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Influence of Masonary Infill on The Behaviour of RC Frames

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Abstract:— **This paper presents the performance based design of RC frame with infill wall and their behavior during earthquake. In the present study the infilled frames are modeled as pin jointed strut elements. Pushover analysis is carried out both with default hinges as per FEMA 356 and ATC 40 guidelines and also with user defined non-linear hinge properties which is available in SAP 2000 software. For the present study four frames are modeled with strut elements with different young's modulus and the frame is designed as per IS code for different load cases. The results reviewed based on the performance of the structure with the formation of hinges at various levels, differences in results of pushover analysis due to default and user-defined nonlinear component properties at different performance levels of the building where studied.**

Keywords:-- **Performance based evaluation, user defined hinge, nonlinear static analysis, capacity curve.**

I. INTRODUCTION

Earthquake is the sudden violent movement of earth's surface and is accompanied by the release of energy in the earth's crust. Father Winthrop says that "it is a wave phenomenon with a train of oscillation waves radiating from an underground center and follows the laws of simple harmonic motion". Earthquake occurs in two major sources natural and manmade. Natural sources such as tectonic earthquake, volcanic earthquakes, Rock faults. Manmade sources such as controlled sources (explosives), Reservoir induced earthquakes, mining induced earthquakes. These earthquake primarily affect the buildings and there structural and non-structural elements.

Construction of RC building with infill wall is regular practice, but effect of infill is not taken in modeling. The strength and stiffness of the infill has a very great influence in the Often in framed structure, the frames are infilled with stiff construction such as brick or concrete block masonry, primarily to create an enclosure and to provide safety to the users. Such masonry walls, known as infill walls, are more ductile than the isolated ones. Unless adequately separated from the frame, there will be structural interaction of the frame and infill panels. The strength and energy dissipation capacity of an infilled frame is very much higher than bare frame. A frame with an infill wall is very effective against earthquake.

Brick infill is extensively used in building construction as interior and exterior partition wall reason being aesthetics and functional needs. There are various types of bricks such as burnt clay bricks, Fly ash bricks, concrete brick, sand-lime brick fire clay brick, Engineers bricks, etc. These are used as infill in wall construction. The strength and energy dissipation capacity of an infilled frame is much higher that of bare frame, So it very much important for seismic evaluation of the structure.

II. LITERATURE REVIEW

Infill frames are "non-integral" by Liauw and Khan 1983, they are composed of two distinct parts in concrete frame and the infill. Modeling of infill wall can be done by micro-models and macro models.

Mallick and Severn(1967) first applied finite element modeling on infilled frames for the calculation of elastic stiffness of one – bay single story infilled frames. Development have been made during several years now micro – models allows in detailed modeling of infilled frames example opening in infills, connection between infill frame. Micro models try to generate force deformation characteristics of the infill.

Macro models aims at the global behavior of the infilled frame. Macro model try to generate the force deformation characteristics of the infill. The other name of macro-model, Equivalent diagonal strut is broadly applied for the assessment of existing reinforced concrete structure. Modelling of strut in given by Holmes 1961, Smith and Carter 1969,Mainstone 1971, Liauw and Kwan 1984, Paulay Priestly 1992. From the comparative study of different expression shows that Paulay and Priestly is the most suitable choice for calculating the diagonal equivalent strut width, due to its simplicity and because it gives an approximate average value among various author.

W=1/4 x r_{inf}------------(1)

r_{inf} = The length of the infill diagonal

The effective width of diagonal strut for infilled frame without opening may be reduced by a reduction factor to simulate the presence of opening of various aspect ratios in the infilled frame (Durrani and Luo 1994, Al chaar 2002). Multi strut models were proposed to represent the local effects due to presence of an opening. The strut method proposed by Smith and Carter 1969 can be used to predict the stiffness of infilled frame. However it should be noted that the stiffness is underestimated by this method about 40%. Smith and Carter method is used to predict the strength Marjani and Ersoy. The simplest version of the strut model is a single strut along the diagonal under compression Flanagan (1994). For the analysis of macro model is done by pushover analysis is one of the powerful tool to perform the analysis. It can be done by various software such as SAP2000, E-tabs,

III. STAAD PRO

Infill wall are adequately separated from the RC frame such that they do not interfere with the frame under lateral deformations. Murthy and Jain (2000). Fiore et al.(2012) proposed modeling the infill panel by two non-parallel struts, the location of which is defined as a function of the aspect ratio L/h of the infills, where L, h are the length and height of the infills. Different empirical formulas are provided to calculate the location of the struts. By adopting of different values of strut width and strut layouts, leads to considerably different results Moretti et al., 2014.

Muty and Jain (2000) presents some experimental results on cyclic test of RC frames with masonry infills. It is observed that the masonry infills contribute significant lateral stiffness, strength, overall ductility and energy dissipation capacity. Das and Murthy (2004 a,b) have reported the design of five reinforced framed buildings with brick masonry infills for the same seismic hazard in accordance with the applicable provision given in Eurocode 8, Nepal building code 201 and Indian seismic code (with and without ductile detailing).

SAP 2000, a commonly used program for the analysis and design of structure, pushover analysis was employed to model beam and column elements as nonlinear frame with lumped plasticity by defining plastic hinge at both ends of beam and column. Here monotonically increasing lateral loads are applied to the structure till target displacement is achieved or the structure is unable to resists further loads. Praveen Rathod, Dyavanal(2014). **Modeling a strut elements:**

Infilled frames behave in a highly non-linear manner and therefore their modeling is complex

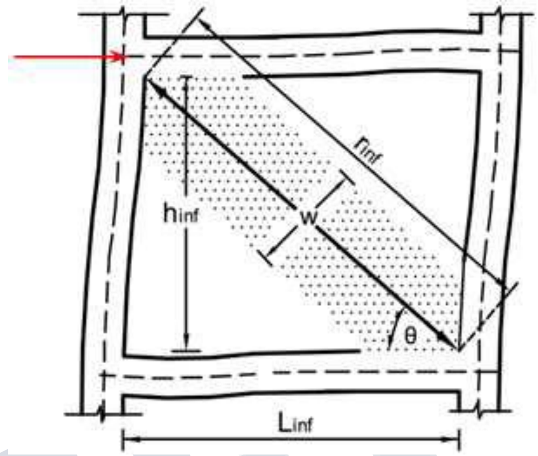

Fig 1: Frame and infill masonry with diagonal strut

The diagonal strut consists of the same material as the infill, has the same thickness, t_{inf} panel and an equivalent width, w. Several formulas proposed by researchers for the calculation of the strut width, w, the simplest version of the model are one strut along the diagonal under compression (“windward” direction”). The area of the diagonal strut is calculated by using the relation.

$A_d = t_{inf}$ x w -------------(2)

A_d = The area of the diagonal strut

t_{inf} = The actual thickness of infill

w = The width of the equivalent strut

the ends of the strut are pinned and are usually assumed to coincide with the intersection of the centerlines of the frame members.

$K_{strut,ed} = A_d \times E_{inf} / r_{inf}$ ------------(3)

Holmes 1961 based on tests on masonry infilled steel frames subjected to racking load was the first to implement the characteristics of an equivalent compression diagonal strut for modeling the infill. The strut had the characteristics of the infill panel and a strut width, *w*

W = 1/3 r_{inf} --------------(4)

Mainstone (1971) proposed to calculate the equivalent strut width, w, which depends on the parameter λ (Equation 6) and on the diagonal length, *r*inf, of the infill. The expression of Mainstone is used in FEMA 306 (1999) and also in ASCE (2007)

$w = 0.175(\lambda h_{col})^{-0.4} r_{inf}$ ------(5)

Liauw and Kwan (1984), based on analytical data and assuming values for the angle, of the equivalent diagonal strut equal to 25° to 50°, proposed to estimate the equivalent strut width.

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$$\lambda = \frac{4\sqrt{E\ w\ t\ inf \quad \sin 2\theta}}{4\ Ef\ I\ col\ h\ inf}\ x\ r\ inf \text{.............}(6)$$

Paulay and Priestley (1992), based on analytical results of masonry infilled RC frames, proposed a conservative value for the strut width.

$W = ¼\ r_{inf}$ --------(7)

Anderson and Brzev, 2009 suggests the use of another width, we, for the strut. It is noted that CSA provisions are basically intended for the design of masonry infilled frames

Accurate nonlinear analysis of a structure requires an elaborate modeling that considers the nonlinear properties of structural elements. These nonlinear features control the behavior of structure during the analysis.

Building Description

- Infill are usually modeled as strut with the ends are pinned, the axial load P is applied to the strut.
- Modulus of elasticity of different infill is for brick infill 3285.9Mpa.
- Modulus of elasticity of solid concrete block wall is 2272Mpa.
- Type of structure – buildings (G+4) and (G+7)
- Zone 3.6
- Live load – 3KN/m
- Floor to floor height = 3.2 m
- Height of building – 16 m
- Grade of concrete M_{25} and Steel Fe 500
- Size of column C1= 0.3x0.3 m
- Size of beam = B1 = 0.3x0.5 m.
- Depth of slab = 150 mm.

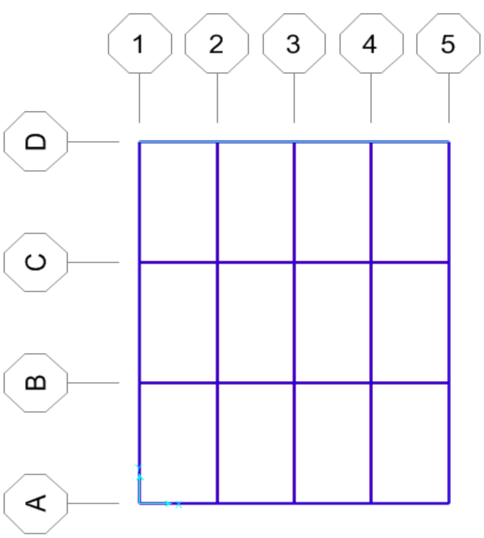

Figure 2: shows the plan view of the structure

IV. PUSHOVER ANALYSIS

Pushover analysis is which is available is SAP 2000 software is a useful tool for assessing inelastic strength and deformation demands in the structure. We can able to analysis the structure based on force controlled and deformation controlled. Moment curvature relationship is required for the finding the user defined hinges in beams and for columns. These moment and the curvature values are been incorporated in SAP 2000 and the analysis are been carried out. The building is designed for different load cases with user defined hinges and the values are incorporated in the table 1 and 2.

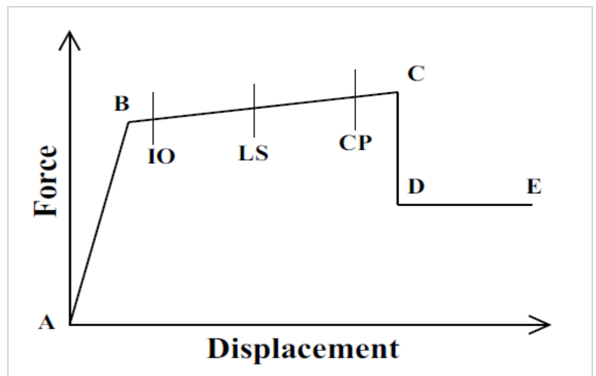

Figure 3: Shows the force versus displacement graph

The main output of the pushover analysis is in the form of force displacement curve, called pushover curve. It is plot of base force versus the lateral displacement. The intensity of lateral load is slowly increased from zero, under constant gravity load and the sequence of cracks, yielding, plastic hinge formation and failure of various structural compounds are recorded. At any stage in pushover curve is possible to locate the plastic hinge formation in the structure The above figure describe the FEMA 356 guidelines

- 'Collapse Prevention' (CP) level, limit state near collapse.
- 'Life safety' (LS) level, limit state of significant damage.
- 'Immediate Occupancy' (IO) level, limit state of damage limitation.

The user defined PMM hinges are assigned at the end of column subjected to axial force and bending moments and M3 hinge are assigned at the ends of the beams.

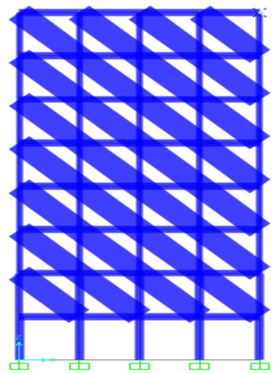

Figure 4: Strut model in 7 story RC frame

The above figure 4 shows the modeling of RC frame with strut elements.

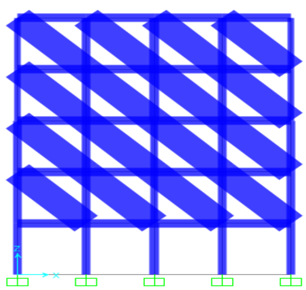

Figure 5: Strut model for 4 story RC frame

V. RESULT AND DISUSSION

From the pushover analysis which is available in SAP 2000. The following results are obtained.

1. Base shear Vs Roof displacement
2. Formation of hinges in RC frames.

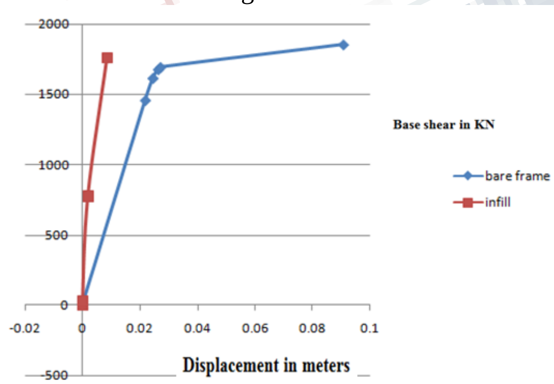

Figure 6: Shows the base shear Vs Roof displacement for four story RC frame building

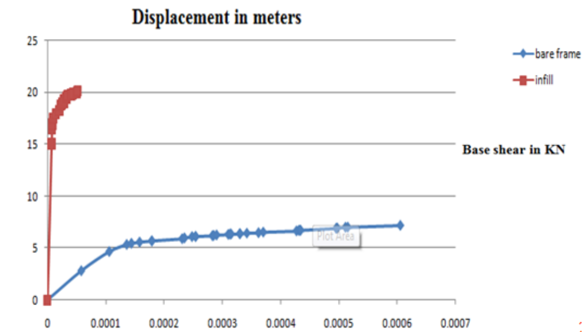

Figure 7: Shows the base shear Vs Roof displacement for four story RC frame building

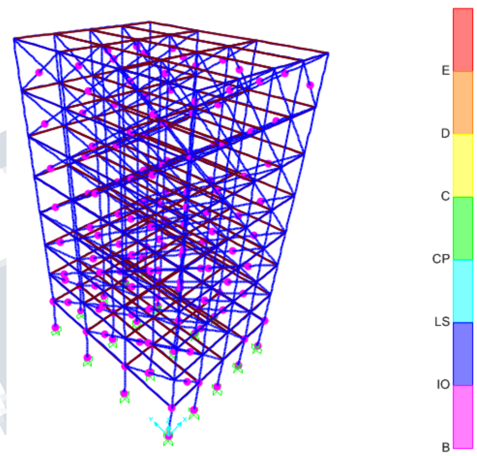

Figure 8: Shows the formation of hinges in RC frames with strut

Table:1 Performance point and location of hinges for four story RC frame structure

	Performance Point	A-B	B-IO	IO-LS	LS-CP	CP-E	TOTAL
D	YIELD	478	32	0	0	0	510
	ULTIMATE	452	18	2	30	8	510
U	YIELD	506	4	0	0	0	510
	ULTIMATE	445	25	0	32	0	510

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Table: 2 Performance point and location of hinges for eightstory RC frame

H	Performance Point	A-B	B-IO	IO-LS	LS-CP	CP-E	TOTAL
D	Yield	814	2	0	0	0	816
	Ultimate	800	13	0	3	0	816
U	Yield	805	11	0	0	0	816
	Ultimate	765	51	0	0	0	816

H-Hinge, D- Default hinge, U- User defined hinge

From the above graph it is observed that difference in result between bare frame and with infill frames. The displacement is more in case of bare frames compared with infill frame and so from this observation it is clear that infill resist to deformation.

VI. CONCLUSION

From the results we can conclude that presence of infill wall in an RC building increase the stiffness significantly. Pushover analysis leads to the formation of hinges in frames and strut. We can able to find the difference in formation of hinges with both with default and user defined hinges. Lateral load resisting of a masonry infill is entirely different from bare frame. The stiffness of masonry infill walls between the frames in RC building should be considered for the analysis. The capacity curve represent the relationship between the base shear and displacement.

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