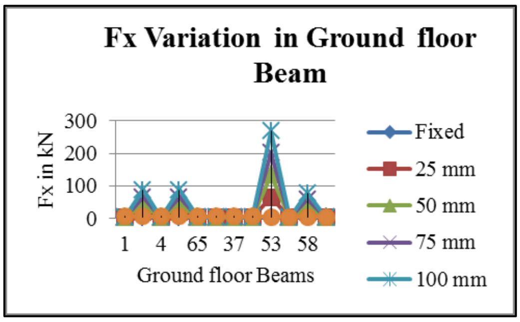

Fig. 4: Variation of FX in Ground floor Beams due to differential settlement

B. Effect of differential settlement on FY on Ground floor Corner & Center Beams

It is found that FY is increases only in Beam no.58. when settlement increased from 00 mm to 100 mm resp. but in beam no.46,50,53 FY decreases when settlement increases. In other beams there is no changes found. Lastly FY increases in all beams when Spring support is applied as shown in table 3 and Fig.5.

B. N	00 mm	25 mm	50 mm	75 mm	100 mm	Spring
1	82.2	82.20	82.2	82.20	82.20	119.4
46	84.8	32.21	17.0	17.02	17.02	120.4
4	80.5	80.51	80.5	80.51	80.51	73.84
50	84.8	32.21	17.0	17.02	17.02	120.4
65	87.2	17.11	17.1	17.11	17.11	80.52
40	80.5	80.51	80.5	80.51	80.51	73.84
37	82.2	82.20	82.2	82.20	82.20	119.4
61	87.2	17.11	17.1	17.11	17.11	80.52
53	78.5	15.89	15.8	15.89	15.89	101.0
21	75.9	75.95	75.9	75.95	75.95	90.27
58	78.0	380.2	682	984.6	1286	90.99
20	76.4	76.4	76.4	76.4	76.4	101.7

Table 3: Variation of FY in Ground floor Beams due to differential settlement

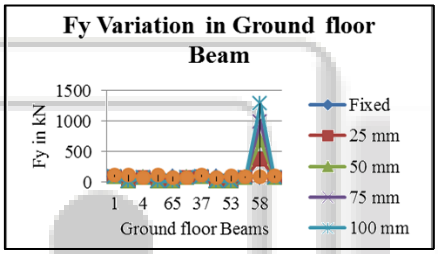

Fig. 5: Variation of FY in Ground floor Beams due to differential settlement

C. Effect of differential settlement on FZ on Ground floor Corner & Center Beams

When differential settlement occur in the building then FZ in beams do not affect and stands same as in case of 00 mm settlement but when spring supports is given then linear change in the value of FZ found in all beams. FZ values increase in terms of Spring support but do not changes even when differential settlement is applied. From above it is clear that FZ is not predominant as FX and FY are. as shown in table 4 and Fig.6.

B.N.	00 mm	25 mm	50 mm	75 mm	100 mm	Spring
1	0.31	0.31	0.31	0.31	0.31	0.4
46	0.29	0.29	0.29	0.29	0.29	0.56
4	0.32	0.32	0.32	0.32	0.32	0.5
50	0.27	0.27	0.27	0.27	0.27	0.50
65	0.29	0.29	0.29	0.29	0.29	0.56
40	0.31	0.31	0.31	0.31	0.31	0.4
37	0.32	0.32	0.32	0.32	0.32	0.5
61	0.27	0.2	0.27	0.27	0.27	0.50
53	0.07	0.07	0.07	0.07	0.07	0.18
21	0.10	0.10	0.10	0.10	0.10	0.23
58	0.07	0.07	0.07	0.07	0.07	0.18
20	0.10	0.10	0.10	0.10	0.10	0.23

Table 4: Variation of FZ in Ground floor Beams due to differential settlement

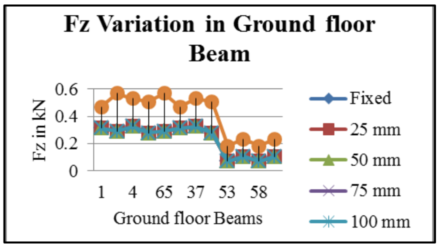

Fig. 6: Variation of FZ in Ground floor Beams due to differential settlement

D. Effect of differential settlement on MX on Ground floor Corner & Center Beams

In this case it is found that differential settlemet do not affect the bending moments changes in beams.as FZ is found having same values in both situations when 00 mm settlement is applied and when 25 mm,50 mm, 75mm, 100mm settlement applied. We can say that MX is not predominent. But when spring supports is applied instead of Fixed support it is seen that MX values are linearly increased as shown in table 5 and Fig.7.

B.N.	00 mm	25 mm	50 mm	75 mm	100 mm	Spring
1	0.354	0.354	0.354	0.354	0.354	0.532
46	0.262	0.262	0.262	0.262	0.262	0.284
4	0.29	0.29	0.29	0.29	0.29	0.288
50	0.323	0.323	0.323	0.323	0.323	0.447
65	0.262	0.262	0.262	0.262	0.262	0.284
40	0.354	0.354	0.354	0.354	0.354	0.532
37	0.29	0.29	0.29	0.29	0.29	0.288
61	0.323	0.323	0.323	0.323	0.323	0.447
53	0.078	0.078	0.078	0.078	0.078	0.091
21	0.069	0.069	0.069	0.069	0.069	0.066
58	0.078	0.078	0.078	0.078	0.078	0.091
20	0.069	0.069	0.069	0.069	0.069	0.066

Table 5: Variation of MX in Ground floor Beams due to differential settlement

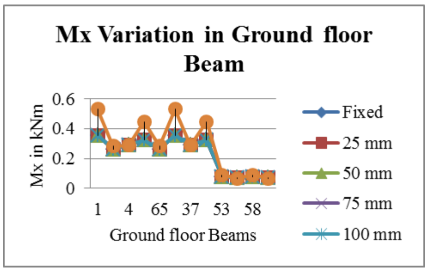

Fig. 7: Variation of MX in Ground floor Beams due to differential settlement

E. Effect of differential settlement on MY on Ground floor Corner & Center Beams

In this case it is found that differential settlemet do not affect the bending moments changes in beams.MY having same values in both situations when 00 mm settlement is applied and when 25 mm,50 mm, 75mm, 100mm settlement applied. We can say that MY is not predominent as MX is also not. But when spring supports is applied instead of Fixed support it is seen that MY values are linearly increased as shown in table 4 and Fig.6.

B.N.	00 mm	25 mm	50 mm	75 mm	100 mm	Spring
1	0.647	0.647	0.647	0.647	0.647	1.122

46	0.621	0.621	0.621	0.621	0.621	1.14
4	0.635	0.635	0.635	0.635	0.635	0.954
50	0.649	0.649	0.649	0.649	0.649	1.269
65	0.492	0.492	0.492	0.492	0.492	0.889
40	0.661	0.661	0.661	0.661	0.661	1.068
37	0.618	0.618	0.618	0.618	0.618	0.994
61	0.519	0.519	0.519	0.519	0.519	1.008
53	0.08	0.08	0.08	0.08	0.08	0.228
21	0.296	0.296	0.296	0.296	0.296	0.63
58	0.208	0.208	0.208	0.208	0.208	0.504
20	0.131	0.131	0.131	0.131	0.131	0.305

Table 6: Variation of MY in Ground floor Beams due to differential settlement

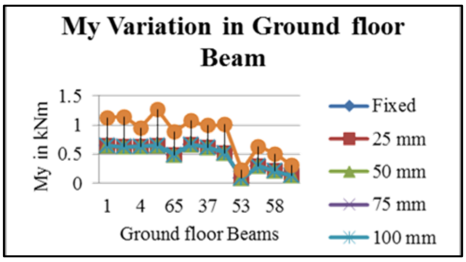

Fig. 8: Variation of MY in Ground floor Beams due to differential settlement

F. Effect of differential settlement on MZ on Ground floor Corner & Center Beams

It is important to know that only Beam no.58 is affected as its MZ values increasing with increase in settlement from 25 mm to 100 mm. and in beam no.46,50,53 value of MZ decreases as settlement increases. and when spring support is applied instead of fixed support it is found that MZ values increases in all beams except beam no.4,65,40,61

B.N.	00 mm	25 mm	50 mm	75 mm	100 mm	Spring
1	85.8	85.8	85.8	85.8	85.8	162.3
46	91.5	36.1	36.1	36.1	36.1	166.4
4	79.9	79.9	79.9	79.9	79.9	64.9
50	91.5	36.1	36.1	36.1	36.1	166.4
65	89.6	32.0	32.0	32.0	32.0	72.5
40	79.9	79.9	79.9	79.9	79.9	64.9
37	85.8	85.8	85.8	85.8	85.8	162.3
61	89.6	32.0	32.0	32.0	32.0	72.5
53	88.4	31.6	31.6	31.6	31.6	130.0
21	83.4	83.4	83.4	83.4	83.4	109.8
58	87.7	692	1296	1900	2504	108.9
20	84.3	84.3	84.3	84.3	84.3	133.4

Table 7: Variation of MZ in Ground floor Beams due to differential settlement

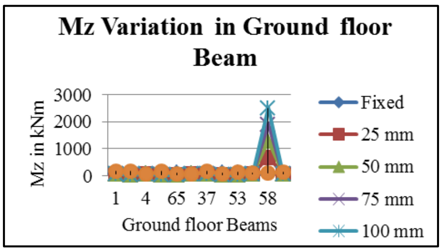

Fig. 9: Variation of MZ in Ground floor Beams due to differential settlement

In above Results and Discussion only Positive forces and moments are taken into consideration of beams. But apart from this Negative Forces and Bending moments are also of equal important hence in conclusion chapter effect of differential settlement on all forces and Moments are mentioned as per results carried out from Software i.e. Staad Pro – V8i.

V. CONCLUSION

Effect of differential settlement on superstructure is studied in this paper in terms of forces & moments changes in Ground floor after applying differential settlement of 25mm, 50mm, 75mm, 100mm and results compared with fixed support & spring supports. From above discussion & study below mentioned points are concluded.

1) +ve FX are predominant in beam no.46,50,53,58 and –ve FX are predominant in beam no.65,61it means near to differential settlement beams are having maximum –ve FX and + ve FX is maximum away from differential supports.
2) In case of FY,- ve FY is predominant in beam no.46,50,65,61,53 and +ve FY is predominant in beam no.58. means along X-axis as shown in Fig.3 beams are having maximum –ve FY except beam no.58
3) When differential settlement occur in building then FZ do not affect because from table 4 it is clear that values of FZ are same in zero mm settlement and 100 mm settlement.
4) As FZ is not affected due to differential settlement MX also do not affect and having equal value of MX in zero mm settlement and 100 mm settlement.
5) As FZ and FX do not affect due to differential settlement, MY also do not affect. Its value remain same before and after differential settlement from table no.6
6) In case of MZ, -ve MZ is predominant in beam no.46,50,65,61,53 and +ve MZ is predominant in beam no.58. means along X-axis as shown in Table 7.beams are having maximum –ve FY except beam no.58

From above points it can be concluded that when differential settlement occur in structure then FY and MZ are predominant and special attention need to be given while designing structure on FY and MZ.

REFERENCES

[1] Agrawal R.and Hora M.S.(2010), “Effect of differential settlements on nonlinear interaction behavior of plane frame – soil system”, ARPN Journal of engineering and applied sciences,Vol.5, No.7,pp.75-87
[2] Ms.I.L.sneha (IJETR-2014) Study on vertical settlement and lateral Displacem,ent in Different types of soils.
[3] Settlement of Building & Associate Damage by J.B.Burland & C.P. Worth
[4] M.A.Sabry and M.Sabry, Dept.of civil Engineering. Cairo Univ., Giza, “ Office building settlement and Remediation
[5] Roy R. and Duuta S.C.(2001), “Differential settlement among isolated fottings of building frames; ghe problem, its estimation and possible measures”, international journal of applied mechanics and engineering, Vol.6, No.1,pp.165-186
[6] Terence A.Weigel, Kenneth J.Ott,Joseph hagerty, “Load Redistribution in frame with settling footings

[7] IS: 9214-1979 " Method of Determination of Modulus of Subgrade Reaction (K-Value) of soils in field"
[8] IS:8009-1976 "Code of Practice for calculation of Settlement of Foundations"
[9] IS: 456-2000 " Code of Practice for general structural use of plain and Reinforced Concrete"
[10] IS: 87-1987 "code of practice for Design load for Building and Structures".