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Pattern Loading Effect on Seismic Behaviour of Structures by Considering With and Without Infilled Walls

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ABSTRACT

The exact estimation of configuration activities on the structure is imperative in basic plan as it altogether influences the last outline and targets. Any mistake in the estimation of configuration activities may prompt to wrong after effects of auxiliary investigation on the structure and prompt to the unlikely measuring of its basic individuals or even crumple of the structure. Accordingly it is vital to represent the most antagonistic impacts of live loads on the structure. The thought of example stacking relies on upon the proportion of dead to live load and the sort of basic part. Nowadays the greater parts of the architects are not considering the distinctive live load examples to get the unfriendly impact of the structure. Considering the live load to all the section boards may not fitting to gauge the plan parameters. In this unique situation, an endeavour is required to see the impact of example live load on the structure under seismic burdens. The impact of example load might be not quite the same as uncovered edge structure and furthermore infill structures. For the present work a customary symmetrical building will be picked and the structure is stacked with various examples live stacking is dissected by utilizing reaction range technique for seismic load case with and without infill walls. A limited component programming ETABS will be utilized for the examination of structures. The conduct of the structure will be examined as far as base shear, story shear, storey floats, day and age and furthermore twisting minutes and shear drives in identified sections.

Introduction

Structural engineering practice, individual structural members are designed for the critical scenarios. Conventionally such critical scenarios are being identified using structural analysis for different load combinations. Live loads such as human occupancy floor loads can be placed in various ways, some of which will result in larger effects than others. Hence, from a live load point of view we need to analyze a given structure for all possible placements of loads. Such placements of loads are known as load patterns. It is easy to see that the number of live load patterns needed in order to find the true critical response of the structure increases exponentially with an increase in the number of structural elements. Hence, the analysis of structures under all possible live load patterns becomes increasingly difficult or impossible for complex multidimensional systems.

Conventionally dead loads, live loads, earthquake loads and wind loads are the primary load types used to analyze a structure for various parameters like span moments, end moments, shear, thrust or deflections. The Muller Breslau Principle for influence lines is an effective way to obtain critical load patterns. Realizing the fact that the efforts required in solving large structures is too much and such efforts further increase as design demands multiple analysis of the structure. In a way, such conventional analysis tools prove to be realistic only in a qualitative sense.

Further, combining load combinations and load patterns requires the engineer to do multiple iterations of structural analyses in order to capture the critical scenario.

Apart from being an impractical task in most situations, it is impossible at times. In fact for
Simplicity standard structural engineering codes of practice have suggested several critical load patterns. In practice, engineers have limited themselves to suggested critical load patterns (ASCE02/ACI02/UBC/IBC). It is important to emphasize that these load combinations are just an effort in order to avoid large number of structural analysis and critical scenarios need not necessarily occur under such load combination and load patterns. In such cases engineers are supposed to make their own judgment and they have to take the risk of missing such critical cases.
The present work is an effort to show structural problems of all sorts of complexities under all possible load patterns and load combinations

Literature Survey

A structure will subjected to different types of loadings. Some loads are permanently constant and some loads are variable. Generally, self-weight of different elements in a structure is permanently constant whereas live loads or imposed loads differ time to time and also position to position. In practice designers consider all floors are subjected to dead load and live loads fully. But it is evident that in structural analysis maximum resultant values such as bending moments, shear forces depends on position of live loads. In this chapter a literature review is presented to know the importance of considering live load patterns in analysis and design of structures.

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ASCE 7-05 Section 4.6 states "The full intensity of the appropriately reduced live load applied only to a portion of a structure or member shall be accounted for if it produces a more unfavorable effect than the same intensity applied over the full structure or member." What this means is that you need to arrange the live load so as to cause maximum effect in your members. You must design your structural elements so that they have sufficient strength to support all possible arrangements of live load. Consequently your analysis needs to provide you with envelope diagrams for each member. Envelope diagrams are internal force diagrams that envelop all the possible values of force at each location along the member. So examples are used below to explain method for determining envelopes. This can seem daunting task as you need to do multiple load cases to account for the various loadings on your structural system. For statically determinate structures, it is often easy to establish critical loading scenarios for shear, moment, reactions, and deflection. Unfortunately for continuous, statically indeterminate structures this is not so obvious and the use of influence lines becomes extremely useful.

Ugur Ersoy (1992) worked on live load arrangements for multi-story frame analysis. He mentioned that 'Code require analyses based on live load arrangements producing the most unfavorable effects. This requirment leads to hundreds of cases in the analysis of multi-story structures which is neither feasible (even with the use of computer) nor sensible (due to the approximations involved). A reasonable number of cases should be analysed to obtain sufficiently accurate results'. In his work he proposed an apporach which requires the analyses of five cases irrespective of the number of stories and bays as shown in fig.1. Numerical comparisons indicated that proposed approach is simpler and it leads to more accurate results than those proposed earlier. From his work he concluded that the live load arrangement proposed in general seem to yield greater moments as compared to the other practical methods.

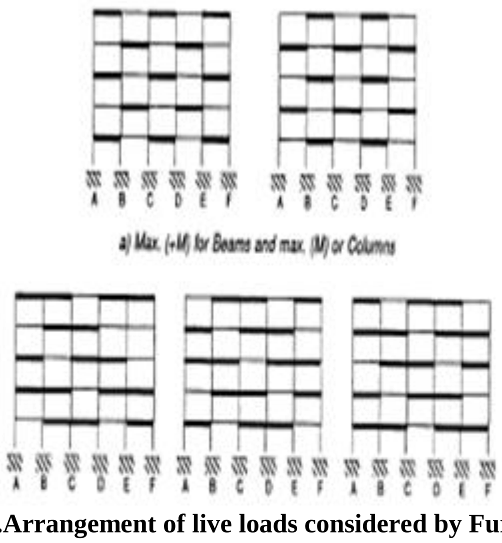


Fig 1.Arrangement of live loads considered by Furlong (1981).

Furlong R.W (1981) worked on rational analysis of multistory concrete structures. Problems to be faced in analysis of structures considering effect of live load patterns. In the work furlong approached the problem of solving the structures for different live load patterns as a practical designer and claimed that all possible live load combinations do not have to be considered for the following reasons. 1. As the number of load cases increases, the probability of occurrence of the most critical combinations decreases. 2. Member forces are not very sensitive to loading not adjacent to such members. 3.Linear elastic analysis is just an approximation for reinforced concrete structures in which I and E change due to cracking and creep. Considering these important points, Furlong proposed simple live load arrangements which he claimed would yield reasonable values for shear and bending moment in beams and columns. The live load patterns considered in the study by furlong given in figure 2.2.

Robert Park et.al.,**(2000)** mentioned some of the important points about the live load patterns in analysis of structures. In addition to the general structural characteristics, the ratio of live load to dead load, or movable load to total load, is very important in determining the significance of pattern loads. Pattern loads are obviously of much greater potential importance in a structure in which the live load is several times the dead load than in a structure in which the live load is only part of the dead load.

Kulkarini J.G, Kore P.N., S.B.Tanawade (2013) studied the analysis of multi story building frames subjected to gravity and seismic loads with varying inertia. his paper presents an elastic seismic response of reinforced concrete frames with 3 bay, 5 bay and 7 bay 9 storey structures which have been analyzed for gravity as well as seismic forces and their response is studied as the geometric parameters varying from view point of predicting behavior of similar structures subjected to similar loads or load combinations.

3.Modelling and Analysis

Generally structures are subjected to dead and live loads. Dead loads are constant through out of the life of the structures where as imposed loads or live loads vary time to time and position to position within the structure. Live loads position influences the design forces in different elements of the structure. In the present study a G+9 floors symmetrical building is chosen as shown in figure plan, elevation and isometric view respectively. Building is having plan dimension of 30 m ×30m , Six bays in each direction and each bay of 5 m. In all the models dead is considered full which includes self-weight of the slab, beams, columns, floor finishes and wall loads. There are Eight different live load patterns are considered for the study viz., loading is in alternate bays, chess board kind of pattern, live load only at the corners panels, loading is only in central panels, full live load in all panels etc. as shown in figures In this paper a detailed report is given which includes models, loading patterns, identified columns, beams bars for the study, parameters considered for the design. The study is conducted in three phases. In the first phase the models are analyzed for static load condition, in the second phase study the models are analyzed for seismic load conditions without considering infills. In the third phase study the models are analyzed for seismic load by considering infills. In seismic analysis response spectrum method has been used in phase 2 and phase 3 study. Columns and beams are identified for the study. A finite element software ETABS is used for the analysis.

Properties considered in the models

The following properties are considered for the analysis.

In the first phase study

Type of frame: Ordinary RC moment resisting frame fixed at the base.

Number of storey: 10 story (G+9).

Floor height: 3.0 m.
Depth of Slab: 175 mm.
Size of beam: (300 × 550) mm.
Size of column: (600 × 600) mm.
Spacing between frames: 5 m along X direction and 5m along Y-directions.
Materials: M 30 concrete,
Fe 415 steel Material.
Thickness of wall: 230 mm.
Unit weight of PPC: 24 kN/m^3
Unit weight of RCC: 25 kN/m^3
Unit weight of in fill: 19 kN/m^3

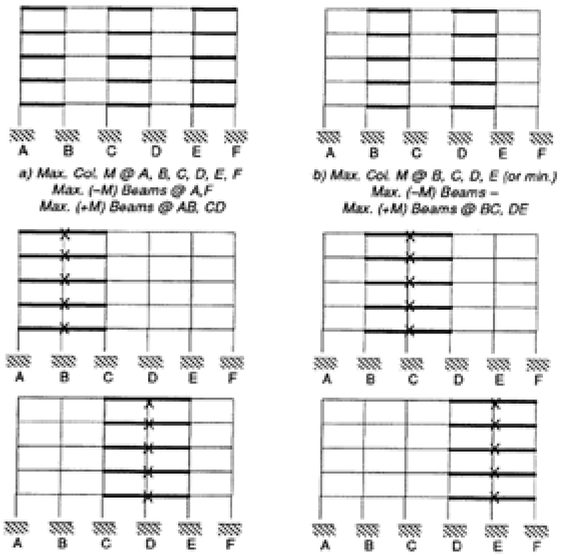


Fig 2. Arrangement of live loads considered by Furlong (1981).

Loadings:

The loads are considered as per IS 875 (part-1) for dead loads, IS 875 (part-2) for live loads
Live load on floor: 3 kN/m^2 (Commercial building)
Wall load: 12 kN/m (assuming 0.23 thick walls)
Parapet Wall load: 4 kN/m (Applied only on roof)
Dead load from slab : 0.175×25=4.375 kN/m^2
Floor finish : 1.0 kN/m^2
Approximate udl from wall load : 4.8 kN/m^2 (12× (5+5)/25)
Total Dead Load = 10.175 kN/m^2
Ratio of Dead Load to Live load = (10.175/3) =3.39

In the second phase study

In the second phase, in addition to the phase 1 study properties the following seismic parameters are considered.
Seismic zone (Z5): V, Seismic Zone factor, Z = 0.36

Fig 3. Plan of the building.

Soil type = III (Soft soil)
Importance factor, I = 1
Response Reduction factor, R = 3 (Ordinary moment resisting frame)
Damping of structure: 5 percent (Concrete)

In the third phase study

In addition to the phase I and II study properties the additional property considered is infill property. Infill is modelled as a compressive strut between a panel. The width of the infill is considered based on Paulay and Priestly infill model.
Width of infill is W=0.25 d_z, where d_z is the diagonal length of infill strut.
In our models dz is 4.94m
therefore width of strut is 0.25×4.94 =1.23 m.
Thickness of infill is 0.23m.

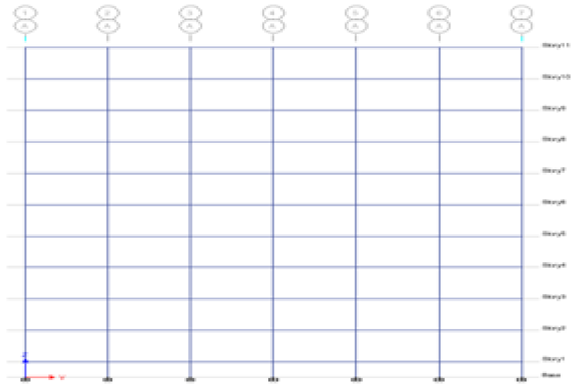


Fig 4. Elevation of the building (without nfill).

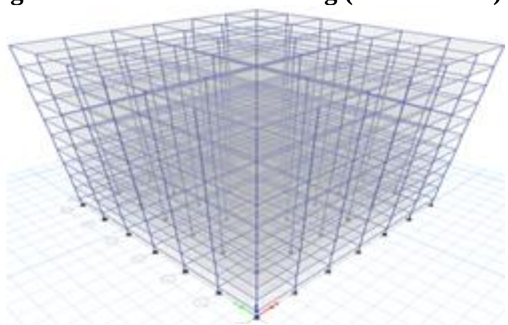
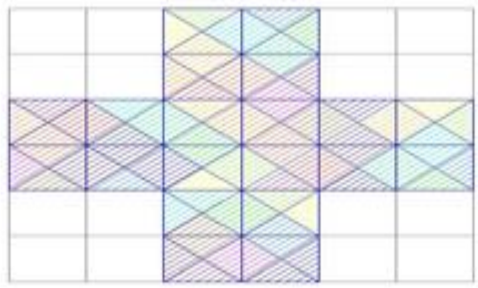
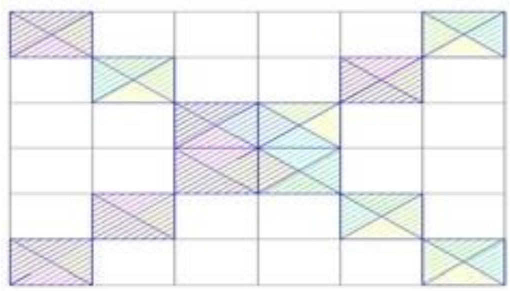


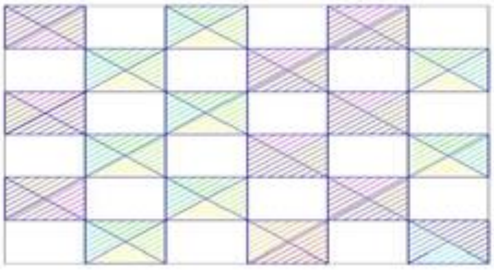
Fig 5 . Isometric view of the building.



Pattern 1

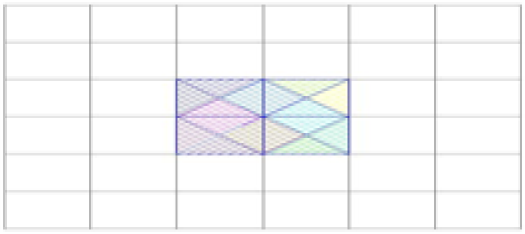


Pattern 2

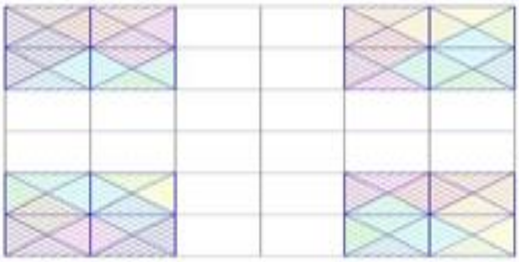


Pattern 3

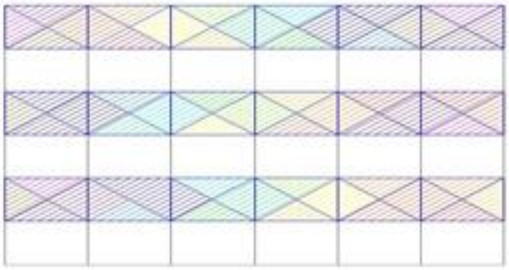
Fig 6 a. Different live load patterns.



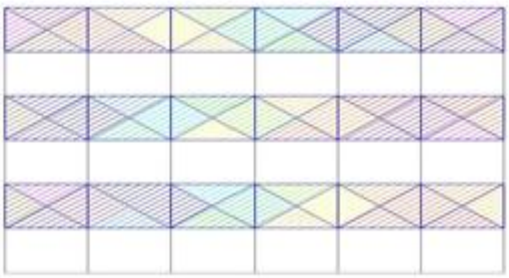
Pattern 4



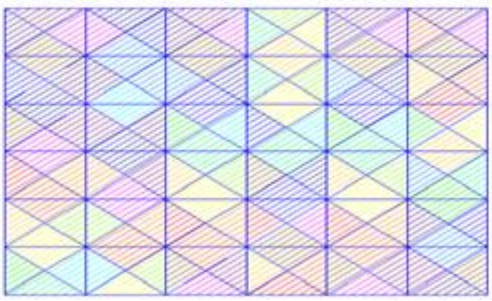
Pattern 5



Pattern 6



Pattern 7



Pattern 8

Fig 7b. Different live load patterns.

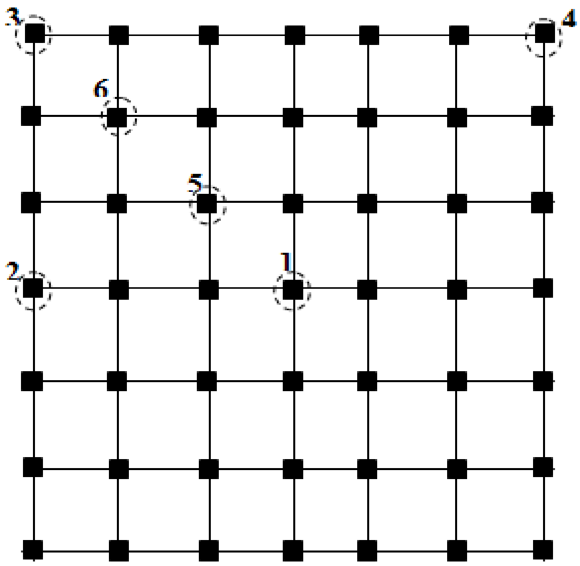


Fig 8. Identified columns for the study.

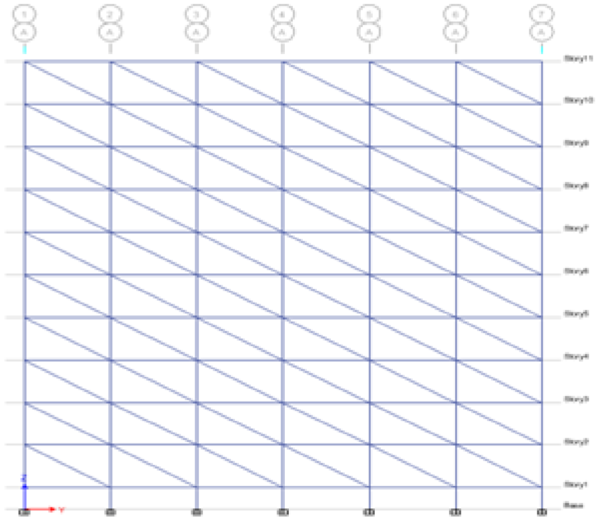


Fig 9. Elevation of frame model with infill.

Results and Discussion

The effect of pattern loading needs to be studied for every structure to design the elements for their worst design forces. In this project an attempt is given by considering Eight different live load patterns in a G+9 structure, which is having 6 bays of each 5m in each direction. The details of parameters considered. In each model eight live load patterns are considered uniformly in all floors of the structure. The dead load to live load ratio is considered 3.39.

The study is conducted in three phases. In the first phase study, for all considered live load patterns models are analyzed for static load condition. The absolute maximum bending moments and absolute maximum shear forces in different chosen columns are tabulated and studied. Similarly the absolute maximum bending moments in chosen beam bars are studied.

In the second phase study, for all considered live load patterns models of bare frame are analyzed for seismic loads. The absolute maximum bending moments and absolute maximum shear forces in different chosen columns are tabulated and studied. Similarly the absolute maximum bending moments in chosen beam bars are studied. In the third phase study, for all considered live load patterns models of infilled frame are analyzed for seismic loads. The absolute maximum bending moments and absolute maximum shear forces in different chosen columns are tabulated and studied.

Similarly the absolute maximum bending moments in chosen beam bars are studied. The results of three phases are presented and discussed here.

Base shear

Table 1. Base shear in kN for different pattern loading.

Patterns	Without infill	With infill
P1	5658.6	12455.22
P2	8704	18722
P3	9332.4	17588.3
P4	9421.3	17453.19
P5	9288.8	17398.81
P6	9332	16766
P7	9455.7	17702.69
P8	9582.63	17784.07

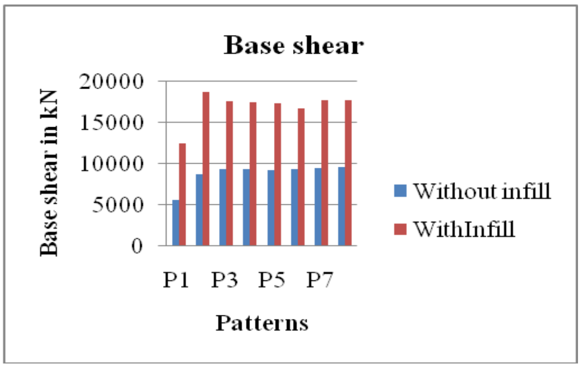


Fig 10. Base shear values in phase 2 and phase 3 studies.

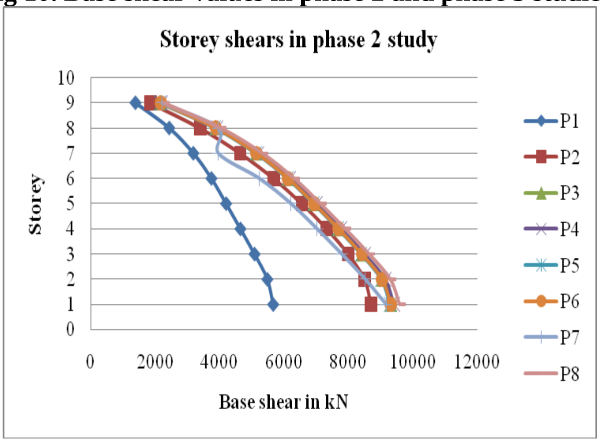


Fig 11. Storey shear in phase 2 study.

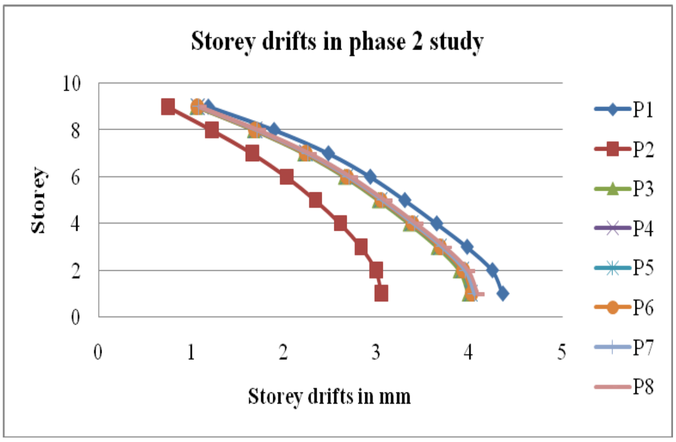


Fig 12. Storey drifts in phase 2 study.

Table 4. Absolute maximum bending moments in kN-m in columns.

Patterns	C1	C2	C3	C4	C5	C6
P1	48.78	42.25	40.57	44.58	42.98	44.78
P2	52.48	48.57	46.65	45.65	44.56	44.89
P3	60.79	56.66	52.64	48.65	46.06	44.16
P4	59.27	54.53	50.87	48.83	47.62	46.13
P5	59.42	56.17	52.63	49.03	46.71	45.18
P6	62.74	58.69	53.29	48.94	45.44	43.28
P7	61.85	57.93	54.33	50.77	48.77	46.74
P8	67.23	64.68	59.80	55.18	52.20	50.05

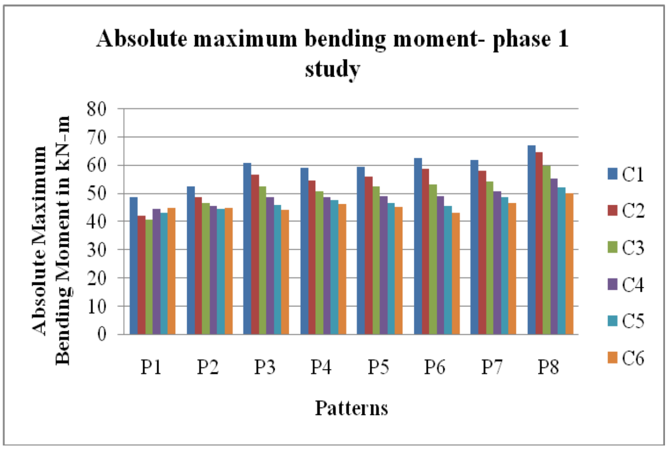


Fig 13. Absolute maximum bending moments in columns-phase 1 study.

Storey shears in phase 2 study

Table 2. Storey shears in kN in Phase 2 study for different pattern loading.

Patterns	Pattern-1	Pattern-2	Pattern-3	Pattern-4	Pattern-5	Pattern-6	Pattern-7	Pattern-8
Story9	1377.543	1839.176	2172.230	2203.966	2155.908	2171.813	2220.528	2261.252
Story8	2427.952	3385.269	3888.361	3938.163	3862.833	3887.614	3962.454	4028.399
Story7	3176.753	4632.360	5153.899	5212.118	5124.225	5152.903	3962.454	5318.140
Story6	3739.091	5670.969	6135.207	6196.521	6104.159	6134.011	5238.515	6308.797
Story5	4195.489	6550.273	6943.430	7006.059	6911.913	6942.068	6222.019	7121.317
Story4	4640.144	7325.975	7707.009	7773.504	7673.641	7705.494	7029.895	7896.156
Story3	5078.389	7986.006	8428.173	8501.835	8391.176	8426.521	7797.735	8637.611
Story2	5478.086	8496.002	9058.015	9141.157	9016.124	9056.250	8529.057	9294.018
Story1	5658.611	8703.904	9332.411	9420.641	9287.883	9330.598	9173.414	9582.633

Storey drifts in phase 2 study

Table 3.Storey drifts in Phase 2 study for different pattern .

Patterns	P1	P2	P3	P4	P5	P6	P7	P8
Story9	1.179	0.741	1.0544	1.0682	1.0615	1.065	1.08	1.093
Story8	1.889	1.218	1.6719	1.6919	1.684	1.689	1.709	1.728
Story7	2.475	1.654	2.2128	2.2366	2.2301	2.235	2.258	2.28
Story6	2.927	2.023	2.6497	2.6753	2.6717	2.676	2.698	2.722
Story5	3.299	2.335	3.0152	3.042	3.0413	3.045	3.067	3.091
Story4	3.643	2.604	3.3464	3.375	3.3758	3.38	3.402	3.428
Story3	3.972	2.826	3.6478	3.6794	3.6798	3.684	3.71	3.738
Story2	4.244	2.986	3.8859	3.921	3.9195	3.925	3.954	3.985
Story1	4.357	3.046	3.9815	4.0182	4.0159	4.022	4.053	4.086

Absolute Maximum shear forces in phase 1 study The absolute maximum shear force in phase 1 study presented in figure and table. The absolute Maximum shear force in phase 1 study is influenced by only pattern 8 (all panels loaded).

Table 5. Absolute maximum shear force in kN in columns.

Patterns	C1	C2	C3	C4	C5	C6
P1	21.27	23.32	23.02	22.67	23.02	23.32
P2	22.29	22.48	22.58	22.58	22.35	22.83
P3	20.04	22.36	22.84	22.95	22.97	22.92
P4	20.91	22.47	23.29	23.00	23.32	22.62
P5	21.13	21.10	22.52	22.84	22.67	22.42
P6	20.67	21.51	21.80	21.99	22.13	22.24
P7	21.87	22.81	22.96	23.00	22.97	22.87
P8	22.01	23.40	23.62	23.68	23.67	23.57

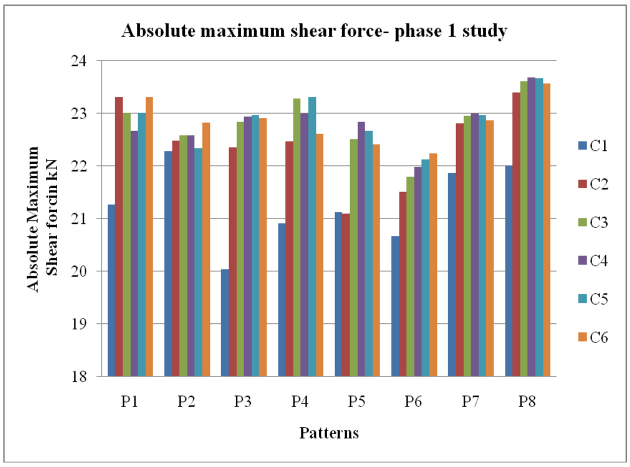


Fig 14. Absolute maximum shear force in columns- phase 1 study.

Maximum storey displacement

Table 6 . Maximum storey displacement in mm in top storey.

Patterns	Static	Without infill	With Infill
P1	7.5	72.75	32.59
P2	3.2	51.99	35.63
P3	3.1	66.83	35.68
P4	3.4	67.40	35.67
P5	3.02	67.42	34.83
P6	3.51	67.50	40.67
P7	3.02	67.95	35.95
P8	3.5	68.47	35.60

The maximum storey displacement is observed in one corner of the top storey. The results are presented in above table and figure. In phase 1 study, the maximum storey displacement is more in pattern 1 (corner panels loading) and is 2 times more than pattern 8. In phase 2 study, pattern 1 has 6% more storey displacement when compared to pattern 8.

In phase 3 study, the storey displacement in top storey is 14% more than the pattern 8.

The storey displacements are more in phase 2 model (dynamic analysis of bare frame) when compared to phase 3 models. The maximum value of phase 2 study is around 80% more than the phase 3 study. For lower values of displacement of phase 3 model for lateral loads indicate higher stiffness than phase 2 model.

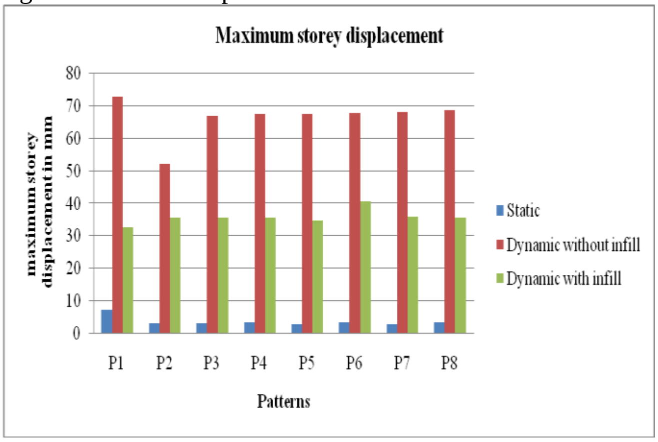


Fig 15. Maximum storey displacement in top storey.

The base shear values of considered structure with and without infill walls are presented in table 1 and depicted in figure 10. In the model without infill the maximum shear is in pattern 8, i.e. live load in all panels. In this, full load is considered in all panels therefore the total mass of the structure increased in turn base shear also increases. The base shear values are higher in structure with infills and lower in without infill structure. If infills are considered, the structure time period will be decreased and S_a/g value increases (depending upon time period in response spectrum). In this case the variation is almost two times from without infill structure to with infilled structure. In the structure with infill, the maximum base shear is in pattern 2.

Absolute Bending moments in Beams

Absolute maximum bending moments are studied in beam bars, which are shown in figure . In each identified beam bar, the absolute moments are observed at end and mid span of each span. The results are presented and discussed as follows.

Absolute bending moments in BAR 1

Static analysis

Absolute maximum moments are presented in table. The results shows that end span moment are influenced by pattern loading and the influence is very nominal and not greater than 1%. Therefore, it can be concluded that there is no influence of pattern loading.

Table 7. Absolute bending moments in kN-m - Static analysis.

	B1			B2			B3			B4			B5			B6		
	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES
P1	60.81	49.86	60.66	62.20	48.38	62.22	52.66	39.33	52.58	52.58	39.38	52.06	62.22	48.38	62.20	60.66	49.85	60.81
P2	50.59	41.10	50.57	52.90	39.42	51.73	62.46	48.40	61.95	61.95	48.35	62.46	51.73	39.29	52.90	50.57	41.09	50.59
P3	60.35	50.10	60.61	52.81	39.13	52.34	61.87	48.63	62.03	52.49	39.09	52.67	61.54	48.60	62.35	50.62	40.81	51.07
P4	50.50	41.09	50.66	52.81	39.42	51.82	62.28	48.39	62.13	61.25	48.78	62.25	35.57	23.36	33.53	48.48	41.42	51.67
P5	50.50	41.09	50.64	52.30	39.66	51.79	72.04	39.63	52.04	52.04	39.63	52.04	51.79	39.61	52.30	50.64	41.11	50.50
P6	60.85	49.84	60.64	62.80	48.07	62.18	62.49	48.10	62.49	62.49	48.10	62.49	62.18	48.14	62.80	60.64	49.86	60.85
P7	60.51	50.12	60.43	52.99	39.14	52.18	62.10	48.66	61.79	52.75	39.11	52.42	61.78	48.63	62.10	50.80	40.83	50.89
P8	60.19	49.87	60.59	62.18	48.14	62.17	62.49	48.10	62.49	62.49	48.10	62.49	62.17	48.07	62.80	60.59	49.83	60.90

Absolute bending moments in bare frame BAR 1-Dynamic analysis

Table 8. Absolute bending moments in kN-m - bare frame dynamic analysis.

Pattern	B1			B2			B3			B4			B5			B6		
	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES
P1	91.93	13.18	91.86	91.89	13.22	91.90	77.92	10.71	78.15	78.15	10.48	77.92	91.90	13.21	91.89	91.86	13.25	91.93
P2	78.04	10.59	78.03	78.30	10.33	77.77	92.01	13.10	91.78	91.78	13.33	92.01	77.77	10.86	78.30	78.03	10.60	78.04
P3	91.84	13.27	91.95	78.14	10.49	77.93	91.86	13.25	91.93	77.99	10.64	78.08	91.71	13.40	92.08	77.93	10.70	78.14
P4	78.00	10.63	78.07	78.26	10.37	77.81	91.93	13.18	91.86	91.67	13.44	92.12	53.67	5.45	52.75	77.31	11.32	78.76
P5	78.00	10.63	78.07	78.15	10.48	77.92	78.04	10.60	78.03	78.03	10.60	78.04	77.92	10.71	78.15	78.07	10.57	78.00
P6	91.94	13.16	91.85	92.04	13.07	91.75	91.89	13.21	91.90	91.90	13.21	91.89	91.75	13.35	92.04	91.85	13.26	91.94
P7	91.91	13.20	91.88	78.22	10.41	77.85	91.97	13.14	91.82	78.11	10.52	77.96	91.82	13.29	91.97	78.02	10.62	78.05
P8	91.97	13.14	91.82	92.04	13.07	91.75	91.89	13.21	91.90	91.90	13.21	91.89	91.75	13.36	92.04	91.82	13.28	91.97

Absolute maximum moments of bare frame phase 2 study are presented in table. The results shows that end span moment are very high and mid span moments are very small compared to end span moments. Though end span moments are more in other than pattern 8 but the difference is very small. Therefore it can be noted that they are not influenced by pattern loading. By comparing the results of static and dynamic analysis of bare frame structure, the end span moments are increased by 50% to 53% in dynamic analysis where as in mid spans the moments are decreased by 70 to 75% in all spans.

Absolute bending moments in infill frame BAR 1-Dynamic analysis

Table 9. Absolute bending moments in kN-m - infill frame dynamic analysis.

	B1			B2			B3			B4			B5			B6		
	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES
P-1	51.82	27.68	12.76	53.44	26.61	13.37	52.68	26.62	13.97	53.19	26.70	13.43	52.86	26.60	13.86	51.65	27.62	12.99
P-2	51.75	27.70	12.78	54.72	26.74	11.94	54.12	26.73	12.62	52.74	26.56	14.04	51.87	26.54	14.76	51.88	27.71	12.64
P-3	51.33	27.58	13.32	53.66	26.75	12.97	53.12	26.58	13.70	52.55	26.65	14.02	52.06	26.47	14.74	51.16	27.64	13.35
P-4	50.84	27.84	13.79	52.79	26.61	13.90	52.57	26.59	14.11	52.40	26.57	14.29	52.29	26.61	14.31	51.64	27.51	13.05
P-5	50.50	27.59	13.98	53.05	26.62	13.69	52.44	26.57	14.25	52.05	26.53	14.64	51.52	26.48	15.16	51.11	27.61	13.44
P-6	52.34	27.72	12.26	54.40	26.75	12.36	53.64	26.70	13.07	53.14	26.64	13.56	52.44	26.59	14.19	51.79	27.63	12.93
P-7	51.63	27.61	13.03	53.97	26.79	12.64	53.49	26.62	13.33	52.93	26.70	13.63	52.44	26.52	14.35	51.49	27.69	13.01
P-8	53.60	27.84	11.05	55.65	26.90	11.11	54.89	26.84	11.81	54.40	26.79	12.30	53.74	26.72	12.94	53.93	27.79	11.67

Absolute maximum moments of infill frame phase 3 study are presented in table 9. The results shows that end span moment are very high and mid span moments are very small compared to end span moments. Though end span moments are more in other than pattern 8 but the difference is very small. Therefore it can be noted that they are not influenced by pattern loading. Mid span moments are increased in comparison of bare frame dynamic analysis. The moments in mid span are increased by two times, but less than 50% of bare frame static analysis results. End span moments are reduced by 40% compared to bare frame dynamic analysis results where as end span moments are decreased by 10%.

Absolute bending moments in BAR 2

Absolute bending moments in bare frame structure - Static analysis

Table 10. Absolute bending moments in kN-m - Static analysis.

Pattern	B1			B2			B3			B4			B5			B6		
	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES
P1	89.38	74.27	88.89	91.10	72.28	91.11	70.98	54.21	71.63	71.63	45.28	70.98	91.11	72.28	91.10	88.89	74.22	88.38
P2	69.06	56.77	68.56	72.06	54.35	70.53	91.43	72.31	90.78	90.78	72.24	91.43	70.53	54.18	72.06	68.56	56.72	69.06
P3	49.58	40.39	51.11	79.95	63.95	80.98	81.20	63.25	81.22	81.13	63.25	81.29	80.73	63.22	81.66	78.62	65.45	79.33
P4	68.99	56.77	68.63	71.98	54.34	70.61	91.36	72.31	90.85	90.09	72.08	91.71	65.83	65.83	53.44	72.14	68.44	56.71
P5	68.91	56.76	68.70	71.14	54.84	70.37	70.80	54.81	70.71	70.71	54.80	70.80	70.37	54.36	71.14	68.70	56.74	68.91
P6	79.25	65.47	78.70	81.58	63.23	80.82	81.20	63.26	81.21	81.21	63.26	81.20	80.82	63.31	81.58	78.70	65.53	79.25
P7	88.78	74.80	88.43	72.31	53.78	71.35	90.74	72.82	90.42	71.99	53.74	71.67	90.29	72.78	90.85	69.02	56.18	69.67
P8	89.55	74.28	88.74	92.08	71.79	91.21	91.65	71.73	91.66	91.66	71.73	91.65	91.21	71.69	92.08	88.74	74.19	89.54

Absolute maximum moments of bar 2 in bare frame static analysis are presented in table 10. The results shows that end span moments and mid span moments are not influenced by pattern loading. Bar 2 moments are more than bar 1 moments as load transferred from slab to beam is more.

Absolute bending moments in bare frame BAR 2-Dynamic analysis

Table 11. Absolute bending moments in kN-m - bare frame dynamic analysis.

Patterns	B1			B2			B3			B4			B5			B6		
	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES
P1	130.69	20.40	130.47	130.58	20.52	130.59	102.71	15.43	103.01	103.01	15.13	102.71	130.59	20.51	130.58	130.47	20.63	130.69
P2	102.98	15.17	102.75	103.21	14.93	102.51	130.73	20.37	130.44	130.44	20.66	130.73	102.51	15.63	103.21	102.75	15.40	102.98
P3	75.34	9.72	78.73	116.49	18.13	116.96	116.72	17.90	116.73	116.69	17.93	116.76	116.51	18.11	116.93	116.56	18.06	116.88
P4	102.94	15.20	102.78	103.17	14.97	102.55	130.70	20.40	130.47	130.37	20.72	130.79	143.76	15.29	102.87	102.70	15.45	103.03
P5	102.91	15.23	102.81	103.04	15.11	102.69	102.88	15.26	102.84	102.84	15.30	102.88	102.69	15.46	103.04	102.81	15.33	102.91
P6	116.85	17.77	116.60	116.90	17.72	116.55	116.72	17.90	116.72	116.72	17.90	116.72	116.55	18.07	116.90	116.60	18.02	116.85
P7	130.66	20.43	130.50	103.08	15.07	102.64	130.65	20.44	130.51	102.93	15.21	102.79	130.45	20.64	130.71	102.71	15.43	103.01
P8	130.77	20.33	130.40	130.78	20.32	130.38	130.58	20.51	130.58	130.58	20.51	130.58	130.38	20.71	130.78	130.40	20.70	130.77

Absolute maximum moments of bar 2 of bare frame phase 2 study are presented in table 11. The results shows that end span moment are very high and mid span moments are very small compared to end span moments. Though end span moments are more in other than pattern 8 but the difference is very small. Therefore it can be noted that they are not influenced by pattern loading. By comparing the results of static and dynamic analysis of bare frame structure, the end span moments are increased by 45% to 50% in dynamic analysis where as in mid spans the moments are decreased by 70 to 75% in all spans.

Absolute bending moments in infill frame BAR 2-Dynamic analysis

Absolute maximum moments of bar 2 infill frame phase 3 study are presented in table 12. The results shows that end span moment are very high and mid span moments are very small compared to end span moments. Though end span moments are more in other than pattern 8 but the difference is very small. Therefore it can be noted that they are not influenced by pattern loading. Mid span moments are increased in comparison of bare frame dynamic analysis. The moments in mid span are increased by two times, but less than 50% of bare frame static analysis results. End span moments are reduced by 40% compared to bare frame dynamic analysis results where as end span moments are decreased by 50% to 60% and mid span moments are increased by 20 to 25%.

Table 12.Absolute bending moments in kN-m - infill frame dynamic analysis.

Pattern	B1			B2			B3			B4			B5			B6		
	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES
P1	52.69	27.70	12.03	52.62	26.42	14.39	51.25	26.45	15.42	52.35	26.63	14.22	52.05	26.48	14.74	49.51	27.19	15.48
P2	52.35	27.72	12.26	54.84	26.83	11.88	53.82	26.63	13.04	51.29	26.23	15.61	49.97	26.35	16.61	49.84	27.36	14.42
P3	52.11	27.90	12.12	54.41	26.64	12.55	52.62	26.52	14.20	51.69	24.46	15.06	50.80	26.38	15.91	49.43	27.24	15.47
P4	51.75	26.74	12.80	52.59	26.46	14.34	51.38	26.44	15.33	51.60	26.50	15.05	51.07	26.40	15.66	49.33	27.22	15.57
P5	50.99	27.60	13.56	52.70	26.50	14.13	51.67	26.45	15.04	51.04	26.40	15.69	50.31	26.34	16.37	49.36	37.29	15.42
P6	52.71	27.72	11.96	53.91.	26.64	12.95	52.73	26.56	14.04	52.04	26.50	14.73	51.19	26.44	15.15	49.85	27.29	15.02
P7	52.24	27.55	12.65	53.48	26.73	13.14	52.64	26.42	14.36	51.60	26.61	14.77	51.10	26.30	15.81	49.13	27.31	15.57
P8	54.59	27.86	10.21	55.27	26.78	11.62	53.92	26.68	12.87	53.60	26.61	13.65	52.16	26.54	14.52	50.44	27.32	14.52

Absolute bending moments in BAR 3

Absolute bending moments in bare frame structure - Static analysis

Absolute maximum moments of bar 3 in bare frame static analysis are presented in table 13. The results shows that end span moments and mid span moments are not influenced by pattern loading. Bar 2 moments are more than bar 1 moments as load transferred from slab to beam is more.

Table 13. Absolute bending moments in kN-m - Static analysis.

Pattern	B1			B2			B3			B4			B5			B6		
	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES
P1	79.25	65.54	78.68	81.05	63.56	80.80	70.82	54.15	71.25	71.25	54.54	70.22	80.80	63.53	81.05	78.68	65.47	79.25
P2	79.39	65.54	78.55	82.14	63.07	80.80	91.59	72.03	91.17	91.17	71.98	91.59	80.80	62.92	82.14	78.55	65.45	79.39
P3	78.62	65.45	79.33	76.14	64.64	71.78	81.56	63.34	80.79	81.14	63.26	81.27	80.73	63.22	81.66	78.55	65.45	79.39
P4	79.33	65.54	78.61	82.09	63.07	80.86	91.53	72.02	91.22	91.14	71.98	91.61	80.70	62.91	82.24	78.49	65.44	79.46
P5	69.04	56.78	68.57	71.63	54.16	70.42	81.13	63.56	80.72	80.72	63.52	81.13	70.42	54.46	71.63	68.57	56.72	69.64
P6	79.32	55.54	78.61	81.60	63.31	80.80	81.20	63.26	81.21	81.21	63.26	81.20	80.80	63.23	81.60	78.61	65.46	79.32
P7	88.85	74.81	88.34	72.32	53.78	71.34	96.73	72.82	90.42	79.99	53.74	71.68	90.26	72.79	96.87	68.89	56.17	69.79
P8	89.67	74.30	88.61	92.10	71.79	91.19	91.65	71.73	91.66	91.66	71.73	91.65	91.19	79.69	92.10	88.6	74.19	89.67

Absolute bending moments in bare frame BAR 3-Dynamic analysis

Table 14. Absolute bending moments in kN-m - bare frame dynamic analysis.

	B1			**B2**			**B3**			**B4**			**B5**			**B6**		
Pattern	**ES**	**MS**	**ES**	**ES**	**MS**	**ES**	**ES**	**MS**	**ES**	**ES**	**MS**	**ES**	**ES**	**MS**	**ES**	**ES**	**MS**	**ES**
P1	116.85	17.77	116.59	116.78	17.84	116.67	102.76	15.38	102.96	102.96	15.19	102.76	116.67	17.95	116.78	116.59	18.03	116.85
P2	130.79	20.30	130.37	130.84	20.26	130.33	130.63	20.47	130.54	130.54	20.56	130.63	130.33	20.77	130.84	130.37	20.72	130.79
P3	116.86	17.76	116.59	116.88	17.74	116.56	116.70	17.92	116.75	116.70	17.92	116.75	116.51	18.10	116.93	116.53	18.09	116.91
P4	130.77	20.32	130.39	130.82	20.28	130.35	130.61	20.49	130.55	130.52	20.58	130.65	130.31	20.79	130.86	130.35	20.74	130.81
P5	102.99	15.15	102.73	103.21	14.93	102.51	130.73	20.37	130.44	130.44	20.66	130.73	102.51	15.63	103.21	102.73	15.41	102.99
P6	116.88	17.74	116.56	116.90	17.72	116.54	116.72	17.90	116.72	116.72	17.90	116.72	116.54	18.08	116.90	116.56	18.06	116.88
P7	130.70	20.40	130.47	103.09	15.06	102.64	130.65	20.44	130.51	102.93	15.21	102.79	130.44	20.65	130.72	102.65	15.49	103.07
P8	130.83	20.27	130.34	130.79	20.31	130.37	130.58	20.51	130.58	130.58	20.51	130.58	130.37	20.72	130.79	130.34	20.76	130.83

Absolute maximum moments of bar 3 of bare frame phase 2 study are presented in table 14. The results shows that end span moment are very high and mid span moments are very small compared to end span moments. Though end span moments are more in other than pattern 8 but the difference is very small. Therefore it can be noted that they are not influenced by pattern loading. By comparing the results of static and dynamic analysis of bare frame structure, the end span moments are increased by 45% to 50% in dynamic analysis where as in mid spans the moments are decreased by 70 to 75% in all spans. The results of bending moments in bar 2 and bar 3 are same as the loads transferred from slab to beams are also same.

Absolute bending moments in infill frame BAR 3-Dynamic analysis

Table 15. Absolute bending moments in kN-m - infill frame dynamic analysis.

Pattern	B1			B2			B3			B4			B5			B6		
	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES	ES	MS	ES
P1	51.84	27.96	12.73	53.49	26.61	13.34	52.46	26.54	14.29	51.88	26.49	14.89	51.18	26.43	15.51	50.20	27.40	14.57
P2	53.05	27.73	11.69	53.78	26.60	13.13	52.35	26.50	14.45	51.45	26.43	15.31	50.49	26.36	16.20	48.83	27.10	16.18
P3	52.25	27.69	12.40	53.44	26.58	13.43	52.20	26.50	14.58	51.46	26.44	15.28	50.62	26.37	16.60	49.31	27.22	15.28
P4	51.54	27.65	13.03	54.01	26.72	12.73	52.92	26.53	13.95	50.38	26.23	16.52	49.05	26.24	17.56	48.92	27.24	15.87
P5	51.05	27.60	13.51	53.53	26.67	13.21	52.44	26.47	14.43	49.84	26.17	17.02	48.57	26.19	18.04	48.47	27.18	16.34
P6	52.34	27.70	12.31	53.54	26.59	13.34	52.30	26.51	14.47	51.56	26.45	15.19	50.73	26.38	15.96	49.41	27.24	15.49
P7	52.19	27.55	12.69	53.42	26.72	13.21	52.55	26.41	14.47	51.58	26.60	14.90	50.96	26.28	15.96	48.99	27.29	15.71
P8	54.55	27.87	10.24	55.21	26.77	11.68	53.81	26.67	12.98	52.96	26.60	13.79	52.01	26.53	14.68	50.29	27.29	14.67

Absolute maximum moments of bar 3 infill frame phase 3 study are presented in table 15. The results shows that end span moment are very high and mid span moments are very small compared to end span moments. Though end span moments are more in other than pattern 8 but the difference is very small. Therefore it can be noted that they are not influenced by pattern loading. Mid span moments are increased in comparison of bare frame dynamic analysis. The moments in mid span are increased by two times, but less than 50% of bare frame static analysis results. End span moments are reduced by 40% compared to bare frame dynamic analysis results whereas end span moments are decreased by 50% to 60% and mid span moments are increased by 20 to 25%.

Conclusion

1. Phase 2 model (bare frame) is not influenced by pattern loading where as phase 3 model influenced and the variation is 5% when compared to full loading pattern. This is due to stiffness variation in the structure.
2. The stroey shears are more in phase 3 models when compared to phase 2 models. The values are increased more than 60%. There is no influence of pattern load for storey shear in phase 2 model but it is influenced by pattern loading in phase 3 model.
3. Storey drifts are influenced in both phase 2 and phase 3 models. Storey drifts values are considerably decreased in phase 3 model. As infills increases the stiffness the deformations and drifts decreases.
4. Time periods are also influenced by pattern loading. The variation is about 5 % compared to full loading i.e. pattern 8. Time periods depends on mass and stiffness of the structure, therefore infill structures have less time period when compared to bare frame structures.
5. The columns absolute maximum bending moments are not influenced by pattern loading in phase 1 study (static analysis of bare frame).
6. Interior columns of absolute maximum bending moments are influenced by the pattern loading in phase 2 study, where as exterior columns have very minimal influence of pattern loading on absolute maximum bending moments.
7. Phase 3 model of absolute maximum bending moments have influenced by the pattern loading and magnitudes are more than 2 times of absolute maximum bending moments of phase 2 model.
8. Absolute maximum shear forces in columns are not influenced by pattern loading in phase 1 study (static analysis of bare frame).
9. Phase 2 and phase 3 columns of absolute maximum shear forces are influenced by pattern load but the influence is nominal.
10. Maximum displacement of top storey are also influenced by pattern loading. Phase 3 model displacements are less than phase 2 model. As the stiffness increases displacements decreases.
11. Absolute bending moments in mid spans are maximum in all spans in static analysis and end span moments are maximum in bare frame dynamic analysis.

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