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EFFECT OF UNREINFORCED MASONRY INFILL WALLS ON SEISMIC RESPONSE OF THREE STOREY STRUCTURE: - REVIEW OF IS 1893 PART-1 2002

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Abstract - Earthquake, its occurrence and effects, its impact and structural response have been studied for many years in earthquake history and is well documented. The structural engineers have tried to examine the various method, with an aim to determine the complex dynamic effect of seismically induced forces in structures, for designing of earthquake resistant structures in a advanced and easy manner. From the study conducted it was found that more precise results are found from nonlinear static anlaysis method. An overview of the past researches conducted on the modelling of masonry infilled frame issues, it was found that macro model which consider the effect of masonry weak links is used for modelling the infill panels. Different factors governing the period of vibration was checked, and the result shows the effect of stiffness of the building is the most important factor influencing the period of vibration. Therefore two curves plotting lateral displacements and dimensionless height, Period of vibration and stiffness ratio with different infill configurations were plotted. This can be used for finding the period of vibration for the calculated stiffness ratio of the building that is considered for the seismic analysis

Key Words: Stiffness, model, dimensionless height, vibration, analysis, dynamic.

1. INTRODUCTION

When a structure is imperiled to ground motions in an earthquake, it responds by vibrating. The random motion of the ground caused by an earthquake can be resolved in any three mutually perpendicular directions. Generally, however, the inertia forces generated by the horizontal components of ground motion require greater consideration in seismic design. Structural analysis is mainly used for finding out the behavior of a structure when subjected to some act. This action can be in the form of load due to the weight of things such as people, furniture, wind, snow, etc. or some other kind of excitation such as an earthquake, quivering of the ground due to a blast nearby, etc. since all these loads are dynamic including the self-weight of the structure because at some point in time these loads were not there.

1.1 Analysis Methods

Static analysis describes a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum It claim that the building responds in its fundamental mode. The response is recite from a design response spectrum, given the natural frequency of the building (either calculated or defined by the building code

Static procedures are appropriate when higher mode effects are not significant. This is generally true for short, regular buildings. Therefore, for tall buildings, buildings with torsional irregularities, or non-orthogonal structures, a dynamic procedure is required. In the linear dynamic procedure, the building is modelled as a multi-degree-of-freedom (MDOF) system with a linear elastic stiffness matrix and an equivalent viscous damping matrix.

In general, linear procedures are applicable when the structure is expected to remain nearly elastic for the level of ground motion or when the design results in almost uniform distribution of nonlinear response throughout the structure. As the performance objective of the structure implies larger inelastic demands, the uncertainty with linear procedures increases to a point that requires a high level of conservatism in demand assumptions and acceptability criteria to elude unintended performance. Therefore, procedures incorporating inelastic analysis can reduce the uncertainty and conservatism.

1.2 Effect of infill wall

The infill wall is known as the supported wall that closes the perimeter of a building. It is generally made of steel or reinforced concrete or masonry. The infill wall has the unique static function to bear its own weight. Though it has been understood that the infills play significant role in enhancing the lateral stiffness of complete structure, serves to the past knowledge in various earthquakes have proved that the partially infilled framed structures somehow are affected adversely. This paper intends to highlight the need of knowledge on infilled frames (Fig-1).

In the literature, different modelling proposal techniques that simulate the behaviour of the infill's' panels can be found and are divided in two different groups, namely micro-models and simplified macro-models. The first of them includes models in which the panel is divided into numerous elements taking into account the local effects in detail, and the second includes simplified models based on the physical understanding of the behaviour of the infill panels submitted to earthquakes loadings and past experimental tests. In the case of the last group, a few of struts are used to represent the effect of this non-structural element on the structural response

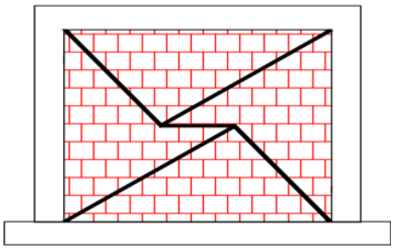


Fig – 1: Recent modelling Technique (Andre Furtado, 2015).

2. NONLINEAR STATIC ANALYSIS USING SAP2000

Nonlinear static analysis were carried out for five storey and ten storey building (Fig-2), their period of vibration was used for comparison it was clear from the comparison the equation formulated in IS 1893-1(2002) needs modification.

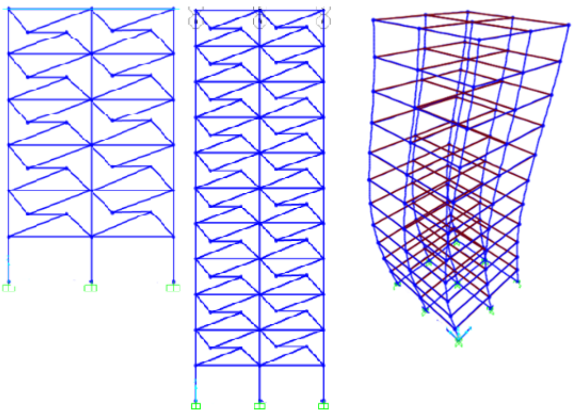


Fig- 2: Ten and Five storey model (SAP2000)

It is clear from the consolidated results Table 1.1, the effect of infill is not fully considered in IS 1893 part 1 2000 therefore modification is required for the time period equation given in IS 1893 part 1 2000
The value of time period decreases for with infill structures it is because time period is inversely proportional to the tiffness of the building by the relation $T = 2\prod\sqrt{\frac{M}{K}}$, as we know the infill impart stiffness to the building

Table -1: Comparison of results for Ten and Five storey

Category		Without Infill		With Infill	
No. of storey		5	10	5	10
Time Period (s)	IS 1893	0.655	1.032	0.567	0.953
	SAP2000	1.2423	2.2526	0.82508	1.2454
Base Shear (kN)	IS 1893	5148.56	6710	7290	9564
	SAP2000	4608	6912	4032	6336

2.1 PERIOD OF VIBRATION

The fundamental period is a vital design parameter that plays a significant role in the computation of design base shear. The inclusion of the masonry panels rigidity in structural modelling cause variation in the fundamental period by stiffening the structure, and in turn affects considerably the overall response of the building to earthquake ground motion. Factors influencing period of vibration- Height of the building, Base dimension of the building, No: of panels in both directions, Amount of infill and properties of infill, Effect of stiffness of the structure. The work carried out takes into account the stiffness, height and dimension of the building. The other factors are neglected because the variation of time period is less (Table 2, 3) when compared to the other factors.

Table- 2: Time period for different Infill materials

Model No:	Material	Time period (s)
Model 1	Brick	0.79461
Model 2	Solid block	0.78774
Model 3	Hollow block	0.79259

Table- 3: Time period for Infill thickness

Model No:	Thickness(mm)	Time period (s)
Model 4	230	0.79461
Model 5	250	0.80503
Model 6	300	0.81676

2.2 STIFFNESS

Infilling panels are found to increase stiffness of the structure, increase in initial stiffness, obtained for small strains, can reach 7 times that of bare frame. The stiffness ratio is calculated in each direction at individual story level. First, obtain the inverse of the angle of the inter-story deflection, r_s at each story level, and then compute the numerical average of r_s of all the stories above grade, $\bar{r}_s$.

The r_s value at individual story level is divided by the $\bar{r}_s$ value, and the result is defined as the stiffness ratio. The computation of stiffness on each floor and the stiffness ratio of the building was by using the displacement at each level and the corresponding height at that level

2.2.1 Effect of beam-to-column stiffness ratio (ρ) on lateral displacement patterns

The beam-to-column stiffness ratio, ρ, as a parameter that oversees the behavior of frame type building systems. It is the ratio of sum of the beam stiffness to column stiffness at the story that is nearest to the mid-height of the building, and it is constant for structures that have uniform lateral stiffness along their height. With the same modulus of elasticity for girders and columns, the general form of ρ is given by

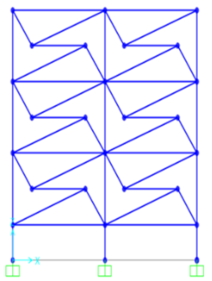
$$\frac{\sum \frac{I}{L}\text{beam}}{\sum \frac{I}{L}\text{column} + \sum \frac{I}{L}\text{infill}} \qquad (1.1)$$

I - Moment of inertia
L- Length

2.2.2 Relation between dimensionless height, ρ , displacements

Height of the building = 10.5m, ρ =1.155, Time period = 0.28611s

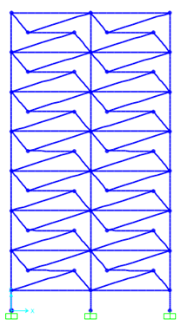
Table-4: Model and Deflection for each level



Dimensionless Height	Deflection
1.0	0.0085
0.714	0.0069
0.428	0.0049
0.142	0.0025

- Height of the building = 16.5m
- ρ =1.040
- Time period = 0.40383s

Table -5: Model and Deflection for each level



Dimensionless Height	Deflection
1.0	0.0501
0.86	0.0447
0.73	0.0383
0.6	0.0314
0.46	0.0242
0.33	0.0173
0.2	0.0111
0.05	0.0054

2.2.3 Dependence of lateral deformation on ρ for first mode

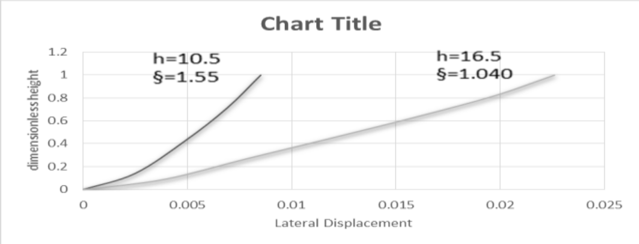


Chart – 1: Dimensionless height and deflection

2.2.4 Dependence of Stiffness ratio and period of vibration

The inclusion of masonry panels rigidity in the structural modelling changes the fundamental periods of the model by stiffening the structure, and in turn affects considerably the overall response of the building to earthquake ground motion. The stiffness ratio is calculated in each direction at each story level. First, obtain the inverse of the angle of the inter-story deflection, r_s at each story level, and then calculate the numerical average of r_s of all the stories above grade, $\bar{r}_s$. The r_s value at each story level is divided by the $\bar{r}_s$ value, and the result is defined as the stiffness ratio. For obtaining the curve between the time period of vibration and stiffness ratio different infill wall configurations are modelled using SAP2000 (Chart –1), therefore every possibility is considered which give accurate time period for any infill configurations.

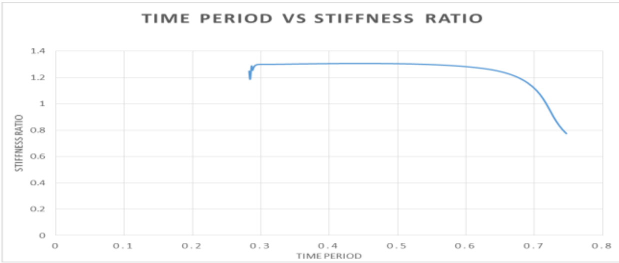


Chart – 2: Curve plotting stiffness ratio and time period

3. VALIDATION OF THE CURVE

A three storey structure with 10m height is used for cross checking the curve obtained(chart-2).

Table -6: Validation of the curve

Storey height (Actual)	Deflection (SAP2000)	Dimensionless Height	Deflection from curve
10	0.0081	0.95	0.008
7.5	0.0069	0.71	0.007
4.5	0.0048	0.42	0.0046
1.5	0.0025	0.14	0.0025

The results obtained from the curve (Chart-2) is almost equal to the value obtained from the analysis therefore the curve plotted are validated.

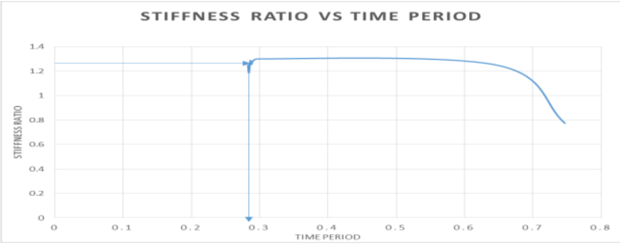


Chart – 3: stiffness ratio and time period

Table -7: Comparison of Time Period

Stiffness ratio (SAP2000)	Time period (SAP2000)	Time period (Chart-3)
1.27	0.286	0.29

4. CONCLUSIONS

Analytical study was carried out to investigate the effect of changes in latest revision of IS: 1893 on Time Period calculations for multistorey buildings. Though the number of buildings analyzed is a few to make generalization about the effect of revisions yet some important conclusions have been arrived. The infill wall impart lateral stiffness to the structure, lateral stiffness is an important factor that influence the period of vibration. Therefore if the stiffness of the building is known we can directly the find the time period of vibration.

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