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How the Seismic Behavior of RC Framed Structures Varies by Changing Position of Infill Walls

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Abstract: **The main purpose of the presented study is the investigation of the dynamic parameters of reinforced concrete frames with and without infill walls. Moreover, lateral strength, stiffness and time of collapse of the frames are also studied. In order to achieve the purpose a 8 storey building was designed and then IDARC software was used to observe the influence of infill walls. Presence of partition walls affected the damaged behavior of the frames and drift is observed to be higher in case. And finally stiffness, strength and energy dissipation properties of frames with partition walls are observed to be dramatically higher than the frames without partition walls. A study is conducted at the NATIONAL INSTITUTE OF TECHNOLOGY SGR using IDARC software. The main objective is to investigate the dynamic behavior of seismically detailed RC frames with and without partition walls. Other objectives are to examine the stiffness and strength behavior of RC frames with partition walls, to observe the interaction between frame and infill wall. Program consisted of testing of eight 8-STOREY frames using IDARC software. Frames were designed considering two parameters: reinforcement detailing and the presence of infill walls. Frames were subjected to inelastic dynamic analysis with increasing intensity of ground acceleration. The study is conducted on the same frame by organizing the partition wall configuration as bare frame (BF), partially infilled frame (PIF) and fully infilled frame (FIF).**

I. INTRODUCTION

Brick wall as a structural member lost its structural importance in modern times and is in use as partition and/or insulation material in various forms. Decision of its use and design is mainly under the control of the architects . Typically structural engineers do not consider partition walls as a structural member of the buildings in their calculations. Therefore interaction of partition wall with the bounding frame is usually ignored in design. The aim of the study presented in this thesis is the experimental investigation of the structural frame/partition wall interaction in RC frames for the purpose of defining implications of hybrid system on dynamic behavior and identification of the dynamic parameters. Partition walls are composed of relatively stiff, brittle and strong bricks and the weak mortar. Strength of combination strongly depends on the weak mortar. The quality control of the partition walls is very low in most applications. Mortar is generally hand mixed at the site and main parameter of mix design is the workability. Other aspect of the brick walls strength is the workmanship of the construction which is highly dependent on the available labor quality. As a whole it is very difficult to quantify the quality and mechanical properties of partition walls. Partition walls function as vital elements for the service of the structures. Even if the loss of the partition does not cause any structural problems, it might stop the service. Also it could cause serious life safety implications. Therefore, understanding the behavior of partition walls in extreme conditions is very important. Inherent geometry of the partition walls leads to a weak out of plane and strong in plane stiffness and strength. Due to the high in plane stiffness, partition walls could resist high loads at very small deformations. When partition walls are integrated with the RC frames, high in plane stiffness results to high force levels in the walls at small drift levels, however, its brittle character causes loss of its resistance before the structural frame reach to its capacity. This condition can effect the mode of failure in the structure. Structural frame and partition wall interaction can induce brittle shear failures by converting RC columns to short columns; moreover partition walls may strengthen the upper stories of a building and may result with soft storey mechanism at the first STOREY which is an undesired event under earthquake loading. Due to difficulty in rationalizing the interaction with the frame and partition walls, they are not considered as a part of the horizontal load resisting of system in the conventional design processes of frame structures.

II. RESULTS FROM IDRAC SOFTWARE

1) Results of Fully Infilled Frames:

STOREY No	Drift Ratio(%)	STOREY Drift(mm)	Displacement (mm)	STOREY Shear (kN)
8	.23	7.9763	160.3900	2498.52
7	.53	18.5183	156 .5581	4172.35
6	.93	32.5753	144.1721	5760.32
5	.99	34.6967	119.5418	6205.55
4	.90	31.5519	87.3575	6101.27
3	.78	27.2494	70.5377	5799.78
2	.85	29.7405	48.7384	7174.14
1	.60	21.0483	21.0483	7865.09

Maximum Response for bare frames

2) Results Of Bare Frames:

STOREY No	Drift Ratio(%)	STOREY Drift(mm)	Displacement (mm)	STOREY Shear (kN)
8	.24	8.3260	174.6511	2296.38
7	.56	19.4656	170.0593	4013.73
6	.92	32.2823	158.2866	5459.26
5	1.01	35.5007	134.7132	5536.52
4	1.00	35.0076	101.7818	5496.90
3	.92	32.0717	77.0424	5535.08
2	.91	32.0043	51.5110	6368.07
1	.61	21.3825	21.3825	7372.43

Maximum Response for partially infilled frames

3) Results of Partial Infill frames (with infills on inner bays)

STOREY No	Drift Ratio(%)	STOREY Drift(mm)	Displacement (mm)	STOREY Shear kN
8	.23	8.1335	166.2924	**2373.86**
7	.54	18.9753	162.2309	**4091.68**
6	.93	32.4649	150.1433	**5615.06**
5	1.00	35.0430	125.8377	**5903.41**
4	.94	33.0044	93.2768	**5823.76**
3	.83	29.2135	73.4160	**5645.44**
2	.88	30.7232	49.9645	**6758.97**
1	.61	21.2616	21.2616	**7510.47**

Maximum Response for partially infilled frames

4) Results for partially infill frames (with infill on outer bays)

STOREY No	Drift Ratio(%)	STOREY Drift (mm)	Displacement (mm)	STOREY Shear (kN)
8	.23	8.1335	166.2924	2373.86
7	.54	18.9753	162.2309	4091.68
6	.93	32.4649	150.1433	5615.06
5	1.00	35.0430	125.8377	5903.41
4	.94	33.0044	93.2768	5823.76
3	.83	29.2135	73.4160	5645.44
2	.88	30.7232	49.9645	6758.97
1	.61	21.2616	21.2616	7510.47

Maximum Response for partially infilled frames

5) Results Of Stilt Infill Frames:

STOREY No	Drift Ratio(%)	StoreyDrift(mm)	Displacement(mm)	STOREY Shear kN
8	.23	7.9774	161.5565	2466.34
7	.53	18.5122	157.6436	4171.21
6	.92	32.3243	145.3781	5749.20
5	.99	34.5369	121.3252	6166.54
4	.91	31.7930	89.3072	6147.71
3	.79	27.5179	71.6356	5858.04
2	.86	29.9601	49.8625	7075.12
1	.62	21.6588	21.6588	7706.18

Maximum Response for stilt infilled frames

6) Results of Alternate Infilled Frames:

STOREY No	Drift Ratio(%)	STOREY Drift(mm)	Displacement (mm)	STOREY Shear (kN)
8	.23	8.0774	166.4915	2346.06
7	.52	18.2873	162.4890	4116.54
6	.95	33.1152	150.8151	5585.35
5	1.00	34.8879	125.9036	5911.17
4	.95	33.2705	93.6268	5781.41
3	.84	29.2710	73.2675	5616.77
2	.88	30.8834	49.7780	6682.78
1	.60	20.9170	20.9170	7507.22

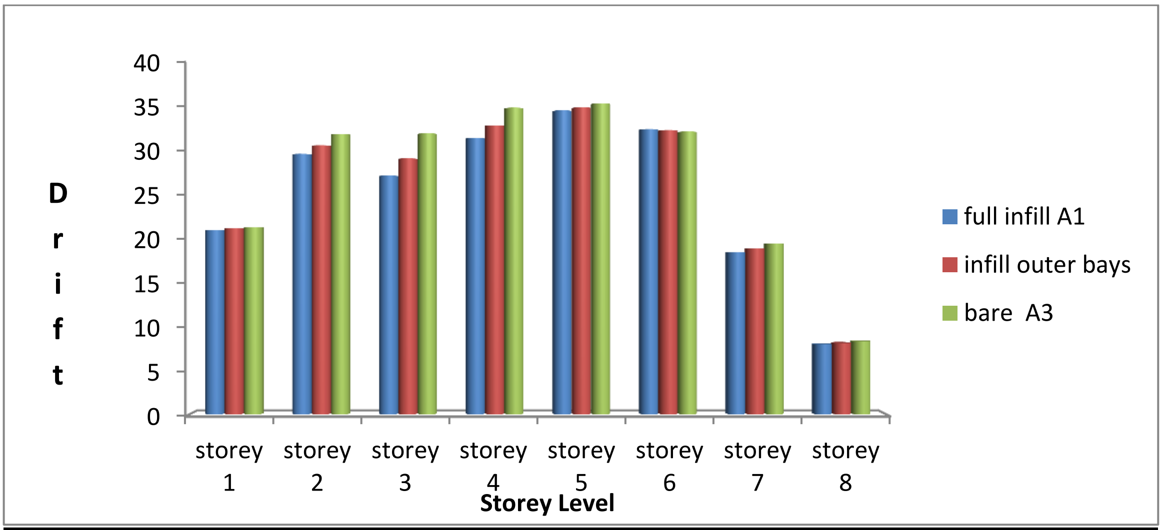
Maximum Response for alternate infilled frames

III. INTERPRETATION OF RESULTS

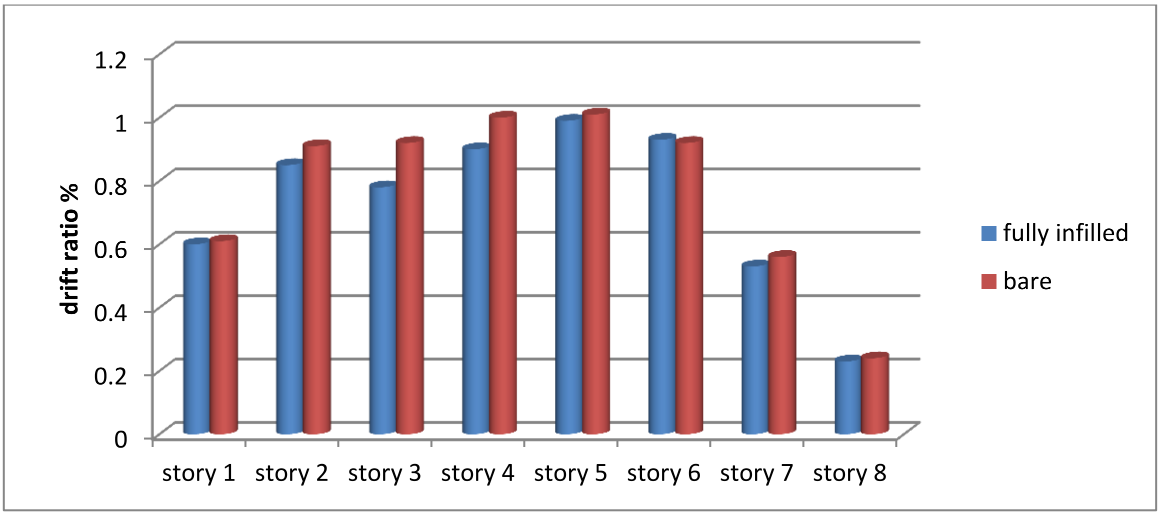
Comparison of Storey Drift

In order to thoroughly understand the lateral stiffness/behavior of infilled plane frames under lateral loading the following parameters and cases have been considered:

1. Case A1: fully infilled frame,
2. Case A2: Partially Infilled Frame (infill outer bays) , and
3. Case A3: the well-known bare frame.



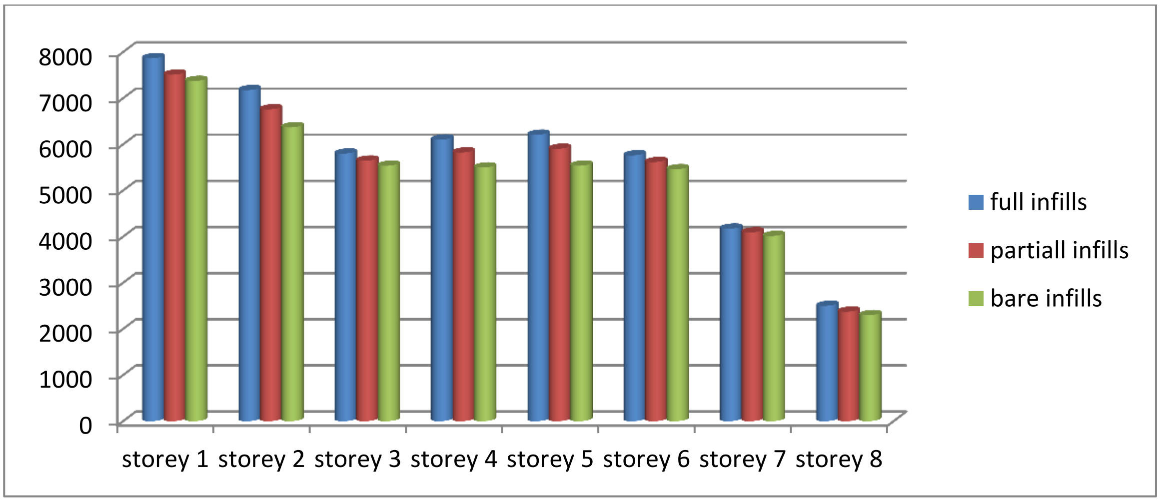
Storey Drift versus Storey Level for Different Infills



Storey Drift ratio versus storey level for different infills

The above Figure. Represent the inter-storey drift of the different building frames at the final stage of the analysis for fixed support conditions. This figure shows that frames with infill strength and stiffness has lesser inter-storey drift, as expected. However, frames without infill strength and stiffness show unexpectedly higher inter-storey drift.

Comparison of STOREY Shear:



Storey shear versus storey level for different infills

Above Fig shows the comparison of the storey shear of three cases fully infilled frame, partially infilled frame and bare frame

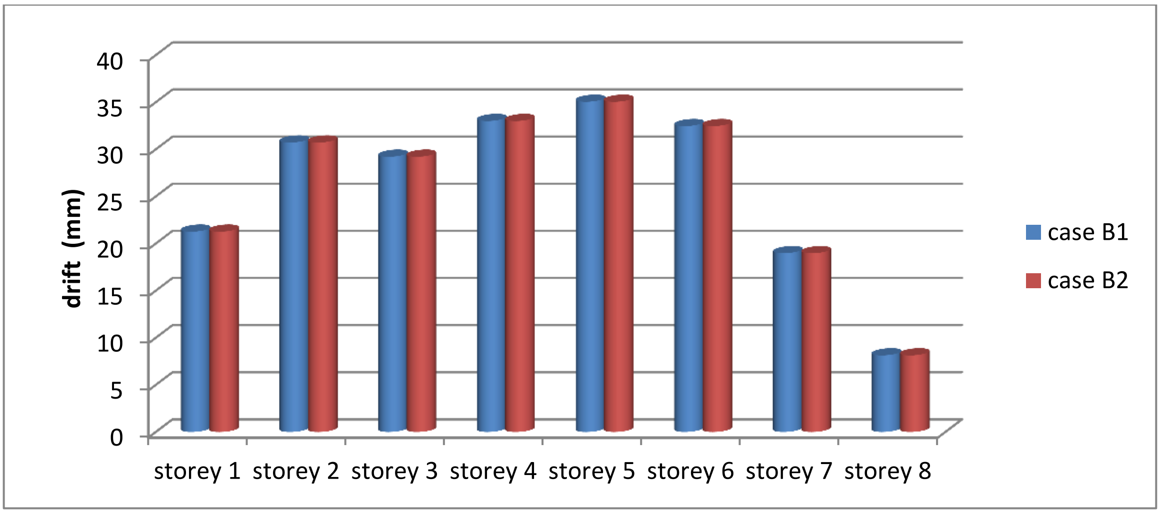
The presence of infill walls in framed buildings accounts for the following issues:

• Increases the base shear
• Increases the shear forces and bending moments in the columns.

There is a clear need to assess the design guidelines recommended by the IS code 1893:2002 because usually while designing a building the influence of infill walls is neglected but they do influence the behavior of the building .

Comparison of arrangement of infills
In order to thoroughly understand the effect of different arrangements of infill walls under lateral loading the following parameters and cases have been considered:

1. Case B1: infills on outermost bays of a frame,
2. Case B2: infills on innermost bays of a frame,
3. Case B3: alternate infilled frame,



Storey Drift Versus Storey No. For Different Pattern of Infills

Above Fig represent the inter storey drift of the different building frames having different infill arrangements at the final stage of the analysis for fixed support conditions.

For openings exceeding 50%, the stiffness factor remains practically constant. Fig. 15 shows the results of effect of opening pattern, we can also observe that for openings exceeding 50 %, the inter STOREY drift remains nearly same in all the three case.

Comparison of time of collapse

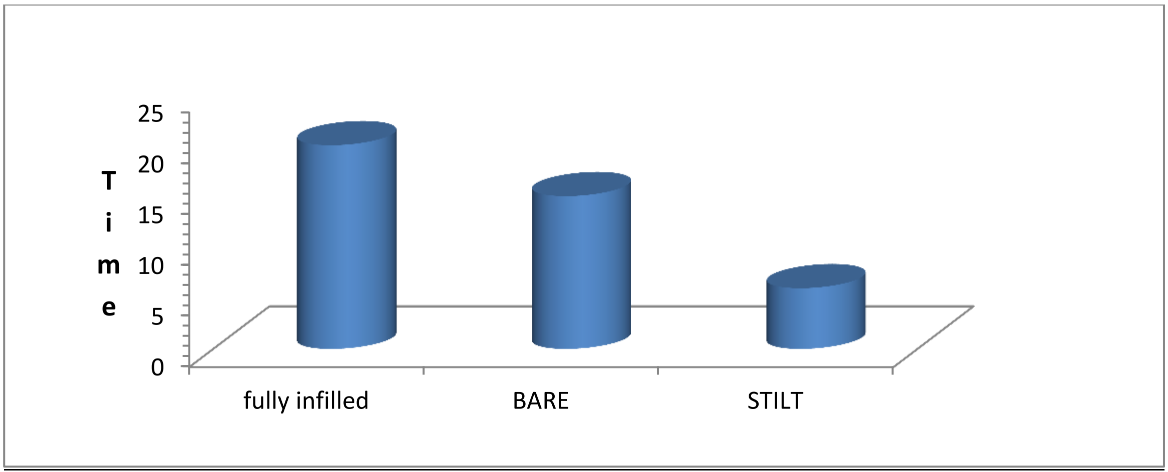
In order to thoroughly understand the lateral stiffness/behavior of infilled plane frames under lateral loading the following parameters and cases have been considered:

1. Case A1: fully infilled frame,
3. Case A2: partially infilled frame, and
4. Case A3: the stilt frame.

TIME OF COLLAPSE

S.No	Type	Time Of Collapse
1	Fully infilled	20
2	Bare frame	15
3	stilt	5.96

TIME OF COLLAPSE



IV. CONCLUSIONS

1. If maximum lateral load carrying capacities of frames with and without partition walls are compared, frames with partition wall had lesser drift under lateral loading. On the other hand, bare frame had a larger drift under lateral loading. As a result, it can be stated that partition walls could increase stiffness of RC frames significantly.

2. The ductile behavior of bare frame enables it to have large displacements but because of infills there occurs a complex mechanism between the infill walls and the frame and it leads to the decrese of ductile behavior of frames. Building can have a brittle mode of failure when the infill stiffness is considered.

3. For openings exceeding 50%, the stiffness factor remains practically constant.

Partition walls cause reductions in structural period of the structures which causes an increase in the response acceleration coefficient Sa/g . Increase in Sa/g causes an increase in the seismic forces. Thus a building faces a higher amount of lateral force than for which the building is actually designed.

Test results indicate that under an earthquake motion ductile design of reinforcement enables a higher deformation capacity and energy dissipation in the bare frame. In this respect ductile reinforcement design will be beneficial for the structure without infill walls. On the other hand, partition walls in the openings of the frames may dominate the behavior and even if the structure has ductile reinforcement design, it might not guarantee an expected ductile failure mechanism due to the complex interaction mechanism between frame and partition walls.

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