**International Journal of Civil and Structural Engineering Research** ISSN 2348-7607 (Online)
Vol. 4, Issue 2, pp: (12-21), Month: October 2016 - March 2017, Available at: www.researchpublish.com

# Approximate Seismic Analysis Procedure for Multibay RC Framed Structures

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***Abstract:*** **In the current earth quake resisting code provisions for building structures, there remains a need for simple model that provide accurate estimate of response. The concept of lateral stiffness is reviewed, where a single value can be used to represent the stiffness of the storey in a rectangular frame with fixed base which is subjected to distribution of lateral load at stories. In this paper an approximate analysis is performed to examine the behaviour of various model of same reinforced concrete moment resisting frame, which differ in stories and column dimensions. The parameter discussed includes Fundamental natural time period, stiffness, lateral displacement and storey drift. The Analysis is carried out by both processes, Equivalent static analysis from which lateral displacement is found due to lateral load and Dynamic analysis (Response spectrum) from which natural time period, frequencies and mode shapes is found. This whole process is carried out by two adapted procedure that is by full structure analysis and lumped mass model by following the codal provisions of IS 1893 (2002).**
**The two adapted results are then compared and analyzed using Spreadsheet and ETAB software.**

***Keywords:*** **Equivalent Static analysis, Response Spectrum, Lateral stiffness, Natural Time Period, Lateral displacement, Story Drift, approximate seismic analysis.**

## I. INTRODUCTION

Detailed Seismic analysis of various structures is carried out to obtain seismic induced stresses, which is used for design of various members of the structures. Analysis is carried out by two processes namely Equivalent static method and Response spectrum method. According to many design codes Equivalent static method is simpler, conservative, cost effective and applicable to those structures which simple dynamic properties. The analysis is made to obtain seismic force and their distribution to different levels along height of the building and to various lateral load resisting elements, depending on the height of the building, severity of the seismic zone in which the building is located and on the classification of the building as regular or irregular. The fundamental natural period of vibration of a building is given by empirical formulae which depend on the height of the building and base dimensions of the structure [5].

In this paper a multibay bare frame (5×10) bay of 5 storeys, 8 storeys and 11 storeys is being adapted. These are assumed as same reinforced moment resisting and being analyzed using linear Equivalent static method and linear Dynamic analysis (Response spectrum method), for evaluating the seismic capacity of the structures with different column dimension for the structures. The analysis and design is being carried manually by Spreadsheet and as well as commercially available ETAB software and results are being compared. All the structures whose performances were evaluated in this study are designed with the provision from IS 1893-2002. [1]

Depending on the same inputs of member sizes, an approximate analysis is made for calculation of seismic load by making a lumped mass model where the total storey stiffness and total mass on storey are calculated. For easier modulation a (1×1) bay frame is been analyzed manually in spreadsheet as shown in method 2 and figure 3.2.

Another method in paper adopted for calculation of storey displacement, drift and time period on lumped mass model in ETAB software is a (1×1) bay frame of 2×2 m spacing is modeled and without applying seismic properties on it, lateral load of Equivalent static method from table 8 is applied laterally on each storey in X direction for displacement and drift as shown in figure 5.

## II. STRUCTURAL DISCRIPTION

In this paper a plane RC frame building of 5 storey, 8 storey, 11 storey is been analyzed by Equivalent static method and Response spectrum method as per IS 1893(part 1) 2002[1].

One of the plane frames in transverse direction has been considered for purpose of illustration by assuming that the building is symmetric in elevation and plan as shown in figure. 1.1 & 1.2

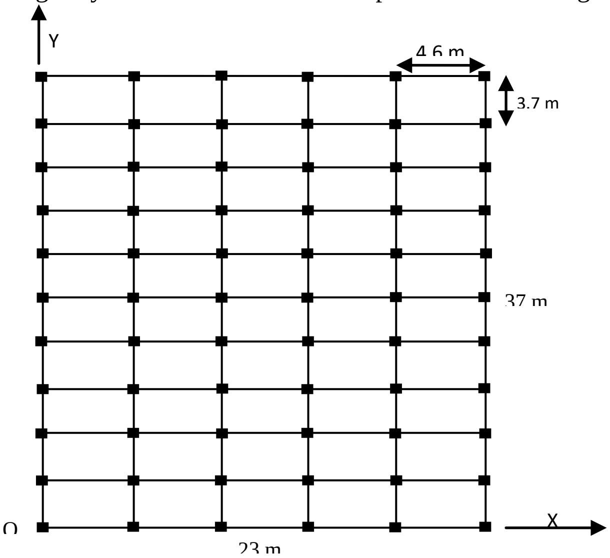


**Fig. 1.1**: PLAN

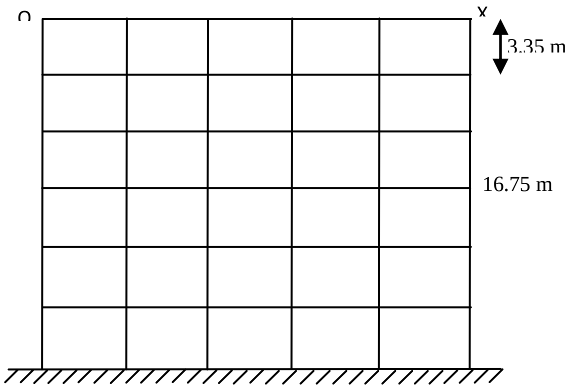


**Fig. 1.2**: ELEVATION

### A. Preliminary data 1 for analysis (full structure in spread sheet):

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Type of Structure: | Multi Storey rigid jointed frame | | | | | | |
| Zone : | 4 | 0.24 | | | | | |
| No. of Storey : | Five Storey (G + 4) | | | | | | |
| Floor Height : | 3.35 | m | | | | | |
| Spacing in X dir : | 4.6 | m | | | | | |
| Spacing in Y dir : | 3.7 | m | | | | | |
| Wall Thickness : | 150 | mm | | | | | |
| Live Load on Roof : | 1.5 | kN/m² ; | Live Load on Floors : | | 3.5 | kN/m² | |
| Materials : | Concrete - M30; Steel - Fe415 | | | | | | |
| Seismic analysis : | Equivalent static method | | | IS 1893 (part 1) : 2002 | | | |
| Design philosophy : | Limit state method | | | IS 456 : 2000 | | | |
| Ductility design : | IS 13920 : 1993 | | | | | | |
| Size of Column : | 300 × 550 mm | | L = | 0.3 m | B = | 0.55 | m |
| Size of Beams : | 300 × 450 mm | | l = | 0.3 m | de = | 0.45 | m |
| Total Depth of Slab : | 120 | mm | D = | 0.12 m | ds = | 0.1 | m |
| Density of Concrete: | 25 | kN/m ; | Density of Bricks : | | 20 | kN/m | |
| Total width of building = d' = | 23 | m | | | | | |
| Total height of building = h' = | 16.75 | m | | | | | |
| Total length of building = l' = | 37 | m | | | | | |
| No. of Walls in Transverse Dir = | 6 | No. of Walls in Longitudinal Dir = | | | 11 | | |
| No. of bay in X dir = | 5 | No. of bay in Y dir = | | | 10 | | |
| No. of Columns = | 66 | (At each Floor) | | | | | |

## III. METHODOLOGY

### *A. Method 1 (Full Structure Analysis In Spread Sheet):-*

Modern computational equipment and current structural analysis techniques have greatly facilitated the development of model of building frames, yet remains a need of simple mathematical model that can be used to approximate the response of building frame to lateral loads.

In this paper a Bare Frame models of (5 × 10) bay (figure1) of reinforced concrete moment resisting, of different stories 5, 8, 11 are assumed for analysis. In which the dimension of columns has been changed. For simplification only 5 storey diagrams and calculations are explained. So for the analysis only one frame in transverse direction has been considered and the design for the frame is done according to IS 13920[2] & IS 456 2000[4] & SP 16.The seismic analysis procedure is carried out by using code provision IS 1893 2002[1]. The analysis is made by using equivalent static method and response spectrum method, from which we get the lateral loads, fundamental natural time periods of different storey level. All the analysis and designs are done and compared in Spreadsheet.

Secondly the same model is then analyzed in computer software named ETAB [7] in which all the parameters & data is entered as same as in preliminary data 1.

### 1. *Equivalent Static analysis:*

Earth Quake loading (EQ) =
$Ah = (Z/2) \times (Sa/g) \times (I/R)$ (Table 7 - IS 1893)
Z = 0.24 (Zone IV) T = 0.09 × h'/√d' = 0.3143 sec
Sa/g = 2.5 for T= 0.32 sec Sa/g = 2.5
R = 5 (SMRF) (IS 1893 (part 1) 2002
I = 1
Ah = 0.06
Total Base Shear = Ah × W = 2980.23 kN
Base Shear in each Frame = TBS/11 = 270.93 kN

**Table 1: Design lateral loads of full structure by static method (300 × 550) mm**

| Storey | W | h | W×h² | $W \times h^2/\Sigma W \times h^2$ | Q(kN) on frame | Q (kN) on Storey of all frames |
|---|---|---|---|---|---|---|
| **5** | 8139.79 | 16.75 | 2283721 | 0.395 | 107.059 | 1177.65 |
| **4** | 10382.68 | 13.40 | 1864314 | 0.323 | 87.398 | 961.38 |
| **3** | 10382.68 | 10.05 | 1048677 | 0.182 | 49.161 | 540.78 |
| **2** | 10382.68 | 6.70 | 466078.6 | 0.081 | 21.85 | 240.35 |
| **1** | 10382.68 | 3.35 | 116519.6 | 0.020 | 5.46 | 60.09 |
| | | | **5779310** | | **270.93** | **2980.23** |

### 2. *Response Spectrum Analysis:*

Seismic Zone 4
Z = 0.24 (IS 1893 2002)
I = 1
R = 5
Moment resisting Frame (IS 13920 – 1993)

**Step 1:** Calculation of Lumped Masses to various Floor levels

**At Roof:**

Imposed load on roof assumed to be zero (Table 8 IS 1893 (part 1) 2002)

Mass of infill + Mass of Column + Mass of Beam + Mass of Slab + Imposed L

$$M_5 = \left\{0.15\times(37+37+23+23)\times\frac{3.35}{2}\times 20\right\}+\{0.3\times0.55\times(3.35\div2)\times66\times25\}+\{0.3\times0.5\times[(23\times11)+(37\times6)]\times25\}+\{0.12\times23\times37\times25\}+0$$

$M_5$ or $M_0$ = 5215.143 kN ; $M_{5(tons)}$ = $M_0$ × 9.81 = 531.62 tons (mass)

**t Floors:** 50 % of Imposed load, if imposed load is greater than3 kN/m²

$M_1$ to $M_4$ = 7763.41 kN ; $M_{(tons)}$ = M × 9.81 = 791.38 tons (mass)

Seismic Weight of building:

W = $(M_1 \times 4) + M_5$ = 36268.79 kN

**Step 2 :** Fundamental natural period

Ta = $0.075 \times h^{0.75}$ = 0.621 sec where h = 16.75 m

**Step 3 :** Determination of Design Base Shear:

Design Seismic Base Shear = $VB = Ah \times W$

$Ah = (Z/2) \times (Sa/g) \times (I/R)$

Ta = 0.621 sec Sa/g = 1.61

$A_h$ = 0.0386

$V_B$ = 1401.75 kN

**Step 4:** Vertical Distribution of Base Shear:

Q = $VB = W \times h^2 / \Sigma W \times h^2$

$Q_1$ = 29.96 kN

$Q_2$ = 119.82 kN

$Q_3$ = 269.60 kN

$Q_4$ = 479.29 kN

$Q_5$ = 503.08 kN

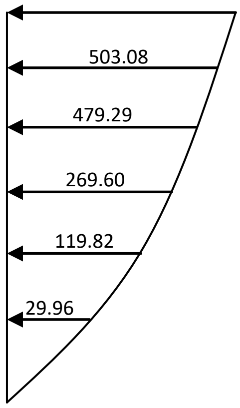


**Fig. 2**: Loading Diagram for full structure

**Step 5:** Determination of Eigen value and Eigen vector:-

Calculation of stiffness of all columns:

K = 12E I / L³ $= K = \left\{12 \times 5000 \times \sqrt{30} \times 1000 \times \left(0.30 \times .55^3 \div 12\right)\right\} \div 3.35^3 = 36358.46$ kN/m

Total lateral stiffness of each storey

$K_1 = K_2 = K_3 = K_4 = K_5 = 66 \times 36358.46 = 2399659$ KN/m (66 no. of columns on each storey)

put K = 2399658.66 M = 791.38 $M_0$ = 531.62

$$K - \omega^2 M = \begin{pmatrix} 2K - \omega^2 M & -K_2 & 0 & 0 & 0 \\ -K_2 & 2K - \omega^2 M & -K_3 & 0 & 0 \\ 0 & -K_3 & 2K - \omega^2 M & -K_4 & 0 \\ 0 & 0 & -K_4 & 2K - \omega^2 M & -K_5 \\ 0 & 0 & 0 & -K_5 & K - \omega^2 0.5M_0 \end{pmatrix}$$

**Step6: MATLAB**

```
K = [4799371 -2399659 0 0 0;-2399659 4799371 -2399659 0 0;0 -2399659 4799371-2399659 0;0 0 -2399659 4799371 -2399659;0 0 0 -2399659 2399659];
M = [791.377 0 0 0 0;0 791.377 0 0 0;0 0 791.377 0 0;0 0 0 791.377 0;0 0 0 0 531.615]
x=zeros(5,5);
%function[w]=naturalfreq(k,m);
syms omega;
a=k-(omega×m);
b=det(a)
c=sym2poly(b)
d=roots(c)
W=sqrt(d)
```

**Eigen value of full structure**

$\omega^2_1$ = 278

$\omega^2_2$ = 2339

$\omega^2_3$ = 5686

$\omega^2_4$ = 9084

$\omega^2_5$ = 11386

**Table 2: Eigen vectors of full structure {φ}: {φ} = { φ1 φ2 φ3 φ4 φ5 }**

| storey | $\varphi_1$ | $\varphi_2$ | $\varphi_3$ | $\varphi_4$ | $\varphi_5$ |
|---|---|---|---|---|---|
| **1** | 0.006611 | 0.017383 | 0.021809 | 0.01858 | 0.009844 |
| **2** | 0.012615 | 0.021357 | 0.002722 | -0.0185 | -0.01728 |
| **3** | 0.017463 | 0.008857 | -0.02147 | -0.00016 | 0.020474 |
| **4** | 0.020711 | -0.01048 | -0.0054 | 0.018657 | -0.01866 |
| **5** | 0.022059 | -0.02173 | 0.020795 | -0.01842 | 0.012266 |

Natural time period of full structure From Stiffness Matrix method, $T = 2\pi / \omega$ for column size (300 × 550) is in table 9.

Table 7 & table 8 shows the lateral displacement and drift of the structure.

***B. ETAB Analysis (Same Full Structure In ETAB) :***

As shown above the results in table 1, table 2, obtained from method 1 which is done in spread sheet of a 5 storeys bare frame model of column dimension 300 × 550 mm for calculation of seismic analysis.

In next step the same parameters and preliminary data 1 is taken and analyzed in software named ETAB for validation of results which are shown in table 3 & table 9.

**Table 3: Mode shapes from ETAB full structure analysis: (300 × 550) mm**

| storey | $\varphi_1$ | $\varphi_2$ | $\varphi_3$ | $\varphi_4$ | $\varphi_5$ |
|---|---|---|---|---|---|
| **1** | -0.0034 | 0.0101 | 0.0157 | -0.0178 | -0.0127 |
| **2** | -0.0084 | 0.0177 | 0.0101 | 0.0088 | 0.0166 |
| **3** | -0.013 | 0.0122 | -0.0134 | 0.009 | -0.0162 |
| **4** | -0.0163 | -0.0029 | -0.0119 | -0.0171 | 0.0112 |
| **5** | -0.0183 | -0.0167 | 0.0131 | 0.0085 | -0.004 |

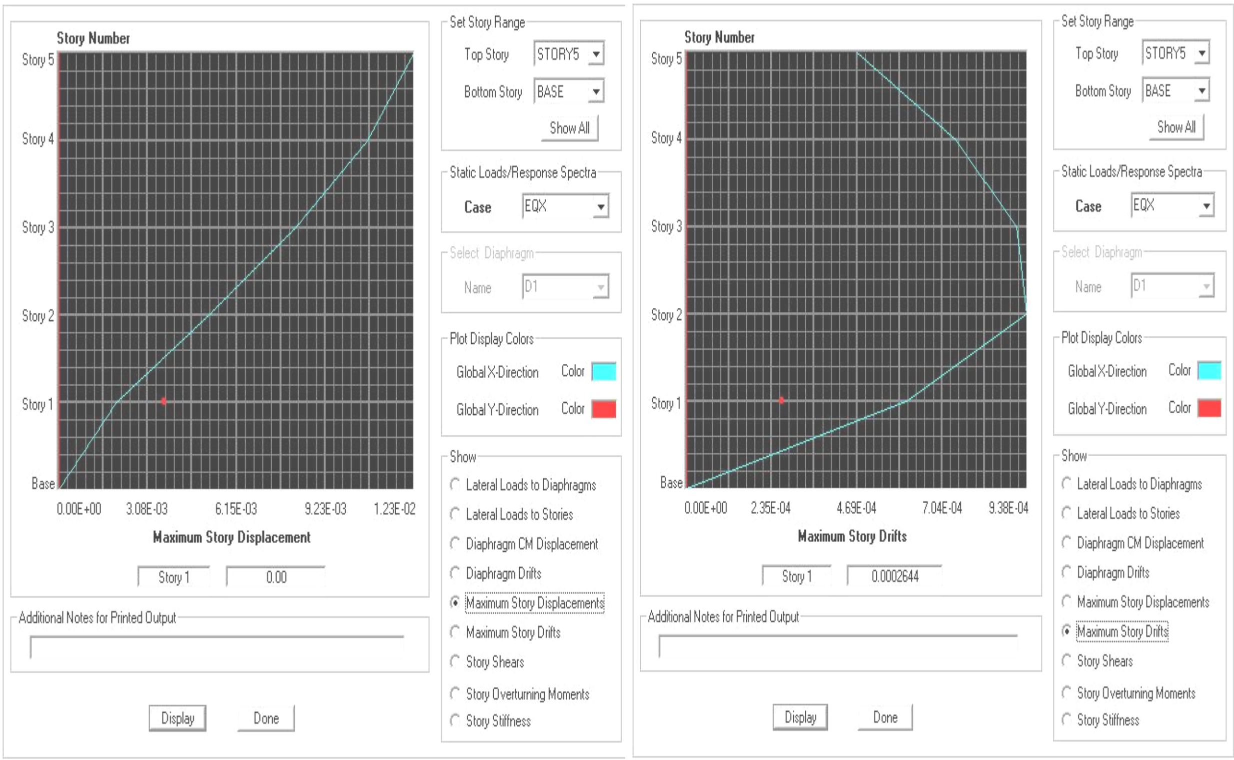


**Fig 3. Maximum storey displacement and drift (300x550) mm in ETAB Full Structure analysis**

***C. Methodology 2 (Lumped Structure In Spread Sheet) :***

The first method which is carried by using IS code 1893 2002[1] parameter for equivalent static analysis and dynamic analysis (Response spectrum method) in both Spreadsheet as well as in ETAB software.

In next method the assumption is made as by considering a lumped mass model method in which all 66 number of column stiffness is considered as single value K and all mass on floor is considered as M as shown in figure 4.1

For easy modulation in ETAB software, lumped mass model is calculated as
Calculation of stiffness of all columns:

$K = 12EI/L^3 \quad K = \left\{12\times5000\times\sqrt{30}\times1000\times\left(0.3\times0.55^3\div12\right)\right\}\div3.35^3 = 36358.46$ kN/m

Total lateral stiffness of each Storey
$k1 = k2 = k3 = k4 = k5 = 66\times36358.46 = 2399658.66$ KN/m (66 columns)

find b & d

$K = 12EI/L^3$

$I = \left\{\left(2399658.66\times3.35^3\right)\div\left(12\times5000\times\sqrt{30}\times1000\right)\right\}$

$= 0.27451875$ ($I = b\times d^3/12$)

$b = 1.347219359$ m $b = d$

$b = 1347.219359$ mm (b of full structure)

$I = b\times d^3/12 = 0.27451875$

$I = 0.27451875/4 = 0.068629688$ (for 4 columns)

$b = (0.068629688\times12)^{(1/4)}$ $I = b\times d^3/12$ & $b=d$

$b = 0.952627944$ m $= 952.63$ mm

$M_1$ = Calculation of Lumped on roof = 5215.143 kN
$M_2$, $M_5$ = Calculation of Lumped on floor = 7763.41 kN
Consider 4 columns of 953 mm and slab 2×2 m and beam size 250mm
Thickness of $S_1$ = Lumped mass - column wt - beam wt - slab wt =
Lumped mass $M_1$ = 5038.6375 kN t $S_1$ = 50.3863 m
Lumped mass $M_2$, $M_5$ = 7586.9062 kN t $S_2$ = 75.8690 m

***Preliminary data 2 (for lumped structure analysis):***

| | | | | | | |
|---|---|---|---|---|---|---|
| Type of Structure : | Multi Storey rigid jointed frame | | | | | |
| Zone : | 4 | 0.24 | | (table 2 - IS1893) | | |
| No. of Storey : | Five Storey (G + 4) | | | | | |
| Floor Height : | 3.35 | m | | | | |
| Spacing in X dir : 2 | m | | | | | |
| Spacing in Y dir : 2 | m | | | | | |
| Wall Thickness : 150 | mm | | | | | |
| Live Load on Roof : | 1.5 | kN/m² | ; | Live Load on Floors : | 3.5 | kN/m² |
| Materials : | Concrete - M30; | Steel - Fe415 | | | | |
| Seismic analysis : | Equivalent static method | IS 1893 (part 1) : 2002 | | | | |
| Design philosophy : | Limit state method | | | IS 456 : 2000[4] | | |
| Ductility design : IS 13920 : 1993 | | | | | | |
| Size of Column : 953 × 953 | | mm | L = 0.952628 m | B = 0.952628 m | | |
| Size of Beams : | 250 × 250 | mm | l = 0.25 m | de = 0.25 m | | |
| Total Depth of Slab : | 120 | mm | D = 50.38638 m | (for M2 to M5 = 75.87 m) | | |
| | | | (approximation made for lumped structure as shown above) | | | |
| Density of Concrete: | 25 | kN/m | Density of Bricks : | 20 kN/m | | |
| Total width of building = d' = | 2 | m | | | | |
| Total height of building = h' = | 16.75 | m | | | | |
| Total length of building = l' = | 2 | m | | | | |
| No. of Walls in Trans Dir = | 2 | ; | No. of Walls in Long Dir = | 2 | | |
| No. of bay in x dir = | 1 | ; | No. of bay in y dir = | 1 | | |
| No. of Columns = | 4 | (at each Floor) | | | | |

***Procedure is same as above done for full structure analysis in method 1:***

The above data is then entered in Spreadsheet and analysis is done using same parameters as discussed in method 1 for full structure analysis,

From above process we get base shear, lateral load, fundamental natural time period and frequencies and as shown in table 6 and table 7 below

Vertical distribution of base shear:

$Q_1$= 30.988 kN

$Q_2$= 123.954 kN

$Q_3$= 278.896 kN

$Q_4$= 495.816 kN

$Q_5$= 508.344 kN

**Eigen value** = $\omega^2{}_1$ = 271

$\omega^2{}_2$ = 2228

$\omega^2{}_3$ = 5554

$\omega^2{}_4$ = 8864

$\omega^2{}_5$ = 11083

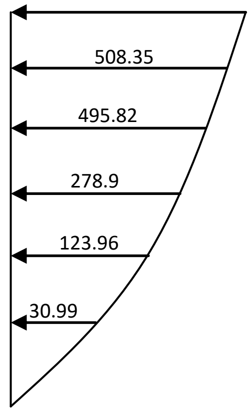


**Fig.6:** Loading Diagram for Lumped structure

**Table 4: Eigen vectors {φ} :{φ} = { $\varphi_1$ $\varphi_2$ $\varphi_3$ $\varphi_4$ $\varphi_5$ }(lumped structure of 300 × 550) mm**

| storey | $\varphi_1$ | $\varphi_2$ | $\varphi_3$ | $\varphi_4$ | $\varphi_5$ |
|---|---|---|---|---|---|
| **1** | 0.006541 | 0.0172 | 0.021546 | 0.018266 | 0.009543 |
| **2** | 0.01248 | 0.021059 | 0.002471 | -0.01843 | -0.01682 |
| **3** | 0.017271 | 0.008584 | -0.02126 | 0.000325 | 0.020088 |
| **4** | 0.020474 | -0.01055 | -0.00491 | 0.0181 | -0.01858 |
| **5** | 0.021793 | -0.0215 | 0.020699 | -0.01859 | 0.012654 |

***D. Methodology 3 (Lumped structure analysis in ETAB):***

The next procedure which is introduced in this paper is the lumped mass model to be done in ETAB software, in method 2 which is discussed earlier and analyzed in spread sheet where a single bay frame of (2 × 2) m of 4 column structure of dimension from preliminary data2 is entered in ETAB software.

Instead of seismic loads and parameters used for spread sheet lumped, in ETAB model the lateral loads of equivalent static analysis are applied in the transverse direction as shown in figure 5 above & in table 5 and rest all dimensions are entered as same preliminary data 2.

**Table 5: Distribution of Lateral load at each storey in Transverse direction**

| Storey | W | h | W×h² | W×h²/Σ W×h² | Q (kN) | Q/2 (Applied lateral loads)kN |
|---|---|---|---|---|---|---|
| **5** | 8139.794 | 16.75 | 2283721 | 0.395155 | 1177.652 | 588.83 |
| **4** | 10382.68 | 13.4 | 1864314 | 0.322584 | 961.375 | 480.69 |
| **3** | 10382.68 | 10.05 | 1048677 | 0.181454 | 540.773 | 270.39 |
| **2** | 10382.68 | 6.7 | 466078.6 | 0.080646 | 240.343 | 120.17 |
| **1** | 10382.68 | 3.35 | 116519.6 | 0.020162 | 60.086 | 30.04 |

The results which are found from ETAB lumped structure is shown in table 6, table 7, table 8 & table 9.

**Table 6: Mode shapes: (lumped structure in ETAB) Transverse direction**

| storey | φ1 | φ2 | φ3 | φ4 | φ5 |
|---|---|---|---|---|---|
| 1 | -0.0027 | -0.0138 | 0.0222 | 0.0203 | -0.0115 |
| 2 | -0.0078 | -0.0217 | 0.01 | -0.0158 | 0.0184 |
| 3 | -0.0142 | -0.0162 | -0.0167 | -0.007 | -0.0206 |
| 4 | -0.0213 | 0.0014 | -0.0116 | 0.0202 | 0.0153 |
| 5 | -0.0282 | 0.0219 | 0.0187 | -0.0141 | -0.0078 |

## IV. RESULTS AND DISCUSIONS

1. With the consideration of equivalent lumped mass model, whole geometry of building is considered as (1×1) bay simple frame. This reduced time consumption in modelling complex structures.
2. Stiffness of all columns at floor is considered as a stiffness of four columns at same floor. This approximation gives same lateral stiffness against lateral loads.
3. Regression equation is developed for calculating time period for (1×1) bay simple frame, as well as the full model. These equations give exact time period as that of analyzed full scale model on ETAB as well as on spread sheet.
4. The method gives acceptable results as compared with the exact result on ETAB.
5. This approximate method can be used for any no of storey structures for quick decisions.

## V. TABLES AND GRAPHS

**Table 7: Lateral Displacement of 5 storey model from ETAB full and ETAB lumped in transverse direction of (300 × 550) & (550 × 300) mm** (figure 6)

| Column size | 300 × 550 | | | 550 × 300 | | |
|---|---|---|---|---|---|---|
| Storey | Displacement | | | Displacement | | |
| | ETAB full | ETAB lumped | % Error | ETAB full | ETAB lumped | % Error |
| 5 | 0.01357 | 0.0136 | 0.187 | 0.0288 | 0.0289 | 0.247 |
| 4 | 0.01096 | 0.0109 | -0.603 | 0.0241 | 0.0239 | -0.778 |
| 3 | 0.00800 | 0.0081 | 1.126 | 0.0183 | 0.0185 | 1.200 |
| 2 | 0.00526 | 0.0052 | -1.332 | 0.0128 | 0.0126 | -1.347 |
| 1 | 0.00225 | 0.0023 | 1.805 | 0.0060 | 0.0061 | 1.307 |
| 0 | 0 | 0 | | 0 | 0 | |

**Table 8: Drift of 5 storey model of ETAB full and ETAB lumped in transverse direction (300 × 550) & (550 × 300) mm (figure 8)**

| Column size | 300 × 550 | | | 550 × 300 | | |
|---|---|---|---|---|---|---|
| Storey | Drift | | | Drift | | |
| | ETAB full | ETAB lumped | % Error | ETAB full | ETAB lumped | % Error |
| 5 | 0.00087 | 0.00081 | -8.359 | 0.00151 | 0.00151 | 0.177 |
| 4 | 0.00124 | 0.00083 | -49.90 | 0.00183 | 0.00161 | -14.337 |
| 3 | 0.00184 | 0.00086 | -114.9 | 0.00218 | 0.00176 | -24.328 |
| 2 | 0.00191 | 0.00085 | -123.9 | 0.00246 | 0.00192 | -27.701 |
| 1 | 0.00089 | 0.00069 | -29.38 | 0.00187 | 0.00183 | -2.491 |
| 0 | 0 | 0 | | 0 | 0 | |

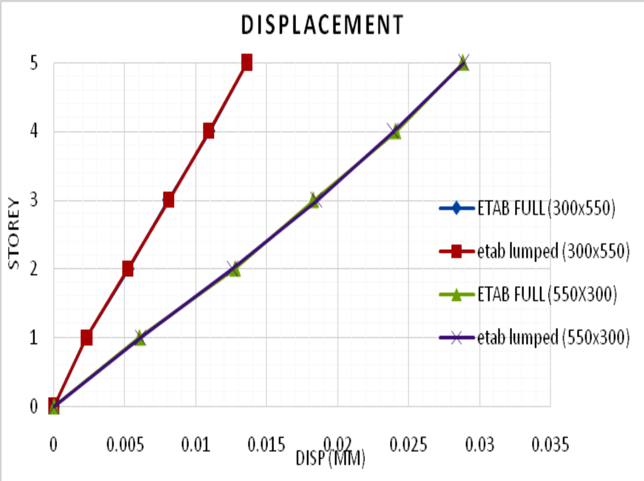


**Figure 7:** Displacement of 5 storey's model (300 × 550) mm and (550 × 300)

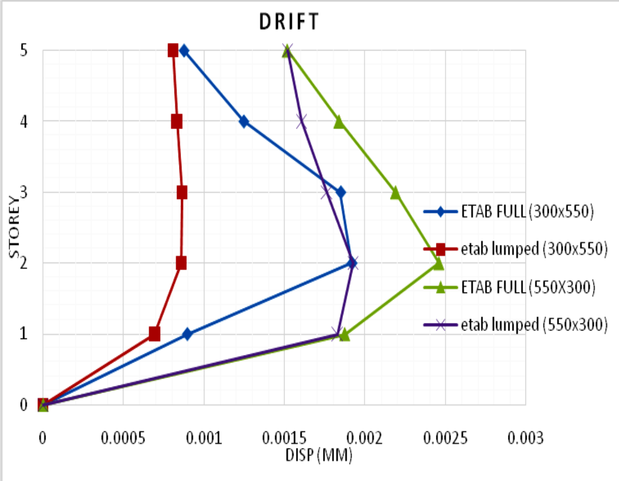


**Figure 8:** Drift of 5 storey's model (300 × 550) mm and (550 × 300) mm

**Table 9: Natural time period of 5 storey's 300 × 550 mm in Transverse direction**

| Storey | Spread sheet full | ETAB full | Spread sheet lumped | ETAB lumped |
|---|---|---|---|---|
| **5** | 0.8599 | 0.86 | 0.8996 | 0.90 |
| **4** | 0.2701 | 0.27 | 0.2200 | 0.22 |
| **3** | 0.1468 | 0.15 | 0.1097 | 0.11 |
| **2** | 0.1065 | 0.1 | 0.0810 | 0.08 |
| **1** | 0.0764 | 0.08 | 0.0692 | 0.07 |
| **0** | 0 | 0 | 0 | 0 |

**Table 10: Natural time period of 5 storey's 550 × 300 mm in Transverse direction**

| Storey | Spread sheet full | ETAB full | Spread sheet lumped | ETAB lumped |
|---|---|---|---|---|
| **5** | 1.164 | 1.164 | 1.319 | 1.32 |
| **4** | 0.389 | 0.39 | 0.350 | 0.35 |
| **3** | 0.231 | 0.23 | 0.178 | 0.18 |
| **2** | 0.165 | 0.17 | 0.137 | 0.134 |
| **1** | 0.143 | 0.14 | 0.117 | 0.12 |
| **0** | 0 | 0 | 0 | 0 |

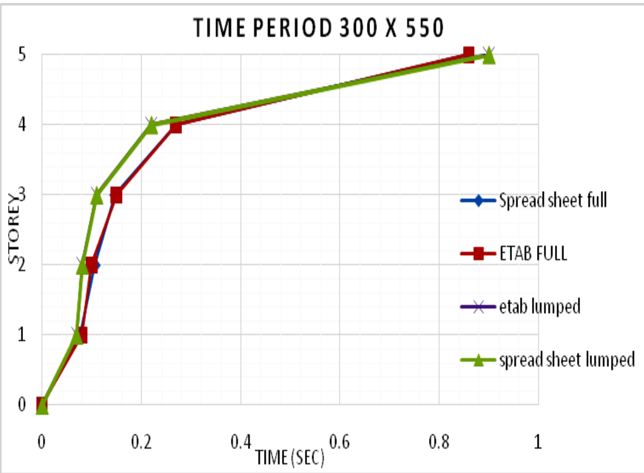


**Figure 9:** Time period of 5 storey's model (300 × 550) mm in transverse dir

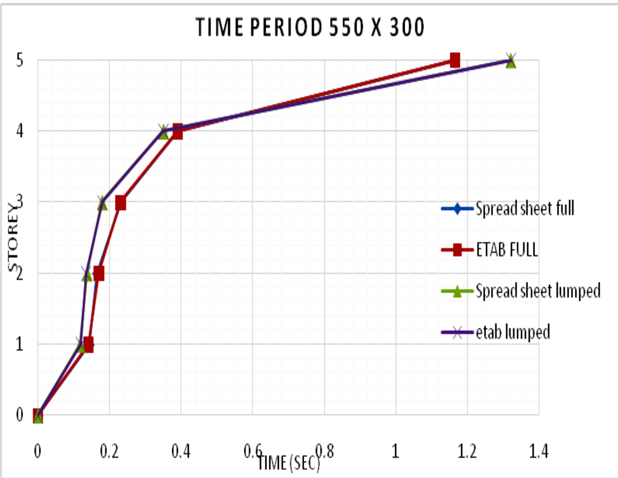


**Figure 10:** Time period of 5 storey's model

## VI. CONCLUSIONS

1. This kind of assumption is applicable for balanced and symmetric structure.
2. From above result we concluded that the time period of spreadsheet is same for ETAB software for same model.
3. Lateral displacement is also same for ETAB full and ETAB lumped model.

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