

ANALYSIS OF BUILDING BEAMS CALCULATION FOR EMPLOYEE MESS IN KONAWE SOUTHEAST SULAWESI

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ABSTRACT

Buildings are certainly planned with the concept of earthquake-resistant buildings. In this research, the author concentrates on one of the structural elements, namely the beam which is reviewed for its structural behavior, by calculating the earthquake area to analyze the beam reinforcement. The analyzed building is located in Sulawesi, the building structure used is a reinforced concrete structure, analyzing only the upper structure, and not analyzing the lower structure which refers to the Indonesian National Standard Regulations including SNI 1726-2019 concerning Procedures for Earthquake Resistance Planning for Building and Non-Building Structures, SNI 2847-2019 concerning Structural Concrete Requirements for Buildings, and SNI 1727-2020 concerning Minimum Design Loads and Criteria. In this final project, structural modeling and analysis were carried out using Etabs20 software. From this study, the largest internal force on the structure of the employee mess building in Konawe, Beam (200x400) on the 2nd floor, with a maximum moment value of 111.554 kNm and a maximum field moment of 53.1946 kNm, shear force of 100.6759 kN. Based on the force in the Etabs output, the beam (200x400) requires 5-D16 pedestal top reinforcement, 3-D16 pedestal bottom reinforcement, 2-D16 top field reinforcement, 3-D16 bottom field reinforcement, D10-100 pedestal stirrup, D10-125 field stirrup. The reinforcement calculation is in accordance with SNI 2847-2019. It is recommended to compare the results of the ETABS analysis with the results of manual calculations based on SNI 2847: 2019. This comparison will provide an overview of the accuracy and reliability of ETABS software in calculating the reinforcement ratio.

Keywords: Planning, Reinforced Concrete, Upper Structure

INTRODUCTION

Building structures must have strong structural elements to withstand the loads they receive. The upper structural elements consist of columns, beams, stairs, walls, and roofs, while the lower structure is in the form of foundations. The upper structure supports the load forces acting on a building. While the lower structure then transmits the load forces from the upper structure to the ground. So that these structural components must be calculated and analyzed based on the appropriate combination of loading and factored forces. Factors that affect the strength of a building structure are live loads, dead loads, wind loads, and earthquake loads.

Beams are elements of a portal structural system that work as a unit to withstand bending, shear and torsion. Reinforced concrete material is basically a combination of concrete and reinforcing steel. This combination aims to overcome the weakness of concrete material in resisting tension. This combination will be successful if the reinforcing steel used has good

adhesion characteristics to the concrete material and is given adequate anchorage length in the concrete.

Planning a construction project always includes the idea of creating an earthquake-resistant structure. Therefore, this study examines the structural behavior of one structural element, namely the beam, by considering the earthquake zone and examining the beam reinforcement.

METHODS

The research method used in this Final Project research is a case study of the mess building structure, which consists of 4 floors and 1 roof floor with an emphasis/focus on beam analysis. In conducting this research, it was also carried out using the help of ETABS v.20 software.

RESULTS AND DISCUSSION

A. Structural Modeling

1. Material Definition

Determine the materials used

2. Section Properties Definition

Enter the dimensions of the beams, columns, and floor slabs used

The results of the building structure modeling can be seen in the following image.

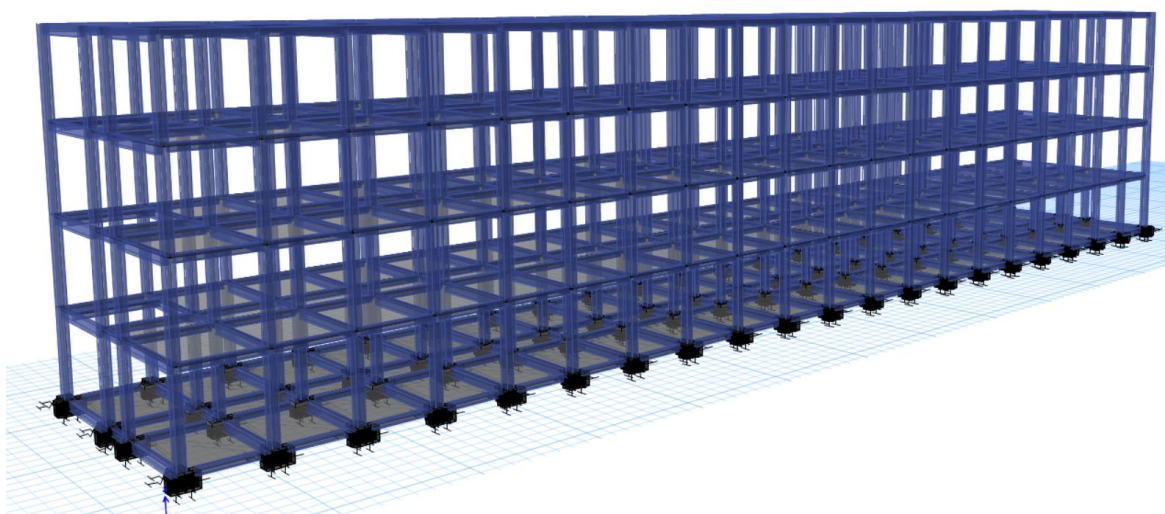


Figure 1. Modeling of the Mess Building Structure

B. Structural Loading

1. Dead Load, which is the self-weight of the structure which is calculated directly by the program.
2. Additional Dead Load

Table 1. Additional Dead Load

Beban Mati tambahan (SDL)	Beban merata (kN/m2)
Berat keramik	0,294
Berat adukan mortar t= 3cm	0,647
Berat plafon, rangka, dan ME	0,294

Berat lain lain, rata rata	0,491
Total beban mati tambahan pada lantai dasar	1.433
Total beban mati tambahan pada lantai	1,727

Beban Mati tambahan (SDL)	Beban merata (kN/m)
Berat dinding ½ batu, tinggi 3,2 m	8
Berat dinding ½ batu, tinggi 3,3 m	8.25

Source: Research

3. Live Load, In accordance with SNI 1727:2018 the live load used is 2.40 kN/m²
4. Wind Load, Wind load is evenly distributed on the columns located on the outer walls of the building.

The wind load of the building which is included as the Main Wind Load Resisting System (SPBAU) is planned

in accordance with the rules in SNI 1727:2020, so that the following results are obtained:

- Longitudinal portal wind load
 - a. incoming wind = 0.1306 kN/m
 - b. away wind = 0.0327 kN/m
- Transverse portal wind load
 - a. incoming wind = 0.1327 kN/m
 - b. away wind = 0.0332 kN/m
- 5. Earthquake Load, The earthquake load used refers to SNI 1726:2019/ASCE 7-16, so that the following results are obtained:

Kategori Resiko Bangunan	II
Kelas Situs	SE (tanah lunak)
Faktor Keutamaan, I_e	1.0
PGA, S_s dan S_1	0.308381 g, 0.668372 g dan 0.187285 g
F_a dan F_v	1.430605 dan 3.414437
S_{DS} dan S_{D1}	0.637451 g dan 0.426315 g
Kategori Desain Seismik	D
Faktor Modifikasi Respon	8
Faktor Kuat Lebih Sistem	3
Faktor Pembesaran Defleksi	5.5

6. Loading combination used in accordance with SNI 1726:2019
 - 1.4 D
 - 1.2 D + 1.6 L + 0.5 (Lr or R)
 - 1.2 D + 1.6 (Lr or R) + (L or 0.5W)
 - 1.2 D + 1.0 W + L + 0.5 (Lr or R)
 - 1.2 D + 1.0 E + L
 - 0.9 D + 1.0 W
 - 0.9 D + 1.0 E

C. Response Spectrum Analysis of Variants

1. Number of Variants, the number of variants given must meet the requirements of 100% participation of the variant mass for all directions of the variant movement. The combined participation of the variant mass of 100% is the X direction of 0.117 and the Y direction of 0.134

Case	Mode	Period	UX	UY	SumUX	SumUY	RZ	SumRZ
		sec						
Modal	1	1.426	0.8382	0	0.8382	0	2.21E-06	2.21E-06
Modal	2	1.118	0	0.8336	0.8382	0.8336	0	2.21E-06
Modal	3	1.094	2.35E-06	0	0.8383	0.8336	0.834	0.834
Modal	4	0.447	0.1086	0	0.9468	0.8336	0	0.834
Modal	5	0.347	0	0.1111	0.9468	0.9447	0	0.834
Modal	6	0.34	0	0	0.9468	0.9447	0.1108	0.9448
Modal	7	0.249	0.0408	0	0.9876	0.9447	0	0.9448
Modal	8	0.191	0	0.0422	0.9876	0.9869	0	0.9448
Modal	9	0.187	0	0	0.9876	0.9869	0.0421	0.9869
Modal	10	0.177	0.0124	0	1	0.9869	0	0.9869
Modal	11	0.134	0	0.0131	1	1	0	0.9869
Modal	12	0.131	0	0	1	1	0.013	1

- Free Vibration Analysis, The results of the analysis show the behavior of various motions, namely translational motion in the X direction for mode 1, translational motion in the Y direction for mode 2, and rotational motion to the Z axis for mode 3.

- Calculating the Vibration Period

In calculating the structural period, the following data are needed:

Parameter SD1: 0.426315 (Design spectrum)

Coefficient Cu: 1.4 (Table 17 SNI 1726:2019)

Coefficient Ct: 0.0466 (Table 18 SNI 1726:2019)

Coefficient x: 0.9 (Table 18 SNI 1726:2019)

Calculation of the structural period based on the formula contained in SNI Earthquake 1726:2019

Tamin = Ct x hnx = 0.0466 x (14.4)0.9 = 0.5139 s

Tamax = Cu x Tamin = 1.40 x 0.5139 = 0.71952 s

h_n (m)	T_{modal} (detik)	T_a (detik)	$C_u T_a$ (detik)	T (detik)
14.4	X-dir: 1.426 Y-dir: 1.118	$0.0466 \times 14.4^{0.9} = 0.5139$	$1.4 \times 0.5139 = 0.71952$	X-dir: 0.71952 Y-dir: 0.71952

- Calculating the Seismic Response Coefficient

The data required are:

SDS Parameter: 0.637

SD1 Parameter: 0.426

Response Modification Factor, R: 8 (Table 12 SNI 1726:2019)

Earthquake Primacy Factor, Ie: I (Table 4 SNI 1726:2019)

Structural Period, Ta: 0,72

Based on the formula, the calculation of the Cs value is carried out as follows:

$$C_s = \frac{S_{DS}}{(R/I_e)} = \frac{0.637}{(8/1)} = 0,08$$

Cs max x value:

$$C_{s_{max, x}} = \frac{S_{D1}}{T_a \times (R/I_e)} = \frac{0.426}{0.72 \times (8/1)} = 0,074$$

The calculated Cs value must not be less than:

Cs min = 0.044.SDS.Ie ≥ 0.01

Cs,min,1 = 0.028 ≥ 0.01

Lower Limit (used if S1 >= 0.6 g)

$$C_{S,min,2} = \frac{0.5S_1}{\left(\frac{R}{I_e}\right)} = 0,012$$

From these requirements, the equation is obtained:

$$C_{s \min} < C_s < C_{s \max} = 0.028 < 0.08 > 0.074$$

Because C_s is greater than $C_{s \max}$, the C_s used is $C_{s \max} = 0.074$ for the x and y directions.

5. Calculating Effective Seismic Weight

Effective Seismic Weight is the total design weight resulting from the sum of the dead load of the structure + additional dead load + reduced live load

Story	Diaphragm	Mass X	Mass Y	Berat (wx)
		ton	ton	kN
LT. DAK	D1	714.5219	7009.46	714.5219 * 9.81 = 7009.46
LT.4	D1	866.4917	683.9878	866.4917 * 9.81 = 8500.28
LT.3	D1	866.4917	683.9878	866.4917 * 9.81 = 8500.28
LT.2	D1	866.4917	683.9878	866.4917* 9.81 = 8500.28
Total				32510.31057

6. Calculating Static Shear Force Manually

$$V_x = C_s \times W_t = 0.074 \times 32510.31057 = 2408 \text{ kN}$$

$$V_y = C_s \times W_t = 0.074 \times 32510.31057 = 2408 \text{ Kn}$$

7. Dynamic Shear Force in Etabs v.20.

Story	Output Case	Case Type	VX	VY	MX	MY
			kN	kN	kN-m	kN-m
LT. DAK	Spec x	LinRespSpec	486.0808	3.06E-06	0.0014	6.3796
LT.4	Spec x	LinRespSpec	870.0419	1.78E-06	0.0028	1761.027
LT.3	Spec x	LinRespSpec	1140.241	1.40E-06	0.004	4806.543
LT.2	Spec x	LinRespSpec	1293.511	0	0.0046	8720.283

Story	Output Case	Case Type	VX	VY	MX	MY
			kN	kN	kN-m	kN-m
LT. DAK	Spec y	LinRespSpec	9.39E-07	591.9604	17.138	0.1608
LT.4	Spec y	LinRespSpec	6.47E-07	1101.581	2155.692	11.0866
LT.3	Spec y	LinRespSpec	0	1455.592	6048.936	17.5302
LT.2	Spec y	LinRespSpec	0	1633.267	11133.01	18.1221

8. Calculating Dynamic Shear Force (Vdynamic)

The dynamic floor shear force resulting from the response spectrum analysis can be seen in the following table:

GEMPA ARAH - X														
Sds	:	0.6375	g											
Sd1	:	0.4263	g											
S1	:	0.1873	g											
R	:	8												
I	:	1												
Tx	:	0.7195	Detik											
k	:	1.1098												
Csx	:	0.0797												
Csxmax	:	0.0741												
Csxmin	:	0.028												
Csxmin	:	0.0117	(untuk S1 ≥ 0.6g)											
diambil														
Cs	:	0.0741												
V = Cs.W														
Vstat	:	2407.8	kN											
1Vstat	:	2407.8	kN											
Vdyn	:	1293.5	kN											
koreksi	:	1.8615												

Lantai	Elevasi (m)	Massa (Ton)	berat (wx) (Kn)	Wx.hx ² /k	CVx (Kn)	STATIK EKIVALEN		STATIK 100%		DINAMIK		DINAMIK KOREKSI		Desaign	
						Vx (Kn)	Fx (Kn)	1 Vx (Kn)	Fx (Kn)	Vx (Kn)	Fx (Kn)	Vx (Kn)	Fx (Kn)	Vx (Kn)	Fx (Kn)
LT. DAK	14.4	714.5219	7009.46	135265.28	0.3699	890.61	890.61	890.61	890.61	486.0808	486.08	904.82	904.82	904.82	904.82
LT.4	10.8	866.4917	8500.28	119201.98	0.3260	1675.45	784.85	1675.45	784.85	870.0419	383.96	1619.54	714.72	1619.54	714.72
LT.3	7.2	866.4917	8500.28	76008.97	0.2078	2175.91	500.46	2175.91	500.46	1140.241	270.20	2122.50	502.96	2122.50	502.96
LT.2	3.6	866.4917	8500.28	35220.41	0.0963	2407.81	231.90	2407.81	231.90	1293.511	153.27	2407.81	285.30	2407.81	285.30
Base	0														
						32510.31	365696.6425								

% gempa : 7.406289

GEMPA ARAH - Y														
Sds	:	0.6375	g											
Sd1	:	0.4263	g											
S1	:	0.1873	g											
R	:	8												
I	:	1												
Ty	:	0.7195	Detik											
k	:	1.1098												
Csy	:	0.0797												
Csymax	:	0.0741												
Csymin	:	0.028												
Csymin	:	0.0117	(untuk S1 ≥ 0.6g)											
diambil														
Cs	:	0.0741												
V = Cs.W														
V stat	:	2407.8	kN											
1Vstat	:	2407.8	kN											
Vdyn	:	1633.3	kN											
koreksi	:	1.4742												

Lantai	Elevasi (m)	Massa (Ton)	berat (wx) (Kn)	Wx.hx ² /k	CVy (Kn)	STATIK EKIVALEN		STATIK 100%		DINAMIK		DINAMIK KOREKSI		Desaign	
						Vy (Kn)	Fy (Kn)	1 Vy (Kn)	Fy (Kn)	Vy (Kn)	Fy (Kn)	Vy (Kn)	Fy (Kn)	Vy (Kn)	Fy (Kn)
LT. DAK	14.4	714.5219	7009.46	135265.28	0.3699	890.61	890.61	890.61	890.61	591.9604	591.96	872.68	872.68	872.68	872.68
LT.4	10.8	866.4917	8500.28	119201.98	0.3260	1675.45	784.85	1675.45	784.85	1101.581	509.62	1623.98	751.30	1623.98	751.30
LT.3	7.2	866.4917	8500.28	76008.97	0.2078	2175.91	500.46	2175.91	500.46	1455.592	354.01	2145.87	521.89	2145.87	521.89
LT.2	3.6	866.4917	8500.28	35220.41	0.0963	2407.81	231.90	2407.81	231.90	1633.267	177.67	2407.81	261.93	2407.81	261.93
Base	0														
						32510.31057	365696.6425								

% gempa : 7.406289

D. Inter-story Deviation

The elastic inter-story deviation value based on the design earthquake must be increased by the deflection increase factor C_D but does not need to take into account the following priority factors:

$$\delta_x = C_D \delta_{xe} i$$

Where:

C_d = deflection magnification factor

δ_{xe} = elastic inter-level deviation due to the planned earthquake

For risk category II, the ratio of deviations between levels should not be more than 0.02.

Lantai	Tinggi (m)	hs (mm)	δx_e (mm)	δx (mm)	δi_{jin} (mm)	Δa (mm)	Cek arah x	δy_e (mm)	δy (mm)	δi_{jin} (mm)	Δa (mm)	Cek arah y
LT. DAK	14.4	14400	61.682	339.25	288.00	288	OKE	43.042	236.73	288.00	288	OKE
LT.4	10.8	10800	52.285	287.57	216.00	216	OKE	36.545	201.00	216.00	216	OKE
LT.3	7.2	7200	36.567	201.12	144.00	144	OKE	26.081	143.45	144.00	144	OKE
LT.2	3.6	3600	13.086	71.97	72.00	72	OKE	12.195	67.07	72.00	72	OKE
Base	0	0										

D. P-Delta Effect

To check the stability of the building/P-Delta effect, it is not necessary to calculate if the stability coefficient (Θ) is equal to or less than 0.1. The table below is for the effect of P-Delta in the X and Y directions.

Arah - X								
Lantai	hsx (m)	Px (Kn)	Δ (m)	Vx (Kn)	θ min	θ	θ max	Cek P Δ opt
LT. DAK	3.6	0.0001	0.0516835	486.0808	0.1	5.4E-10	0.0909	P-Delta tidak perlu
LT.4	3.6	0.0003	0.086449	870.0419	0.1	1.5E-09	0.0909	P-Delta tidak perlu
LT.3	3.6	0.0004	0.1291455	1140.2407	0.1	2.3E-09	0.0909	P-Delta tidak perlu
LT.2	3.6	0.0004	0.071973	1293.5108	0.1	1.1E-09	0.0909	P-Delta tidak perlu

Arah - Y								
Lantai	hsx (m)	Py (Kn)	Δ (m)	Vy (Kn)	θ min	θ	θ max	Cek P Δ opt
LT. DAK	3.6	0.0047	0.035734	591.9604	0.10	1.4E-08	0.090909	Pdelta tidak perlu
LT.4	3.6	0.3193	0.057552	1101.581	0.10	8.4E-07	0.090909	Pdelta tidak perlu
LT.3	3.6	0.5052	0.076373	1455.592	0.10	1.3E-06	0.090909	Pdelta tidak perlu
LT.2	3.6	0.5221	0.067073	1633.267	0.10	1.1E-06	0.090909	Pdelta tidak perlu

E. Largest Beam Analysis

1. Output Force In Etabs

Momen		Geser	Torsi
M (-)	M (+)		
kN.m	kN.m	kN.m	kN.m
109.801	53.1946	94.7466	16.3088

2. Geometry of Blocks

Lebar Balok	b	200	mm
Tinggi Balok	h	400	mm
Panjang Balok	L	4500	mm
Selimut Bersih	c_c	40	mm

3. Material

Kuat Tekan Beton	f'_c	25	MPa
Kuat Leleh Baja Tulangan Longitudinal	f_y	420	MPa
Kuat Leleh Baja Tulangan Transversal	f_{yv}	420	MPa

CONCLUSIONS

From this study, with a live load of 2.4 Kn/m², the largest internal force in the structure of the employee mess building in Konowe is the beam (200x400) on the 2nd floor, with a maximum support moment value of 111,554 kNm and a maximum field moment of 53.1946 kNm, a shear force of 100.6759 kNm. Based on the internal force of the Etabs output results, Beam B1 (200x400) requires 5-D16 upper support reinforcement, 3-D16 lower support reinforcement, 2-D16 upper field reinforcement, 3-D16 lower field reinforcement, D10-100 support stirrups, D10-125 field stirrups. The calculation of reinforcement is in accordance with SNI 2847-2019. The support reinforcement ratio is 1.28%, and the field is 0.576%. The calculation of the beam reinforcement ratio is in accordance with SNI 2847-2019.

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