CHAPTER III

BASIC THEORY

3.1 Structure Loading

In the planning of high-rise buildings, structural componentsplanned to be strong enough to bear all the workload. Understanding the loaditself is loads either directly or indirectly, thataffect the structure of the building. Pursuant to Rule Imposition Indonesia's 1983 Building article 1 page 7, stated that the imposition which should be considered are as follows.

1. The dead load is the weight of all the parts of a building thatisremain, including any additional elements, completion,and machineas well as fixed equipment which is an integral partof that building.
2. The burden of life is that all costs incurred as a result of residential orthe use of a building, and into it including the loads onfloors that come from items that can move, machinesand equipment that is not an integral part of building and canbe replaced during the lifetime of the building, soresulting in a change in the loading floor and the roof. Especially on the roof can live load, including the load from waterrain, both due to inundation or due to falling pressure (kinetic energy)droplets.
3. Load the earthquake is all the equivalent static loads acting on the building or part of the building that mimics the effect of ground motion duethe earthquake. In terms of the effect of the earthquake on the structure of the building determined based on a dynamic analysis, it is interpreted by the load

earthquake here is style within the structure that occurs byground movement caused by theearthquake.

4. Wind load is all of the load acting on the buildings or partsthe building causedby the difference in air pressure.

3.1.1 Strong need

Strong need is calculated based on the load combinations in accordance with SNI 2847:2013 and 1726:2012, following a strong combination should be used:

1. $(1{,}2 + 0{,}2S_{DS})D + Q_E + L$
2. $(0{,}9 – 0{,}2S_{DS})D + Q_E + 1{,}6H$

Base combination for required tension is,

1. $(1{,}0 + 0{,}14S_{DS})D + H + F + 0{,}7\,Q_E$
2. $(1{,}0 + 0{,}105S_{DS})D + H + F + 0{,}525Q_E + 0{,}75L + 0{,}75(L_r \text{ or } R)$
3. $(0{,}6\text{-}0{,}14S_{DS})D + 0{,}7Q_E + H$

Notasi :

U = Ultimate

D = dead load

L = live load

Ex = earthquake load (x direction)

Ey = earthquake load (y direction)

3.1.2 Strength Reduction Factor

The strength provided by a structural component,its connection with other structural components, and the cross-section, with respectby bending, normal load, shear, and torsion,must be taken by force Face calculated in accordance with the requirements, which is multiplied by the strength reduction factor (φ) shall be follows ACI 318M-11.

Table 3.1 Strength Reduction Factor Design

No	Information	Reduction Factor
1	Tension controlled section	0.90
2	Compression-controlled section: a. Structural components with reinforcement spiral b. Other components of the bony structure	 0.75 0.70
3	Slide and torque	0.85
4	Bearing on concrete (except for postention anchorrage zones and strut-and-the models)	0.70
5	Post-tentioned anchorage zones	0.85
6	Strut-and-the models and struts,tles,nodal zones, and bearing areas in such models.	0.85
7	Flexure section without aaxial load in pretensioned members where strand embedment is less than the development length as provided in.	0.85

3.2 <u>Element of the upper structure</u>

A high-rise buildings are formed from structural elements arewhen combined produce a complete skeletal system. But at this time the authordiscusses the elementstop structure in this design, especially plates, beams, columns.The definition of the structural elements is a major supporter of buildingis as follows:

3.2.1 Slab

Slabs are structural components which is a flat slab thatwidth with parallel top and bottom surfaces. Slabs were analyzed as two orone direction only, depending on the system structure. When the ratio between the length and width of the slab does not exceed 2, used reinforcement 2-way

Types of plates consisting of (frederick S. Merritt,1968) :

a. One way slab, supported on beams or walls spans a distance in one direction more than in the perpendicular direction, so much of the load is carried on the short span that the slab may reasonably be assumed to be carrying all the load in that direction.

b. Two way slab, when a rectangular reinforced-concrete slab is supported on all four sides,reinforcement placed perpendicular to the sides may be assumed to be effective in the two directions if the ratio of the long sides to the short sides is less than about 2 to 1. In effect, a two-way slab distributes past of the load on it in the long direction and usually a much larger part in the short direction.

3.2.2 Beam

The beam is a structural element that transmits loads from the platefloor to buffer the vertical. (Nawy,1990). Beam elementsstructurally designed to withstand the forces acting transverselyabout its axis, which causes the bending moment and stylesliding along the span.

3.2.3 Column

Columns are vertical press rod of the frame structure of the shoulderthe load of the beam. The column is a structural element compressiveplays an important role of a building,so that collapse ona column is a critical location that could lead to the collapse(Collapse) the floor is concerned and also the total collapse (total collapse) allstructure (Sudarmoko,1996).

3.3 Earthquake Planning Based on SNI 1726 :2012

3.3.1 S_{DS} and S_{D1}

Value S_{DS} and S_{D1} can find by observing the location of the buildingdesigned in Figure 9 and 10 SNI 1726:2012, or by webdesign spectra Indonesia;

http://puskim.pu.go.id//Aplikasi/desain_spektra_indonesia_2011/

3.3.2 Risk Category

For various categories of risk and non- building structurebuildingsaccording to Table 3.2 earthquake effect against plans should be multiplied bya virtue factor I_e according Table 3.5.

Table 3.2 Category Building Construction and Non – Building

Nature of Occupancy	Category
Buildings and other structures that represent a low hazard to human life in the event of failure including, I but not limited to: -Agricultural facilities -Certain temporary facilities -Minor storage facilities	I
All buildings and other structures except those listed in Categories I, III, and IV	II
Buildings and other structures that represent a substantial hazard to human life in the event of failure III including, but not limited to: Buildings and other structures where more than 300 people congregate in one area Buildings and other structures with day care facilities with capacity greater than 150 Buildings and other structures with elementary school or secondary school facilities with capacity greater than 250 Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities Jails and detention facilities Power generating stations and other public utility facilities not included in Category IV Buildings and other structures not included in Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of hazardous materials to be dangerous to the public if released. Buildings and other structures containing hazardous materials shall be eligible for classification as Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the hazardous material does not pose a threat to the public.	III
Buildings and other structures designated as essential facilities including, but not limited to: IV Hospitals and other health care facilities having surgery or emergency treatment facilities Fire, rescue, ambulance, and police stations and emergency vehicle garages Designated earthquake, hurricane, or other emergency shelters Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response Power generating stations and other public utility facilities required in an emergency Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling	IV

towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Category IV structures during an emergency Aviation control towers, air traffic control centers, and emergency aircraft hangars Water storage facilities and pump structures required to maintain water pressure for fire suppression Buildings and other structures having critical national defense functions Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing extremely hazardous materials where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction. Buildings and other structures containing extremely hazardous materials shall be eligible for classification as Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the extremely hazardous material does not pose a threat to the public. This reduced classification shall not be permitted if the buildings or other structures also function as essential facilities.	

(Quoted from Table 1-1 ASCE 7.2002)

3.3.3 Seismic Design Category

In determining the value of S_{DC} seen by parameter response acceleration in a short period and a period of one second.

Table 3.3 seismic design categories based on the acceleration response parametershort period

Value of S_{DS}	Risk Category		
	I or II	III	IV
S_{DS} < 0,167g	A	A	A
0,167g< S_{DS}<0,33g	B	B	C
0,33g< S_{DS}<0,50g	C	C	D
0,50g< S_{DS}	D	D	D

Tabel 3.4 seismic design categories based on the acceleration response parameter

1 second period

Value of S_{D1}	Risk Category		
	I or II	III	IV
$S_{D1} < 0,167$	A	A	A
$0,167 < S_{D1} < 0,133$	B	B	C
$0,133 < S_{D1} < 0,20$	C	C	D
$0,20 < S_{D1}$	D	D	D

(Quoted from Table 1613.3.5 ASCE 9)

The structure should be set to have a seismic design category.

If $S_1 > 0.75$:

a. For Risk Category I / II / III : the SDCE

b. Risk to Category IV: so SDCF

3.3.4 Structural Systems and Structural Parameters

Table 3.5 Factors R, Cd , ΩO for seismic force resisting system.

Sistem penahan-gaya seismik	Koefisien modifikasi respons, R^a	Faktor kuat-lebih sistem, $\Omega_0^{\,g}$	Faktor pembesaran defleksi, $C_d^{\,b}$	Batasan sistem struktur dan batasan tinggistruktur, h_n (m) [c]				
				Kategori desain seismik				
				B	C	D[d]	E[d]	F[e]
A. Sistem dinding penumpu	**7.1.1**	**7.1.2**	**7.1.3**	**7.1.4**	**7.1.5**	**7.1.6**	**7.1.7**	**7.1.8**
1. Dinding geser beton bertulang khusus	5	2½	5	TB	TB	48	48	30
2. Dinding geser beton bertulang biasa	4	2½	4	TB	TB	TI	TI	TI
3. Dinding geser beton polos didetail	2	2½	2	TB	TI	TI	TI	TI
4. Dinding geser beton polos biasa	1½	2½	1½	TB	TI	TI	TI	TI
5. Dinding geser pracetak menengah	4	2½	4	TB	TB	12[k]	12[k]	12[k]
6. Dinding geser pracetak biasa	3	2½	3	TB	TI	TI	TI	TI
7. Dinding geser batu bata bertulang khusus	5	2½	3½	TB	TB	48	48	30
8. Dinding geser batu bata bertulang menengah	3½	2½	2¼	TB	TB	TI	TI	TI
9. Dinding geser batu bata bertulang biasa	2	2½	1¾	TB	48	TI	TI	TI

Sistem penahan-gaya seismik	Koefisien modifikasi respons, R^a	Faktor kuat-lebih sistem, $\Omega_0{}^g$	Faktor pembesaran defleksi, $C_d{}^b$	Batasan sistem struktur dan batasan tinggi struktur, h_n (m)[c]				
				Kategori desain seismik				
				B	C	D[d]	E[d]	F[e]
10. Dinding geser batu bata polos didetail	2	2½	1¾	TB	TI	TI	TI	TI
11. Dinding geser batu bata polos biasa	1½	2½	1½	TB	TI	TI	TI	TI
12. Dinding geser batu bata prategang	1½	2½	1¾	TB	TI	TI	TI	TI
13. Dinding geser batu bata ringan (AAC) bertulang biasa	2	2½	2	TB	10	TI	TI	TI
14. Dinding geser batu bata ringan (AAC) polos biasa	1½	2½	1½	TB	TI	TI	TI	TI
15. Dinding rangka ringan (kayu) dilapisi dengan panel struktur kayu yang ditujukan untuk tahanan geser, atau dengan lembaran baja	6½	3	4	TB	TB	20	20	20
16. Dinding rangka ringan (baja canai dingin) yang dilapisi dengan panel struktur kayu yang ditujukan untuk tahanan geser, atau dengan lembaran baja	6½	3	4	TB	TB	20	20	20
17. Dinding rangka ringan dengan panel geser dari semua material lainnya	2	2½	2	TB	TB	10	TI	TI
18. Sistem dinding rangka ringan (baja canai dingin) menggunakan bresing strip datar	4	2	3½	TB	TB	20	20	20
B. Sistem rangka bangunan								
1. Rangka baja dengan bresing eksentris	8	2	4	TB	TB	48	48	30
2. Rangka baja dengan bresing konsentris khusus	6	2	5	TB	TB	48	48	30
3. Rangka baja dengan bresing konsentris biasa	3¼	2	3¼	TB	TB	10[j]	10[j]	TI[j]
4. Dinding geser beton bertulang khusus	6	2½	5	TB	TB	48	48	30
5. Dinding geser beton bertulang biasa	5	2½	4½	TB	TB	TI	TI	TI
6. Dinding geser beton polos detail	2	2½	2	TB	TI	TI	TI	TI
7. Dinding geser beton polos biasa	1½	2½	1½	TB	TI	TI	TI	TI
8. Dinding geser pracetak menengah	5	2½	4½	TB	TB	12[k]	12[k]	12[k]
9. Dinding geser pracetak biasa	4	2½	4	TB	TI	TI	TI	TI
10. Rangka baja dan beton komposit dengan bresing eksentris	8	2	4	TB	TB	48	48	30
11. Rangka baja dan beton komposit dengan bresing konsentris khusus	5	2	4½	TB	TB	48	48	30
12. Rangka baja dan beton komposit dengan bresing biasa	3	2	3	TB	TB	TI	TI	TI
13. Dinding geser pelat baja dan beton komposit	6½	2½	5½	TB	TB	48	48	30
14. Dinding geser baja dan beton komposit khusus	6	2½	5	TB	TB	48	48	30
15. Dinding geser baja dan beton komposit biasa	5	2½	4½	TB	TB	TI	TI	TI
16. Dinding geser batu bata bertulang khusus	5½	2½	4	TB	TB	48	48	30
17. Dinding geser batu bata bertulang menengah	4	2½	4	TB	TB	TI	TI	TI
18. Dinding geser batu bata bertulang biasa	2	2½	2	TB	48	TI	TI	TI
19. Dinding geser batu bata polos didetail	2	2½	2	TB	TI	TI	TI	TI
20. Dinding geser batu bata polos biasa	1½	2½	1½	TB	TI	TI	TI	TI
21. Dinding geser batu bata prategang	1½	2½	1¾	TB	TI	TI	TI	TI
22. Dinding rangka ringan (kayu) yang dilapisi dengan panel struktur kayu yang dimaksudkan untuk tahanan geser	7	2½	4½	TB	TB	22	22	22
23. Dinding rangka ringan (baja canai dingin) yang dilapisi dengan panel struktur kayu yang dimaksudkan untuk tahanan geser, atau dengan lembaran baja	7	2½	4½	TB	TB	22	22	22

Sistem penahan-gaya seismik	Koefisien modifikasi respons, R^a	Faktor kuat-lebih sistem, Ω_0^g	Faktor pembesaran defleksi, C_d^b	Batasan sistem struktur dan batasan tinggi struktur, h_n (m)[c] Kategori desain seismik B	C	D^d	E^d	F^e
24. Dinding rangka ringan dengan panel geser dari semua material lainnya	2½	2½	2½	TB	TB	10	TB	TB
25. Rangka baja dengan bresing terkekang terhadap tekuk	8	2½	5	TB	TB	48	48	30
26. Dinding geser pelat baja khusus	7	2	6	TB	TB	48	48	30
C. Sistem rangka pemikul momen								
1. Rangka baja pemikul momen khusus	8	3	5½	TB	TB	TB	TB	TB
2. Rangka batang baja pemikul momen khusus	7	3	5½	TB	TB	48	30	TI
3. Rangka baja pemikul momen menengah	4½	3	4	TB	TB	10[h,i]	TI[h]	TI[i]
4. Rangka baja pemikul momen biasa	3½	3	3	TB	TB	TI[h]	TI[h]	TI[i]
5. Rangka beton bertulang pemikul momen khusus	8	3	5½	TB	TB	TB	TB	TB
6. Rangka beton bertulang pemikul momen menengah	5	3	4½	TB	TB	TI	TI	TI
7. Rangka beton bertulang pemikul momen biasa	3	3	2½	TB	TI	TI	TI	TI
8. Rangka baja dan beton komposit pemikul momen khusus	8	3	5½	TB	TB	TB	TB	TB
9. Rangka baja dan beton komposit pemikul momen menengah	5	3	4½	TB	TB	TI	TI	TI
10. Rangka baja dan beton komposit terkekang parsial pemikul momen	6	3	5½	48	48	30	TI	TI
11. Rangka baja dan beton komposit pemikul momen biasa	3	3	2½	TB	TI	TI	TI	TI
12. Rangka baja canai dingin pemikul momen khusus dengan pembautan	3½	3[o]	3½	10	10	10	10	10
D. Sistem ganda dengan rangka pemikul momen khusus yang mampu menahan paling sedikit 25 persen gaya gempa yang ditetapkan								
1. Rangka baja dengan bresing eksentris	8	2½	4	TB	TB	TB	TB	TB
2. Rangka baja dengan bresing konsentris khusus	7	2½	5½	TB	TB	TB	TB	TB
3. Dinding geser beton bertulang khusus	7	2½	5½	TB	TB	TB	TB	TB
4. Dinding geser beton bertulang biasa	6	2½	5	TB	TB	TI	TI	TI
5. Rangka baja dan beton komposit dengan bresing eksentris	8	2½	4	TB	TB	TB	TB	TB
6. Rangka baja dan beton komposit dengan bresing konsentris khusus	6	2½	5	TB	TB	TB	TB	TB
7. Dinding geser pelat baja dan beton komposit	7½	2½	6	TB	TB	TB	TB	TB
8. Dinding geser baja dan beton komposit khusus	7	2½	6	TB	TB	TB	TB	TB
9. Dinding geser baja dan beton komposit biasa	6	2½	5	TB	TB	TI	TI	TI
10. Dinding geser batu bata bertulang khusus	5½	3	5	TB	TB	TB	TB	TB
11. Dinding geser batu bata bertulang menengah	4	3	3½	TB	TB	TI	TI	TI
12. Rangka baja dengan bresing terkekang terhadap tekuk	8	2½	5	TB	TB	TB	TB	TB
13. Dinding geser pelat baja khusus	8	2½	6½	TB	TB	TB	TB	TB
E. Sistem ganda dengan rangka pemikul momen menengah mampu menahan paling sedikit 25 persen gaya gempayang ditetapkan								
1. Rangka baja dengan bresing konsentris khusus[f]	6	2½	5	TB	TB	10	TI	TI[h,k]
2. Dinding geser beton bertulang khusus	6½	2½	5	TB	TB	48	30	30

Sistem penahan-gaya seismik	Koefisien modifikasi respons, R^a	Faktor kuat-lebih sistem, Ω_0^g	Faktor pembesaran defleksi, C_d^b	Batasan sistem struktur dan batasan tinggi struktur, h_n (m) [c]				
				Kategori desain seismik				
				B	C	D[d]	E[d]	F[e]
3. Dinding geser batu bata bertulang biasa	3	3	2½	TB	48	TI	TI	TI
4. Dinding geser batu bata bertulang menengah	3½	3	3	TB	TB	TI	TI	TI
5. Rangka baja dan beton komposit dengan bresing konsentris khusus	5½	2½	4½	TB	TB	48	30	TI
6. Rangka baja dan beton komposit dengan bresing biasa	3½	2½	3	TB	TB	TI	TI	TI
7. Dinding geser baja dan betonkomposit biasa	5	3	4½	TB	TB	TI	TI	TI
8. Dinding geser beton bertulang biasa	5½	2½	4½	TB	TB	TI	TI	TI
F. Sistem interaktif dinding geser-rangka dengan rangka pemikul momen beton bertulang biasa dan dinding geser beton bertulang biasa	4½	2½	4	TB	TI	TI	TI	TI
G. Sistem kolom kantilever didetail untuk memenuhi persyaratan untuk :								
1. Sistem kolom baja dengan kantilever khusus	2½	1¼	2½	10	10	10	10	10
2. Sistem kolom baja dengan kantilever biasa	1¼	1¼	1¼	10	10	TI	TI[h,i]	TI[h,i]
3. Rangka beton bertulang pemikul momen khusus	2½	1¼	2½	10	10	10	10	10
4. Rangka beton bertulang pemikul momen menengah	1½	1¼	1½	10	10	TI	TI	TI
5. Rangka beton bertulang pemikul momen biasa	1	1¼	1	10	TI	TI	TI	TI
6. Rangka kayu	1½	1½	1½	10	10	10	TI	TI
H. Sistem baja tidak didetail secara khusus untuk ketahanan seismik, tidak termasuk sistem kolom kantilever	3	3	3	TB	TB	TI	TI	TI

(quoted from SNI 1726:2012)

3.3.5 Seismic Importance Factor

Factors virtue obtained from the following table:

Table 3.6 Earthquake virtue factor

Risk Category from Table 1.5-1	Snow Importance Factor, I_s	Ice Importance Factor—Thickness, I_i	Ice Importance Factor—Wind, I_w	Seismic Importance Factor, I_e
I	0.80	0.80	1.00	1.00
II	1.00	1.00	1.00	1.00
III	1.10	1.25	1.00	1.25
IV	1.20	1.25	1.00	1.50

(Quoted from Table 1.5-2 ASCE 7-10)

3.3.6 Period Fundamental

The period of the fundamental structure, T, in the direction of the review should be obtained use the property structure and deformation characteristics of the retaining elements the analysis tested. The period of the fundamental structure, T, cannot exceed the results coefficient for the limitation on the period calculated Ct from Table 3.8.

Approach the fundamental period (Ta), in seconds, to be determined from

The following equation:

$$T_a = c_t h_n^{x} \tag{3.19}$$

Description hn = is the height of the structure, in (m) , above the base up

The highest level of the structure, and the coefficients Ct and x is determined from Table 3.7.

Table 3.7 Value parameter approaches period Ct and x

Structure Type	C_t	x
Moment-resisting frame systems in which the frames resist 100% of the required seismic force and are not enclosed or adjoined by components that are more rigid and will prevent the frames from deflecting where subjected to seismic forces:		
Steel moment-resisting frames	0.028 (0.0724)[a]	0.8
Concrete moment-resisting frames	0.016 (0.0466)[a]	0.9
Steel eccentrically braced frames in accordance with Table 12.2-1 lines B1 or D1	0.03 (0.0731)[a]	0.75
Steel buckling-restrained braced frames	0.03 (0.0731)[a]	0.75
All other structural systems	0.02 (0.0488)[a]	0.75

[a] Metric equivalents are shown in parentheses.

(Quotes from 12.8-2 ASCE 7-10)

Table 3.8 Coefficients for the upper limit of the period are counted

Design Spectral Response, S_{D1}	Coefficient C_u
≥ 0.4	1.4
0.3	1.4
0.2	1.5
0.15	1.6
≤ 0.1	1.7

(Quoted from Table 12.8-1ASCE 7-10)

3.3.7 Factors Earthquake Response

Earthquake response factor can be obtained by the following formula:

$$C_s = \frac{Sds}{\frac{R}{Ie}} \qquad (3\text{-}20)$$

Information :

Cs = coefficient of seismic response

S_{DS} = parameter in the design acceleration responsespectrum rangesshort period

R = the response modification factor

Ie = factor virtue earthquake

Cs value which is calculated according to the equation (3-20) does not have to exceed the following equation:

$$C_s = \frac{S_{DS}}{T\frac{R}{Ie}} \qquad (3\text{-}21)$$

With C_s :

C_s min = 0,044 S_{DS} l_e

C_s min = 0,01

$C_s \text{ min} = \frac{0{,}5\ Sds}{\frac{R}{Ie}}$ (just for $S_1 \geq 0{,}6$ g)

And then use the small C_s

3.3.8 Slide Style Earthquake

Seismic shear force obtained by the formula:

$$V = C_s\ W \tag{3-22}$$

Known ;

C_s = seismic respons coefisien
W = efective seismic weight

3.3.9 Distribution of lateral load on each floor

Obtained by the formula:

$$F_x = C_{vx}\ V \tag{3-23}$$

$$C_{vx} = \sum_{i=1}^{n} \frac{W_x h_x^k}{W_i h_i^k} \tag{3-24}$$

$$k = 0{,}5T + 0{,}75 \tag{3-25}$$

Information :

CVX	= vertical distribution factor
V	= the total design lateral force or shear at the base of the structure (W)(kN)
Wi and wx	= parts by weight of the total effectiveness of seismicstructure (W) areplaced or worn on a level i or x
hi and hx	= height from the base to the level i or x , (m)
k	= exponent associated with the period of the structurefor structures having a period of 0.5 secondsor less ,k = 1for structures having a period of 2.5 secondsor less , k = 2for structures having a period between 0.5 and 2.5second , k must be by 2 or be determined bylinear interpolation between the 1 and 2

3.4 Design Element Structure

3.4.1 Design of Slab

1. Determination of the type slab

There are two types of slabs that plate one-way and two-way slab

a. One way slab

One-way slab supported on two edgesface so that bending arises only in one direction.

b . Two way slab

Two-way slab supported on four edges,thus bending arising both directions.

When Ly / Lx < 2 using the table;

When Ly / Lx ≥ 2 , it can be calculated regarded as two platesdirections or regarded as a one-way plate structure with the main flexurein the direction of the shortest side.

2. Minimum Thickness Slab One Direction

Table 3.9 The minimum thickness of the slab in one direction when the deflection is not counted

<table>
<tr><td colspan="5">Tebal minimum, h</td></tr>
<tr><td rowspan="2">Komponen struktur</td><td>Tertumpu sederhana</td><td>Satu ujung menerus</td><td>Kedua ujung menerus</td><td>Kantilever</td></tr>
<tr><td colspan="4">Komponen struktur tidak menumpu atau tidak dihubungkan dengan partisi atau konstruksi lainnya yang mungkin rusak oleh lendutan yang besar</td></tr>
<tr><td>Pelat masif satu arah</td><td>1/20</td><td>1/24</td><td>1/28</td><td>1/10</td></tr>
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(Quoted from Table 9.5aSNI2847 2013)

Note:
Span in mm.
The values given should be used directly for structural components withnormal concrete and the yild stress of the reinforcement bars 420 MPa. For other conditions, the value inabove shall be modified as follows:

(A) For the structure of lightweight concrete with a specific gravity (density equilibrium), wc, inbetween 1440 to 1840 kg / m3 , the value had to be multiplied by (1.65 -0,0003wc) but not less than 1.09 .
(B) To fy other than 420 MPa, the value must be multiplied by (0.4 + fy/700).

2 Shrinkage and temperature reinforcement

Area of shrinkage and temperature reinforcement shall provide at least the following ratios of reinforcement area to gross concrete area, butnot less than 0.0014:

a. Reinforcement f_y = 280 or 350 MPa, min = 0.0020 As bh

b. Reinforcement f_y = 420 MPa, min = 0.0018 As bh

c. Reinforcement f_y> 420 Mpa, As min = 0.0018 (420/f_y)

Terms spaced main reinforcement and reinforcement shrinkage andtemperature:

a. Main reinforcement, have the smallest value

$s \leq 3h$ (h = slab thickness)

$s \leq 450$ mm

b. Reinforcement of shrinkage and temperature, have the smallest value

$s \leq 3h$ (h = slab thickness)

$s \leq 450$ mm

3.4.2 Design Beam

Design stages beam is done by ;

1. Determine f'c and f_y .
2. p = 0,01
3. Calculate $R_n = pf_y(1- 0.59\,\frac{pfy}{fc})$ (3-26)

   With ;
   R_n = coefisien of resistant
   p = rasio of reinforcement
   f'c = compresive strength of concrete
   f_y = yield stress of steel

4. Counting the moments due to factored loads, Mu, forecasted moment due to its own weight of the beam is 10% -20% Total load moments.
5. Determine the combination of b_w and d by the equation:

$$d = \overline{\frac{M_u}{0{,}9R_n b_w}} \qquad (3\text{-}27)$$

   Information :
   bw = Width of the beam section
   d = Effective height of the beam

6. Determining the value of h (high beam), rounding it up multiples of 50mm with regard to :
   a. High beam deflection minimum required in order not be examined
   b. If h_{aktual}<h_{min}beam, have to check the deflection use table 8 SNI 2847 2013
   c. b_w≥0,3 h or b_w≥250 mm (Pasal 21.5.1.3 SNI 2847:2013)
7. Recalculating the M_u by inserting its own weight can beam in the new M_u.

8. Determine flexural shear

1. Reinforcement for Bending

To pull the pedestal area taken $M_u = M_n$ value. Article 21.5.2.2 SNI 2847:2013, the power of positive moments in advance should join not less than half the power of negative moment (in the region urged M_u = new pedestal $0,5M_u$). Either negative or positive force momenton every cross section throughout the length of the structural components may not be less than a quarter of the maximum moment strength provided (On the drop area and urges courts new M_u = 0.25).

$$R_n = \frac{M_n}{bd^2} \quad (3\text{-}28)$$

$$\rho = \frac{0,85 f'_c}{fy}\left(1 - \sqrt{1 - \frac{2R_n}{0,85\, f'_c}}\right) \quad (3\text{-}29)$$

$$\rho_{min} = \frac{1,4}{fy} \quad \text{or,} \quad \rho_{min} = \frac{0,25\sqrt{f'c}}{fy} \quad (3\text{-}30)$$

For beam in special moment frame $\rho \leq 0.025$ (sect 21.5.2.1 SNI 2847:2013)

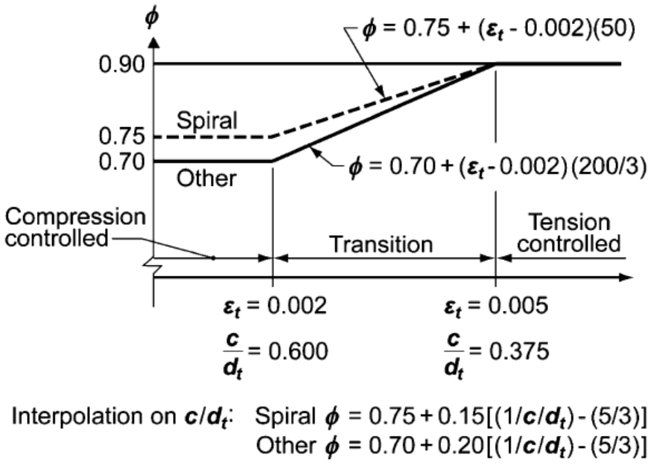
Requiredreinforcement $As = \rho b_w d$ (3-31)

Number of reinforcement $= \frac{As}{\text{area of 1 bar}}$ (3-32)

Determining a and c: $a = \frac{A_g f_y}{0,85 f'c b_w}$ andc $= \frac{a}{\beta_1}$

Calculate $\varepsilon_t = 0,003 \left(\frac{dt-c}{c}\right)$ (3-33)

Terms $\varphi M_n \geq M_u$



Graph 2.2 Variasi of ϕ

(from ACI 318M-11)

2. Shear Reinforcement

The initial step in determining the shear reinforcement beam islook for seismic shear force (V_e). Article 21.5.4.1 SNI 2847:2013 declaredthat the shear force V_e plan must be determined from a review of the static force on the component parts of the structure between the front face of the join. It is assumed that the moment of moments of opposite sign related to the strength of bending moments that may, M_{cre} work on faces pedestal, and the components of the structure burdened with the factored gravity load along its span.

The maximum value of flexural strength reinforcement can be calculated by:

$$M_{cre} = (I/y_t)(0,5\lambda \sqrt{f_c'} + f_{pe} + f_d) \qquad (3\text{-}34)$$

The shear forces caused by the earthquake is calculated by

$$V_{cw} = (0{,}29\lambda \sqrt{f_c'} + 0{,}3 f_{pc}) b_w \, d_p + V_p \quad (3\text{-}35)$$

Known :
M_{cre} = maximum flexural strength
A_s = extensive steel reinforcement is used.
Article 21.6.5.2 SNI 2847 2013 states that the plastic hinge region, Vc = 0 if both (a) and (b) occur:

a. Shear forces caused the earthquake, which is calculated in accordance with 21.6.5.1, representing half or more of the maximum shear strength necessary in the l_o.
b. factored axial compressive force, Pu, including the effect of the earthquake less than Agf'c/10.

If the shear contribution of concrete $V_c \neq 0$, Article 11.2.1.1 SNI 2847:2013 set a shear strength concrete for structural components subjected to shear and bending as follows:

$$V_c = 0{,}71\lambda \sqrt{f_c'} b_w d \quad (3\text{-}36)$$

With λ=1 for normal concrete

Nominal shear strength that must be retained by the shear reinforcement is calculated byequation:

$$V_s = \frac{Vu}{\emptyset} - V_c \quad (3\text{-}37)$$

Where , $$V_s \max = \frac{2}{3} \sqrt{f_c'} b_w d \quad (3\text{-}38)$$

Spaced shear reinforcement in accordance with Article 11.4.7.2 SNI 2847:2013 is calculated by the equation:

$$S = \frac{A_v f_y \mathrm{d}}{V_s} \tag{3-39}$$

According to Article 21.5.3.2 SNI 2847: 2013, the first closed stirrups should placed ≤50 mm from the face of structural components. Spaced cross bar shall not exceed:

a. d/4
b. 6 times the diameter of the main stem flexural
c. 150mm

According to Article 11.4.5.1 SNI 2847:2013 in areas that do not requireclosed stirrups, hooks sengka quake at both ends should be installed spaced not more d / 2 in the long span structural components.

3.4.3 Design of column

Estimated dimensions of the column is determined based on axial load work on that column. The work load includes dead load and live beams, plates, as well as the weight of the floors above the field. For non-prestressed structural components with reinforcement stirrup under section 10.3.6.2 SNI 2847:2013:

$$\phi P_{n\,max} = 0{,}8\phi\ [0{,}85\ f'c(A_g - A_{st}) + f_y A_{st}] \tag{3-40}$$

Where ϕ = 0,65

Slenderness Column

According to Article 10.10.1 SNI 2847:2013 for press structure components swaying, the effect may be ignored if the slenderness:

$$\frac{kl_u}{r} \leq 22 \tag{3-41}$$

Information :
k = effective length factor structure components press
r = radius of gyration of a cross-section of the structural components press
l_u = net long press structural components

Flexural strength

Flexural strength designed should have the power to detainbeam moment that works in both directions. Moment minimal designedminimum 20% larger than the beam moments sector in relation beamcolumns to prevent melting in the column is basically designedas a component of lateral load bearer. Article ACI 318M-11, thereequation :

$$M_{nc} \geq 1.2 \quad M_{nb} \qquad (3\text{-}42)$$

Where :

$\sum M_e$= nominal amount of the bending strength columns merangka into the joint,evaluated in face-to-face joint. The flexural strength of the fields must calculated for the factored axial force, consistent with the direction of lateral forces that review, which resulted in the lowest flexural strength.

M_g = the amount of bending strength merangka nominal beam into the joint, evaluated in face-to-face joint. At the T-beam construction, when slab in the drop due to the condition of the moments in front of the joint, reinforcement slab in the effective slab width defined in 8:12 should assumed to contribute to the Σnb if channeled slab reinforcement at the cross kriris for bending.

Shear Force

Based on ACI 318M-11 shear force design, V_e, should determined maximum moment of strong M_{pr} from each end of the structural components that meet the beam column.

According to ACI 318M-11 about planning a cross-slide must meet:

$$\varphi V_n \geq V_u \tag{3-43}$$

Where V_c is the nominal shear strength provided by the concrete is calculated, and V_s = is the nominal shear strength provided by shear reinforcement calculated.

$$V_n = V_c + V_s \tag{3-44}$$

Where V_c = is the nominal shear strength provided by the concrete is calculated in accordance with, and V_s= I_s the nominal shear strength provided by shear reinforcement calculated.

According to Article ACI 318M-11 planning cross-section of the shear must meet the following requirements:

$$\varphi V_n \geq V_u \tag{3-45}$$

Information
vc = nominal shear strength provided by concrete
Vs = nominal shear strength provided by shear reinforcement

According to Article 11.2.1.2 SNI 2847:2013, shear strength provided by the concrete for structural components loaded axial compressive force is determined by the following equation:

$$Vc = \left(1 + \frac{N_u}{14\,A\,g}\right)\left(\frac{\sqrt{f'c}}{6}\right) b_w d \qquad (3\text{-}46)$$

and

$$V_s = \frac{A_v f_y d}{s} \qquad (3\text{-}47)$$

Information :
Av = area of shear reinforcement
Vs = nominal shear strength contributed by the shear reinforcement
Ag = gross area column section
Nu = factored axial loads that occur
Bw = width of beam
Fy = yield stress of steel
f'c = compressive strength of concrete

Transversal Reinforcement for Column

The tip end of the column sufficient restraint necessary to ensure ductility in case of formation of plastic hinge. It is also necessary to prevent the first transverse reinforcement shear failure before reaching the cross section bending capacity and the second reinforcement bend.

According to Article 21.6.4.4 SNI 2847:2013, total cross-sectional area of reinforcement square stirrup determined:

$$A_{sh} = 0,3\frac{S_{bc} f'c}{f_{yt}}\left(\frac{A_g}{A_{ch}} - 1\right) \qquad (3\text{-}48)$$

$$A_{sh} = 0,9\,\frac{S_{bc} f'c}{f_{yt}} \qquad (3\text{-}49)$$

Information :
A_{sh} = total cross-sectional area enclosed stirrup square
A_g = gross cross-sectional area
A_{ch} = cross-sectional area of the outer side to side transverse reinforcement

Hc = dimensional cross-section of the left column measured from the axis to the axis of the reinforcementstraitjacket
S = spacing of reinforcement
f_{yh} = transverse reinforcement steel yield stress
f'c = compressive strength of concrete

Pursuant to Article 21.6.4.3 SNI 2847:2013, Space transverse reinforcement along long lo components of the structure shall not exceed the smallest of:

a. A quarter of the minimum dimensions of structural components;
b. Six times the diameter of the smallest longitudinal reinforcement rods; and
c. $S_o = 100 + \frac{350 - h_x}{3}$

Rated So should not exceed 150 mm and should not be less than 100 mm.

3.4.4. Beams Columns Joints

The important factor in determining the nominal shear strength of beams relationship column is effective area of the beam-column relationship. Relations beam column that is restrained by all four sides, the capacity or nominal shear strength relationship beam column according to SNI 2847:2013 amounted 1,7As $\sqrt{f'c}$ and beam columns confined in two opposite sides are 1,25As $\sqrt{f'c}$.