RESEARCH ARTICLE OPEN ACCESS

Moment Magnifier Factors in Multi-story Building Columns with Variation Length and Height due to P-Delta Effect

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ABSTRACT
Linear analysis is used in determining the forces and moments that occur in a structure due to external loads commonly. However, linear analysis (first-order) has not been able to accommodate the forces and moments that occur in the analyzed structure, such as in column members. In this case, the effects and moments that occur in the column will be enlarged due to lateral deformation. According to American Concrete Institute (ACI) regulations, can be approximated by usingmoment magnifier method, which is multiplying by a factor δ. The moment enlargement method can be used if the column slenderness (kl / r) between(22≤ kl⁄r≤100). This numerical study uses column slenderness between this value so that linear analysis (first-order) is not possible to be applied because there isa moment magnification factor with the moment magnifier methodshould be considered during analysis.The result shows thatanalysis of column slenderness effect the second-order analysis conducted on buildings with variations in the number of spans and height, the trend of amplification factors is getting greater from the highest level to the lowest level. The results of the analysis are expected to be considered in an initial design (preliminary design) of multi-story building structures so that the stability of the building structure remains in a safe condition.
Keyword: P-delta effect, magnifier method, slender column

Date of Submission: 20-12-2019 Date Of Acceptance: 31-12-2019

I. PRELIMINARY

Components of the RC frame in a building consist of beams and columns which are rigidly connected. The columns in a reinforced concrete frame structure carry a combination of axial forces, moments, and shear forces. The skeletal analysis is generally carried out by linear analysis (first-order) so that the moments acting on the column do not take into account the secondary moments due to the P-Delta effect. The P-Delta effect due to gravity and lateral loads on the column gives rise to lateral deformations, which cause secondary moments. The secondary moment can be calculated by the moment enlargement approach (amplification), namely amplification due to gravity load (δb) and amplification due to lateral load (δs). The moment enlargement approach is calculated if the column slenderness ratio (kl / r) is 22≤ (Kl_u) / r≤100. The slimness of the column (kl / r) is greater than 100 then it is calculated by the second-order analysis method (ACI Code 318-83)

This numerical research is expected to provide an amplification factor trend in many multi-story buildings with variations in span length and height. This research is interesting because the moment enlargement factor (amplification) is obtained due to gravity and lateral loads (earthquake). Also, the trends that will be given by both gravity loads and lateral loads will later be the same or different, and the effect of the variation in span length and level height on the moment enlargement factor generated by the gravity load and lateral load.

II. THEORETICAL BASIS

Earthquake Loads

In this numerical study using the analysis of equivalent static earthquake loads following SNI 03-1726-2002

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Equivalent Static Earthquake Loads

The fundamental shear force due to earthquake is determined based on the Procedure for Earthquake Resistant Planning for Buildings SNI 03-1726-2002 viz

:

$$V = \frac{C_1 I}{R} W_t$$

V = Total fundamental shear force
C =basic earthquake coefficient
I = virtue factor
R = earthquake reduction factor

Wt = The total weight of the structure

Effect of P-Delta (PΔ)

The sufficient length of the portal column The column slenderness factor is calculated by taking into account the degree of restraint at the ends of the columns calculated by the equation

$$\psi_a = \frac{\sum \frac{EI}{lc} \text{col}}{\sum \frac{EI}{l} \text{beam}}$$

$$\psi_b = \frac{\sum \frac{EI}{lc} \text{col}}{\sum \frac{EI}{l} \text{beam}}$$

where ψa is the upper column stiffness ratio, ψb is the lower column stiffness ratio

The sufficient length of the portal column is expressed as an average ratio (K.L). The effective length factor is a function of the degree of column restraint factor (ψa, ψb) and can be determined with the help of Jackson and Moreland nomograms (Paulay 187)

Moment Magnification Factor

The influence of P-delta on the slim column must be taken into account in the planning because it causes enlargement of the moment in the column. In ACI (American Concrete Institute) 318-83, Eq (10-6) stated that the moment column of the P-delta effect is the sum of the magnification of the moment due to gravity load and the magnification of the moment due to the earthquake. To calculate the enlargement of the moment, the column is calculated by the equation ie

$$M_c = \delta_b M_{2b} + \delta_s M_{2s}$$

Where

M2b the moment of the end of the column is the biggest due to the factored gravity load

M2s moment of the most significant column tip due to factored earthquake load

Δb moment magnification factor due to factored gravity load

Δs moment magnification factor due to factored earthquake load

The equation can calculate the moment magnification factor due to gravity load

$$\delta = \frac{C_m}{1 - {P_u}/{\varphi P_{cr}}} \geq 1{,}0$$

where Cm is the moment coefficient, Pu is the ultimate gravity load factored into the element, and Pcr is the Euler buckling load

ACI-10.11.5.3 for components that are subjected to side-shake, the Cm value is calculated by the equation

$$C_m = 0{,}6 + 0{,}4 \left({M_{1b}}/{M_{2b}} \right) \geq 0{,}4$$

where M1b is the smallest end moment due to factored gravity load

The equation can calculate Euler's critical buckling load

$$Pcr = \frac{\pi^2 EI}{(k.h)^2}$$

where E is the elastic modulus, I is the moment of inertia, k is the effective length factor, and h is the column height

EI value is a structure made of reinforced concrete that can the with the equation

$$EI = \frac{\frac{E_c I_g}{5} + E_s I_s}{1 + \beta_d}$$

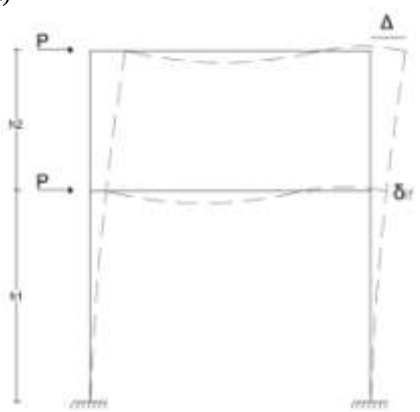
$$\beta_d = \frac{\text{dead load factor}}{\text{grafitation load factor}}$$

The equation calculates the moment magnification factor due to lateral load

$$\delta_s = \frac{1}{1 - {P_u}/{\varphi P_{cr}}} \geq 1{,}0$$

Drift and Interstory Drift

Story Drift is a lateral deflection that occurs on a floor/level of a building structure, as shown in Figure 3.3. In the calculation of drift and story drift due to moments, the formula (3.13-3.18) can be used (Bryan Stafford Smith and Alex Coull in the book Tall Building Structure: Analysis and Design)



Picture. Story Drift and Drift on the portal

Total drift at the nth level is calculated by equation (3.13) viz

$$\Delta_n = \Delta_{nf} + \Delta_{ns}$$

where Δn is the total drift of the nth level, Δnf is the drift on the nth floor due to bending on the uncluttered portal, and Δns is the overall drift on the nth floor due to the lateral force on the portal with the claimant.

The equation can calculate total drift on the nth floor due to bending on the portal without the confessor:

$$\Delta_{nf} = \sum_{1}^{n} \delta_{if}$$

where δif is story drift on the i floor

The equation can calculate story drift on the i floor

$$\delta_{if} = h_i\theta_{if}$$

where hi is the level of height for each level i, θif is the apparent number of each level i. Pseudo figures of each i-level can be calculated by the equation

$$\theta_{if} = \frac{M}{EI}$$

While due to lateral forces, total drift on the nth floor is calculated by the equation

$$\Delta_{ns} = \sum_{1}^{n} \delta_{is}$$

$$\delta_{is} = \frac{Q_i}{E}\left[\frac{d^3}{L^2A_d} + \frac{L}{A_g}\right]$$

where δis is the story drift on the third floor of the portal with the confessor.

III. ANALYSIS METHOD

The method of analysis is a series of analyses carried out to find answers to a problem described according to a systematic stage.

The structural model used in this study is an 8-story, 10-story, and 12-story building with a combination of the span between 4, 5 and 6 m.

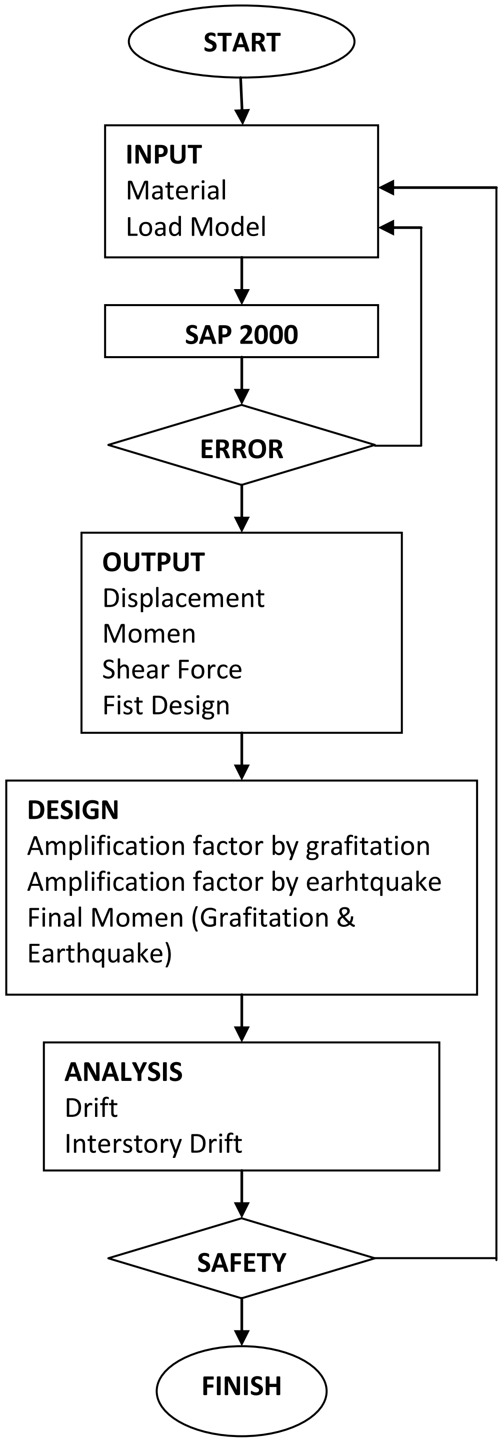
Material and Loading Data

1. Quality of concrete used fc '= 35 MPa
2. Steel reinforcement quality fy = 400 Mpa
3. The function of the building for offices
4. Structural loading applies the Indonesian Load Regulations for the 1987 Building
5. Earthquake loads use equivalent static horizontal loads which refer to SNI 03-1726-2002
6. The location of the building is planned to be in the earthquake area V which is located above the hard soil layer.

Based on the above, further Dowrick (1977) provides a limitation ratio between height and width of the building or H / L should be greater than 4. While according to Wofgang Scheuller (1977), the rate should be <5. According to PPTGUG 1983, buildings with a high ratio of width <3 and> 3 categorized will have different responses. The horizontal force distribution indicates this due to different earthquakes

Stages of Analysis

Processing is done by the steps - steps below



ANALYSIS

Structural analysis for this design planning uses a three-dimensional (3D) model with 12 levels of leveling. The basis of designing applies SK SNI T-15-1991-03 (Procedure for Calculating Concrete Structures for Buildings). Earthquake shear force planning is based on SNI 03-1726-2002 (Procedure for Earthquake Resilience Planning for Buildings), where the earthquake shear force is planned to use concrete structures with full ductility levels. To ensure that the building remains elastic, an earthquake reduction factor (R) of 8.5 should be taken. The capacity planning stage begins after the dimensions of the earthquake energy dispersing elements are obtained from the planning analysis which includes "Strength design". The "limit state" criterion which is the strength limit, is the inter-story drift taken up to a maximum of 0.005h (5%).

STRUCTURAL LOADING

Control the thickness of the planned plate

$$h_{min} = \frac{0{,}8 + \frac{f_y}{1500}}{36 + 9\beta}(l_n)$$

$$h_{min} = \frac{0{,}8 + \frac{300}{1500}}{36 + 9(3000/3000)}(3000)$$

$$h_{min} = 66{,}67 \text{ mm}$$

120 mm plate thickness is used
Plate weight = 240 kg/m2
Ceiling weight = 18 kg/m2
waterproof coating = 48 kg/m2
ducting AC = 15 kg/m2
= 321 kg/m2
Reduced living load
= 60 kg/m2
Floor loading
Workload
Dead load
Plate weight = 288 kg/m2
Sand weight = 90 kg/m2
Mortar Weight = 48 kg/m2
Tile weight = 24 kg/m2
Ceiling weight = 18 kg/m2
Ducting AC = 15 kg/m2
= 483 kg/m2
Reduced living load = 150 kg/m2
Wall load = 841,2 kg/m

Table weight of each floor and total weight of the structure

Story	Load Structure (kg)
12 (floor)	588816
11	942048
10	997248
9	997248
8	997248
7	1011648
6	1021728
5	1045728
4	1045728
3	1078848
2	1088448
1	1088448
W total	11903184

Calculation of Basic Shear Force due to earthquake and its distribution along with the height of the building

1. **Vibration time structure (T)**

Arrangement without shear wall

$T = 0{,}06H^{3/4} = 0{,}06.48^{3/4} = 1{,}094$ seconds

2. **Basic earthquake coefficient**

The structure is in the earthquake area 5 (structure without the shear wall) and is above hard ground
T = 1,094 seconds, then C (according to figure 3.1) = 0,823

3. **Priority factor (I) and earthquake load reduction factor (R)**

Determined the value of I = 1 (office building) and R = 8.5 (special moment bearing frame) for structures without shear walls, and R = 8.5 then the horizontal bottom shear force due to earthquake

$$V = \frac{C_1 I}{R} W_t = \frac{0{,}823.1}{8{,}5} 11903184 = 1152508{,}286 \text{ kg}$$

4. **Distribution of fundamental shear forces due to earthquake**

Floor	Hi (m)	Wi (kg)	Hi.wi	Fx,y (kg)
12	48	588816	28263168	110825,4
11	44	942048	41450112	162534,0
10	40	997248	39889920	156416,2
9	36	997248	35900928	140774,6
8	32	997248	31911936	125132,9
7	28	1011648	28326144	111072,4
6	24	1021728	24521472	96153,5
5	20	1045728	20914560	82010,1
4	16	1045728	16731648	65608,0
3	12	1078848	12946176	50764,5
2	8	1088448	8707584	34144,1
1	4	1088448	4353792	17072,0
			293917440	1152508,2

Gravity load calculation

RC equivalent load table

Floor	Portal 1, 5, A, & E (Kg)	Portal 2, 3, 4, B, C, & D (Kg)
12	1524	2486,4
11	1524	2486,4
10	1668	2630,4
9	1668	2630,4
8	1668	2630,4

7	1668	2630,4
6	1718,4	2680,8
5	1718,4	2680,8
4	1718,4	2680,8
3	1884	2846,4
2	1884	2846,4
1	1884	2846,4

P-Delta Effect Analysis on column planning

The amplification factor/moment magnification method

In this way, deflection and the final moment can be determined only by multiplying the magnification factor that is suitable for both the deviation and the moment of the result of the linear analysis.

Enlargement factors that occur for each level will be described as follows

Reinforced Concrete Frame Structure

$$E = 4700\sqrt{f'_c} = 27805{,}57\ Mpa$$

$$I_{c1} = {}^1/_{12}\, bh^3 = {}^1/_{12}\, 500.500^3 = 5208333333\ mm$$

$$I_{c2} = {}^1/_{12}\, 600.600^3 = 1{,}08.10^{10} mm^4$$

$$I_{c3} = {}^1/_{12}\, 600.700^3 = 1{,}715.10^{10} mm^4$$

$$I_{c4} = {}^1/_{12}\, 650.800^3 = 2{,}773.10^{10} mm^4$$

$$I_{c5} = {}^1/_{12}\, 700.800^3 = 2{,}987.10^{10} mm^4$$

$$\frac{I_{c1}}{h} = \frac{5208333333}{4000} = 1302083\ mm^3$$

$$\frac{I_{c2}}{h} = \frac{1{,}08.10^{10}}{4000} = 2700000\ mm^3$$

$$\frac{I_{c3}}{h} = \frac{1{,}715.10^{10}}{4000} = 4287500\ mm^3$$

$$\frac{I_{c4}}{h} = \frac{2{,}773.10^{10}}{4000} = 6932500\ mm^3$$

$$\frac{I_{c5}}{h} = \frac{2{,}987.10^{10}}{4000} = 7467500\ mm^3$$

$$I_{g1} = {}^1/_{12}\, 350.650^3 = 8009895833\ mm^4$$

$$I_{g2} = {}^1/_{12}\, 350.700^3 = 1{,}0004.10^{10} mm^4$$

$$I_{g3} = {}^1/_{12}\, 350.750^3 = 1{,}2304.10^{10} mm^4$$

$$I_{g4} = {}^1/_{12}\, 400.800^3 = 1{,}707.10^{10} mm^4$$

$$\frac{I_{g1}}{L} = \frac{8009895833}{6000} = 1334982{,}639\ mm^3$$

$$\frac{I_{g2}}{L} = \frac{1{,}0004.10^{10}}{6000} = 1667333{,}333\ mm^3$$

$$\frac{I_{g3}}{L} = \frac{1{,}2304.10^{10}}{6000} = 2050666{,}667\ mm^3$$

$$\frac{I_{g4}}{L} = \frac{1{,}707.10^{10}}{6000} = 2845000\ mm^3$$

12th floor

Column inside (K2)

Due to gravity

$P_u = 1{,}2P_d + 1{,}6P_1 = 387{,}3412\ kN$

$M_{1b} = 1{,}2M_d + 1{,}6M_1 = 44{,}4259\ kNm$

$M_{2b} = 1{,}2M_d + 1{,}6M_2 = 45{,}9543\ kNm$

Due to earthquake and gravity loads

$P_u = 0{,}75.1{,}05(D + L + E) = 290{,}505\ kN$

$M_{2b} = 0{,}75(1{,}2M_d + 1{,}6M_1) = 113{,}139\ kNm$

$M_{2s} = 0{,}75(1{,}7M_e) = 88{,}7074\ kNm$

$$P_n = \frac{P_u}{\varphi} = \frac{387{,}3412}{0{,}65} = 595{,}9095\ kN$$

$$M_n = \frac{M_u}{\varphi} = \frac{113{,}1398}{0{,}8} = 128{,}6989\ kNm$$

Estimasi $\frac{kh}{r} = \frac{1{,}3.4}{0{,}3.0{,}5} = 34{,}667$

$22 < \left(\frac{kh}{r} = 29\right) < 100$then the moment magnification method must be taken into account factor k

$$\psi a = \psi b = \frac{1302083{,}33 + 1302083{,}33}{0{,}5.1334982{,}639} = 7{,}8$$

From Fig. 13-10 (without stiffener) ks = 2.76

Critical buckling load

$$P_{cr} = \frac{\pi^2 EI}{(kh)^2}$$

Calculate EI

$$I_{sc} = 109032{,}04\ mm^3$$

$$E_s = 2000\ MPa$$

$$\beta_d = \frac{1{,}2.76{,}0488}{163{,}400} = 0{,}558$$

$$EI = \frac{\frac{27805{,}57.8009895833}{5} + 109032.20000}{1 + 0{,}558} = 28591{,}86\ kN/m^2$$

For calculationδ_s; $\beta_d = 0$

$$EI = \frac{\frac{27805{,}57.8009895833}{5} + 109032.20000}{1} = 44546{,}132\ kN/m^2$$

$$P_{cb} = \frac{\pi^2.28591{,}86}{(0{,}95.0{,}6)^2} = 868545{,}51\ kN$$

$$P_{cs} = \frac{\pi^2 44546{,}132}{(1{,}3.0{,}6)^2} = 722637{,}57\ kN$$

Outer column due to the P-delta effect

$$C_m = 0{,}6 - 0{,}4\left(\frac{124{,}93}{133{,}66}\right) = -0{,}92$$

uses$C_m = 1{,}0$ (konservatif)

$$\delta_b = \frac{1{,}0}{1 - \frac{214{,}43}{0{,}8.5180403{,}71}} = 1{,}0002$$

$$\delta_s = \frac{1}{1 - \frac{P_u}{\varphi P_{cr}}}$$

$$\delta_s = \frac{1}{1 - \frac{214{,}43}{0{,}8.5180403{,}71}} = 1{,}0001$$

The minimum moment for a slim column effect

$$M_{2s} \geq P_u(0{,}6 + 0{,}03h) = 25{,}86\ kNm$$

$$M_c = \delta_b M_{2b} + \delta_s M_{2s} = 138{,}37\ kNm$$

Worn

$$P_n = \frac{214,43}{0,65} = 329,89 \text{ kN}$$

$$M_n = \frac{138,37}{0,8} = 172,97 \text{ kNm}$$

Drift Calculation and Interstory Drift

Story drift is a lateral deflection that occurs on a floor. In calculating the structure due to the moment, it can be used (Bryan Stafford Smith and Alex Coull in the book Tall Building Structures: Analysis and Design) the following formula

The equation calculates total drift at level n

$$\Delta_n = \Delta_{nf} + \Delta_{ns}$$

Where

Δ_n = n-th level total drift

Δ_{nf} = total drift on the nth floor due to bending on the portal without confession

Δ_{ns} = total drift on the nth floor as a result of lateral force on the portal with the confessor

Total drift on the nth floor due to bending on the portal without confession can be calculated by equation

$$\Delta_{nf} = \sum_{1}^{n} \delta_{if}$$

where δ_if is the-i floor story drift

Story drift on the the-i floor is calculated by

$$\delta_{if} = h_i \theta_{if}$$

Where hi is the level of each i-th floor, θif is the apparent number of each i-th level. The equation can calculate pseudo numbers from each level

$$\theta_{if} = \frac{M}{EI}$$

whereas due to lateral forces, the total drift on the n-th floor is calculated by

$$\Delta_{ns} = \sum_{1}^{n} \delta_{is}$$

$$\delta_{is} = \frac{Q_i}{E}\left[\frac{d^3}{L^2 A_d} + \frac{L}{A_g}\right]$$

δ_{is} is the story drift on the third floor of the portal with the confessor

IV. DISCUSSION

Structural analysis that is usually used in practice for determining the distribution of moments, latitude, and regular forces that occur in the structure due to external loads is linear (fist order analysis). In this analysis, the relationship between stress and strain of the material is considered direct, and the effect of deformation on the structural equilibrium equation is ignored. The report produces a connection between deflection load is direct and overestimate both stiffness and strength of the analyzed structure.

An accurate analysis can be done using structural equations that are formulated based on a deformed configuration whose value is unknown. In other words, the secondary moment (P-delta effect) produced by the axial force acting on the column has been subjected to side-shake has been calculated its influence in the analysis, namely nonlinear analysis / second-order analysis.

After analyzing and calculating using the above method of building level and span variations, the final result can be seen from the calculation due to earthquake and gravity loads in the form of the moment, end moment, and deflection factors arising from the moment acting on the structure, shown in the table - the following table :

Moment Amplification Factor column 4 spans 12 floors

Fl	4 Spans					
	K1		K2		K3	
	δb	δs	δb	δs	δb	δs
12	1,0002	1,0001	1,0002	1,0002	1,00025	1,0002
11	1,0005	1,0003	1,0006	1,0004	1,0007	1,0004
10	1,0008	1,0005	1,001	1,0007	1,0011	1,0007
9	1,0013	1,0081	1,0014	1,0009	1,0015	1,0010
8	1,0017	1,0011	1,0018	1,0011	1,002	1,0012
7	1,0032	1,0021	1,0031	1,0020	1,0034	1,0021
6	1,0031	1,0020	1,0029	1,0018	1,0031	1,0019
5	1,0051	1,0033	1,0045	1,0028	1,0048	1,0030
4	1,0061	1,0039	1,0051	1,0032	1,0055	1,0034
3	1,0043	1,0028	1,0035	1,0022	1,0037	1,0023
2	1,0052	1,0033	1,0041	1,0026	1,0043	1,0027
1	1,0058	1,0038	1,0045	1,0028	1,0047	1,0029

The Final Moment of Column in Building 4 spans 12 floors

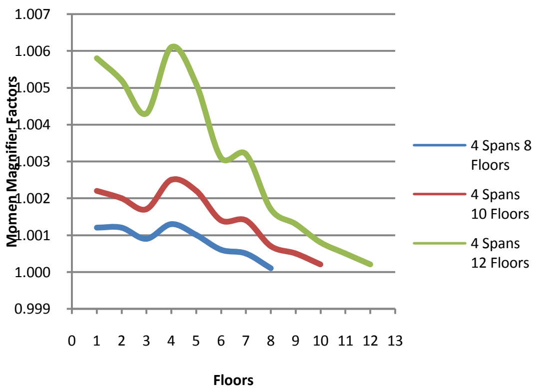
Fl	4 Spans		
	K1	K2	K3
12	138,37	201,68	255,20
11	314,59	425,14	460,21
10	472,85	645,09	669,89
9	615,01	842,25	857,90
8	741,14	1016,90	1024,01
6	645,48	1303,84	1293,44
5	1036,92	1417,01	1396,83
4	1116,09	1505,34	1474,17
3	861,83	1568,13	1525,06

2	1334,07	1615,58	1552,31
1	1543,07	1539,15	1499,41

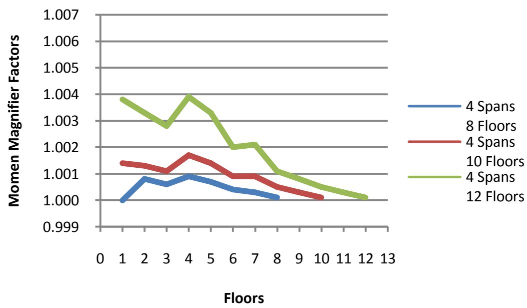
Drift and Story Drift in Building 4 spans 12 floors

Fl	4 Spans					
	K1		K2		K3	
	Story Drift (mm)	Drift (mm)	Story Drift (mm)	Drift (mm)	Story Drift (mm)	Drift (mm)
12	43,90	279,62	61,13	382,57	62,24	379,71
11	41,77	235,72	58,03	321,44	58,32	317,47
10	36,94	193,94	51,50	263,41	51,25	259,15
9	33,44	156,99	46,72	211,91	46,28	207,90
8	28,88	123,55	40,48	165,18	39,93	161,61
7	23,39	94,66	32,95	124,70	32,34	121,68
6	19,41	71,26	27,48	91,75	26,88	89,33
5	16,40	51,84	21,40	64,26	20,85	62,44
4	13,41	35,44	17,31	42,86	16,82	41,59
3	10,19	22,03	12,97	25,54	12,57	24,76
2	7,70	11,83	8,45	12,57	8,17	12,19
1	4,13	4,13	4,12	4,12	4,01	4,01

Momen magnifier factor by gravitation load



Momen magnifier factor by earthquake load



From the above results, it can be seen after conducting a P-Delta analysis of the structure that is reviewed with varying spans and heights to obtain the amplification factor, the final moment, and deflection due to the P-Delta effect. The deflection value and the last moment are more significant than the first moment, so it needs to be controlled against the deflection, and the moment that occurs.

Control of the moment that occurs needs to be done because the stability and security of the structure are strongly influenced by the moments that work. With the enlargement of the moment (amplification) that occurs above, it is more likely to cause the structure to be unable to withstand the final moment so that the structure is still unsafe.
While the control of the final deflection needs to be done as a condition for the comfort of building occupants. Based on the Earthquake Resilience Planning Regulations for Houses and Buildings 1987, it was stated that in order to avoid panic occupants and also reduce the influence of secondary moments (P-delta effect on columns), deflection of each level should not be higher than the smallest value of the following two benefits, namely 0.005 of the height of the scale being reviewed, or 2 cm

From the analyzed structure, the level height is 4 m for all floors and spans, so the allowable deflection is

$$0{,}005 \times 4.000 = 20 \text{ mm}$$

From the results of calculations performed, both on the level height and span differences in each structure, the deflection that occurs for the structure is still uncomfortable because there is a final deflection that exceeds the requirements above. It is necessary to do more careful planning, namely by paying attention to the concept of a "strong column weak beam" for planning multi-story structures. In this situation, the column is made relatively stronger compared to the beam, so that there will be a collapse in the beam (beam sway mechanism), this is appropriate because if there is a collapse of the column, then it is an ultimate collapse of the entire structure that it must be avoided. Also, it is stated that one of the advantages of the above concept is the danger due to structural instability due to the P-delta of being small so that the idea must be considered in the structure planning.

From the description above, it is clear that in the planning of many-story building structures that must be considered is the existence of the P-delta effect, so it needs to be included in the calculation and also the problem of the configuration of the structure and the concept of correct shake on the structure in order to obtain a really safe structure.

V. CONCLUSIONS AND SUGGESTIONS

Conclusion

Based on the analysis and calculation of the effect of P-delta on the building column planning with variations in the number of spans and height, the following conclusions can be drawn :

1. From the calculations on the analyzed portal, gravity and lateral amplification factors are more likely to expand from the highest level to the lowest level
2. As a result of the P-delta effect, deflection and the final moment that occurs in the structure is getting bigger. The value of these results is higher than the initial deflection, so it needs to be checked/controlled against the final results
3. To minimize structural instability due to the P-delta effect, what needs to be considered is the concept of correct fundamental shake and building configuration to achieve a genuinely safe structure.

Suggestion

Considering the above, recommendations can be given as follows

1. This analysis only uses static equivalent analysis so that it can further be developed with dynamic analysis
2. The model used is the asymmetrical concrete structure, so it needs to be also developed with an asymmetrical structure model
3. Gravity loads that work are given evenly so that it can be developed by providing point loads and loads evenly distributed simultaneously
4. In this description do not take into account wind loads as lateral loads so that further research can be developed as wind loads and earthquake loads as lateral loads
5. The model used is a non-configurable structure, so newanalysis can be compared to the structure that the claimant provides such as a shear wall

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Lalu Ibrohim Burhan "Moment Magnifier Factors in Multi-story Building Columns with Variation Length and Height due to P-Delta Effect" International Journal of Engineering Research and Applications (IJERA), vol. 9, no. 12, 2019, pp 61-68