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DYNAMIC BEHAVIOUR OF REINFORCED CONCRETE BUILDING WITH AND WITHOUT OPENING IN MASONRY INFILLS

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ABSTRACT:

Masonry infills are normally considered as non-structural elements, and their stiffness contributions are generally ignored in practice, such an approach can lead to an unsafe design. The masonry infill walls though constructed as secondary elements behave as a constituent part of the structural system and determine the overall behavior of the structure especially when it is subjected to dynamic loads.

In this paper, dynamic analysis has been performed using Equivalent Lateral Force Method for different reinforced concrete (RC) frame building models that include a bare frame, infilled frame and different percentages of opening in infilled frame. The results of bare frame, infilled frame and different percentages of the opening in the infilled frame are discussed and conclusions are made.

The opening size of the infill has a significant influence on the fundamental period, lateral displacement; inter story drift and maximum story acceleration, generally, they increases as the opening size increases. The base shear decreases as the opening size increase. In modeling the masonry infill panels, the Equivalent diagonal Strut method is used and the software ETABS used for the analysis of all the frame models.

INTRODUCTION

The behavior of masonry infilled frame structures has been studying from last four decades in attempts to develop a rational approach to the design of the frames. It is a general practice in all developing countries to provide brick masonry infill walls within the columns and beam of Reinforced concrete frame structures. Such composite structures formed by the combination of a moment resisting plane frames and infill walls are known as "**infilled frames.”** Reinforced concrete (RC) frames consist of horizontal elements (beams) and vertical elements (columns) connected by rigid joints. RC frames provide resistance to both gravity and lateral loads through bending in beams

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and columns. Reinforced concrete frame buildings often incorporate masonry infill panels as partitions with in a building or as cladding to complete the building envelope. However, the properties and construction details of infilled panels can have a significant influence on the overall behavior of a structure. There are a lot of researches done so far for infilled frames, however partially infilled frames are still the topic of interest. Though it understood that the infill's play a significant role in enhancing the lateral stiffness of complete structure, the experience in various earthquakes has proved that the partially infilled framed structures somehow are affected adversely.

Infill walls provide Durable and economical partitions having relatively excellent thermal and sound insulation with high fire resistance. In the areas where the burnt clay bricks are simply available, these infill's made in brick masonry, and in other sectors, hollow or solid concrete blocks used. Infill walls usually provided for functional and architectural reasons, and they are usually considered as non-structural elements, and their strength and stiffness contributions are ignored in the analysis work despite significant advances in computer technology and availability of modern computational resources. The reasons for ignoring their presence may be due to the complication involved in analysis and also the uncertainty about the non-integral action between infill and the frame. Thus, the study of structures should also base on the infill frames. The infill's have energy dissipation characteristics that contribute to improved seismic resistance. It has observed from past earthquakes that the infill's give in the enhancement of overall lateral stiffness of the structure. Strong infill's have often prevented the collapse of relatively flexible and weak reinforced concrete frames. [5] discussed about a method, This scheme investigates a traffic-light-based intelligent routing strategy for the satellite network, which can adjust the pre-calculated route according to the real-time congestion status of the satellite constellation. In a satellite, a traffic light is deployed at each direction to indicate the congestion situation, and is set to a relevant color, by considering both the queue occupancy rate at a direction and the total queue occupancy rate of the next hop. The existing scheme uses TLR based routing mechanism based on two concepts are DVTR Dynamic Virtual Topology Routing (DVTR) and Virtual Node (VN). In DVTR, the system period is divided into a series of time intervals. On-off operations of ISLs are supposed to be performed only at the beginning of each interval and the whole topology keeps unchanged during each interval. But it has delay due to waiting stage at buffer. So, this method introduces an effective multi-hop scheduling routing scheme that considers the mobility of nodes which are clustered in one group is confined within a specified area, and multiple groups move uniformly across the network.

In an earthquake, the building base experiences high-frequency movements, which results in inertial forces on the structure and its components. The energy created by the building's tendency to remain at rest, and in its original position, even though the ground beneath it is moving. This is by an important physical law known as D'Alembert's Principle, which states that a mass acted upon by acceleration tends to oppose that acceleration in an opposite direction and proportionally to the magnitude of the acceleration (Figure 1.1). This inertial force

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imposes strains upon the building's structural elements such as beams, columns, walls, and floors. If these strains are large enough, the building's structural elements suffer damage of various kinds, which may lead to the collapse of the building.

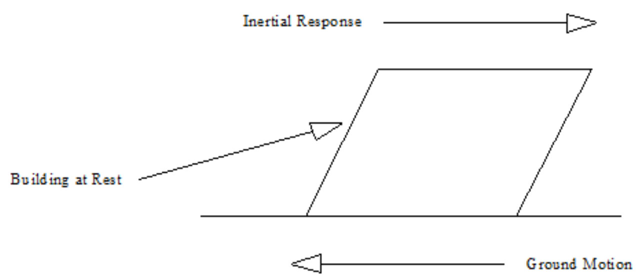

Fig 1: Structure Responses towards the Ground Motion

The infill masonry is seldom included in the numerical analysis of a structural system, because masonry panels generally considered as structural elements of secondary importance, which introduce unwanted analytical complexities without having pronounced effect on the structural performance. However, many researchers have realized the significant result of the infilled masonry on the structural responses of frames that it can affect the seismic behavior of framed building to at-large extend without the presence of nonstructural masonry infill's. These effects are positive: masonry infill's can dramatically increase global stiffness and strength of the structure. On the other hand, potentially negative results may occur such as torsional effects make by in plan-irregularities, soft-story effects induced irregularities in elevation and short-column effects due to openings.

TYPES OF INFILL PROVISIONS

Infill's are provided totally or with openings as per the needs of partitions or for doors and windows. The four different general types of frames shown in the figures below; bare frame (Fig 2), fully infilled frame (Fig 3), infilled frame with an opening (Fig 4) and partial infilled frame (Fig 5).

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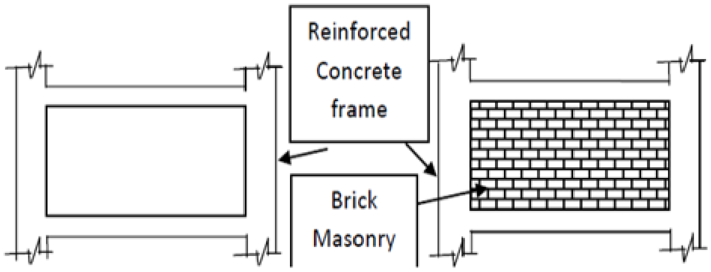

Fig 2: Bare Frame   Fig 3: Fully Infilled Frame

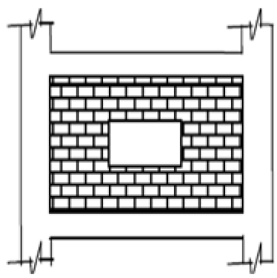

Fig 4: Infilled Frame with Opening

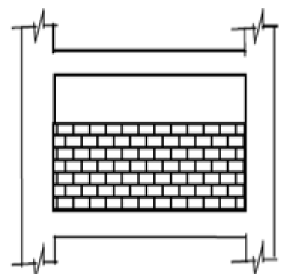

Fig 5: Partial Infilled Frame

FAILURE MECHANISM OF INFILLED FRAME

The failure mechanism of masonry infilled frames are quite complex and depends upon some factors such as relative strength and stiffness properties of MI and RC frame, RC frame wall interface gaps, openings, shear connectors, and such other characterizes. Figure 1.13 shows the five most common modes of failure of masonry infilled frame under increasing intensity of lateral loads.

Mode1: Sliding shear failure through bed joint of an MI-associated with MI with weak junctions and strong members. This formation of the shear cracks separates the panel into two parts, which reduces the effective column height approximately to half. At this cracked condition, the system will behave as a knee-braced system.

Mode 2: Shear failure at the side column or beam-column joint-associated with strong infill and weak frame. The diagonal/sliding cracks in the MI will be first noticed followed by shear failure of the loaded side columns.

Mode 3: Corner crushing in the MI at least one of its loaded corners- associated with strong infill surrounded by a strong frame.

Mode 4: Diagonal shear was cracking in the form of a crack connecting the two loaded corners and columns yielding in flexure –associated with strong MI surrounded by a weak frame or a frame with weak joints and powerful members. Cracking of the wall occurs from one corner to the diagonally opposite corner, and the MI wall fails in shear or diagonal tension.

Mode 5: Frame failure in the form of plastic hinges in the columns or the beam column connection-also associated with strong MI surrounded by a weak frame or frame with weak joints and touch members.

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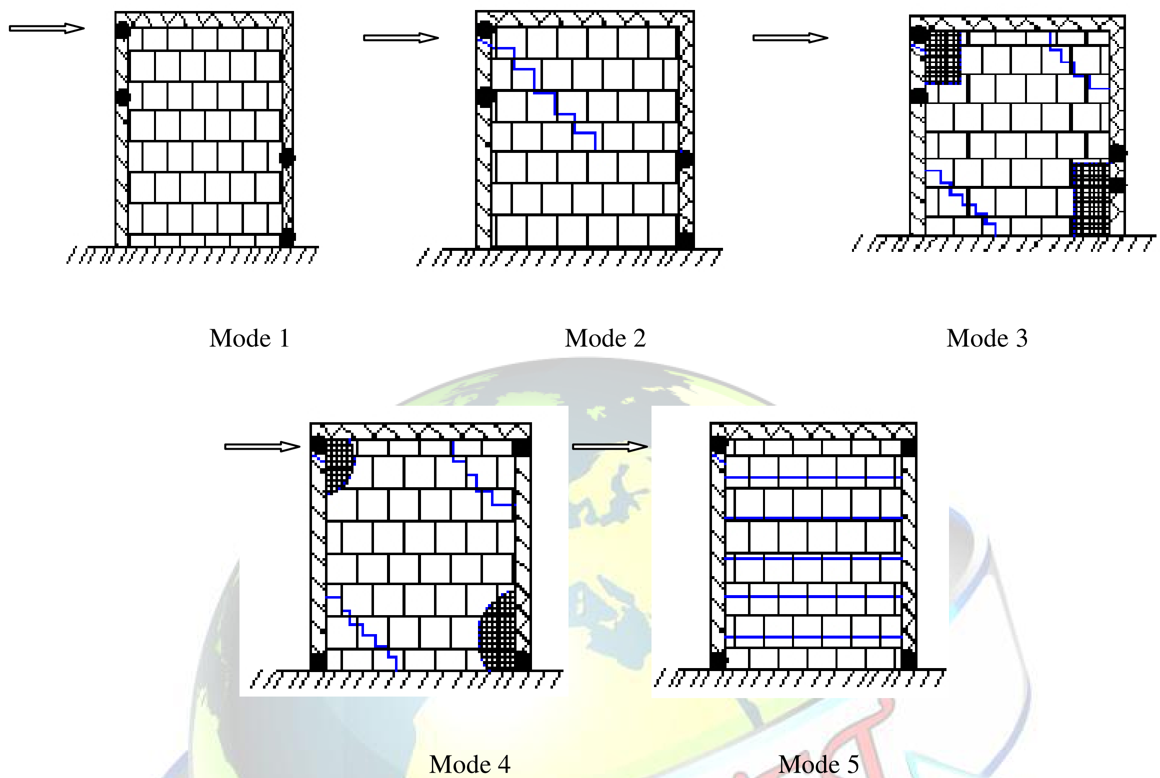

Figure 6: Failure mechanism of infilled frame

LITERATURE REVIEW

A summary of the major research works that have been carried out on masonry infilled RC frames with and without openings has presented in this section. Different types of loads such as static load, pseudo-static load, pseudo-dynamic load, and a dynamic load applied in these studies.

SMITH (1962) the paper deals with the lateral stiffness of infill frames by assuming an equivalent diagonal strut to replace the infill. The effective width of the equivalent strut was derived theoretically and checked by model experiments. The major conclusions of his work are as follows:

An infill frame subject to lateral loads may approximately represented by an equivalent frame in which the infill's are replaced by diagonal struts, provided no permanent bonding occurs between frame and infill. Assuming the diagonal load to be entirely applied near the corner of the infill, the effective width of the equivalent strut varies from d/4 for a square infill to d/11 for an infill having a sides ratio of 5 to 1, where d is the diagonal length of infill.

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MAINSTONE (1971) describes the test on the full scale and model steel frames with brick infill's. The approach to the problem based on the concept of the diagonal strut. It has visualized replacing infill by several or single strut depending upon the degree of initial fit of the infill to the frame. Simple equations have been derived to predict equivalent width of strut, lateral stiffness and strength of the infilled frames.

GOUTAM MONDALA AND SUDHIR K. JAIN, M.EERI The paper deals with Lateral Stiffness of Masonry-Infilled Reinforced Concrete (RC) Frame with Central Opening. Window and door openings are inevitable parts of infill walls for functional reasons. Currently, publications like FEMA-273 and ATC-40 contain provisions for the calculation of stiffness of solid infilled frames mainly by modeling infill as a "diagonal strut." However, such providing not provided for infilled frames with openings.

The study, proposes a reduction factor for effective width of diagonal strut over that of the solid reinforced concrete (RC) infilled frame to calculate its initial lateral stiffness when a central window opening is present. The study based on initial lateral stiffness which is taken at 10% of the lateral strength of the infilled frames.

PROJECT DEFINITION

Masonry infill's commonly used in buildings for functional and architectural reasons. However, their structural contributions neglected usually in the design process. The Behavior of building in the recent earthquake and illustrate that the presence of infill walls has significant structural implications. The difficulties in considering masonry infill walls in the design processes are due to the lack of experimental and analytic results about their behavior under lateral loads.

PARAMETRIC STUDIES

Following Seismic analyses of 3D building frames with 4&3 Bay of 4 and ten stories.

Building frames with fixed base

Different types of frames considered for this analysis are

- Bare frame
- Complete infill without opening
- 15% opening infill frame
- 20% opening infill frame
- 30% opening infill frame
- 40% opening infill frame

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OBJECTIVE OF WORK

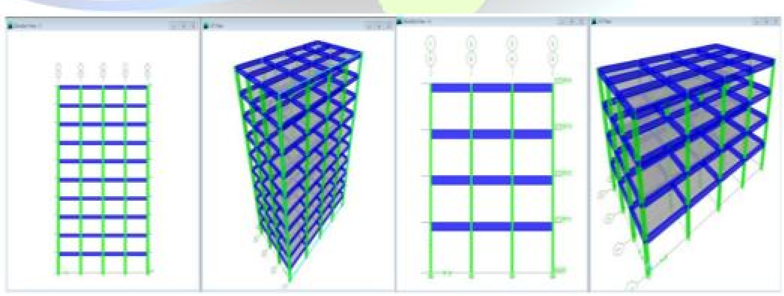
The major objectives of this research are:

- Using equivalent diagonal strut method and finding the width of the strut according to **Mainstone R.J** formulae.
- Displacement in structures at various levels relative to ground displacement in Horizontal and Vertical directions.
- Response accelerations at different floors to estimate the Lateral forces including Shear.
- Response evaluation of 3D RC frames with and without opening in masonry infill's under dynamic loading.
- To aim at the determination of fundamental natural period for different building models with and without brick masonry infill.
- The generation of response spectra and time history as per IS 1893-2002.

DIFFERENT TYPES OF FRAMES CONSIDERED FOR THIS ANALYSIS:

- Bare frame
- Complete infill without opening
- 15% opening infill frame
- 20% opening infill frame
- 30% opening infill frame
- 40% opening infill frame

DIAGRAMS FOR FOUR AND TEN-STORY BUILDING MODELS



Ten-story bare frame four-story bare frame

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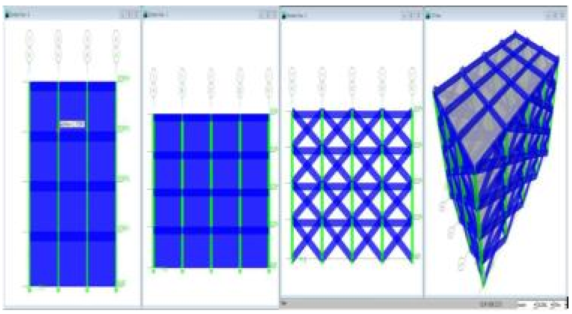
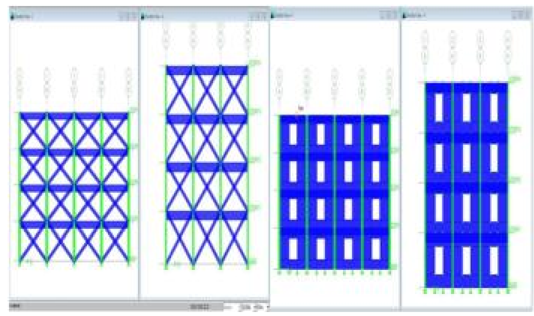
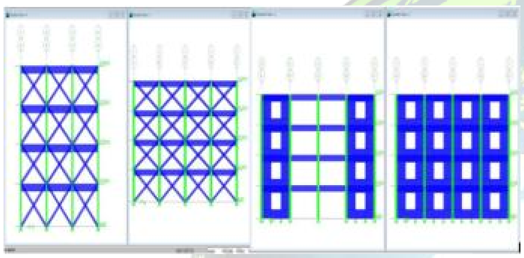
FOUR-STORY BUILDING DIAGRAMS



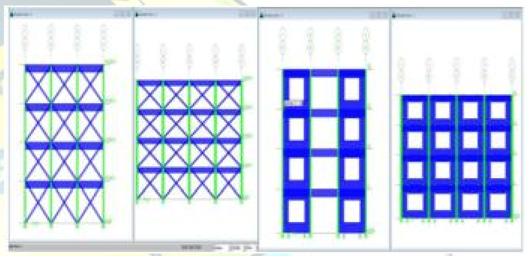
Elevation of fully infilled frame with wall and with strut



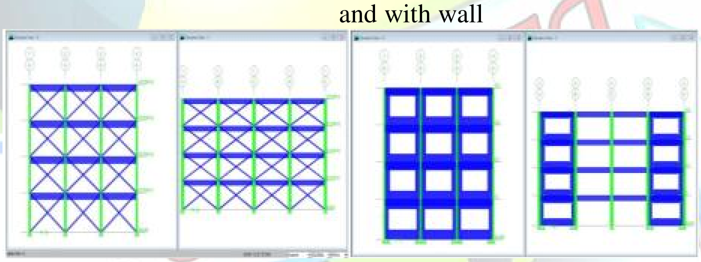
Elevation of 15% opening frame with strut and with wall



Elevation of 20% opening frame with strut and with wall

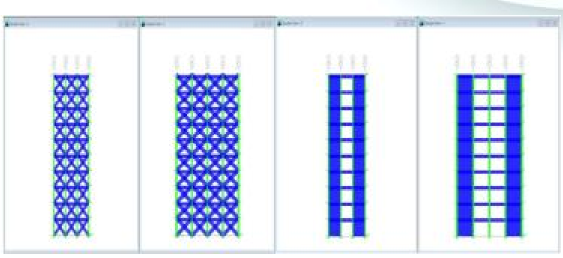


Elevation of 30% opening frame with strut and with wall

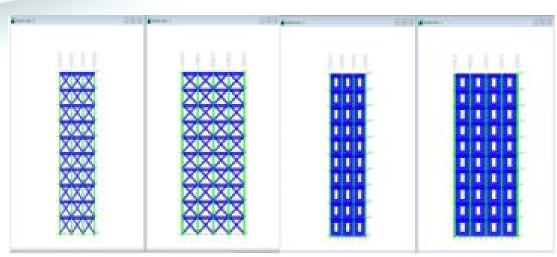


Elevation of 40% opening frame (a) with strut (b) with wall

TEN-STORY BUILDING DIAGRAMS:



Elevation of fully infilled frame with a strut and with wall



Elevation of 15% opening frame with strut and with wall

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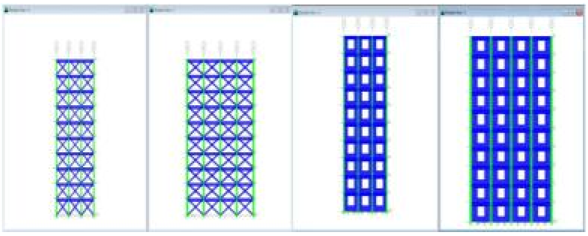
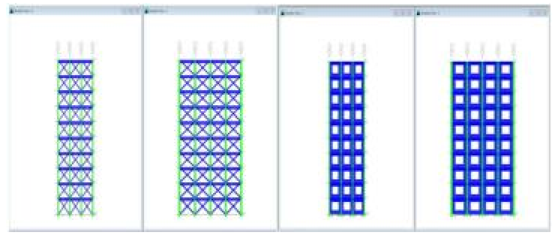
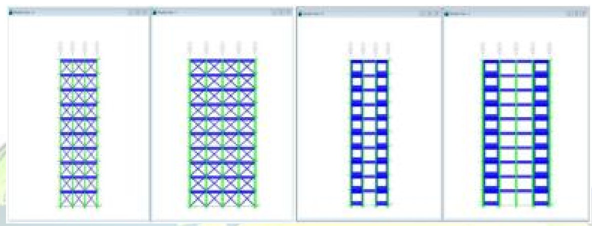
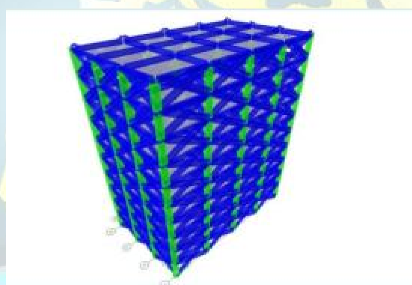

Elevation of 20% opening frame with strut and with wall


Elevation of 30% opening frame with strut and with wall


Elevation of 40% opening frame with strut and with wall


Fully infilled as strut 3D model

RESULTS AND DISCUSSIONS

1. COMPARISION OF FUNDAMENTAL NATURAL TIME PERIOD

Model	Fundamental natural periods along X- direction (sec)		Fundamental natural periods along Y- direction (sec)	
	Codal	Analysis	Codal	Analysis
Four storied building model				
Model I	0.516	0.6311	0.516	1.0047
Model II	0.241	0.2601	0.321	0.2928
Model III	0.241	0.3241	0.321	0.3716
Model IV	0.241	0.3476	0.321	0.4031
Model V	0.241	0.388	0.321	0.4604
Model VI	0.241	0.4278	0.321	0.5214
Ten storied building model				
Model I	1.016	1.2087	1.016	1.5132
Model II	0.593	0.6213	0.791	0.7282.
Model III	0.593	0.7311	0.791	0.8463
Model IV	0.593	0.7719	0.791	0.8933
Model V	0.593	0.8403	0.791	0.9768
Model VI	0.593	0.9056	0.791	1.0605

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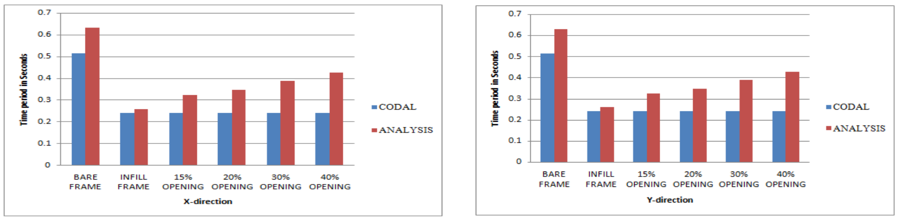
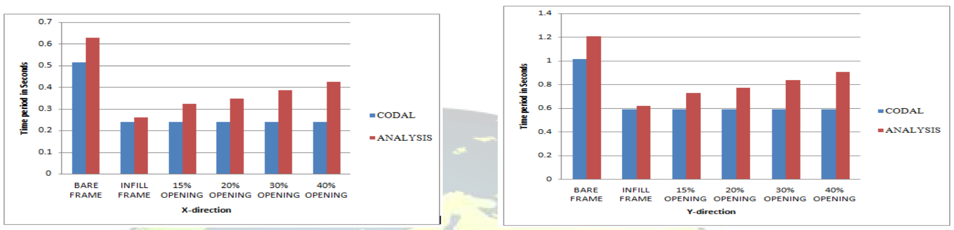


Variation of the fundamental natural time period in both X and Y direction for four-story building system

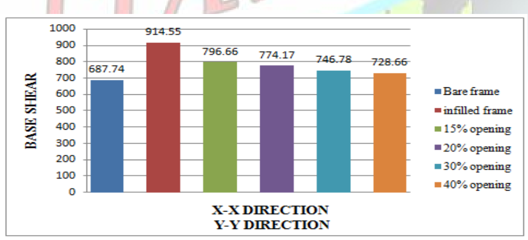


Variation of the fundamental natural time period in both X and Y direction for ten-story building system

2. COMPARISION OF BASE SHEAR IN BOTH STATIC AND DYNAMIC ANALYSIS

Variation of Base shear (KN) in static analysis for four-story building model

Model	Manual Results (KN)		Analysis Result V_B (KN)		Scaling factor	
	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse
Four-story building						
Model 1	860.65	860.65	687.74	687.74	2.07	3.297
Model 2	1314.12	1314.12	914.55	914.55	1.85	1.85
Model 3	1257.01	1257.01	796.66	796.66	1.84	1.84
Model 4	1151.3	1151.3	774.17	774.17	1.84	1.84
Model 5	1119.88	1119.88	746.78	746.78	1.84	1.823
Model 6	1088.47	1088.47	728.66	728.66	1.833	1.812



Variation of Base shear in X-X and Y-Y Directions for Four-story Models

Variation of Base shear (KN) in dynamic analysis for four-story building m**odel**

Model	Time history Analysis Result V_B (kN)		Response spectra Analysis Result V_B (kN)	
	Longitudinal	Transverse	Longitudinal	Transverse
Four-story building				
Model 1	1849.9	1727.18	687.74	687.74
Model 2	3250.09	2425.77	914.55	914.55
Model 3	2510.94	2398.44	796.66	796.66
Model 4	2487.63	2325.64	774.17	774.17
Model 5	2345.64	2291.2	746.78	746.78
Model 6	2193.93	2127.43	728.66	728.66

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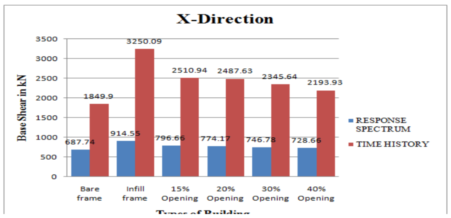
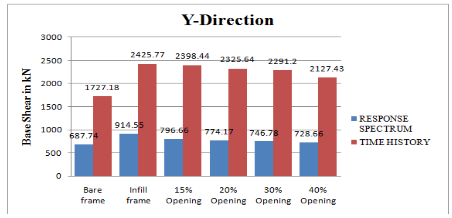
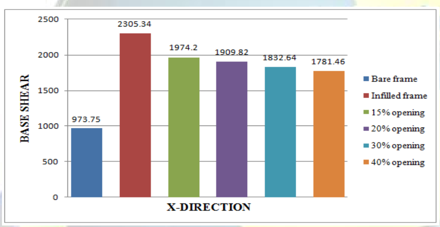


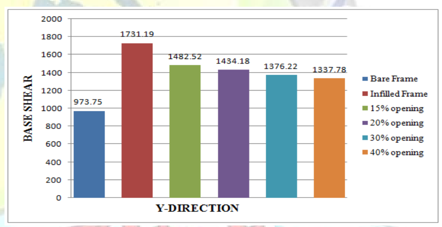


Variation of Base Shear for Response Spectrum and Time History Analysis

Variation of Base shear (kN) in static analysis for Ten-story building model

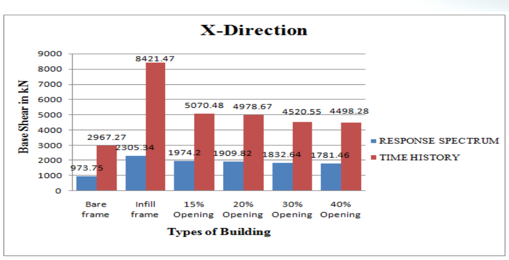
Model	Manual Results (KN)		Analysis Result V B (KN)		Scaling factor	
	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse
Ten-story building						
Model 1	1112.6	890.15	973.75	973.75	2.292	2.73
Model 2	2641.35	1983.6	2305.34	1731.19	2.01	1.786
Model 3	2245.15	1686.06	1974.20	1482.52	2.347	2.07
Model 4	2113.08	1586.88	1909.82	1434.18	2.51	2.163
Model 5	1848.95	1388.52	1832.64	1376.22	2.74	2.357
Model 6	1584.81	1190.16	1781.46	1337.78	2.934	2.534

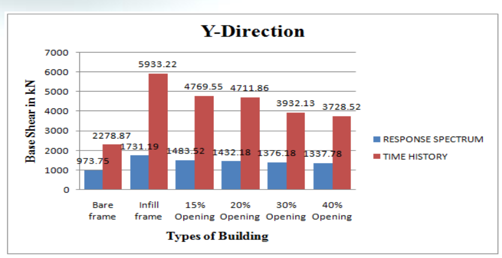




Variation of Base shear (KN) in dynamic analysis for Ten-story building model

Model	Time history Analysis Result V B (kN)		Response spectra Analysis Result V B (kN)	
	Longitudinal	Transverse	Longitudinal	Transverse
Ten-story building				
Model 1	2967.27	2278.87	973.75	973.75
Model 2	8421.47	5933.22	2305.34	1731.19
Model 3	5070.48	4769.55	1974.2	1482.52
Model 4	4978.67	4711.86	1909.82	1434.18
Model 5	4520.55	3932.13	1832.64	1376.22
Model 6	4498.28	3728.52	1781.46	1337.78





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3. COMPARISION OF LATERAL STORY DISPLACEMENT v/s STORY NUMBER AND MAX.STORY DRIFTS:

FOR 4 STORY BUILDING

A. Displacement and Story Drift for without Infill Wall (Bare frame) in Ux Direction and Uy Direction

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY4	10.68769	26.23362	0.000556	0.001269
STORY3	8.909581	22.17243	0.000859	0.001959
STORY2	6.160332	15.90377	0.001	0.002282
STORY1	2.961298	8.602641	0.000846	0.002458

B. Displacement and Story Drift for with Infill Wall (Infill frame) in Ux Direction and Uy Direction

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY4	1.86006	2.38583	0.000102	0.000139
STORY3	1.533758	1.941794	0.000148	0.000191
STORY2	1.061554	1.330859	0.000165	0.000206
STORY1	0.534914	0.672451	0.000153	0.000192

C. Displacement and story drift for with15% opening Infill Wall in Ux Direction and Uy Direction

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY4	2.839116	3.736951	0.000151	0.000203
STORY3	2.357448	3.086118	0.000223	0.000292
STORY2	1.64333	2.151236	0.000254	0.000324
STORY1	0.83003	1.113346	0.000237	0.000318

D. Displacement and Story Drift for with20% opening Infill Wall in Ux Direction and Uy Direction

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY4	3.252104	4.368404	0.000171	0.000234
STORY3	2.704875	3.620795	0.000255	0.000339
STORY2	1.888442	2.53519	0.000292	0.000379
STORY1	0.953579	1.321225	0.000272	0.000377

E. Displacement and Story Drift for with 30% opening Infill Wall in Ux Direction and Uy Direction

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY4	4.038346	5.65392	0.000211	0.000296
STORY3	3.364693	4.706727	0.000317	0.000436
STORY2	2.35059	3.310669	0.000365	0.000493
STORY1	1.181228	1.734363	0.000337	0.000496

F. Displacement and Story Drift for with 40% opening Infill Wall in Ux Direction and Uy Direction

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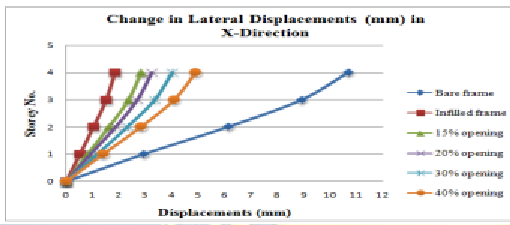
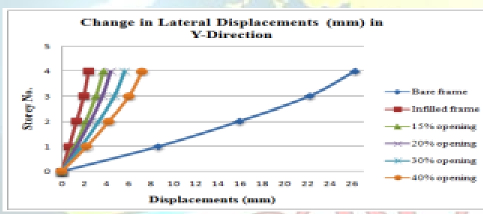
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 16, April 2017

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY4	4.898362	7.210289	0.000254	0.000371
STORY3	4.08554	6.022358	0.000385	0.000553
STORY2	2.853416	4.251895	0.000446	0.000629
STORY1	1.425713	2.238543	0.000407	0.00064

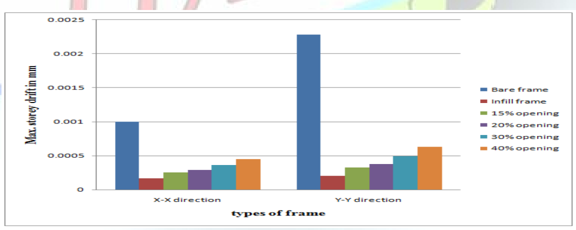
Displacement Vs Story No. For With and Without Infill Wall in Ux Direction



Displacement Vs Story No. For With and Without Infill Wall in Uy Direction



Maximum Story Drifts For With and Without Infill Wall in Ux Direction and Uy Direction at the level of 2nd story



FOR 10 STORY BUILDING

Displacement and Story Drift for Without Infill Wall (Bare frame) in Ux Direction and Uy Direction

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International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 16, April 2017

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY10	34.72677	36.58699	0.000318	0.000477
STORY9	32.70796	35.05911	0.000491	0.000752
STORY8	30.8369	32.65192	0.000647	0.000976
STORY7	27.96787	29.52767	0.00077	0.001146
STORY6	24.60526	25.86031	0.00086	0.001268
STORY5	20.85265	21.80417	0.000922	0.001347
STORY4	16.90345	17.49323	0.000956	0.001391
STORY3	12.84343	13.04044	0.000959	0.001406
STORY2	8.773788	8.540023	0.000895	0.001394
STORY1	[illegible]	[illegible]	[illegible]	[illegible]

Displacement and Story Drift for With Infill Wall (Infill frame) in Ux Direction and Uy Direction

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY10	11.27739	12.10134	0.000211	0.00028
STORY9	10.60292	11.20481	0.000279	0.000339
STORY8	9.710256	10.11899	0.000335	0.000385
STORY7	8.639605	8.888277	0.000375	0.000415
STORY6	7.440514	7.56029	0.0004	0.000431
STORY5	6.159321	6.181999	0.000412	0.000432
STORY4	4.839554	4.799177	0.000412	0.00042
STORY3	3.521266	3.455635	0.0004	0.000394
STORY2	2.241746	2.193246	0.000381	0.000358
STORY1	1.022223	1.048171	0.000292	0.000299
BASE	0	0	0	0

Displacement and Story Drift for with15% opening Infill Wall in Ux Direction and Uy Direction

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY10	15.22422	15.65909	0.000251	0.000303
STORY9	14.42049	14.68949	0.000351	0.000395
STORY8	13.29725	13.42595	0.000435	0.000467
STORY7	11.90638	11.9325	0.000496	0.000518
STORY6	10.31796	10.27582	0.000538	0.000549
STORY5	8.595929	8.518344	0.000562	0.000563
STORY4	6.798112	6.718268	0.00057	0.000559
STORY3	4.975602	4.92874	0.000553	0.000541
STORY2	3.172785	3.198222	0.000547	0.000511
STORY1	1.420877	1.562143	0.000406	0.000446
BASE	0	0	0	0

Displacement and Story Drift for with20% opening Infill Wall in Ux Direction and Uy Direction

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY10	16.87135	17.25879	0.000269	0.000317
STORY9	16.01151	16.24564	0.000382	0.000422
STORY8	14.79061	14.89432	0.000477	0.000505
STORY7	13.26432	13.277	0.000548	0.000565
STORY6	11.51093	11.46861	0.000597	0.000603
STORY5	9.601835	9.538474	0.000625	0.000621
STORY4	7.600966	7.550436	0.000636	0.000621
STORY3	5.564252	5.562078	0.000633	0.000605
STORY2	3.539724	3.62516	0.000616	0.000578
STORY1	1.568862	1.775534	0.000448	0.000507
BASE	0	0	0	0

Displacement and Story Drift for with30% opening Infill Wall in Ux Direction and Uy Direction

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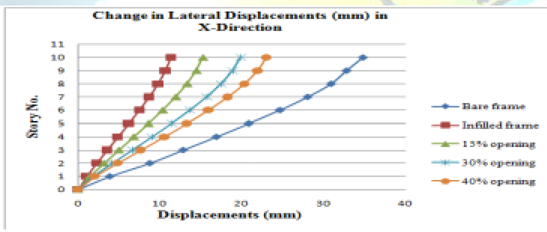
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 16, April 2017

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY10	19.84213	20.32869	0.000301	0.000345
STORY9	18.87953	19.22628	0.000437	0.000476
STORY8	17.48158	17.70251	0.000554	0.000581
STORY7	15.70986	15.84461	0.000642	0.000657
STORY6	13.65692	13.74316	0.000703	0.000707
STORY5	11.40756	11.48064	0.000741	0.000734
STORY4	9.036952	9.131802	0.000759	0.00074
STORY3	6.609997	6.762875	0.000759	0.000728
STORY2	4.182778	4.432129	0.000738	0.000705

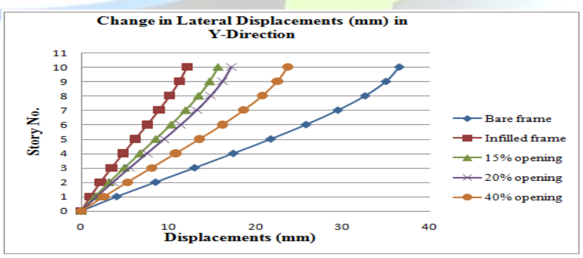
Displacement and Story Drift for with 40% opening Infill Wall in Ux Direction and Uy Direction

STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
STORY10	22.93214	23.70169	0.000335	0.000377
STORY9	21.86059	22.49645	0.000495	0.000537
STORY8	20.27714	20.77945	0.000634	0.000664
STORY7	18.24863	18.65395	0.00074	0.000758
STORY6	15.88173	16.22759	0.000815	0.000822
STORY5	13.27519	13.59735	0.000862	0.000859
STORY4	10.51603	10.85008	0.000887	0.000871
STORY3	7.67899	8.061666	0.00089	0.000864
STORY2	4.830792	5.29767	0.000863	0.000844
STORY1	2.07071	2.598258	0.000592	0.000742
BASE	0	0	0	0

Displacement Vs Story No. For With and Without Infill Wall in Ux Direction



Displacement Vs Story No. For With and Without Infill Wall in Uy Direction



Maximum Story Drifts For With and Without Infill Wall in Ux Direction and Uy Direction at the level of 4th and 5th story

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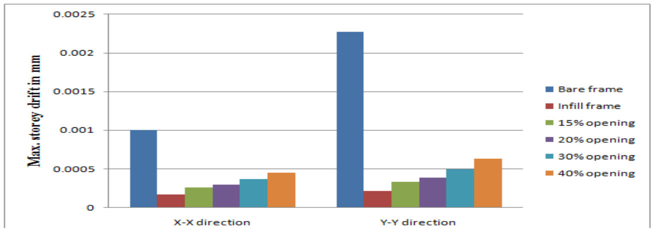
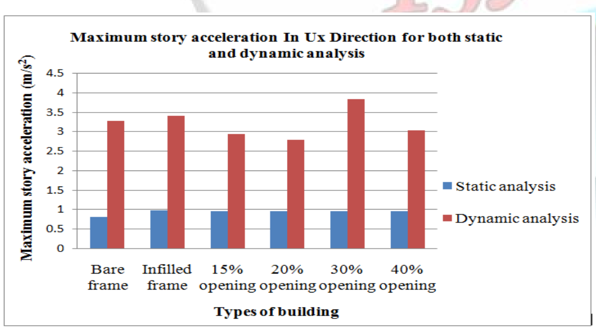
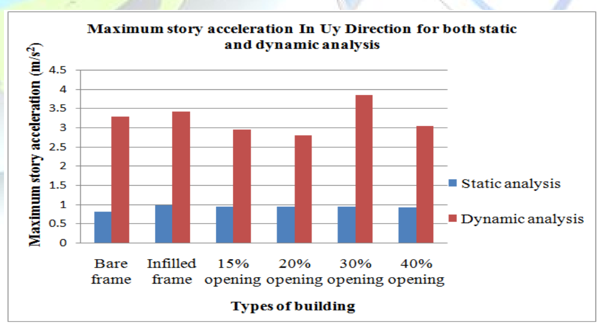


4. COMPARISION OF MAXIMUM STORY ACCELERATION IN BOTH STATIC AND DYNAMIC ANALYSIS:

Maximum story acceleration in Ux and Uy direction for both static and dynamic analysis

FOR FOUR-STORY BUILDING				
	STATIC ANALYSIS		DYNAMIC ANALYSIS	
Type of building	Maximum story acceleration In Ux Direction	Maximum story acceleration In Uy Direction	Maximum story acceleration In Ux Direction	Maximum story acceleration In Uy Direction
Bare frame	0.798	0.821	3.281	3.281
Infilled frame	0.975	0.989	3.413	3.413
15% opening	0.962	0.961	2.949	2.949
20% opening	0.958	0.959	2.792	2.792
30% opening	0.956	0.946	3.845	3.845
40% opening	0.951	0.936	3.044	3.044
FOR TEN-STORY BUILDING				
	STATIC ANALYSIS		DYNAMIC ANALYSIS	
Type of building	Maximum story acceleration In Ux Direction	Maximum story acceleration In Uy Direction	Maximum story acceleration In Ux Direction	Maximum story acceleration In Uy Direction
Bare frame	0.708	0.753	2.224	2.224
Infilled frame	1.081	0.872	4.041	4.041
15% opening	1.079	0.856	3.381	3.381
20% opening	1.073	0.854	3.198	3.198
30% opening	1.058	0.839	2.985	2.985
40% opening	1.032	0.817	2.759	2.759





Variation of Maximum story acceleration for both static and dynamic analysis in longitudinal and transverse direction for four storied building

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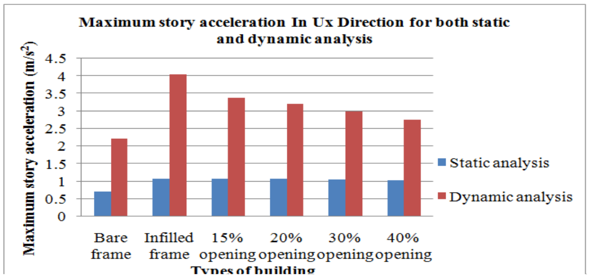

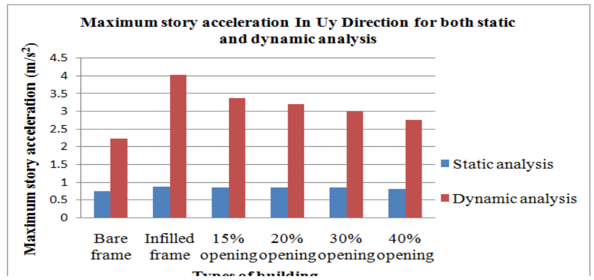

Variation of Maximum story acceleration for both static and dynamic analysis in longitudinal and transverse direction for ten storied building

CONCLUSIONS

1) The Introduction of infill panels in the RC frame reduces the time period of a bare frame. Bare frame leads to over estimation of the natural period and under estimation of lateral forces.
2) The increase in the opening percentage leads to a decrease in the lateral stiffness and increase in the 20% time period of the infilled frame for every 10% increase in the opening percentage.
3) The presence of infill's leads, in general, to increase the base shear compare to a bare frame. In a case of infill frame with different opening percentages, the base shear is reduced compare to complete infilled frame.
4) The opening size of the infill has a significant influence on the fundamental period, lateral displacement; inter-story drift and maximum story acceleration, generally, they increase as the opening size increases, indicating that the decrease in stiffness is more significant than the decrease in mass.
5) The lateral displacement and inter-story drift with the increase in opening size as the frame become more flexible. The lateral displacement increases by an average value of 28% for every 10% increase in opening size and there is a corresponding increase in inter-story drift.
6) The presence of infill in the RC frame increases the maximum story acceleration of bare frame.
7) The increase in opening size there will be a decrease in maximum story acceleration for both static and dynamic analysis.
8) For four-story building the maximum story acceleration is nearly same for bare frame, infill frame and percentages of the opening in dynamic analysis.
9) For ten-story building the maximum story acceleration decreases by an average value of 10% for every 10% increase in opening size, hence according to IS 1893 (part-1) 2002 dynamic analysis is made only if the height of the building greater than 30 m.

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Vol. 4, Special Issue 16, April 2017

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