CHAPTER II

LITERATURE REVIEW AND THEORICAL FOUNDATION

2.1 GENERAL REVIEW

This literature review will discuss several journals and the theoretical basis regarding the planning of the Cirebon Cultural Center Building in general and using reinforced concrete. At the planning stage of the building structure, it is necessary to conduct a literature study to determine the relationship between the functional arrangement of the building and the structural system to be used, as well as to know the theoretical basis. In certain types of buildings, planners are often required to use patterns due to functional and structural requirements. This is one of the determining factors, for example in situations that require large spans of space, and must be free of columns, so that it will cause a larger load to be borne by the beam.

2.2 SIMILAR PLANNING

Research that has been carried out previously with case studies that have problems of analysis and discussion with similarities which can later be used as a reference in the preparation to be carried out, below are some analyzes of studies that have been carried out previously, including the following:

First Planning carried out by Deni Mardiana (2020) conducted a Building Structure Development Planning. The title of the research is **Analysis and Design The Structure Of Sangkan Hotel In Kuningan Regency**. The problem faced in the form of a hotel building that is still a little in the area so that it is not enough to accommodate the tourists who come to the Kuningan Regency area.

The second Planning carried out by Alya Tri Puspita Dewi (2021) carried out The Planning of Building Structure Construction. The title ofthe study is ***Perencanaan Struktur Gedung Hotel 5 Lantai Di Desa Linggarjati Kecamatan Cilimus Kabupaten Kuningan***. The problem faced in the form of a hotel building that is still a little in the area so that it is not enough to accommodate the tourists who come to the Kuningan Regency area.

Based on the results of the author's study of the three plans above about the planning of a building structure. The author judged that the closest and have similarities in terms of structural planning with the planning that the author did was the first planning.

2.3 THEORICAL FONDATION

2.3.1 REINFORCED CONCRETE

Nowadays, concrete is the most used material in the field of civil engineering, both in building buildings, bridges, Bendung, and other construction.

Simply put, concrete is formed by the hardening of the intermanagement mixture, water, fine aggregate (sand), and coarse aggregate (ruptured stone). Sometimes added other ingredients (admixture) to improve the quality of concrete. The mixture of stacking material (cement, sand, gravel, water) that is still plastic is casted into the reference and treated to accelerate the hydration reaction of the water cement mixture, which causes hardening of the concrete. This formed material has high compressive strength, but resistance to low tensile.

The mixture of cement and water will form a cement paste that serves as a connective material. mile sand and gravel is an aggregate material that is work as a filler, and also as a material that is tied by cement paste. The bond been cement paste and the aggregate becomes a compact unit, and finally the passage of time will be hard and solid called concrete.

1. Stacking Materials Requirements

The quality of concrete is determined by the quality of the ingredients. Therefore, in order to obtain good concrete, it must be selected good quality stacking materials. These good stacking materials have specific requirements that can be fulfilled.

A. Water Requirements

Water for the manufacture of concrete should be used drinkable clean water. Water taken from the ground (e.g. water wells) or water coming from drinking water companies, generally good enough when used for concrete manufacture.

B. Cement Requirements

Cement that is often used in Indonesia is divided into 5 types, namely:

1) Type I: Portland cement for general use, does not require any special requirements.
2) Type Il: Portland cement for sulphate resistant concrete and have medium hydration heat.
3) Type Ill: Portland cement for concrete with high initial strength (fast hardened).
4) Type IV: Portland cement for concrete that requires low hydration heat
5) Type V: Portland cement for concrete that is highly resistant to sulphate.

C. Sand Requirements

Sand is a fine aggregate that has a diameter of 1 mm - 5 mm. Sand used as concrete material, must meet the following conditions:

1) Sharp and loud-based.
2) is eternal, which is not easily weathered/destroyed by weather changes, such as the sun and rain.
3) Not allowed to be used by sea sand (except with expert staff instructions), because this sea sand contains many salt that can damage concrete/steel reinforcement.

D. Gravel Requirements

Gravel is a rough aggregate that has a diameter of 5mm — 40mm. In lieu of gravel, the split stone can also be worn. Gravel or stone rupture that has a diameter over 40mm is not good for the manufacture of concrete.

Gravel or broken stone used as concrete material, must meet the following conditions:

a) is solid and hard, non-porous.
b) Should be clean, should not contain mud more than 1%. If the mud content is more than 1% then the gravel/stone rupture should be washed.
c) In the event of forced gravel, can be worn round.

2.3.2 BASIC PLANNING

1. Dead Load

The dead load is the weight of all parts of a building that are fixed, including all additional elements, settlements, fixed machines and equipment that are an integral part of the building. For the purposes of analysis and design of building structures, the magnitude of the dead load must be estimated or determined in advance.

Dead loads are those that work down on the structure and have building characteristics, such as floor coverings, mechanical tools, and partitions. The unit weight or weight itself of some construction materials and building components of the building can be determined from the regulations that apply in Indonesia, namely the Indonesian Loading Regulation for Buildings 1983 or the 1987 regulation.

A. Building Materials

Table 2.1 Own weight of building materials

No.	Material	Weight	Explanation
1	Steel	7850 Kg/m^3	
2	Natural Stone	2600 Kg/m^3	
3	Split stone, round stone, mountain rock	1500 Kg/m^3	Heavy stack
4	Coral Reef	700 Kg/m^3	Heavy stack
5	Broken Stone	1450 Kg/m^3	
6	Stone Rock	7250 Kg/m^3	
7	Concrete	2400 Kg/m^3	
8	Reinforced Stone	2400 Kg/m^3	
9	Wood	1000 Kg/m^3	Class 1
10	Gravel, Coral	1650 Kg/m^3	Dry the air until it's moist, without stiffing
11	Red Stone Pair	1700 Kg/m^3	

12	Split stone pair, round stone, mountain rock	2200 Kg/m^3	
13	Slit stone pair	2200 Kg/m^3	
14	Pair of rock	1450 Kg/m^3	
15	Sand	1600 Kg/m^3	Dry the air until it's moist
16	Sand	1800 Kg/m^3	Saturated water
17	Gravel Sand, Coral	1850 Kg/m^3	Dry the air until it's moist
18	Soil, Clay and Slit	1700 Kg/m^3	Dry the air until it's moist

Source : *Pedoman Perencanaan Pembebanan untuk Rumah dan Gedung*

B. Building Components

Table 2.2 Own weight of building components

No.	Material	Weight	Explanation
1.	Stir, per cm thick : • From cement • From chalk, red cement/trash	21 Kg/m^2 17 Kg/m^2	
2.	Asphalt, per cm thick	14 Kg/m^2	
3.	Concrete brick wall : • One stone • Half a stone	450 Kg/m^2 250 Kg/m^2	

4.	Concrete brick wall : Hollow : • Thick wall 20 cm (HB 20) • Thick wall 10 cm (HB 10) Without holes : • Thick wall 15 cm • Thick wall 10 cm	200 Kg/m^2 120 Kg/m^2 300 Kg/m^2 200 Kg/m^2	
5.	Ceiling & walls, consisting of: • Asbestos cement (eternity), Thickness max 4 mm • Glass, thick 3-5 mm	11 Kg/m^2 10 Kg/m^2	Including ribs, without hangers or stiffeners
6.	Simple wooden floor with wooden beams.	40 Kg/m^2	No celling, max 5 m span, max life load 200 kg/m2
7.	Ceiling hangers (wood)	7 Kg/m^2	Max span is 5m, distance s.k.s min 0,80 m
8.	Roof tile cover	50 Kg/m^2	With battens and swabs per m2 roof area
9.	Shingle roof covering	40 Kg/m^2	With battens and swabs
10.	Wave zinc roof cover (BJLS-25)	10 Kg/m^2	Without battens
11.	Title floor cover, 7 cm thick	24 Kg/m^2	Portland cement tiles, terrazzo and concrete, without stirring
12.	Asbestos cement waves (5 mm thick)	11 Kg/m^2	

Source : *Pedoman Perencanaan Pembebanan untuk Rumah dan Gedung*

2. Live Load

The burden of life is a burden that occurs due to the occupancy / use of a building and its depth including loads on the floor derived from moving goods, machinery and equipment that are parts of the building that are inseparable from the building and can be replaced during the life span of the building, resulting in changes in the loading of the floor and roof.

The amount of the burden of life is divided evenly equivalent which must be taken into account on the structure of the building, in general it can be determined based on applicable standards. In planning the constructionof the hall to accommodate the implementation of the burden of life in accordance with the function of the room that has been planned, in this case the loading refers to SNI 1727:2020 for building buildings for building buildings areas follows:

1) Live Load on the Building Floor

Table 2.3 Live load on the building floor

Occupancy or use	Evenly, Lo psf (kN/m^2)	Live load reduction allowed? (Article No.)	Multi-story live load reduction allowed? (Article No.)	Centered lb (kN)	Also See Article
Apartments (see residential houses)					
Access floor system					
Office room	50 (2,4)	Yes (4.7.2)	Yes (4.7.2)	2.000 (8,9)	
Computer room	100 (4,79)	Yes (4.7.2)	Yes (4.7.2)	2.000 (8,9)	
Armory and training room	150 (7,18)	No (4.7.5)	No (4.7.5)		
Meeting room					
Fixed seat (bound to floor)	60 (2,87)	No (4.7.5)	No (4.7.5)		
Lobby	100 (4,79)	No (4.7.5)	No (4.7.5)		

Seats can be moved	100 (4,79)	No (4.7.5)	No (4.7.5)		
Meeting stage	100 (4,79)	No (4.7.5)	No (4.7.5)		
podium floor	150 (7,18)	No (4.7.5)	No (4.7.5)		
	100 (4,79)				4.14
Spectator stands Stadiums and arenas with fixed seats (tied to the floor)	60 (2,87)	No (4.7.5)	No (4.7.5)		4.14
More meeting rooms	100 (4,79)	No (4.7.5)	No (4.7.5)		
Balcony and deck	1.5 times the live load for the area served. No need to exceed 100 psf (4.79 kN/m2)	Yes (4.7.2)	Yes (4.7.2)		
Path for maintenance access	40 (1,92)	Yes (4.7.2)	Yes (4.7.2)	300 (1,33)	
Corridor					
First floor	100 (4,79)	Yes (4.7.2)	Yes (4.7.2)		
Another floor	Same as residential service unless stated otherwise				
Dining room and restaurant	100 (4,79)	No (4.7.5)	No (4.7.5)		
Occupancy (see residence)					
Elevator machine seat					
(at a 2 in. x 2 in. [50 mm x 50 mm] area)		-	-	300 (1,33)	
Lightweight finishing floor slab construction					
(in a 1 in. x 1 in. [25 mm x 25 mm] area)		-	-	200 (0,89)	

Fire escape route	100 (4,79)	Yes (4.7.2)	Yes (4.7.2)		
Only one family occupancy	40 (1,92)	Yes (4.7.2)	Yes (4.7.2)		
Garage/Parking (See Article 4.10)					
Passenger car only	40 (1,92)	No (4.7.4)	Yes (4.7.4)	See Article 4.10.1	
Truck and Bus	See Article 4.10.2	-	-	See Article 4.10.2	
Handrails and safety railings	See Article 4.5.1	-	-	See Article 4.5.1	
handle rod				See Article 4.5.2	
Helipad (See Article 4.11)					
Helicopters with a take-off weight of 3,000 lb (13.35 kN) or less	40 (1,92)	No (4.11.1)	-	See Article 4.11.2	
Helicopters with take-off weight Over 3,000 lb (13.35 kN)	60 (2,87)	No (4.11.1)	-	See Article 4.11.2	
Hospital					
Operating room, laboratory	60 (2,87)	Yes (4.7.2)	Yes (4.7.2)	1.000 (4,45)	
Patient room	40 (1,92)	Yes (4.7.2)	Yes (4.7.2)	1.000 (4,45)	
Corridor above the first floor	80 (3,83)	Yes (4.7.2)	Yes (4.7.2)	1.000 (4,45)	
Hotel (see residence)					
Library					
Reading room	60 (2,87)	Yes (4.7.2)	Yes (4.7.2)	1000 (4,45)	
Storage room	150 (7,18)	No (4.7.3)	Yes (4.7.3)	1000 (4,45)	4.13
Corridor above the first floor	80 (3,83)	Yes (4.7.2)	Yes (4.7.2)	1000 (4,45)	
Factory					
Light	125 (6,00)	No (4.7.3)	Yes (4.7.3)	2000 (8,90)	

Heavy	250 (11,97)	No (4.7.3)	Yes (4.7.3)	3000 (13,35)	
Office building					
File and computer rooms should be designed for heavier loads based on estimated occupancy					
First floor lobby and corridor	100 (4,79)	Yes (4.7.2)	Yes (4.7.2)	2000 (8,90)	
Office	50 (2,40)	Yes (4.7.2)	Yes (4.7.2)	2000 (8,90)	
Corridor above the first floor	80 (3,83)	Yes (4.7.2)	Yes (4.7.2)	2000 (8,90)	
Legal institution					
cell block	40 (1,92)	Yes (4.7.2)	Yes (4.7.2)		
Corridor	100 (4,79)	Yes (4.7.2)	Yes (4.7.2)		
Recreation areas					
Bowling, billiards and similar uses	75 (3,59)	No (4.7.5)	No (4.7.5)		
Dance hall and ballroom	100 (4,79)	No (4.7.5)	No (4.7.5)		
Gym	100 (4,79)	No (4.7.5)	No (4.7.5)		
Residential home					
One and two family occupancy					
Uninhabitable attic without warehouse	10 (0,48)	Yes (4.7.2)	Yes (4.7.2)		4.12.1
Uninhabitable attic with warehouse	20 (0,96)	Yes (4.7.2)	Yes (4.7.2)		4.12.2
Liveable attic and bedroom	30 (1,44)	Yes (4.7.2)	Yes (4.7.2)		
All rooms except stairs	40 (1,92)	Yes (4.7.2)	Yes (4.7.2)		
All other residential houses					
Private rooms and corridors	40 (1,92)	Yes (4.7.2)	Yes (4.7.2)		
Public area	100 (4,79)	No (4.7.5)	No (4.7.5)		
Public space corridor	100 (4,79)	Yes (4.7.2)	Yes (4.7.2)		
Roof					

Flat, pitched and arched roofs	20 (0.96)	Yes (4.8.2)	-		4.8.1
The roof used by residents	Same as serviced usage	Yes (4.8.3)	-		
Roof for gathering	100 (4,70)	Yes (4.8.3)	-		
Vegetative roof and landscaping roof					
The roof is not for housing	20 (0,96)	Yes (4.8.2)	-		
Roof for gathering	100 (4,79)	Yes (4.8.3)	-		
Roof for other uses	Same as serviced usage	Yes (4.8.3)	-		
Awnings and canopies					
Fabric construction roof supported by lightweight rigid frame structure	5 (0,24)	No (4.8.2)	-		
Cover screen support frame	5 (0.24) based on the tributary area of the roof supported by the truss members	No (4.8.2)	-	200 (0.89)	
All other construction					
The main roof structure component, which is directly connected to the work floor	20 (0,96)	Yes (4.8.2)			4.8.1
Single panel point of the bottom truss of the roof truss or a point along the main structural member supporting the roof over		-	-	2000 (8,90)	

factories, warehouses and workers, and workshop garages					
All other major roof structure components		-	-	300 (1,33)	
All roof surfaces with maintenance worker load		-	-	00 (1,33)	
School					
Class room	40 (1,92)	Yes (4.7.2)	Yes (4.7.2)	1.000 (4,45)	
Corridor above the first floor	80 (3,83)	Yes (4.7.2)	Yes (4.7.2)	1.000 (4,45)	
First floor corridor	100 (4,79)	Yes (4.7.2)	Yes (4.7.2)	1.000 (4,45)	
Scuttles, ribs for glass roofs and accessible ceilings				200 (0,89)	
Sidewalks for pedestrians, driveways and land/roads for trucks	250 (11,97)	No (4.7.3)	Yes (4.7.3)	8.000 (35,60)	4.15
Stairs and exits	100 (4,79)	Yes (4.7.2)	Yes (4.7.2)	300 (1,33)	4.16
Residential house for one and two families only	40 (1,92)	Yes (4.7.2)	Yes (4.7.2)	300 (1,33)	4.16
Warehouse above the ceiling	20 (0,96)	Yes (4.7.2)	Yes (4.7.2)		
Warehouse storage and workers (should be designed for heavier loads if required)					
Light	125 (6,00)	No (4.7.3)	Yes (4.7.3)		
Heavy	250 (11,97)	No (4.7.3)	Yes (4.7.3)		
Shop					
Retail					
First floor	100 (4,79)	Yes (4.7.2)	Yes (4.7.2)	1.000 (4,45)	
The floor above	75 (3,59)	Yes (4.7.2)	Yes (4.7.2)	1.000 (4,45)	
Wholesale, on all floors	125 (6,00)	No (4.7.3)	Yes (4.7.3)	1.000 (4,45)	

Vehicle barrier					See Article 4.5.3
Railings and raised platforms (other than exits)	60 (2,87)	Yes (4.7.2)	Yes (4.7.2)		
Yards and terraces, walking paths	100 (4,79)	No (4.7.5)	No (4.7.5)		

Source: SNI – 1727 – 2020 Minimum Load of buildings (Article 4.3)

3. Earthquake Load

Earthquake load is the load that arises due to the acceleration of ground vibrations when an earthquake occurs. To plan earthquake-resistant building structures, it is necessary to know the classification of the soil site and the acceleration that occurs in the bedrock.

1. Soil Site Classification

SNI Earthquake 1726:2019 (BSN 2019) Article 5, as shown in table 2.1 (or Table 5, Site Classification in SNI Earthquake 1726:2019), classifies soil sites into 6 groups. Grouping is based on

Table 2.4 Site classification (SNI 1726:2019, Table 5)

Site Class	v_s (m/second)	N or N_{ch}	S_u (kPa)
SA (hard rock)	> 1500	N/A	N/A
SB (rock)	750 until 1500	N/A	N/A
SC (hard soil, very dense and soft rock)	350 to 750	> 50	≥100
SD (medium ground)	175 until 350	15 until 50	50 until 100
SE (soft soil)	< 175	< 15	< 50

	Or any soil profile containing more than 3 m of soil with the following characteristics: 1. Plasticity index, PI > 20 , 2. Moisture content, w ≥ 40% , 3. Shear strength without $_{su}$ 25 kPa
SF (special soil, which requires a specific geotechnical investigation and site-specific response analysis following 0)	Any subsoil profile that has one or more of the following characteristics: - Vulnerable and potentially fail or collapse due to earthquake loads such as easy liquefaction, very sensitive clay, weak cemented soil - Highly organic clay and/or peat (H thickness > 3 m) - Very high plasticity clay (H thickness > 7.5 m with plasticity index PI 75) Soft/semi-firm clay layer with H thickness > 35 m with su 50 kPa

NOTE: N/A = cannot be used

2. Building Category

Building risk categories are distinguished according to the function and the building. Many factors affect the level of building risk categories, such as the level of risk to the human soul when a failure occurs, causing economic impacts or mass disturbances to people's lives in the event of a failure, as well as the necessity to maintain the function of the building structure in accordance with SNI 1726:2019 Table 3.

Table 2.5 Building and non-building risk categories for earthquake loads (SNI 1726:2019 Table 3)

Type of Utilization	Risk Category
Buildings and non-buildings that have a low risk to the human psyche in the event of a failure, including, but not limited to, among others: - Agricultural facilities, plantations, farms and fisheries - Temporary facilities - Storage building - Home Guard and other small structures	I
All structure of buildings and other structures, including the risk category I, Ill, IV, including but not limited to: - Housing - Home shop and Home Office - Market - Office buildings - Apartment building/stacked House - Shopping Center/Mall - Industrial Building - Manufacturing facilities	II

- Factory	
Buildings and non-buildings with a high risk to the human psyche in the event of a failure, including, but not limited to: - Cinema - Meetinghouse - Stadion - Health facilities that do not have a surgical unit and emergency unit - Childcare facilities - Prison - Building for the elderly Buildings and non-buildings that do not belong to the risk of IV have the potential to cause large economic impacts and/or mass disruption to the lives of everyday society in the event of failure, including, but not limited to: Ordinary power station. - Ordinary power station - Water treatment facilities - Waste handling facilities - Telecommunication Center Buildings and non-buildings that do not belong to the risk of IV (including, but not limited to manufacturing, handling, storing,	III

utilization of hazardous fuel disposal, hazardous chemicals, hazardous waste, or explosive materials) that contain toxic or explosive materials where the amount of material content exceeds the value of the limit that is inscribed by the authorities and poses enough ham to the community in case of leakage.	
Buildings and non-buildings that are indicated by important facilities, including, but not limited to: - Monumental buildings - School buildings and educational facilities - Hospitals and other health facilities that have surgical facilities and emergency units - Firefighting facilities, ambulance and police station and emergency vehicle garage - Sanctuary against earthquakes, winds, storms, and other emergency shelter. - Emergency readiness, communication, Operation Center and other facilities for emergency response - Energy generation centers and other public facilities required during emergencies	IV

- Additional structures (including telecommunication towers, fuel storage tanks, cooling towers, electric station structures, water tanks, fire extinguishers) that are hinting to operate during emergencies. Buildings and non-buildings needed to maintain the functions of other building structures including the IV risk category	

Sources : SNI 1726:2019 (Category risks of building and non-building)

3. Seismic Design Category

All structures should be assigned a design category of seismic based on their risk category and their design acceleration spectral response parameters, S_{DS} and $S_{D1.}$

Table 2.6 Seismic design category based on the acceleration response parameters on short period

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

Sources : (SNI 1726:2019, Table 8)

Table 2.7 Seismic design categories based on acceleration response parameters at 1 s stain

Value S_{DS}	Risk Category	
	I or II or III	IV
$S_{DS1} < 0,067$	A	A
$0,067 \leq S_{D1}$ 0,133	B	B
$0,133 \leq S_{D1} < 0,20$	C	C
$0,20 \leq S_{D1}$	D	D

Sources : (SNI 1726:2019, Table 9)

To determine the value of S_{DS} and S_{D1} can be obtained from; nital parameter of response acceleration spectra forging (S_S) and (S_1) on the map of the Indonesian earthquake map.

SNI 1726:2019

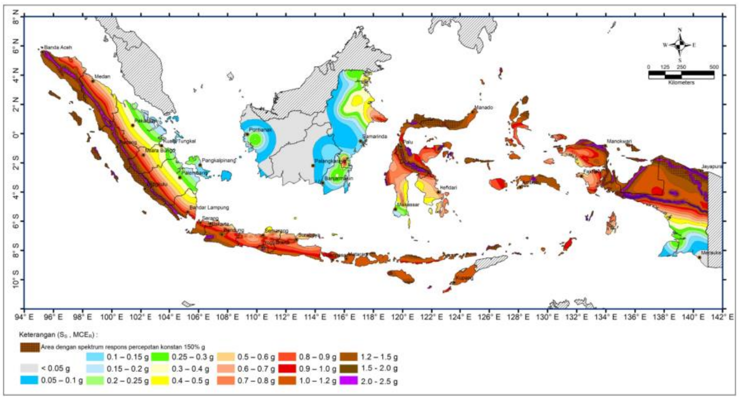


Figure 2.1 Ground motion parameter Ss, maximum considered-risk-targeted earthquake (MCER) (SNI 1726:2019 Figure 15)

SNI 1726:2019

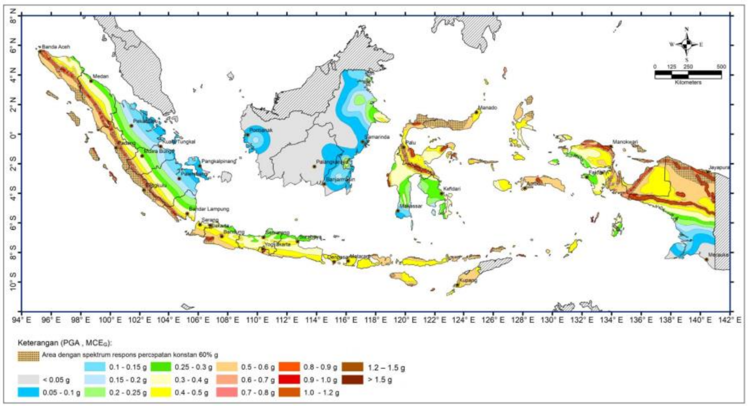


Figure 2.2 Ground motion parameter, S1, maximum considered risk-targeted earthquake (MCER) (SNI 1726:2019 Figure 16)

Parameters of acceleration response spectrum at short period (Sms) and 1 second period (sm1) adjustable by the effect of site classification, should be determined by the following formulation in accordance with SNI 1726.2019 and press 8.

$SMS = F_A S_S$

$SM1 = F_V S1$

Information:

SS = MCER earthquake acceleration spectral response parameter mapped for a short period,

S1 = MCER earthquake acceleration spectral response parameter mapped for a period of 1 second.

FA = Amplification factor includes vibration amplification factor related to acceleration in short period vibration.

FV = Acceleration related amplification factor representing the vibration period of 1 second.

The coefficients of Fa and FV follow the following table:

Table 2.8 Site Coefficient, Fa (SNI 1726:2019 Table 6)

Site Class	**The risk-targeted maximum considered seismic acceleration spectral response parameter (MCER) is mapped over a short period, T = 0.2 seconds, Ss**					
	Ss ≤ 0,25	Ss = 0,5	Ss = 0,75	Ss = 1,0	Ss = 1,25	Ss ≥ 1,5
SA	0,8	0,8	0,8	0,8	0,8	0,8
SB	0,9	0,9	0,9	0,9	0,9	0,9
SC	1,3	1,3	1,2	1,2	1,2	1,2
SD	1,6	1,4	1,2	1,1	1,0	1,0
SE	2,4	1,7	1,3	1,1	0,9	0,8
SF	SS(a)					

Notes: [a]SS-Sites that require a specific Geotechnical Investigation and site-specific response analysis

Table 2.9 Site Coefficient, Fv (SNI 1726:2019 Table 7)

Site Class	The risk-targeted maximum considered seismic acceleration spectral response parameter (MCER) is mapped over a short period, T = 0.2 seconds, Ss					
	Ss ≤ 0,1	Ss = 0,2	Ss = 0,3	Ss = 0,4	Ss = 0,5	Ss ≥ 0,6
SA	0,8	0,8	0,8	0,8	0,8	0,8
SB	0,8	0,8	0,8	0,8	0,8	0,8
SC	1,5	1,5	1,5	1,5	1,5	1,4
SD	2,4	2,2	2,0	1,9	1,8	1,7
SE	4,2	3,3	2,8	2,2	2,2	2,0
SF	SS(a)					

Notes: [(a)] SS= Sites requiring specific geotechnical investigations and site-specific response analysis

The design spectra acceleration parameters for the short period (sds) and in the 1 second period (sd1) should be determined through the following formulation of SNI 1726 2019 pers 9 and pers 10.

$$S_{DS} = \frac{2}{3} S_{MS}$$

$$S_{D1} = \frac{2}{3} S_{M1}$$

4. Design Response Spectrum

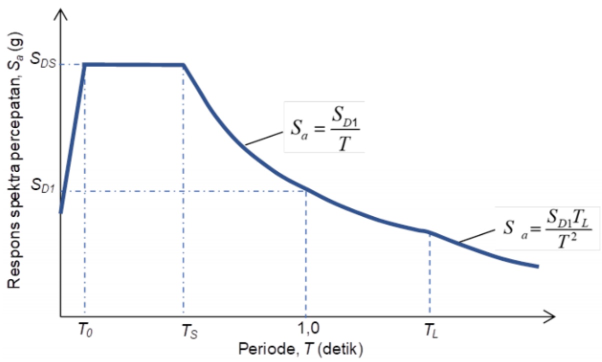


Figure 2.3 Design response spectrum (SNI 2847:2019 Figure 3)

$T_0 = 0{,}2\,\frac{SD1}{SDS}$

$T_S = \frac{SD1}{SDS}$

T_L = The long-period transition map shown in Figure 2.6 whose values are taken from picture 20 on SNI 1726:2019.

Provisions for the calculation of the response spectrum according to SNI 1726:2019 Article 6.4 The design response spectrum.

1) For periods smaller than to, the design acceleration response spectrum, Sa must be taken from the equation:

$$S_a = S_{DS}\left(0,4 + 0,6\frac{T}{T_0}\right)$$

2) For periods greater than or equal to T_0 and less than or equal to Ts, the design acceleration response spectrum, S_a, is equal to S_{DS};
3) For periods greater than T_s but less than or equal to T_L, the design acceleration spectral response, S_a, is taken according to the equation:

$$S_a = \frac{S_{D1}}{T}$$

4) For periods greater than T_L, the design acceleration spectral response, S_a, is taken according to the equation:

$$S_a = \frac{S_{D1}T_L}{T^2}$$

Information:

SDS = design acceleration spectral response parameter in the short period;

SD1 = design acceleration spectral response parameter over a period of 1 second;

T = period of fundamental vibration of the structure

4. Wind Load

The amount of wind load acting on the building structure depends on wind speed, confluence of air masses, geographical location, shape and height of the building, and structural rigidity. The building that has the upper hand trajectory, will cause the wind to spin or may stop. As a result, the kinetic energy of the wind will change to potential energy, in the form of pressure or suction on building.

The wind loads used in the design of the main wind load retaining system (SPBAU) should be designed with the minimum design wind loads for enclosed or partially enclosed buildings that cannot be smaller than 16 lb/ft2 (0.77 kN/m2) multiplied by the wall area of the building and 8 lb/ft2 (0.38 kN/m2) multiplied by the roof of the building that is projected on the vertical plane perpendicular to the assumed wind. Wall and roof loads should be applied simultaneously.

The general requirements of use define basic parameters for wind load determination in the main wind load retaining system (SPBAU), the basic parameters are:

Wind speed base wind speed base (V), which is used in determining the wind load design in buildings and other structures must be determined from the authorized institution, in.

A. accordance with the risk category of building buildings and structures.
B. Wind direction factor the wind influence in determining the wind load should be based on the analysis for wind speed.

Table 2.10 Wind Direction Factor

Structure type	**Wind Direction Factor K**
Building Main wind load retaining system Components and Klading	0,85
Curved Roof	0 85
Round Shaped Dome	1,0[a]
Chimneys, tanks and similar structures Rectangle Hexagon Octagonal Round	0,90 0,95 095 1,0[a] 1,0[a]
reestanding Wall Stand Free nd free-standing, solid signage and boards 10) billboards tied	0,85
Open signage and lattice frameworks	0,85
Tower Rod Frame triangle, rectangular, Rectangular their sections	0,85 0,95
Note: Wind direction [a]factor Kd = 0.95 is permitted for circular structures or octagonal structures with non-asymmetric structural systems.	

Sources: SNI 1727:2020 Table 26.6-1 Wind Direction Factor, K_d

C. Exposure to each wind direction is taken into account, the exposure of the opponent wind is based on the determined ground surface roughness of the topography of nature, vegetation, and facilities built.

D. Topographical factors of increased wind speed should be included in the calculation of design wind loads.

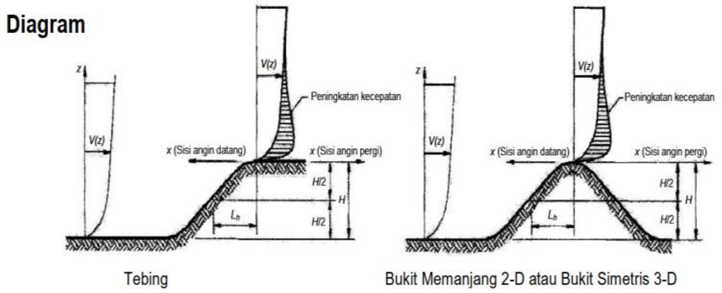


Figure 2.4 Topographical factors

If the condition of the site and building location and other building structures do not meet all the required conditions then, KZT = 1.0

E. Wind blowing effect the wind-blowing effect (G), for a building and other rigid structures, can be taken at 0.85. Flexible sensitive buildings or dynamic sensitive buildings or other structures, wind blowing effect factors should be calculated by:

$$G_f = 0{,}925\left(\frac{1+1{,}7 I_{\bar{z}}\sqrt{g_Q^2 Q^2 + g_R^2 R^2}}{1+1{,}7 g_v I_{\bar{z}}}\right)$$

g_Q and g_v must be taken as 3.4 and g R is

$$g_R = \sqrt{2\ln(3.600 n_1)} + \frac{0{,}577}{\sqrt{2\ln(3.600 n_1)}}$$

R, is a resonant response factor

F. Internal pressure coefficient Internal pressure coefficient value (GCpi) is determined based on the classification of the building.

Table 2.11 Internal Pressure coefficient

Cover classification	Criteria for classification of closure	Internal pressure	(GC_{pi})
Open air Buildings	Each wall is at least 80% open	Ignore	0,00
Partially enclosed building	Ao > 1.1Aoi and Ao > less than 0.01Ag or 4 ft2 (0.37 m2) and Aoi/Agi 0.2	High	- 0,55 - 0,55
Partially open building	Buildings that do not conform to the closed, partially enclosed, or open classification	Currently	- 0,18 - 0,18
Enclosed buildings	Ao less than the smallest 0.01Ag or 4 ft2 (0.37 m2) and Aoi/Agi 0.2	Currently	- 0,18 - 0,18

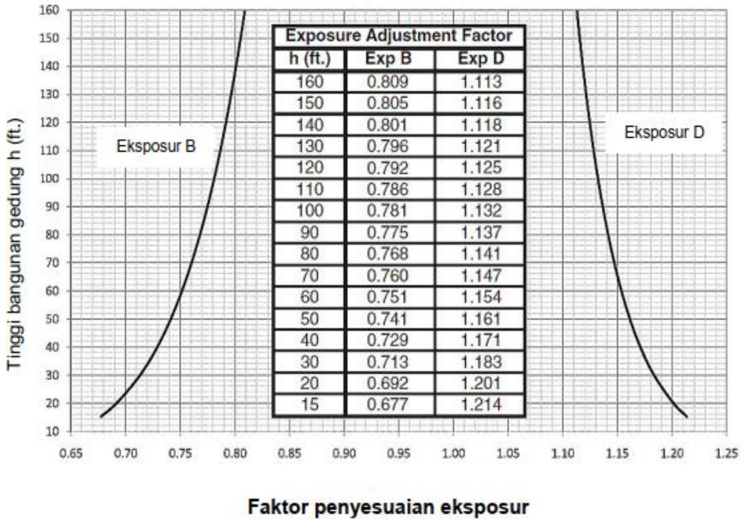
Note :

1. The plus and minus signs indicate the pressure acting towards and away from the inner surface, respectively
2. Value (GCpi) should be used with qz or qh as required.
3. Two cases must be taken into account to determine the critical load requirements for the condition appropriate:
   a) A positive value (GCpi) is applied to all inner surfaces, or
   b) A negative value (GCpi) is applied to all inner surfaces.

Exceptions : Other test methods and/or performance criteria are permitted to be used if approved.

Sources : SNI 1727:2020, Table 26.13.1

G. Pressure exposure coefficient of velocity based on the category of exposure the value of exposure coefficient velocity pressure, Kz or Kh obtained from the table.



Exposure Adjustment Factor		
h (ft.)	Exp B	Exp D
160	0.809	1.113
150	0.805	1.116
140	0.801	1.118
130	0.796	1.121
120	0.792	1.125
110	0.786	1.128
100	0.781	1.132
90	0.775	1.137
80	0.768	1.141
70	0.760	1.147
60	0.751	1.154
50	0.741	1.161
40	0.729	1.171
30	0.713	1.183
20	0.692	1.201
15	0.677	1.214

Figure 2.5 Exposure adjustment factor, exposure B and D

H. Velocity pressure

$$Q_z = 0{,}613\ K_z\ K_zT\ K_dV\ (N/m^2)$$

Where:

Kd = Wind direction factor.

Kz = exposure coefficient of velocity pressure.

KZT = topographical factor.

V = base wind speed.

QZ = velocity pressure at z height.

QH = velocity pressure on average height h

I. Wind Load Diagram

$$P = {}_qGC_p - {}_{qi}\ GC_{pi}\ (N/m^2)$$

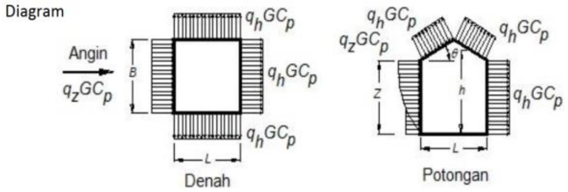


Figure 2.6 Wind load design

Notation:

B = horizontal dimension of the building, measured perpendicular to the wind direction, in ft (m)

L = horizontal dimension of the building, measured parallel to the wind direction, in ft (m)

h = average roof height, in ft (m), the height of the underside of the roof must be used if θ ≤ 10 degrees

z = height above ground, in ft (m)

G = wind gust influence factor

g_z, q_h = pressure velocity, in lb/ft2 (N/m2), evaluated at each altitude

θ = angle of the roof plane from the horizontal, in degrees.

Sources: SNI 1727:2020 *(Gambar 27.3-1) – (Sistem Penahan Gaya Angin Utama, Bagian 1 (seluruh ketinggian): koefisien tekanan eksternal,* Cp*, untuk bangunan tertutup dan bangunan tertutup sebagian dinding dan atap*).

5. Rain Load

Each part of the roof must be designed to be able to withstand the load of rainwater that accumulates when the primary drainage system in that section is blocked plus a uniform load due to the increase of water above the inlet of the secondary drainage system in its design flow.

$$\mathbf{R = 5{,}2\ (d_s + d_h)}$$

$$\mathbf{R = 0{,}0098\ (d_s + d_h)}$$

If the secondary drainage system consists of several canals, these drains and the point of discharge must be separated from the primary drain. The rainwater load shall be based on the total height (static height [ds] plus hydraulic head [dh]) associated with the design flow rate for the drainage system and drains. specified secondary. The total height corresponding to the design flow rate for the specified line shall be based on the hydraulic test data.

Symbol:

D_h = additional depth of water in the non-flexible roof above the inlet of the secondary drainage system in its design flow (ie, hydraulic head), in inches. (mm)

D_s = depth of water on the roof that does not deflect rising to the inlet of the secondary drainage system when the primary drainage system is closed (ie, static height), in inches. (mm)

R = rainwater load on a non-flexible roof, in lb/ft2 (kN/m2). Where the term "roof that is not deflected" is used, the deflection of the load (including dead load) need not be taken into account when determining the amount of rainwater on the roof.

6. Elevator Loading

1) Load acting on the girder

The loads acting on the girders are dead loads (slabs, asphalt, ducting, etc.) and live loads.

2) Faucet live load shock coefficient

Article 3.3 (3) of the 1983 PPIUG states that the load burdening the bearer consists of its own weight plus the load being lifted. As a design load, the workload must be taken by multiplying it by a shock coefficient determined by the following formula

$$\Psi = (1 + k_1 k_2 V) \geq 1{,}15$$

Information:

Ψ = shock coefficient whose value should not be taken less than 1,15.

V = The maximum lifting speed in m/s at the maximum lifting of the load in the most attractive main and lifting crane positions for the structure under consideration, and its value need not be taken more than 1.00 m/s

K_1 = The coefficient that depends on the stiffness of the main crane structure, which for a main crane with a frame structure, in general its value can be taken as 0.6

K_2 = The coefficient which depends on the nature of the lifting machine of the lifting crane, and is taken as 1.3

According to SNI PPIUG 1983 article 3.1 Electrical mechanical live loads in the Floors for: factories, workshops, warehouses, libraries, archive rooms, bookstores, iron shops, tool rooms and machine rooms, must be designed against a live load that is determined separately, with a minimum of 400 Kg/m^2.

7. Load Combination

The combination load is calculated based on the likelihood of the load acting on the structure at the same time during the plan. Combination of loading caused by the dead loads, live loads, earthquake loads, rain loads and wind loads simultaneously. The values are multiplied by a factor load magnification called load factor, it is intended that the structure and components become more secure, qualified strength and unsuitable for use against various combinations of the load.

Combination of loading with Load Factor which is used in accordance with SNI 2847:2019 Article 5.3.1. The following are, the load combination that refers to load minimum:

1. 1.4D
2. 1.2D + 1.6L + 0.5 (Lr or S or R)
3. 1.2D + 1.6 (Lr or S or R) + (L or 0,5W)

4. 1.2D + 1.0W + L + 0.5 (Lr or S or R)
5. 1.2D + 1.0E + L + 1.0L
6. 0.9D + 1.0W
7. 0.9D + 1.0E

Where:

D = Dead Load

L = Live Load

R = Rain Load

W = Wind Load

E = Earthquake Load

Lr = Roof Load

S = Snow Load

8. Load Combination on Portal Structure

In Indonesia, in general, the design life of the building structure the average is 50 years. Therefore, during the life of the plan, building structures that must be able to accept or assume a wide variety of combinations of load that may occur. The loads acting on the building structure, can be any combination of multiple load cases occurring simultaneously.

To ensure that a building structure can persist for the life of the plan, then the design process of the structure, necessary to review some combination of loading that may occur in structure. Load combination that must beconsidered in the design of building structure is:

A. Fixed Loading Combination

Loading at this fixed combination, the burden to be calculated work on the structure is (SNI 1727:2020).

B. Combination of Temporary Charges

On this temporary load combination, the load to be reckoned with work on the structure is (SNI 1727:2020).

Imposition of temperature, concrete creep and shrinkage coefficient of 1.0, 1.2, 1.6, 1.4, is the multiplier of expenses, which is called the load factor, While the factors of 0.5 and 0.9 are the reduction factor. Structural systems and structural elements must be weighed against two combinations of loading, that is loading permanent and temporary loading, bending moment (Mu), torsional or torsional moment (Tu), shear force (Vu), and the normal force (Pu), which occurs in an element- the second consequence of structural elements combination of loading are reviewed, selected the most substantial costs, for subsequent use in the design process.

For the purposes of analysis and design of a building structure, necessary engineering mechanics calculations of the concrete portal with two loading combinations are still loading and loading while. Combination of loading to the structural design of buildings that are often used in Indonesia is (SNI 1727:2020).

In general, as the horizontal forces are working on the system in terms portal structure is earthquake loads, therefore Indonesia has the burden of an earthquake greater than the wind load. Earthquake load acting on the structure of the system can be directed back and forth, therefore this effect needs to be reviewed in the calculation. Dead load and live load are always trending down since it is a gravitational load, while the wind load or seismic load is trending horizontal load.

2.3.3 BASIC CALCULATION AND LOADING PLAN

For planning reinforced concrete building structures must bein accordance with current guidelines or using the latest guidelines, at this time the guidelines used for planning reinforced concrete structure buildings using SNI 2847:2020. The following is the basis for planning reinforced concrete structural elements according to SNI 2847:2020:

1. Plate Planning

   Floor plate is a floor that is not located on the ground directly, is a floor level between the level one to another level. Floor plates are supported by beams that rest on building columns. Based on the comparison between long spans and short spans the plates are divided into two, namely one-way plates and two-way plates.

   A. One-way plate

      One-way plates are plates that are supported on two opposite edges only, so that delection arises in onlyone direction, namely in a direction perpendicular to the direction of edge support. In other words, if the Ly/Lx value > 2 then the plate is considered a one- way plate.

Table 2.12 Minimum thickness of non-prestressed beams or one-way plates ifdeflection is not calculated

<table>
<tr><th colspan="5">Minimum Thick, h</th></tr>
<tr><td rowspan="3">Structure Component</td><td>Two pedestals</td><td>One end</td><td>Second end</td><td rowspan="2">Cantilever</td></tr>
<tr><td>Simple</td><td>Continuous</td><td>Continuous</td></tr>
<tr><td colspan="4">Components that don’t hold or are not incorporated intopartitions
Or
Other constructions that might be damaged by largedeflections</td></tr>
</table>

One-way massive plate	L/20	L/24	L/28	L/10
Beams / ribs One way	L/16	L/18.5	L/21	L/8
Note : The inner span length (mm) of the given value must be used directly for structural components with normal concrete and reinforcement fy 240 Mpa. For other conditions, the above values must be modified as follows: *a.* For lightweight concrete structures with equilibrium density, between 1440 and 1840 kg / cm^3, the value must be multiplied by (1,65 – 0,003 wc) but not less than 1,09. *b.* For fu other than 240 Mpa, the value is multiplied by (0.4 + fy√700).				

Source : Procedure for Planning Reinforced Concrete Structure of Buildings (SNI 2847:2019).

1) For non-prestressed solid slabs not resting on or adhering to partitions or other constructions which may be damaged by heavy borrowing, the total thickness of the slabs shall not be less than the minimum limits in Table 2.19

Table 2.13 Minimum plate thickness non-prestressing one-way solid

Focus condition	h[1] Minimum
Simple Support	ℓ/20
One end continuously	ℓ/24
Both ends continuous	ℓ/28
cantilever	ℓ/10
[1] This figure applies to normal weight concrete and fy = 420 MPa.	

Source : SNI 2847:2019 Minimum plate thickness non-prestressing one-way solid (Article 7 – One Way Plate)

2) Deflection shall be checked when the slab is bearing a structure which will suffer damage due to large deflections. The deflection limit is determined according to table 2.4

Table 2.14 Calculation of maximum allowable deflection

<table>
<tr><th>Types of structural components</th><th colspan="2">Condition</th><th>Calculated deflection</th><th>Deflection limit</th></tr>
<tr><td>Flat Roof</td><td colspan="2" rowspan="2">Does not support or is not attached to non-structural elements that may be damaged by large deflections</td><td>Instantaneous deflection due to maximum Lr and R</td><td>ℓ/180[1]</td></tr>
<tr><td>Floor</td><td>Instantaneous deflection due to L</td><td>ℓ/360</td></tr>
<tr><td rowspan="2">Roof or Floor</td><td rowspan="2">Bearing or attached to non-structural elements</td><td>It might be damaged by the large deflection</td><td rowspan="2">The part of the total deflection that occurs after the installation of non-structural elements, namely the sum of the long-term deflections due to all fixed loads and instantaneous deflections due to the addition of live loads[2]</td><td>ℓ/480[3]</td></tr>
<tr><td>Will not be damaged by large deflection</td><td>ℓ/240[4]</td></tr>
<tr><td colspan="5">[1] Restrictions are not intended as a safeguard against standing water. Puddles should be checked based on the calculation of deflections, including additional deflections due to standing water, and taking into account the long-term effects of fixed loads, resistance to deflection, construction tolerances, and reliability of the drainage system.
[2] Long-term deflection shall be calculated according to 24.2.4, but may be reduced by the value of deflection occurring prior to the installation of non-structural elements. The magnitude of this deflection value must be calculated based on acceptable technical data related to the characteristics of the time-deflection relationship of the structural member which is similar to the member under review.
[3] This limit may be exceeded when steps to prevent damage to the supported or bonded components have been taken.</td></tr>
</table>

[4] The limits must not exceed the tolerance limits provided for non-structural elements.

Source : SNI 2847:2019 Calculation of maximum allowable deflection (Article 24.2.2)

B. Two-way plate

When a concrete plate structure is supported by the four sides, and the ratio between the length to the short span is less than 2, the plate is categorized as a bidirectional plate.

The two-way plate system itself can be distinguished into the following types:

1) Two-way plate beam system

In this structure system a concrete plate is shed by the fourth beam. The load from the plate is transferred to the four-beam The two-way plate system with this beam can be used for 6-9 meters stretch, with a life load of 2.5-5.5 kN/m2. The beam will increase the stiffness of the plate, so the lending occurs will be relatively small.

2) Flat Slab System

In this structure system a concrete plate is shed by the fourth beam. The load from the plate is transferred directly to the column. Columns are likely to cause a slide punch failure on the plate.

3) Flat plate System

The system consists of plates that are concentrated directly into the column without any thickening of the panels and the column head. Flat slab system can be used for a 6 - 7.5 m stretch plate structure and a life load of 2.5 to 4.5 kN/m2.

4) Pierced two-way plates and waffle plates

It is a bidirectional plate system with a thickness of 50 mm to 100 mm between plates that are placed by the ribs in directions. The distance between the rib's ranges from 500 mm to 750 mm. The edges of the plates can be supported by beams, or they can also direct plates on the column by giving thickening on the plate around the column. The last-mentioned plate system is often referred to as the Waffle plate term.

C. Minimum Thickness Plate

SNI 2847:2019 Article 8.3.1.2 specifies the minimum thickness of two-way plates to prevent more lendutan occurrence. Since the lending calculation of a bidirectional plate is quite complicated, and to prevent a large lendutan, then the plate thickness can be determined using the empirical formula as follows:

1) For 0,2 < αfm < 2,0

$$h = \frac{\ell_n \left(0,8 + \frac{f_y}{1400}\right)}{36 + 5\beta\left(\alpha_{fm} - 0,2\right)}$$

But not less than 125 mm.

2) For αfm > 2,0

$$h = \frac{\ell_n \left(0,8 + \frac{f_y}{1400}\right)}{36 + 9\beta}$$

Not less than 90 mm.

3) For αf < 2,0

H= Minimum plate thickness without beams

With:

Ln = The length of the net in the extending direction of the two-way construction, measured from the face to the focus on the plate without beams, and the face to the face of the beam or another focus in other cases (mm).

B = Ratio of the net in the long direction to the short direction of the bidirectional plate.

afm = The average value of af for all beams on the edges of a plate.

Af = The ratio of beam cross-section bending (Ecblb) to plate bending stiffness (Ecsls), which is bordered laterally to the middle axis lines of the adjacent plates on each side of the beam.

$$Af = \frac{Ecblb}{Ecsls}$$

lb = The gross moment of inertia from the cross-section of the beam against the heavy axis, the cross-section of the beam includes the plates on each block of the projection of the beam above or below the plate, but not more than four times the thick plate.

Is = Moment of gross inertia from cross section of plate.

Table 2.15 *Minimum thickness*

Fy (MPa)	Without thickening Panel			By thickening Panel		
	Outer Panel		Inner Panel	Outer Panel		Inner Panel
	No edge beams	With Edge beams		No edge beams	With Edge beams	
280	In/33	In/36	In/36	In/36	In/40	In/40
420	In/30	In/33	In/33	In/33	In/36	In/36
520	In/28	In/31	In/31	In/31	In/34	In/34

[1] ℓn is the clear distance in the longitudinal direction, measured from face to face of the support (mm).
[2] For fy with values between those given in the table, the minimum thickness should be calculated by linear interpolation.
[3] Drop panel according to 8.2.4.
[4] Slabs with beams between columns along exterior edges. Exterior panels shall be considered without side beams if f is less than 0.8. The value of f for edge beams shall be calculated according to 8.10.2.7.

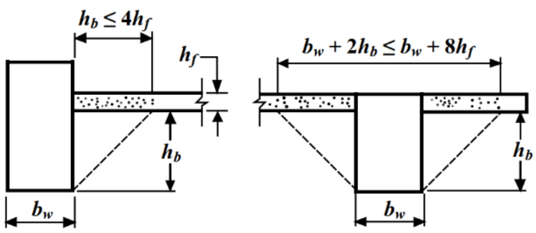


Figure 2.7 effective width of plate

to find the width of the flange on the middle beam according to SNI is as follows:

Be value :

$Be = bw + 2hb\ bw + 8hf$

From the two values of *Be*, the smallest is taken where:

α_m = the average value of α for a beam on the edge and all panels

α = the ratio of the flexural stiffness of the beam cross section to the flexural stiffness of the beam and slab to the width bounded laterally by adjacent panel lines on each side of the beam

ℓ_b = length of clear span in longitudinal and bidirectional construction measured and face-to-face of supports in slab without beam

β = ratio of clear span in a longitudinal direction to the transverse direction of the slab

h_b = Effective width of the plate

b_w = beam width

h_f = high plate

h_w = high beam

D. Plate reinforcement

Based on SNI 2847:2019 article 24.4.3.2 the area of reinforcement must be adjusted in the table below:

Table 2.16 The ratio of the area of shrinkage reinforcement and minimum temperature to the gross concrete cross-sectional area

<table>
<tr><th>Reinforcement type</th><th>f_y MPa</th><th colspan="2">Minimum reinforcement ratio</th></tr>
<tr><td>Threaded rod</td><td>< 420</td><td colspan="2">0,0020</td></tr>
<tr><td rowspan="2">Threaded rod or welding wire</td><td rowspan="2">≥ 420</td><td rowspan="2">Biggest of :</td><td>$\frac{0,0018\ x\ 420}{fy}$</td></tr>
<tr><td>0,0014</td></tr>
</table>

Sources : SNI 2847:2019, article 24.4.3.2

For a maximum spacing of s the longitudinal thread reinforcement shall be less than 2h and 450 mm in critical sections and less than 3h and 450 mm in other sections. Spacing of shrinkage reinforcement and temperature shall not exceed the smallest value between 5h and 450 mm.

Calculation steps for flexural reinforcement on the plate:

1) Find nominal moment (Mn)

Mn = $\frac{Mu}{\phi}$

Where:

Mu = ultimate moment of the plate under consideration

ϕ = plate reduction factor (taken = 0.90)

2) Find the coefficient of moment resistance (Rn)

Rn = $\frac{Mn}{b\ d^2}$

Where :

b = element width (m) for slab is calculated every 1 meter

d = effective height of element

3) Find reinforcement ratio

Table 2.17 The value of $\beta 1$ for the equivalent square concrete stress distribution

f_c', MPa	β_1	
$17 \leq f_c' \leq 28$	0,85	a)
$28 < f_c' < 55$	$0{,}85 - \frac{0{,}05(f_c' - 28)}{7}$	b)
$f_c' \geq 55$	0,65	c)

Sources : SNI 2847:2019, table 22.2.2.4.3

4) find the required reinforcement ratio (P_{need})

$$P_{need} = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2\ x\ m\ x\ Rn}{Fy}}\right)$$

If $P_{need} < P_{min}$, so P_{need} increased by 30% so that

$P_{wear} = 1{,}3 \times P_{need}$

5) Calculate the need for reinforcement (As)

As necessary = $P_{need}\ x\ b\ x\ d$

Reinforcement used > As needed

Where:

P = required reinforcement ratio

b = element width (m) / for slab calculated every 1 meter

d = effective height of element

6) Check cross-sectional capacity

$$a = \frac{As.Fy}{0{,}85.Fc.b}$$

$$c = \frac{a}{\beta 1}$$

$$\varepsilon t = 0{,}003\ \frac{d-c}{c} > 0{,}005$$

2. Beam Planning

A. Beam

The beam is part of a rigid horizontal structure and thic't the burden received from the floor plate to the sustaining column and then passed onto the foundation. In designing a building beam, the first step to take is to calculate the magnitude of the load that the beam gained from the combination of load occurring. Broadly, the things that should be considered in the selection of beam types are:

1) Material availability
2) The amount of load to be received
3) Length of Beam stretch

4) Time and cost required in the implementation of the project
5) Aesthetic value of buildings.

B. Type of beam

The beam itself is one of the most important elements in construction. Its function is to support loads or horizontal reinforcing frames in standing buildings. There are several types of beams in construction that have developed, including, Types of beams based on their growth:

1) Simple Focus Beam

Beams that focus on the tip of the column, dynamic in rotating and zero-resistant moments or more often called the same focus of the joints (Wo-way horizontal and vertical styles) and the one focused roll (horizontal directional force).

2) Cantilever Beam

The stem of a horizontal structure that has only one focus is the clamp/fix (horizontal style, vertical style and moment) and the other tip is free. The cantilever beam that supports gravity loads will have a negative moment across the beam's length. Therefore, the repatriation of cantilever beams requires more iron depending on the amount of load received.

3) Overhanging Beams

The beam is elongated in column focus. The beams with their edges remain strong in order to support the magnitude of the translation and rotation styles due to their own load or outside load.

4) Continuous beam

The continuous beam is a beam that focuses on the most outer focus and is arranged sustainably at a certain distance. This continuous beam is often used because when using concrete and steel beams has only the effective length of the span of 6-8 meters. It is necessary to focus on the center of the beam to increase the strength of the beam can also reduce the cross-section used.

C. Preliminary design of beam

Preliminary design is the initial stage to determine the initial dimensions of a structural component that refers to the provisions of SNI 2847:2019. Some of these structural components include, Beam Dimensional Planning Based on SNI 2847:2019 Article 9.5.2.1 in determining the initial dimensions of the beam can be done by following these steps:

1) Determine the data design which includes:
   a) Beam Length
   b) Material properties data
   c) Planned width of block (b) is 2/3 h
   d) Minimum height of beam

Table 2.18 Minimum height of beam

Attachment condition	**Minimum h[1]**
Simple attachment	ℓ/16
Single sided	ℓ/18,5
Continuous double sided	ℓ/21
Cantilever	ℓ/8
[1] The formula is applicable to normal strength concrete and 420 strength reinforcement. In other cases, the	

minimum h shall be modified in accordance with 9.3.1.1.1 to 9.3.1.1.3, as appropriate on SNI 2847:2019.

Source: SNI 2847:2019 Minimum height of beam (Article 9.3.1.1)

D. Beam reinforcement

Based on SNI 2847:2019 article 18.7.4, the provisions for longitudinal reinforcement are as follows:

1) Beams must have at least two continuous bars at the top and bottom of the section. On the opposite side of the cross section, the amount of reinforcement must not be less than that required by SNI 2847:2019 article 9.6.1.2 and the reinforcement ratio P must not exceed 0.025, both for the top and bottom reinforcement.

   a) $\frac{0,25\sqrt{f_c'}}{f_y} b_w d$

   b) $\frac{1,4}{f_y} b_w d$

2) The 0.025 reinforcement ratio limit is based primarily on reinforcement density considerations and, directly, limits the beam shear stress to typical proportions.
3) The positive moment strength at the joint face shall be not less than half the negative moment strength at the joint opening. The positive and negative moment strength at any cross section along the span of the structural member shall not be less than one-fourth the maximum moment strength at the joint face.
4) Longitudinal cast-over splices are permitted if confinement or spiral studs are installed along the splice joints. The spacing of the transverse reinforcement enclosing the cross-joined bars shall not exceed the minimum values of d/4 and 100 mm. skip connection may not be used on location:

a) In joint
b) Within twice the beam height from the joint face
c) Within twice the beam height from the critical section where flexural yielding is possible as a result of lateral deformation that exceeds the elastic behavior.

The steps for the calculation of reinforcement on the beam:

1) Calculate Mu obtained from the support and pitch moments in the beam obtained from the output of the ETBAS V19 auxiliary program.
2) Calculating reinforcement needed
   - Minimum reinforcement area (SNI 2847:2019, Article 9.6.1.2)

     As min 1 = $\frac{0,25\sqrt{Fc'}}{Fy} b_w d$

     As min 2 = $\frac{1,4}{Fy} b_w d$

     Used as the biggest min

   - Check the maximum ratio reinforcement

     P_{max} = 0,25 (SNI 2847:2019, Article 18.6.3.1)

     As_{max} = 0,25 $b_w d$
3) Torsion longitudinal reinforcement

   θ = 45° (SNI 2847:2019, Article 22.7.6.1.2)

   Tn $= \frac{\phi Tu}{\phi}$

   $Ag = b\ h$

   $A_{cp} = Ag = Agh$

$Pcp \quad = 2\,(b + h)$

$A_0 \quad = 0{,}85\, A_{oh}$

$P_h \quad = (\, b - 2c - 2\frac{D}{2}) + (\, h - 2c - 2\frac{D}{2})$

$A_1 \quad = \frac{TnPh}{2\, Ao\, Fy\, cot\theta}$ (SNI 2847:2019, Article 22.7.6.1)

Torsion longitudinal reinforcement area control

$0{,}01\, Ag < Asl < 0{,}06\, Ag$ (SNI 2847:2019, Article 18.7.4.2)

4) Reinforcement Needs

- Reinforcement requirements are sought using the double reinforced method

  ϕ = 0.9 Tension Controlled (SNI 2847:2019, Table 21.2.1)

  $\epsilon_t \geq 0{,}005$ (SNI 2847:2019, Article 21.2.2)

  $\epsilon_{t\ min} \geq 0{,}005$ (SNI 2847:2019, Article 9.3.3.1)

  Check assumptions Fs' = Fy

  $d = h - cover - Ø - \frac{D}{2}$

  $d' = cover + Ø + \frac{D}{2}$

  $c = \frac{(A's - As)Fy}{0{,}85\, Fc'\beta 1\, b}$

  $\alpha = \beta 1\, c$

  $\epsilon_y = \frac{Fy}{Es}$

  $\epsilon'_s = \frac{c - d'}{c}$

- Nominal flexural strength of beam

  $\phi Mn = \phi\, (As'fy\, (d - \frac{\alpha}{2}) + As\, fs'(d - d'))$

- Check for single reinforcement

α = $\frac{As'fy}{0,85\ fc'b}$

ϕ *Mn single* = ϕ *(As'fy (d-* $\frac{\alpha}{2}$*))*

- Check beam capacity

  $Mu^+ < \phi$ *Mn single*

  $Mu^- < \phi$ *Mn single*

5) Count the reinforcing bars

$\phi_s = 0,6$ (SNI 2847:2019, Article 21.2.4)

- Check the need for shear reinforcement

  $A_{v\ min}$ must be provided when $V_u \geq 0,5\ \phi\ V_c$

  $V_c = \phi\ 0,17\sqrt{fc'}bw\ d$

- Transverse reinforcement

  Vs must be provided when $V_u \geq 0,5\ \phi\ V_c$ (SNI 2847 2019, Article 22.5.10)

  $Vs = \frac{Vu}{\phi} - V_c$

  $Vs = \frac{Av\ fyt\ d}{s}$

- Check minimum space

  $\frac{Av\ min}{S} = 0,062\sqrt{fc'\ bw\ d}$

  $\frac{Av\ min}{S} = 0,35\frac{bw}{fyt}$

  $\frac{Av}{S}$

  Looking for value $\frac{Av}{S} \leq \frac{Av\ min}{S}$

- Check condition V_s

  $0,33\sqrt{fc'\ bw\ d}$

  $Vs < 0,33\sqrt{fc'\ bw\ d}$

  so

$S_{max} = \frac{d}{2}$ (SNI 2847:2019, Table 9.6.3.3)

S_{max} = 600 mm (SNI 2847:2019, Table 9.6.3.3)

3. Column

A. Preliminary Design Column

$$\frac{h\ column}{l\ column} \geq \frac{h\ beam}{l\ beam}$$

Where:

h column = column net height

h beam = beam net height

l column = column inertia *(1/12.b.h²)*

l beam = beam inertia *(1/12.b.h²)*

With the condition that the column dimension planning refers to SNI 2847:2019 article 18.7.2.1

1) The smallest passenger dimension, measured on a straight line through the center of the geometry, is not less than 300mm
2) The ratio of the smallest cross-sectional dimensions to the perpendicular dimensions is not less than 0.4

B. Column reinforcement

1) Flexural Repetition

The design of the column length reinforcement uses a 4 ssi interaction diagram.

Based on SN 2847:2019 article 18.7.32, the flexural strength of the SRPMK column must meet the provisions of the Strong Column Weak Beam, namely:

$$\Sigma Mnc \geq 1,2\ \Sigma Mnb$$

ΣMnc = sum of the nominal flexural strengths of the columns framing into the joint, evaluated at the joint faces

ΣMnb = the nominal flexural strength of the beam framing into the joint, evaluated at the joint faces.

2) Slide Repeat

Based on SNI 2847:2019 article 18.7.5.1 the required transverse reinforcement must be installed 10 from each joint face and on both sides of any cross section where flexural yielding is possible as a result of lateral displacement that exceeds the elastic behavior. The length of 10 must not be less than:

- The height of the column at the joint face or at the cross-section where flexural yielding is possible
- One-sixth the net height of the column
- 450 mm.

Transverse reinforcement spacing does not exceed the smallest value of:

- Quarter of the smallest dimension of the column cross-section
- Six times the diameter of the longitudinal reinforcement
- So, which is calculated by

$So = 100 + (\frac{350-hx}{3})$ (SNI 2847:2019 Article 18.7.5.3)

The planning steps for column shear reinforcement are:

a) Determine the value of fc', fy, and the diameter of the stirrup

b) Calculate the moment of support:

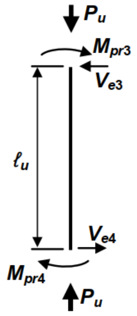


Figure 2.8 Slide designs for beams and columns

Sources: SNI 2847:2019 figure R18.6.5

- Top pedestal moment

$$M_{pr3} = A_S \; x \; 1{,}25 \; x \; fy \; x \; (d - \frac{a}{2})$$

- Bottom pedestal moment

$$M_{pr4} = A_S \; x \; 1{,}25 \; x \; fy \; x \; (d - \frac{a}{2})$$

Where: $\alpha = \frac{As \; x \; fy}{0{,}85 \; x \; fc' \; x \; b}$

c) Calculate the reaction at the ends of the column

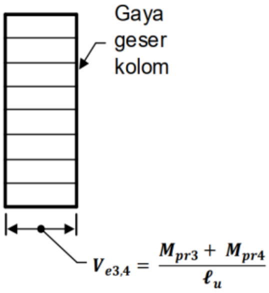


Figure 2.9 Slide designs for beams and columns

Sources: SNI 2847:2019 figure R18.6.5

$Ve = \frac{Mpr3 + Mpr4}{lu}$

Where: lu = length of clear span of column

d) Calculate the design shear strength

$Vs = \frac{Vu}{\phi} - Vc$

Where Vc = O if Ve due to earthquake is greater than 1/2 Vu and the factored axial force on the column does not exceed $\frac{Ag\ .\ Fc'}{10}$ (SNI 2847:2019 Arcticle 18.7.5.6)

e) Install shear reinforcement needs

S = $\frac{Av\ .\ fy\ .\ d}{Vs} < S_{max}$

Where: Av = area of stirrup reinforcement (mm^2)

f) Check the total cross-section of the square stirrup reinforcement (Ash) The Ash value is taken from the smallest, which is as follows:

Ash = 0,3 $\frac{s\ .\ bc\ .\ fc'}{fyt}\ [\left(\frac{Ag}{Ach}\right) - 1]$

Ash = 0,09 $\frac{s\ .\ bc\ .\ fc'}{fyt}$

Where:

s = distance between shear reinforcement

Bc = Cross-sectional width of confined concrete core

Ag = net area of column

Ach = The cross-sectional area of the concrete core, calculated from the outermost fiber of the stirrup on the other side.

g) Thick concrete covers minimum, for reinforced concrete:

Table 2.19 Thick concrete covers minimum, for reinforced concrete

Type Concrete	Concrete Blanket Minimum Thickness (mm)
a) Cast concrete on top and always in touch with the ground.	75
b) Concrete wether-related: - D57 D19 rod hinggan - D16 wire rod M16 threaded or plainandsmaller.	50 40
c) Concrete that is not related to the weatheror in connection with the land : - Reinforcement rods D44 and D57 - Reinforcement rods and a smaller D36.	40 20
d) Beams, columns: Main reinforcement, binder, stirrups, andspiral.	40
e) Components shell structure, spiral stirrups: - Reinforcement rods and larger D19 - D16 reinforcement rods, wire M16threaded or plain, and smaller.	20 13

Source: Planning Procedures for Concrete Structures Building (SNI – 2847:2019).

4. Foundation Planning

Among the differences in field tests, sondir or cone penetration test (CPT) is often highly considered the role of geoengineering. CPT or sondir is a very fast, simple, economical test and the test can be trusted in the field with continuous measurement of the surface of the ground ground base. This CPT or sondir can also classify the soil layer and can estimate the strength and characteristics of the soil. In planning the foundation of the pile, sliding soil data is necessary in planning the bearing capacity of the stake before construction begins, in order to determine the ultimate capacity of the Pile. Ultimate carrying capacity is determined by the following equations:

Qu = Qb + Qs = qbAb + f.As

Description:

Qu = Axial capacity of the ultimate Pile

Qb = Prisoner capacity at the end of the pole

Qs = Skin prisoner capacity

qb = Capacity at the end of the broad unity pile

Ab = Area at the end of the pile

f = Broad unity leather detention units

As = Pile leather area

Planning the foundation of the stake with Sondir is classified on several methods including:

a) Aoki and De Alencar Methods

Aoki and Alencar propose to estimate the ultimit support capacity of the Sondir data. The capacity to support the broad end of the union (qb) is obtained as follows:

$$Qb = \frac{qca\ (base)}{Fb}$$

Description:

qca = (base) = Konus resistance averages 1.5D above the end of the pole, 1.5D below the end of the pole and Fb is an empiric factor of pole prisoners depending on the type of pole. Prisoners of the skin of the broad union (f) are predicted as follows:

$$F = qc\ (side)\ \frac{as}{Fs}$$

Description:

qc (side) = Average konus resistance on each layer along the pile

Fs = Empiric factor of leather prisoners depending on the type of pile

Fb = Empiric factor holds the end of the pole depending on the type of pole

Table 2.20 Empiric Factor Fb and Fs

Pile Type	Fb	Fs
Bore Pile	3,5	7,0
Steel	1,75	3,5
Prestressed Concrete	1,75	3,5

Empiric factor value for soil type (Titi & Farsakh, 1999) At as value for sand = 1.4 percent, as value for lanau = 3.0 percent and as value for clay = 1.4 percent.

b) Direct Method

This direct method was put forward by several experts including: Meyerhof, Tomlinson, Begemann. The carrying capacity of the pole foundation is stated in the formula as follows:

$$Qu = qc \times Ap + JHL \times Kt$$

Description:

Qu = Pile Capacity

Qc = Sondir tip prisoners (Resistance to konus penetration at reviewed depths)

Can be used Meyerhof correction factor:

Qcl = Average PPK (qc) 8D above the end of the pile

qc2 = Average PPK (qc) 4D below the end of the pole

JHL = Number of attached obstacles

Kt = Pile circumference

Ap = Cross-sectional area of the pile

The carrying capacity of the pole foundation permit is stated in the formula as follows:

$$\text{Qu Permit} = (qc \times Ap)/3 + (JHL \times Kt)/5$$

Description:

Qu Permit = Pile permit carrying capacity.

QC = Prisoners end sondir using Begemann correction factor

JHL = Total friction

Kt = Pole circumference

Ap = Cross-sectional area of the pile

3 = Safety factors for pole carrying capacity

5 = Safety factors for friction on pole blankets.

(*Husnah. "Analisa Daya Dukung Pondasi Tiang Pancang Pada Proyek Pembangunan Pondasi Tissue Block 5 & 6". Riau.)*

2.3.4 SELECTION STRUCTURE SYSTEM

The system selection upper structure has a close relationship with the functional system of the building. Structural design will affect the overall design of the building. The factors that determine the selection system structure are as follows:

A. Architectural aspects

This is related to the floor plan and structure selected, in terms of architecture.

B. Functional aspects

This is related to the use of space. Usually, this will affect the use of the span of structural elements used.

C. Structural aspects of strength and stability

This aspect relates to the ability of structures to receive loads that work both vertical and lateral loads and structural stability in both directions.

D. Economic aspects and ease of implementation

Usually in a building, can be used several kinds of structure. Therefore, economic factors and ease of implementation of workmanship is a factor that affects the system structure to be selected.

E. The ability factor of structure to accommodate building service system.

Selection of structural systems should also be considered the ability of the structure to accommodate the existing service system, which involves mechanical and electrical work. While to choose the type of bottom structure (lower structure) that is the foundation, it must implement the steps – steps as follows:

- Obtain the closest information regarding the state of the building and the loads transferred to the foundation.
- Determine basement conditions in general.
- Immediately consider the general form of the

foundation, to decide whether the foundation can be made under existing conditions. In the introductory step, the unsuitable shape is omitted.

- Make a more detailed study and early design of the most suitable foundation form.
- Estimates the cost of each form of foundation.

2.3.5 SUPPORTING SOFTWARE

A. Autodesk AutoCAD

AutoCAD is a software that works for graphic design, which can produce 2D images. In addition, this software is very light compared to other software. This program is a flexible 2D modeling application program that is fast and practical. AutoCAD is also commonly used to design buildings and details with an easy-to-read 2D appearance.

B. ETABS (Extended Three Analysis Building Systems)

ETABS is one of the programs used by engineers to analyze, design and model building structures. ETABS (Extended Three Analysis Building Systems) is a program that is used to analyze and design building structures precisely and quickly. The use of this program has an interesting interface and the tools are easy to use. The use of this app can help you improve your guaranteed accuracy. The use of ETABS is considered relevant to design the structure of high-rise buildings or high-rise buildings by calculating the weight of the structure and other loads.

C. Sketchup

Sketchup is one of the software that has a function in the graphic design of 3-dimensional models that are used and designed for professionals in the field of civil engineering, architecture, in making games, movies, and related designs therein. The program includes drawing layout functions, surface rendering, and supports third-party plugins from the Extension Warehouse. The app has a variety of applications, including in the world of architecture, interior design, landscaping, and video game design. Sketchup also found success with people who wanted to create, share, or download 3D models for use with 3D printers.

2.3.6 CONDITIONS OF LOAD PLANNING

Building analysis or building planning must have guidelines regulations that apply in Indonesia, including:

1. Requirements for structural concrete for buildings (SNI 2847:2019).
2. Minimum load for building design and other structures (SNI 1727:2020).
3. Procedure for planning earthquake resistance forstructures of buildings and non-buildings (SNI 1726:2019).