Analysis of Irregular RCC Framed Structure for Fundamental Natural Period

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Abstract:- The determination of the fundamental period of vibration of structures is essential to design and assessment against earthquake loading. A reasonably accurate estimation of the fundamental period in such irregular structures is necessary in both response spectrum and static earthquake analysis of structures. An accurate estimation would allow for an improved estimation of the global seismic demands on an irregular structure. As such, the goal of this research is to investigate the accuracy of existing code-based equations for estimation of the fundamental period of irregular building structures and provide suggestions in the form of new equations to improve their accuracy.

INTRODUCTION:- As a part of structural design, members in buildings are selected and detailed such that the expected demands, such as forces or displacements, on a structure are less than the capacity of the structure to resist those forces and displacements. However, to obtain these forces or displacements, structural analysis is required considering the loading applied to the building from its weight, its use, and other factors such as wind, or shaking of the ground in the case of earthquake. The sophistication of the structural analysis affects both the detail of the analysis results. Simple methods (e.g., Equivalent Static method) may provide a reasonable representation of the likely seismic behavior to enable rapid assessment of the expected building performance. More complex methods, such as inelastic dynamic time history analysis provide more information about the response, but take more time and computational cost to perform properly.

1.1 NEED OF THE STUDY

Engineers need conceptually simple methods for the following reasons:-To design full structures ,To enable a rapid check of likely building performance ,To preliminary size members before some more sophisticated studies are undertaken. Simple analysis methods have been developed from studies carried out on structures with different structural forms, structural materials, and heights which have been idealized as being regular. However, no real structure is perfectly Regular as a result of accidental or intentional non-uniform mass, stiffness, strength, structural form, or a combination of these in the horizontal or vertical directions as shown in Figure 1.1 Also structures with a high degree of irregularity have the possibility of behaving significantly differently from that of a nominally regular structure.

1.2 FUNDAMENTAL OF NATURAL PERIODS:-

When the ground shakes, the base of building moves with the ground, and the building swings back-and-forth. If the building were rigid, then every point in it would move by the same amount as the ground. But, most buildings are flexible, and different parts move back and forth by different amounts. The time taken (in seconds) for each complete Z cycle of oscillation (i.e., one complete back and forth motion) is the same and is called Fundamental Natural Period (T) of the building. Value of T depends on the building flexibility and mass; more the flexibility, the longer is the T, and more the mass, the longer is the T. In general, taller buildings are more flexible and have larger mass, and therefore have a longer T. On the contrary, low to medium rise buildings generally have shorter T. Fundamental natural period T is an inherent property of a building. Any alterations made to the building will change its T.

The ground shaking during an earthquake contains a mixture of many sinusoidal waves of different frequencies, ranging from short to long periods. The time taken by the wave to complete one cycle of motion is called period of the earthquake wave. In general, earthquake shaking of the ground has waves whose periods vary in the range 0.03-33sec. Even within this range, some earthquake waves are stronger than the others. Intensity of earthquake waves at a particular building location depends on a number of factors , including the magnitude of the earthquake, the epi-central distance, and the type of ground that the earthquake waves travelled through before reaching the location of interest.

In a typical city, there are buildings of many different sizes and shapes. One way of categorizing them is by their fundamental natural period. The Ground motion under these buildings varies across the city. If the ground is shaken back-and-forth by earthquake waves that have short periods, then short period buildings will have larger response. Similarly, if the earthquake ground motion has long period waves, then long period buildings will have larger response. Thus, depending on the value of T of the buildings and on the characteristics of earthquake ground motion, some buildings will be shaken more than the other.

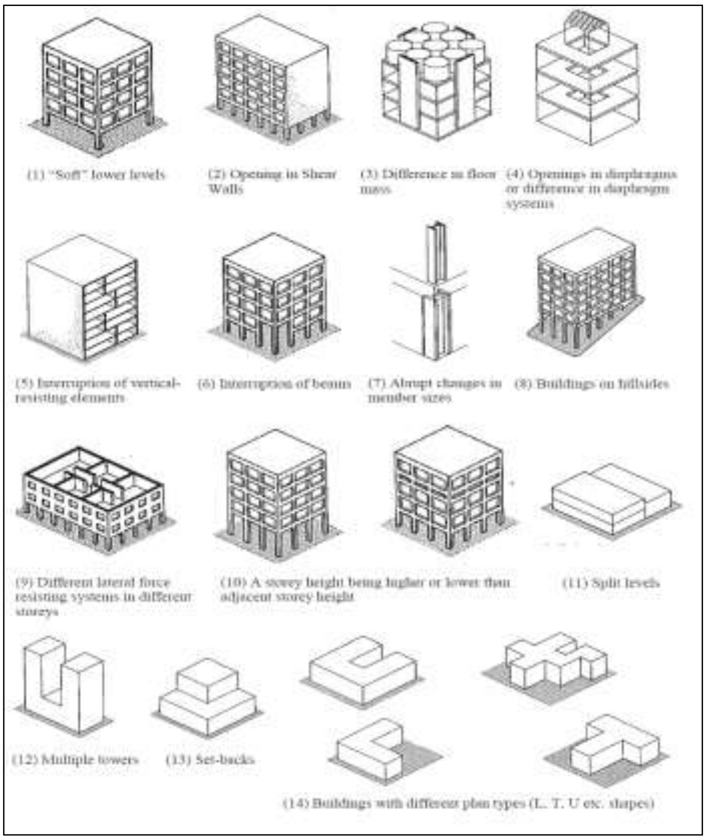

FIGURE :- EXAMPLES OF SOME COMMON IRREGULARITIES IN STRUCTURES

LITERATURE REVIEW: IRREGULAR STRUCTURE:-

VERTICALIRREGULARITIES-

Many researchers have studied the effects of irregularities on the seismic behavior of structures. However, most of the research has focused on torsional issues that arise from in plane irregularities in the distribution of masses, stiffness, or strengths. The number of research studies focusing on the effects of vertical irregularities is significantly smaller than it counterpart.

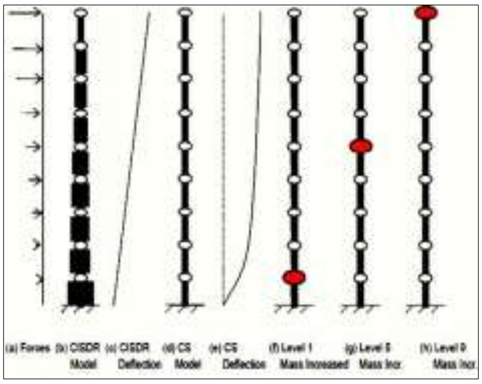

FIGURE 0.1 :DEFORMED SHAPES FOR DIFFERENT METHODS AND MASS IRREGULARITY

PLANIRREGULARITIES

The parameters that affect the behavioural performance of irregular structures under seismic action were investigated in many recent earthquakes. Most of the literatures described the effects only qualitatively and the codes used some percentages that limited the structural performances; but not necessarily are obtained with large and deep investigation.

CODAL PROVISIONS FOR FUNDAMENTAL PERIOD OF STRUCTURES

Seismic design codes specify empirical formulas to estimate the fundamental period which are based on data from instrumented buildings subjected to ambient vibrations or small to moderate earthquakes. The approximate fundamental natural period of vibration (T_a), in seconds, of a Moment-resisting frame building without brick in fill panels may be estimated by IS-1893 (Part 1): 2002, Clause7.6.1,forconcretestructures is in the form.

T_a=0.075$H^{0.75}$ ………………………………………(1)

Where , H=Height of building, in m. This excludes the basement storey's ,where basement walls are connected with the ground floor deck or fitted between the building columns. But it includes the basement storey's ,when they are not so connected.

Up until 2002, the fundamental period estimated by (American Society Of Civil Engineers) ASCE7-02[i]code for all structures was in the same form where the parameter 0.075waschosenspecifically by structure type .Equation 1 is still in use in the building code so many countries , including Euro code 8[ii],which limits its use to buildings less than40 m (131 feet). Also present in certain design. Codes for many years , the fundamental period of braced steel frames and concrete shear walls is estimated as:

T_a= 0.05 H /√D…………………………………….. (2)

Parameter D corresponds to the dimension of the braced frame in a direction parallel to the applied force, called the depth of the structure in this paper. In Equation 2, H and D are in feet.

FUNDAMENTALPERIODBASEDONVIBRATIONTHEORY

The code specifies that the fundamental period may be determined through an alternative substantiated analysis such as normal mode analysis or Rayleighs method, both of which require the use of a computer program, making these theory based methods of determining the fundamental period cumber some for most practicing engineers. More commonly, the fundamental period is determined through empirical equations provided in design codes such as IS-1893 (Part 1):2002.

The Rayleigh equation is based on structural properties and deformational characteristics. The fundamental period in seconds is computed through the following formula:

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$$T = 2\pi \sqrt{\sum_{i=1}^{N} \omega_i \delta_i^2 \Big/ g \sum_{i=1}^{N} f_i \delta_i}$$

Where, φ i is the portion of the total weight to the structure assigned to level, f_i is the lateral force at level i, $d_i$is the deflection at level i relative to the base due to lateral forces, g is acceleration due to gravity, and N is the total number of stories in the building.

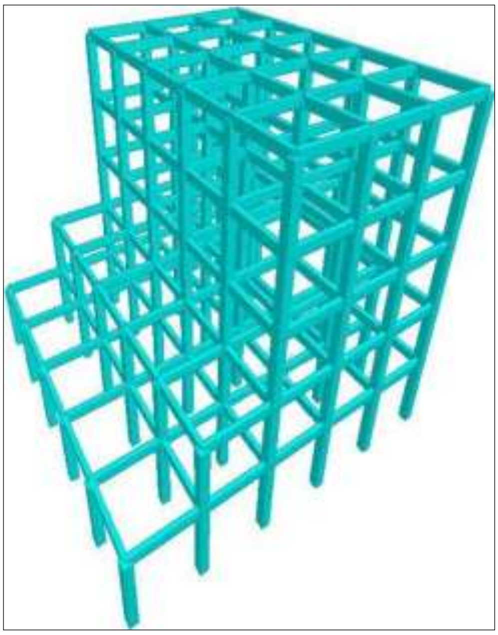
ANALYTICAL APPROACH

VERTICAL IRREGULARITY – SETBACK

The estimation of the fundamental period of a building structure is essential for determination of the design base shear and lateral design forces. A number of studies have been performed on the fundamental period of building structures. As more buildings are instrumented and recorded seismic response data have become available, a number of recent studies have compared results obtained from empirical code equations for the fundamental period with actual measured data of structures during seismic events.

BUILDING DESIGN MODEL

All MRF structures are modeled with either 20 stories, 10 stories, or 5 stories (N) and 5 or 10 bays (Nb). All structures have a uniform storey height of 3.5m. The bays have a uniform spacing of 4m. A total of 31 MRF Structures are evaluated: 11 types of setback structures for each type



CONCLUSION:-

A study has been conducted on the fundamental period of irregular concrete structures. A total of 273 MRFs (31 MRF structures for Setback, 114 MRF structures for Mass Irregularity, 75 MRF structures for Soft Storey, 33 MRF structures for Re-entrant Corner and 20 MRF structures for Torsional Irregularity Due to Heavy Mass) were analysed and their fundamental periods were determined by several different methods.

VERTICAL IRREGULARITY-SET BACKS

Through a comparison of the fundamental period of 31 MRFs by the IS Code equations (Equation 1 & 4), Rayleigh equation (Equation 6), and STAAD.Pro V8i generated period, the following conclusions are made:

1) Equation 4 yields the most conservative result for all examples within 35m height of the building, followed by Equation 1. But for higher buildings, Equation 1 becomes more conservative than Equation 4.

2) In general, structures without irregularities tend to have a longer period compared with irregular structures.

VERTICAL IRREGULARITY-MASS IRREGULARITY:-Through a comparison of the fundamental period of 114 MRFs by the IS Code equations (Equation 1 & 4), Rayleigh equation (Equation 6), and STAAD.Pro V8i generated period, the following conclusions are made:

1) Equation 4 yields the most conservative result for all examples within 35m height of the building, followed by Equation 1. But for higher buildings, Equation 1 becomes more conservative than Equation 4.

2) In general, structures without irregularities tend to have a longer period compared with irregular structures.

VERTICAL IRREGULARITY-SOFT STOREY

Through a comparison of the fundamental period of 75 MRFs by the IS Code equations (Equation 1 & 4), Rayleigh equation (Equation 6), and STAAD.Pro V8i generated period, the following conclusions are made:

1) Equation 4 yields the most conservative result for all examples within 35m height of the building, followed by Equation 1. But for higher buildings, Equation 1 becomes more conservative than Equation 4.

2) In general, structures without irregularities tend to have a longer period compared with irregular structures.

HORIZONTAL IRREGULARITY RE-ENTRANT CORNER

Through a comparison of the fundamental period of 33 MRFs by the IS Code equations (Equation 1 & 4), Rayleigh equation (Equation 6), and STAAD.Pro V8i generated period, the following conclusions are made:

1) Equation 4 yields the most conservative result for all examples within 35m height of the building, followed by Equation 1. But for higher buildings, Equation 1 becomes more conservative than Equation 4.

2) In general, structures without irregularities tend to have a longer period compared with irregular structures.

HORIZONTAL IRREGULARITY TORSIONAL IRREGULARITY DUE TO HEAVY MASS

Through a comparison of the fundamental period of 20 MRFs by the IS Code equations (Equation 1 & 4), Rayleigh equation (Equation 6), and STAAD.Pro V8i generated period, the following conclusions are made:

1) Equation 4 yields the most conservative result for all examples within 35m height of the building, followed by Equation 1. But for higher buildings, Equation 1 becomes more conservative than Equation 4.

2) In general, structures without irregularities tend to have a longer period compared with irregular structures.

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