PANA ACADEMY

NEPAL ENGINEERING COUNCIL
LICENSE EXAM PREPARATION COURSE

FOR

CIVIL ENGINEERS

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5. Design of Structure

5.1 Loads and load combination

Sub topics

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- Dead Load
- Imposed Load
- Wind Load
- Snow Load
- Earthquake Load

Dead Load

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Loads structure has to withstand due to the self weight of various component
Depends on unit weight and dimensions
Walls, floors beams, columns
also permanent fixtures present in the structure.
The unit weight of materials are given in code IS 875 (part-I):2015 and NBC 102.

Dead Load

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	γ
Plain Cement Concrete	24 kN/m³
Reinforced Cement Concrete	25 kN/m³
Steel	78.5 kN/m³
Brick Masonry	20 kN/m³

Imposed Load / Live Load

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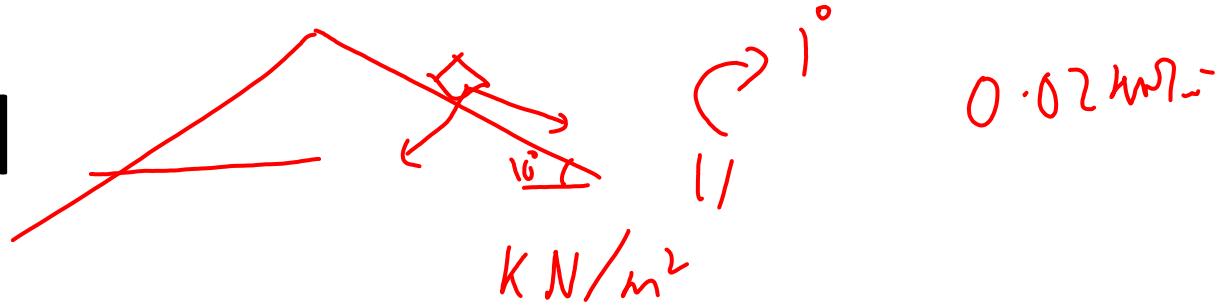
Consideration for temporarily or movable loads.
Loads of people, furniture.
Also called live or occupancy load.

IS 875 (Part-2) :2015 and NBC 103.

The selection of imposed loads depends on use case of part of building considered.
Table 1 of IS 875 (Part-2)

Imposed Load



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Roof (no access)	0.75
Roof (Access provided)	1.5
Dwelling house	2.0-3.0
Hotels	2.0-4.0
Balconies	3
Store rooms- industrial rooms	5.0

not less than 0.4 KN/m²

For roofs of slope greater than 10°, the imposed load is reduced by $0.02KN/m^2$ for every degree rise in slope.

11° → 0.75 − 0.01 = 0.73
12° → 0.75 − 0.02×1 = 0.73

Wind Load

The loads due to wind acting laterally/ horizontally.

IS 875-part 3.

NBC 104 provides guidelines on wind load.

Country divided to two regions

- Above 3000m (55 m/s)
- Below 3000m (47 m/s)

V_b

Peak velocity of 3 sec and 50 year return period.

Wind Load

$V_z = V_b \times k_1 \times k_2 \times k_3$

V_b is the basic wind speed 10 m above ground

k_1 risk coefficient

k_2 terrein height and size

k_3 topography

Wind Pressure (p_z)$=0.6\ V_z^2$

All units are SI for this formula

$F = (C_{pe}-C_{pi})\ A\ p$

The pressure(p) should not be taken less than 0.7 p_z

Wind Load

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k_1 risk coefficient varies from 0.67 for temporary structures (5 years exceedance) to 1.08 for important buildings(100 years exceedance) Usually taken 1.0 for general buildings and structures(50 years exceedance)

k_2 terrein height and size, obstruction for wind

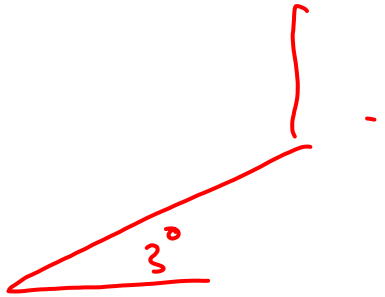
Four terrain categories and three building classes(A,B,C)

Class A maximum horizontal dimension less than 20 m

Class B maximum horizontal dimension 20 m to 50 m

Class C maximum horizontal dimension more than 50 m

Wind Load



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Four terrain categories

Category 1: Exposed open terrain with few or no obstructions, surrounding structure less than 1.5 m

Category 2: Open terrain with well scattered obstructions having heights generally between 1.5 to 10 m

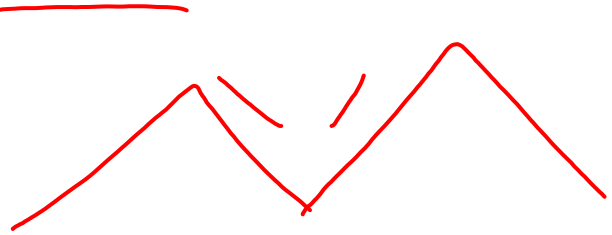
Category 3: Terrain with numerous closely spaced obstructions having the size of building-structures up to 10 m

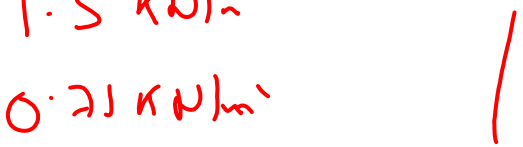
Category 4: Terrain with numerous large high closely spaced obstructions.

- k_3 topography (1.0 to 1.36) maximum value at ground which reduces to 1.0 at height

  Needed to be considered for upwind slope more than 3^o

Snow Load





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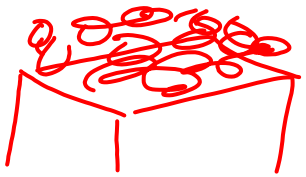
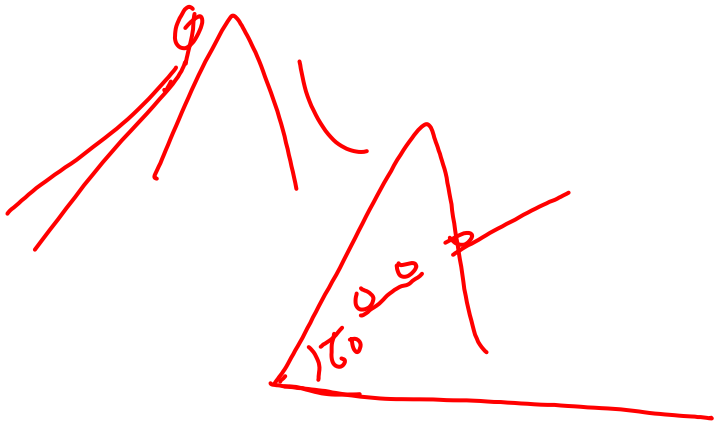
Buildings at regions where snowfall is very common, are to be designed for snow loads.

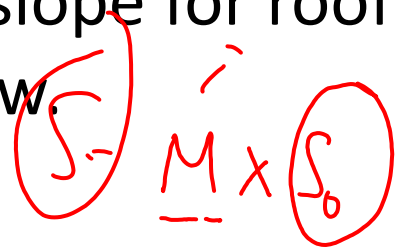


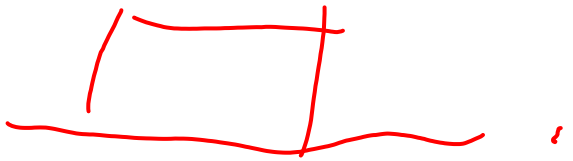


IS 875 (Part-4)

NBC 106 provides guidelines on snow load.

The minimum slope for roof is 2:1 (V:H) for efficient removal of snow.





Snow Load

The slope of roof making angle 60^o or more do not need to consider snow load.

Considering wind and snow load 2:1 (V:H) is the optimum slope of roof.

Snow load on roof is given by formula $s = \mu s_o$, where μ is the shape coefficient based on character of roof and s_o is the snow load on ground.

Earthquake Load

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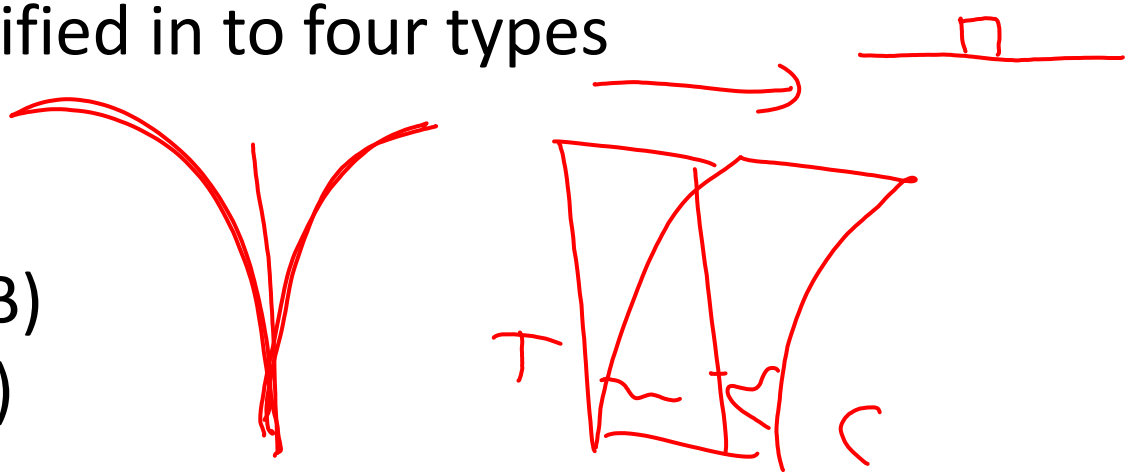
Earth quake load due to various reasons.

IS 1893(2016). NBC 105 : 2020

The soil conditions are classified in to four types

- very soft soil (Soil type D)
- soft soil (Soil type C)
- medium soft soil (Soil type B)
- stiff or hard soil (Soil type A)



Earthquake Load

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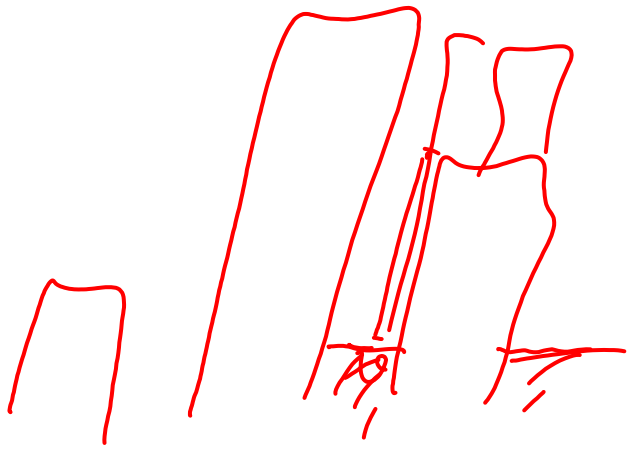
Fundamental natural period

For moment resisting frame,

$T_a = 0.075h^{0.75}$ for RC frame

$T_a = 0.085h^{0.75}$ for steel frame



For general frame,

$T_a = 0.05h^{0.75}$

$T_a = \frac{0.09h}{d^{1/2}}$ for steel frame

Earthquake Load

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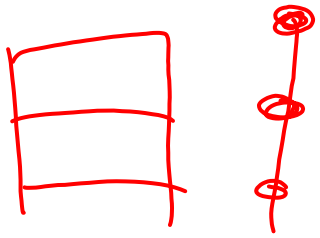
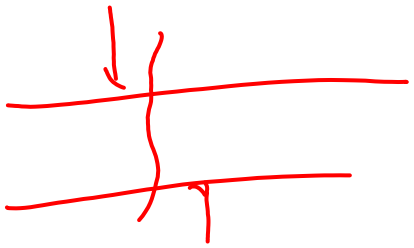
Base shear:

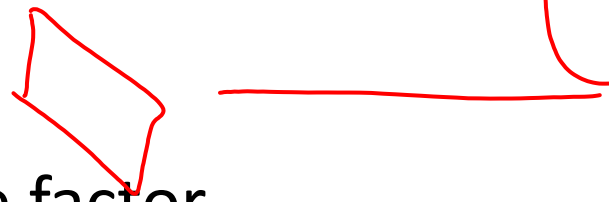


$$V_B = A_h . W$$



Where, w is seismic weight, A_h is design horizontal acceleration

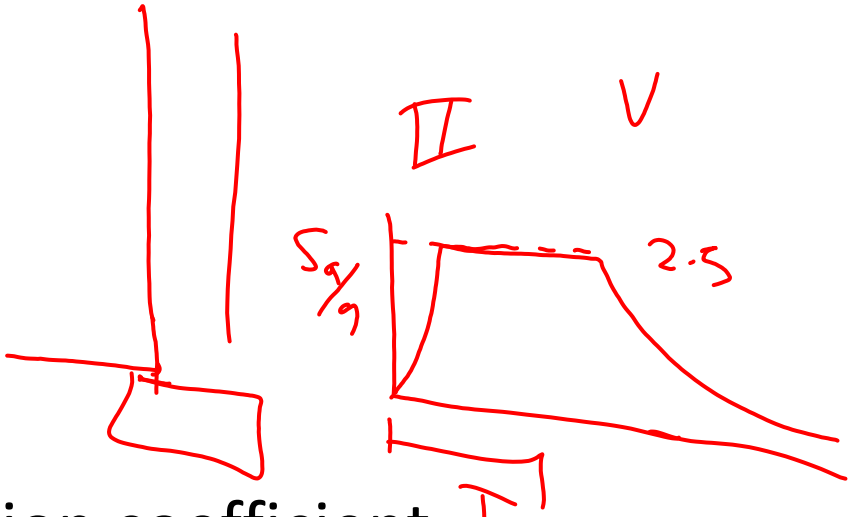
$$A_h = \frac{Z}{2}\frac{I}{R}\frac{S_a}{g}$$



Z is zone factor

I is importance factor (taken 1 to 1.5)

R is response reduction factor (taken 5)



$\frac{S_a}{g}$ is average response (spectral) acceleration coefficient

Earthquake Load

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Seismic Zone factor (Z) is around 0.25 to 0.4 throughout Nepal.

I I = 0.10
I II = 0.16
IV = 0.24
V = 0.36

It is peak ground acceleration for 475 year return period.

Importance factor varies from 1 to 1.5.

Earthquake Load

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Importance Class	Structure	I
I	Ordinary Structures (those not falling in classes II and III)	1.0
II [2]	Schools, colleges, cinemas, assembly buildings such as shopping malls, convention halls, temples, monumental structures, Police stations, Emergency vehicle shelters/garages, Food storage structures, Emergency relief stores, Water works and water towers, Radio and television facilities, Telephone exchanges and transmission facilities, Offices and residential quarters for senior personnel required for rescue and relief operations and any other buildings designed to accommodate more than 500 persons.	1.25
III	Hospitals, fire stations, police headquarters, power stations (including standby power-generating equipment for essential facilities), distribution facilities for gas or petroleum products, structures for support or containment of dangerous substances (such as acids, toxic substances, petroleum products)	1.5

[2] Importance factor of 1.5 shall be applied if the facilities listed in Importance Class II are to be used as a shelter in case of a disaster.

Earthquake Load

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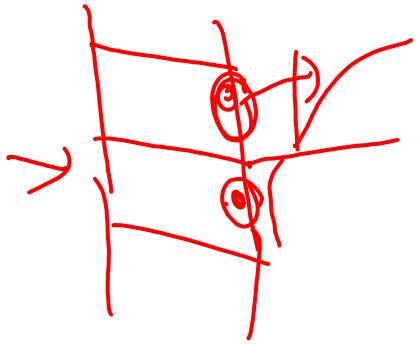
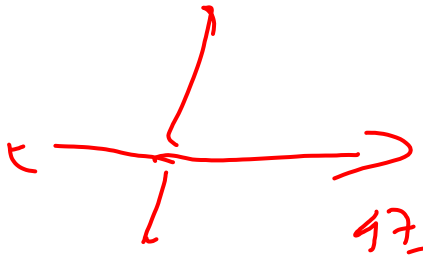
- Weak storey - storey having lower strength than storey above

- Soft storey - storey having lower stiffness than storey above



Load Combinations

Linear combination



IS 1893 : 2016

1.5 (DL + IL)

1.2 (DL + IL ± (EL_x ± 0.3EL_y ± 0.3EL_z))

1.2 (DL + IL ± (EL_y ± 0.3EL_x ± 0.3EL_z))

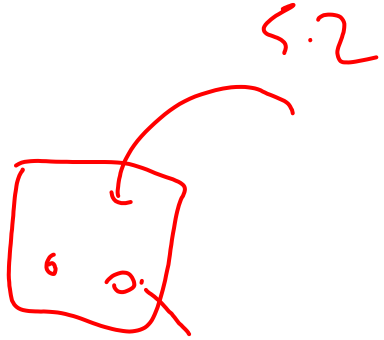
1.5 (DL ± (EL_x ± 0.3EL_y ± 0.3EL_z))

1.5 (DL ± (EL_y ± 0.3EL_x ± 0.3EL_z))

0.9 DL ± 1.5 (EL_x ± 0.3EL_y ± 0.3EL_z)

0.9 DL ± 1.5 (EL_y ± 0.3EL_x ± 0.3EL_z)

Load Combinations



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NBC 110

Load Combination	Limit Stage of Collapse			
(1)	DL (2)	LL (3)	WL (4)	SL (5)
DL+LL	1.5	1.5	-	-
DL+WL	1.0*	-	1.25	-
DL+LL+WL	1.0	1.3	1.25	-
DL+SL+WL	1.0	-	1.25	1.25

MCQs

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What is permanent action, according to classification of actions by IS code?

a) Due to self weight

b) Due to construction and service stage loads

c) Due to accidents

d) Due to earthquake loads

MCQs

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The wind load are placed under which of the following IS code

a) IS 875 Part 1 → DL

b) IS 875 Part 2 → LL / IL / OL

c) IS 875 Part 3 → WL

d) IS 875 Part 4 → SL

Eql → 1893

MCQs

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The wind load are placed under which of the following Nepal Standard code

a) NBC 102 - DL

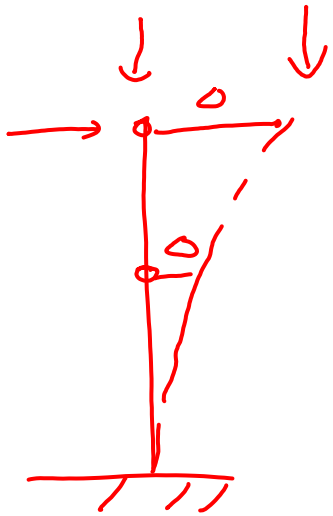
b) NBC 103 → LL

c) NBC 104 → WL

d) NBC 105 EQL

106 SNL

MCQs



What is P-Δ effect?

a) Earthquake load

b) Second order moments arising from joint displaced

c) Second order moments arising from member deflection

d) Load due to shrinkage effect

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MCQs

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For roofs of slope greater than 10˚, the imposed load is reduced by ____ for every degree rise in slope.

a) 0.02 kN/m²

b) 0.05

c) 0.75

d) 0.5

MCQs

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Internal pressure coefficient in a building is positive if acting from _____ and external pressure coefficient in a building is positive if acting from _____

a) outside to inside, inside to outside

b) inside to outside, outside to inside

c) outside to inside, outside to inside

d) inside to outside, inside to outside

MCQs

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For earthquake loads, axially loaded members have to resist _____

a) Tension only

b) Compression only

c) Both tension and compression

d) Bending moment

MCQs

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Which of the following factors does not influence earthquake resistance design?

a) Geographical location of structure

b) Strength of structure

c) Site soil Condition

d) Wind of location

MCQs

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Structures should be designed such that _____

a) Minor and frequent earthquakes can collapse the structure

b) Moderate earthquakes can cause damage to the structure

c) Major earthquakes should not cause any damage to the structure and the structure should be functional

d) Minor earthquake should not cause any damage to the structure and the structure should be functional

MCQs

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Which of the following assumption is correct for earthquake design resistant structure?

a) Earthquake will not occur simultaneously with wind

b) Earthquake will occur simultaneously with maximum flood

c) Earthquake will occur simultaneously with wind

d) Earthquake will not occur simultaneously with imposed load

MCQs

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Which of the following relation is correct for design horizontal seismic coefficient?

a) $ZIS_a \times 2Rg$

b) $(ZIS_a)/2Rg$

$$A_h = \frac{Z}{2} \frac{I}{R} \frac{S_a}{g}$$

c) $ZIS_a - 2Rg$

d) $ZIS_a + 2Rg$

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Thank YOU !!!