A STUDY ON THE APPLICABILITY OF TIME PERIOD FORMULA FOR HIGH RISE BUILDINGS

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***Abstract*—** *According to Indian Seismic code, the fundamental natural period can be calculated by using empirical formulae or by performing computer analysis. After advancement of science, usage of time period value arrived after doing computer analysis is started and becoming popular for the calculation of design base shear force. Accurate estimation of mass and underestimating of stiffness gives the greater value of time period which in turn gives the value of design base shear force of lower magnitude.*

In this project work, the time period formula given in IS 1893 for the high rise buildings has been investigated. By considering buildings of 5, 10, 15, 20, 25, 30, 35,40, 45 and 50 storey buildings, the percentage changein time period of these buildings without infill which were computed based on the formulae given by the various countries such as Australia, Canada, Euro, Taiwan USA in comparision to IS 1893.It is observed from the seismic codes of various countries that the time period of the building increases with the number of storeys . Seismic codes of various countries showing lot of variation compared to IS code 1893.

Multistoried buildings of 5,10,15,20,25,30,35,40,45 and 50 storeys were modeled in STAAD Pro and the time period is evaluated. The percentage change in time period of these buildings which were computed based on STAAD Pro. is compared with IS 1893.It can seen that for high rise buildings (i.e. above 10 floors), there is a significant variation (i.e. to an extent of 23 %) in the time periods between IS 1893 and STAAD Pro, as it calculates the time period from fundamentals. (i.e. by considering mass, stiffness etc.) Hence, it is concluded the formula suggested by the IS 1893 is applicable to only low and medium rise buildings.

To investigate the effect of time period on high rise buildings with infill, multistoried buildingof 40,45,50,55,60 were modeled in SAP and the time period is evaluated.The percentage change in time period of these buildings which were computed based on SAP is compared with IS 1893.It can be said that for high rise buildings (i.e. upto 60 floors) there is a significant variation (i.e. to an extent of 49 %)in the time periods between IS 1893 and SAP, as it calculates the time period from fundamentals. (i.e. by considering mass, stiffness etc.) Hence, it can be said that the formula suggested by the IS 1893 is applicable to only low and medium rise buildings.

Keywords*—Mass; Stiffness; Time period formula;IS1893 code; STAAD Pro;SAP.*

I.INTRODUCTION

DYNAMIC CHARACTERISTICS OF BUILDINGS:

During earthquake buildings oscillate. The oscillation induces inertia force in the building. The intensity, duration of oscillation and the magnitude of inertia force induced in a building depend dynamic characteristics of buildings, (i.e.., features of the building) along with characteristics of the earthquake shaking itself. Modes of oscillation and damping are the important dynamic characteristics in buildings. Mode of oscillation of a building defined by the deformed shape and natural period of oscillation.

NATURAL PERIOD :

Natural Period Tn of a building is the time taken by it to undergo one cycle of oscillation. It is an inherent property of a building controlled by mass m and stiffness k. These three quantities are related by

$$T_n=2\pi$$

Thus, buildings that are heavy (larger mass m) and flexible (smaller stiffness k) have larger natural period than light & stiff buildings. Buildings oscillate by translating along the X, Y or Z directions, or by rotating about the X, Y or Z axes, or by a combination of the above. When a building oscillates, there will be a associated shape of oscillation.

The reciprocal (1/Tn) of natural period of building is called the natural frequency (fn); its unit is defined as Hertz (Hz). The building gives minimal resistance when it shakes at natural frequency (or natural period). Hence, when the building is shaken at natural frequency than at other frequencies, it undergoes larger oscillation. Usually, natural periods (Tn) of 1-20 ordinary reinforced concrete buildings and steel buildings fall in the range of 0.05s - 2.00 s. In building design practice, engineers commonly work with Tn and not with fn. Resonance occurs in a building, if the frequency at which the ground shakes remains steady around any of the natural frequencies of building, applied over an extended period of time. But, earthquake ground motion has departures from these two conditions. The ground motion contains a range of frequencies that change continuously and randomly at every instant of time.

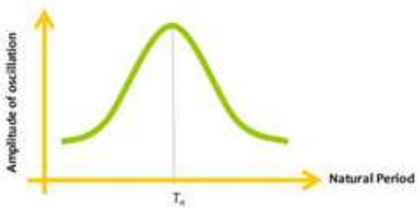


FIG. 1.2 : VARIATION OF AMPLITUDE OF OSCILLATION WITH NATURAL PERIOD

1)Fundamental translational natural periods, Tx, Ty and Tz, associated with its horizontal translational oscillation along X and Y directions, and vertical translational oscillation along Z direction, respectively, and

2)Fundamental rotational natural period Tθ associated with its rotation about an axis parallel to Z axis.

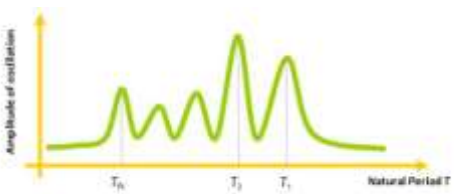


Fig. 1.3 : Amplitude of oscillation in a building when vibrating at the natural frequencies

Factors influencing Natural Period :

The factors that influences the natural period are,

(a)Stiffness(k) :

Increasing the column size increases both stiffness(k) and mass(m) of buildings. But, when percentage increase in the stiffness as a result of increase in a column size is more than the percentage increase in mass, then natural period reduces. Hence, the usual discussion that increase in column size reduces the Tn of buildings does not consider the simultaneous increase in mass; in that context, buildings are said to have shorter natural periods with increase of column size.

(b)Mass(m) :

Mass of a building which is effective in lateral oscillation during earthquake moment is called the seismic mass of the building. It is the sum of seismic masses at various floor levels. Seismic mass on each level of floor is equal to full dead load and appropriate fraction of live load. The fraction of live load depends on the intensity of the live load and how it is fixed to the floor slab. Seismic design codes of each region /country provide fraction of live loads to be determined for design of buildings to be built in that country / region.

(c)Building Height:

The height of building increases, its mass increases but its overall stiffness decreases. Hence, the T_n of a building increases with increase in height.

(d) Column Orientation :

Orientation of rectangular columns influences lateral stiffness of buildings along two horizontal directions. Hence, changing the orientation of columns changes the translational natural period of buildings.

(e) Unreinforced Masonry Infill Walls in Reinforced concrete Frames :

In various countries, the space between the beams and columns of building are filled with un-reinforced masonry (URM) infills. These infills participate in the lateral response of buildings and as a consequence alter the lateral stiffness of buildings. Hence, natural periods (and modes of oscillation) of the building are affected in the presence of URM. In design process, the masses of the infill walls are considered, but their lateral stiffness are not. Modelling the infill wall along with the frame elements is necessary to include additional lateral stiffness offered by URM infill walls.

In summary, Tn of buildings depend on the distribution of mass(m) and stiffness(k) along the building (in all directions). Some important observations in relation to Tn of buildings of regular geometries are,

(i) Tn of buildings decrease with increase in stiffness.

(ii) Tn of buildings increase with increase in mass.

(iii) Tall buildings have larger values of fundamental of translational natural periods.

(iv) They tend to oscillate in the directions in which they are most flexible and have more translational natural periods.

(v) Tn of buildings is influenced by magnitude and extent of spatial distribution of unreinforced masonry infill walls.

Mode Shape :Mode shape of oscillation associated with a natural period of a building is the deformed shape of the building when vibrating at the natural period. Hence, a building has mode shapes equal to number of natural periods. For a building, there are infinite numbers of natural period. But, in the mathematical modelling of building, usually the building is discretized into number of elements. The junctions of these elements are known as nodes. Each node is free to translate in all the three cartesian directions and rotate about the three cartesian axes. Hence, if the no. of nodes of discretisation is N, then there will be 6N modes of oscillation. The deformed shape associated with oscillation at fundamental natural period is termed its first mode shape. Similarly, the deformed shapes associated with oscillations at second, third, and other higher natural periods are called second mode shape, third mode shape, and so on, respectively.

Fundamental Mode Shape of Oscillation : Three basic modes of oscillation, namely, pure translational along X-direction, Y-direction and pure rotation about Z-axis. Regular buildings have these pure mode shapes. Irregular buildings (i.e., buildings that have irregular geometry, non uniform distribution of mass and stiffness in plan and along the height) have mode shapes that are a mixture of these pure mode shapes. Each of these mode shapes are independent, implying, it cannot be obtained by combining any or all of the other mode shapes.

Also, there are a no. of possibilities in which buildings can oscillate along each direction of oscillation. When the building oscillates along the X-axis, it offers less resistance to motion while oscillating in its fundamental mode, and increased resistance to oscillation in the higher modes (second, third, and so on). A unique situation rises in buildings that will be perfectly symmetric in mass and stiffness distribution in both plan and elevation. Some fundamental or early modes of oscillation are along the diagonal direction and not along the sides of the building. Generally, in such cases, the torsional mode is also an early mode of oscillation. In such buildings, columns undergo bending about axes oriented along their diagonal. But rectangular columns have least resistance along their diagonal directions. Hence, their corners of the columns are severely damaged under this type of oscillation of buildings. This situation can be avoided by ensuring that the building does not have the same structural configuration about both the axes and is symmetric about each of the two plan axes.

Factors influencing Mode Shapes :

(a) Effect of Flexural Stiffness of Structural Elements

(b) Effect of Axial Stiffness of Vertical Members

(c) Effect of Degree of Fixity at Member Ends

(d) Effect of Building Height

(e) Effect of Unreinforced Masonry Infill Walls in RC Frames

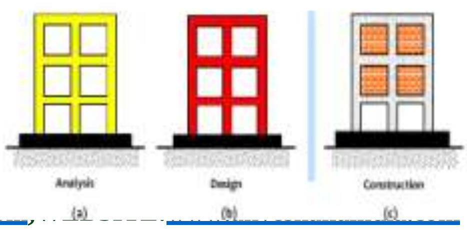


Fig. 1.5 : Unreinforced Masonry Infill Walls in RC Frame buildings

SCOPE OF THE STUDY:

The formula for the estimation of time period given in IS 1893 (Both for bare frame buildings and Infill buildings) is critically reviewed for its applicability to high rise buildings. Various high rise buildings are modeled, analyzed and checked the percentage variation of IS 1893 formulae with Staad Pro & SAP.

OBJECTIVES OF THE STUDY:

The objectives of the project work are as listed below.

In this project work, the applicability of the time period formula for bare frame buildings given in the IS 1893 has been investigated by analyzing buildings of 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 storey buildings using Staad Pro software

In this project work, the applicability of the time period formula for brick infill buildings given in the IS 1893 has been investigated by analyzing buildings of 40, 45, 50, 55 and 60 storey buildings using SAP software.

A new formula has been proposed to estimate the time period for bare frame buildings and infill buildings as the variation between the code formulae and obtained from software's is significant.

The variation in dynamic response parameters such as base shear, top displacement is assessed between IS 1893 and Proposed formula.

LITERATURE REVIEW

Pulkit D Velani and Ramancharla Pradeep Kumar [1] studied the formula given in seismic code of various countries, comparing them with Indian seismic code IS 1893:2002. There are several earthquake issues involved in planning, designing and constructing the tall buildings. Some of the problems related to seismic behaviour are still not solved even in developed countries like U.S.A and Japan. All over the world, Researchers are continuously working towards development of latest techniques for improving earthquake safety of tall buildings. In India there are few codes which specify guidelines for earthquake resistant design of structures. However, the guidelines given in this code are useful for regular and relatively small and low raised buildings. When it comes to tall buildings every structure is special, several parameters need to be considered. One of the parameter is time period, T. Empirical natural period equation given in IS 1893 is suitable only for small to medium rise buildings. Hence, natural period equation for high rise buildings has to be proposed. They compared the empirical equations for natural period of different countries.

Study shows that there is a need to propose the new time period formula exclusively for tall structures based on Indian conditions.

They concluded that, empirical natural period equation given in IS 1893 is insufficient for calculating time period of tall buildings. There is a necessity to propose new expression exclusively for tall structures based on forced vibration studies.

Sudhir K Patel et al. [2] modeled various R.C.C. buildings in Staad Pro software. All R.C.C. buildings modeled are having base dimensions of 70m ×70 m. The height of the R.C.C. buildings is approximately 90 m. The storey height of the R.C.C. building is different for different model. The variation in the storey height is in the range of 0.25 m. As the storey height increases, the number of storeys will decrease. In each and every model the storey height is kept constant for every storey. With the use of Staad Pro software, analysis is carried out.

They concluded that, as the number of storeys increases, natural time period increases although the height of the building remains same.

Nilesh V Prajapati et al. [3] studied the natural time period of a multi-storey building. The design of structures subjected to natural calamities such as earthquakes and hurricanes need safety of structures which depends on the natural frequencies and the magnitude of damping in each mode of vibration. The dynamic analysis compared the empirical time period, investigated the effect of number of stories on natural time period and investigated the effect of height and number of floors on behaviour of structure. Moreover, behaviour of a building under dynamic excitation is governed by the fundamental natural frequency and the magnitude of damping manifested by each mode of vibration. Fundamental frequency of a building and its damping has a remarkable effect on the magnitude of its response. They showed that natural time period is also depends on the number of floors and not only the height of the building, which is not mentioned in IS 1893:2002

They concluded that, as the number of floors and in turn the height of building is increased, variation in natural frequency will be obtained. The results for variation in number of floors and height of building is obtained.

For seismic design of building, natural period of structure helps in determining out the base shear to be resisted by the structure and mode shape gives the estimation of the distribution of base shear at every storey. Most of the codes gave simple expression to find the time period formula. Such expressions are related with building geometry such as height of building (H), number of storey's (N), base dimension of building (D). Some of the expressions used by the different countries are listed in the following table.

PROBLEM DESCRIPTION:

In the present study, RC framed buildings (5,10,15,20,25,30,35,40,45,50 storeys) were modelled and analyzed in Staad Pro. To study the applicability of time period formula given is IS:1893, various RC framed buildings (40,45,50,55,60 storeys) were modelled and analyzed in SAP. The description of the various modelled considered in the present study is given below.

- Plan dimensions: 20 m × 15 m
- Height of building : 15,30,45,60,75,90,105,120,135,150 m. (bare frame)
- Height of building: 120,135,150,165,180 m. (infill frame)
- Height of each storey: 3m
- Number of bays along X-direction: 4 nos.
- Number of bays along Z-direction: 3 nos.
- Length of each bay (in X-direction): 5m
- Length of each bay (in Z-direction): 5m
- Column size: 500 mm × 500 mm (for buildings of 20 storeys and less)
- Beam size: 300 mm × 500 mm (for buildings of 20 storeys and less)
- Column size: 800 mm × 800 mm (for buildings of more than 20 storeys)
- Beam size: 300 mm × 600 mm (for buildings of more than 20 storeys)
- Grade of concrete: M 25
- Grade of steel: Fe 415
- Density of concrete: 25 kN/m3
- Density of brick masonry: 20 kN/m3
- Live load: 3 kN/m2
- Slab thickness: 120 mm
- Wall thickness: 230 mm (outer wall)
- 115 mm (inner wall)

CALCULATION OF TIME PERIOD BASED ON DIFFERENT CODES:

Australian code (AS 1170.4 – 2007):

Ex.1 (a) 5Storey Building

T1 = 1.25 Kthn0.75

hn= height from the base of structure

kt= Constant depends on type of frame = 0.075

T1= 1.25(0.075) (5 × 3)0.75= 0.714 Sec
1(b) 10Storey Building
T1 = 1.25 Kthn0.75
T1= 1.25(0.075) (10 × 3)0.75= 1.202Sec
1(c) 15Storey Building
T1 = 1.25 Kthn0.75
T1= 1.25(0.075) (15 × 3)0.75= 1.628 Sec
1(d) 20Storey Building
T1 = 1.25 Kthn0.75
T1= 1.25(0.075) (20 × 3)0.75= 2.021 Sec
1(e) 25Storey Building
T1 = 1.25 Kthn0.75
T1= 1.25(0.075) (25 × 3)0.75=2.389 Sec
1(f) 30Storey Building
T1 = 1.25 Kthn0.75
T1= 1.25(0.075) (30 × 3)0.75=2.739 Sec
1(g) 35storey Building
T1 = 1.25 Kthn0.75
T1= 1.25(0.075) (35 × 3)0.75= 3.075 Sec
1(h) 40Storey Building
T1 = 1.25 Kthn0.75
T1= 1.25(0.075) (40 × 3)0.75=3.399 Sec
1(i) 45Storey Building
T1= 1.25 Kthn0.75
T1= 1.25(0.075) (45 × 3)0.75=3.713 Sec
1(j) 50Storey Building
T1 = 1.25 Kthn0.75
T1= 1.25(0.075) (50 × 3)0.75=4.018 Sec

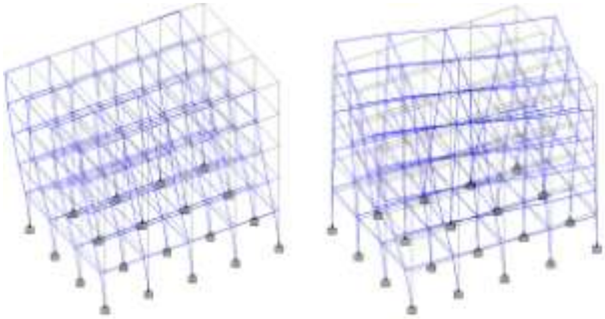
Canada code (NBCC 2005):
Ex. 2(a) 5 Storey Building:
T =λ h n3/4
λ = Type of frames
hn= height of the building in meter
T1 = (0.075) (5 × 3)3/4= 0.572 Sec
2(b) 10Storey Building:
T1= (0.075) (10×3)3/4= 0.961 Sec
2(c) 15Storey Building:
T1= (0.075) (15×3)3/4= 1.303 Sec
2(d) 20storey Building:
T1= (0.075) (20×3)3/4= 1.616 Sec
2(e) 25storey Building
T1= (0.075) (25×3)3/4=1.911 Sec
2(f) 30storey Building:
T1= (0.075) (30×3)3/4=2.191 Sec
2(g) 35storey Building:
T1= (0.075) (35×3)3/4=2.460 Sec
2(h) 40storey Building:
T1= (0.075) (40×3)3/4=2.719 Sec
2(i) 45storey Building:
T1= (0.075) (45×3)3/4=2.971 Sec
2(j) 50storey Building:
T1= (0.075) (50×3)3/4
=3.215 Sec

EURO code(EN 1998 – 1 2004):
Ex. 3(a) 5 Storey Building
T1 =CtH3/4
Ct = Type of frame;
H = Height of the building; m
T1 = 0.075 × (5 × 3)0.75
= 0.075 × (5 × 3)0.75
= 0.572 Sec
3(b) 10Storey Building
T1= 0.075 × (10 × 3)0.75
= 0.961 Sec.
3(c) 15Storey Building
T1 = 0.075 × (15 × 3)0.75= 1.303
3(d) 20storey Building
T1 = 0.075 × (20 × 3)0.75= 1.617 Sec
3(e) 25storey Building
T1 = 0.075 × (25 × 3)0.75= 1.911 Sec
3(f) 30storey Building
T1 = 0.075 × (30 × 3)0.75= 2.192 Sec
3(g) 35storey Building
T1 = 0.075 × (35 × 3)0.75= 2.460 Sec
3(h) 40storey Building
T1= 0.075 × (40 × 3)0.75= 2.719 Sec
3(i) 45storey Building
T1 = 0.075 × (45 × 3)0.75= 2.970 Sec
3(j) 50storey Building
T1= 0.075 × (50 × 3)0.75= 3.215 Sec

India code (IS 1893 - Part 1 :2002)
Ex. 4(a) 5Storey Building
T1 = CtH3/4
Ct = Type of frame;
H =Height of the building; m
T1 = 0.075 × (5 × 3)0.75= 0.572 Sec
4(b) 10Storey Building
T1 =0.075 × (10 × 3)0.75= 0.961 Sec
4(c) 15Storey Building
T1 = 0.075 × (15 × 3)0.75= 1.303 Sec
4(d) 20Storey Building
T1 = 0.075 × (20 × 3)0.75= 1.616 Sec
4(e) 25storey Building
T1 = 0.075 × (25 × 3)0.75= 1.911 Sec
4(f) 30Storey Building
T1 = 0.075 × (30 × 3)0.75= 2.191 Sec
4(g) 35Storey Building
T1 = 0.075 × (35 × 3)0.75= 2.460 Sec
4(h) 40storey Building
T1 = 0.075 × (40 × 3)0.75= 2.719 Sec
4(i) 45storey Building
T1 = 0.075 × (45 × 3)0.75= 2.970 Sec
4(j) 50storey Building
T1 = 0.075 × (50 × 3)0.75= 3.214 Sec

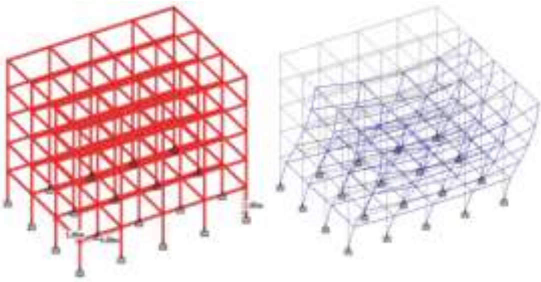
Taiwan (2005):
Ex.5 (a) 5StoreyBuilding
T1 =CtH¾
Ct = Type of frame;
H = Height of the building;
T1=0.07 × (5 × 3)0.75= 0.533 Sec
5(b) 10Storey Building
T1=0.07 × (10 × 3)0.75= 0.897 Sec
5(c) 15Storey Building
T1=0.07 × (15 × 3)0.75= 1.216 Sec.
5(d) 20Storey Building
T1= 0.07× (20 × 3)0.75= 1.509 Sec
5(e) 25Storey Building
T1= 0.07× (25 × 3)0.75= 1.784 Sec
5(f) 30Storey Building
T1= 0.07× (30 × 3)0.75= 2.045 Sec
5(g) 35Storey Building
T1= 0.07× (35 × 3)0.75= 2.296 Sec
5(h) 40Storey Building
T1= 0.07× (40 × 3)0.75
= 2.538 Sec
5(i) 45Storey Building
T1= 0.07× (45 × 3)0.75= 2.772 Sec
5(j) 50Storey Building
T1= 0.07× (50 × 3)0.75= 3.000 Sec
US code (ASCE 7 – 10):
Ex. 6(a) 5Storey Building
T1=CtHn¾
Ct = Type of frame;
H = Height of the building; m
T1= 0.0466 × (5 × 3)0.9= 0.533 Sec
6(b) 10Storey Building
T1= 0.0466 × (10 × 3)0.9=0.995 Sec
6(c) 15Storey Building
T1= 0.0466 × (15 × 3)0.9= 1.433 Sec.
6(d) 20Storey Building
T1= 0.0466 × (20 × 3)0.9= 1.856 Sec
6(e) 25Storey Building
T1= 0.0466 × (25 × 3)0.9= 2.269 Sec
6(f) 30Storey Building
T1= 0.0466 × (30 × 3)0.9= 2.674 Sec
6(g) 35Storey Building
T1=0.0466 × (35 × 3)0.9= 3.072 Sec
6(h) 40Storey Building
T1= 0.0466 × (40 × 3)0.9= 3.465 Sec
6(I) 45Storey Building
T1= 0.0466 × (45 × 3)0.9= 3.852 Sec
6(j) 50Storey Building
T1= 0.0466× (50 × 3)0.9= 4.235 Sec

General example of 5 storey building & 45 storey building:



Modeling of a 5 Storey Building

Fundamental Mode shape of a 5 Storey Building



Figures of 5 storey and 45 storey building

Mode shape 2 Mode shape 3

Mo de	X	YZ	Z	Sum -X	Sum -Y	Sum -
1 2 3 4 5 6 7 8 9 1 0	0. 00 76 .3 0. 00 0. 00 0. 00 0. 29 0. 00 0. 00 0. 00 0. 00	0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0	75. 98 0.0 0 0.0 0 0.0 0 0.4 7 0.0 0 0.0 0 0.0 0 0.0 1 8.8 8	0.0 0 76. 35 76. 35 76. 35 76. 35 76. 64 76. 64 76. 64 76. 64 76. 64	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00	75.9 8 75.9 8 75.9 8 75.9 8 76.4 6 76.4 6 76.4 6 76.4 6 76.4 6 85.3 3

RESULTS AND DISCUSSION

Time period for bare frame buildings is calculated using seismic code of different countries and the values obtained are listed in Table 5.1 and presented in Figure 5.1. Percentage variation in time period calculated from seismic code of different countries with respect to IS:1893-2002 is listed in Table 5.2 and presented in Figure 5.2

Table 5.1 - Calculation of Time Period as per different codes for Bare Frame

Number of Storeys	Staad Pro	Australian code (AS 11704-2007)	Canadian code (NBCC 2005)	Euro code (EN 1998-1 2004)	India (IS 1893 - 2002)	Taiwan code 2005	USA code (ASCE 7-10)
5	0.593	0.714	0.572	0.628	0.572	0.533	0.533
10	1.225	1.202	0.961	1.009	0.961	0.897	0.995
15	1.888	1.628	1.303	1.346	1.303	1.216	1.433
20	2.593	2.021	1.616	1.657	1.616	1.509	1.856
25	2.699	2.389	1.911	1.949	1.911	1.784	2.269
30	3.271	2.739	2.191	2.227	2.191	2.045	2.674
35	3.960	3.075	2.460	2.495	2.460	2.296	3.072
40	4.703	3.399	2.719	2.75	2.719	2.538	3.465
45	5.504	3.713	2.970	3.003	2.970	2.772	3.852
50	6.366	4.018	3.214	3.246	3.214	3.000	4.235

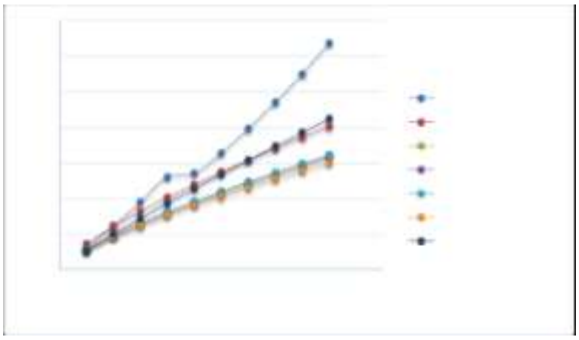


Fig. 5.1 - Time Period as per different codes for Bare Frame

The percentage difference in Time Period calculated from IS:1893, obtained from SAP and calculated from proposed formula for infill frame - outer wall, outer +inner walls are listed in Tables 5.6, 5.7.

Table 5.6 - Percentage Variation between time period from IS:1893, SAP and Proposed formula for infill frame(outer wall)

No. of Stories	IS:1893	SAP	Proposed formulae	Percentage variation	
				IS:1893 & SAP	SAP & proposed formula
40	2.7	3.533	3.640	-30.8	10.7
45	3.037	3.990	4.090	-31.3	2.4
50	3.375	4.504	4.550	-33.5	1
55	3.712	5.345	5.010	-43.9	-6.7
60	4.05	6.005	5.468	-49	-9.8

Table 5.7 - Percentage Variation between time period from IS1893, SAP and Proposed formula for infill frame(outer wall & inner wall)

No. of Stories	IS:1893	SAP	Proposed formulae	Percentage variation	
				IS:1893 & SAP	SAP & proposed formulae
40	2.7	3.250	3.640	-20.3	10
45	3.037	3.752	4.090	-23.5	8.2
50	3.375	4.1	4.550	-24	9.8
55	3.712	4.745	5.010	-28	5.3
60	4.05	5.765	5.468	-42	-3.6

CONCLUSIONS

- It can be observed from the analysis that there is a significant difference in the time period of buildings without brick infill obtained from STAAD Pro and calculated from IS 1893 (i.e. to an extent of 100 percent).

• It can also be observed that there is considerable difference in time period of buildings with brick infill obtained from SAP and IS 1893 (i.e. to an extent of 50 percent)

• It seems to be the formula given in IS 1893 is applicable only for low and medium rise buildings without brick infill and with brick infill.

• As the time period is an important parameter in the dynamic analysis of tall buildings, buildings of different heights ranging from 15 to 150 m. are modelled, analysed and concluded that there is a need to modify the formula given in IS 1893
and hence a new formula has been proposed in this project for buildings with brick infill and without brick infill.

• The percentage variation in the time period of buildings without brick infill obtain from STAAD Pro and IS 1893 (to an extent of 100%) has been drastically reduced to an extent of 12% with the proposed formula.

• The percentage variation in the time period of buildings with brick infill obtained from SAP and IS 1893 (to an extent of 50%) has been drastically reduced to an extent of 10% with the proposed formula.

• As there is a significant difference in base shear obtained from IS:1893 and proposed formula for bare frame buildings, economy can be achieved to some extent while designing the columns.

• As there is a significant reduction in top displacement obtained from IS:1893 and proposed formula for bare frame buildings, results in to stiff and rigid structures which is desirable.

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