TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2082 Shrawan

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Earthquake Resistance Design of Structures *(Elective II) (CE 76501)*

- ✓ *Candidates are required to give their answers in their own words as far as practicable.*
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Define a magnitude of an earthquake. Explain different type of magnitudes. [2+5]

   b) Estimate the moment magnitude of an earthquake with a rupture length of 100 km, rupture width of 40 km and average fault slip of 2.6 m. Take the modulus of rigidity as 3.5×10^{10} N/m^2. [5]

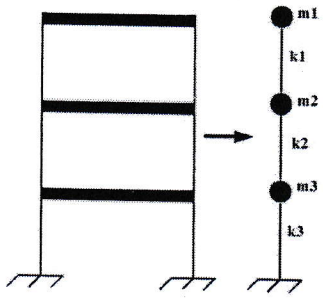
2. a) What are seismic waves? Explain the major characteristics of seismic waves with velocity relationships. [6]

   b) Why attenuation laws are used in seismic hazard analysis? Explain with examples. [6]

3. a) A three storey building with given vibration properties is shown below. [12]

$$[m] = \begin{bmatrix} 250 & 0 & 0 \\ 0 & 325 & 0 \\ 0 & 0 & 325 \end{bmatrix} \text{kg} \quad \{S_v\} = \begin{Bmatrix} 0.625 \\ 0.625 \\ 0.623 \end{Bmatrix} \text{m/s}$$

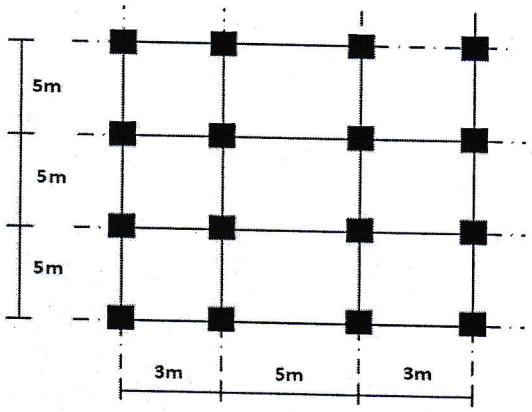
$$[\phi] = \begin{bmatrix} 1 & 1 & 1 \\ 0.68 & -0.69 & -3.36 \\ 0.37 & -0.77 & 4.01 \end{bmatrix} \quad \{\omega\} = \begin{Bmatrix} 3.39 \\ 7.81 \\ 12.54 \end{Bmatrix} \text{rad/s}$$



Take height of the building as 3 m. Determine displacement, overturning moment, and shear force due to all modes of vibration at time t during an earthquake using the response spectrum method if the model spectral velocity values are as given in $\{S_v\}$ above.

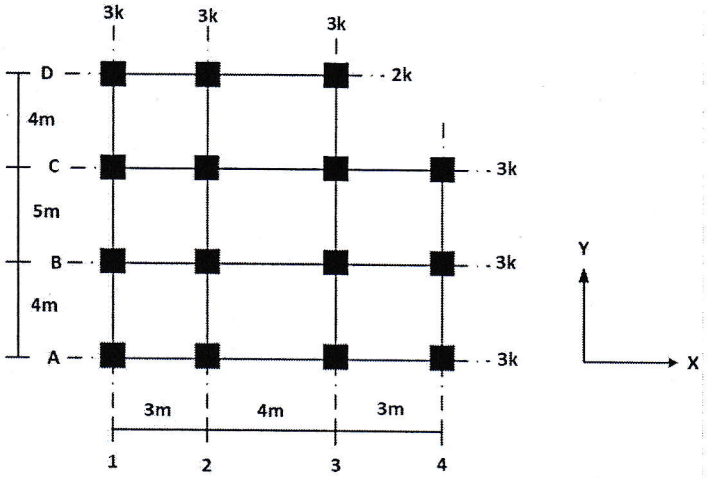
   b) Explain the failure modes of RC structures. [4]

4. a) The figure below shows a plan of 5-storey RC framed structures to be constructed in Patan area. The height of each storey is 3.5 m., all columns are 500 X 500 mm^2 and all beams are 300 X 500 mm^2. The slab thickness is 150 mm. The masonry wall is 230 mm thick. The soil below the foundation is soft. Assume the live load on all floors is 3 kN/m^2 and on the roof is 2 kN/m^2. Determine the seismic force and lateral force at different floor levels. Assume relevant data if required as per NBC 105: 2020. [12]



b) Determine the return period of an earthquake event with 10% probability of exceedance in 50 years. [4]

5. a) The plan of a one-story building is given in the figure below. The building is composed of 2-D frames along the orthogonal directions. The roof diaphragm is rigid in its own plane, and the mass of the roof is uniformly distributed. Calculate the lateral force in the 2-D frames when the building is subjected to an earthquake load of 380 kN in Y- direction. [10]



b) Explain how confinement of concrete improves ductile behavior of structural members. [6]

6. Write short notes on: (Any Two) [2×4]

a) Ground motion parameters

b) Fault mechanism and types

c) Strength of masonry in shear and flexure

d) Basic principles of developing PSHA.

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2081 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV/ II	Time	3 hrs.

Subject: - Earthquake Resistance Design of Structure *(Elective II) (CE 76501)*

- ✓ *Candidates are required to give their answers in their own words as far as practicable.*
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain plate tectonics theory. Mention different types of magnitudes. [4+3]

   b) An earthquake causes an average of 2.6 m strike slip displacement over 90 km long 30 km deep of a transform fault. Assuming the rock along the fault had average rupture strength of 160 kPa, estimate the seismic moment and moment magnitude of an earthquake. [5]

2. a) Explain different ground motion parameters. [6]

   b) Explain how the probabilistic seismic hazard analysis is carried out. [6]

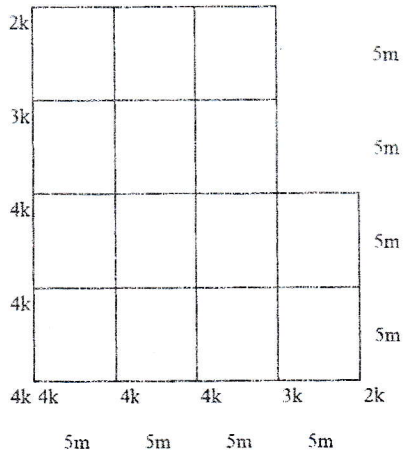
3. Determine displacement, overturning moment, and shear force at each storey at time 't', during an earthquake when the response integral for a 3-storey building is as given below. [12]

$$[m] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1.5 & 0 \\ 0 & 0 & 2 \end{bmatrix} \text{kip} - \frac{s^2}{\text{ft}} \qquad \{v(t)\} = \begin{Bmatrix} 1.56 \\ -0.5 \\ 0.75 \end{Bmatrix} \text{ft/s}$$

$$[\phi] = \begin{bmatrix} 1 & 1 & 1 \\ 1.648 & -0.60 & -2.26 \\ 0.2 & -0.67 & 2.1 \end{bmatrix} \qquad \{\omega\} = \begin{Bmatrix} 4.88 \\ 9.15 \\ 14.31 \end{Bmatrix} \text{rad/s}$$

   b) Explain the behavior of masonry building during failure. [4]

4. a) The plan of one storey building composed of 2-D frames along orthogonal directions is shown below. The floor diaphragm is rigid in its own plane and mass of floor is uniformly distributed. Take the mass of the roof as 1500 kg/m^2.Calculate lateral force in the frames of building when subjected to a lateral force of 300 kN in x-direction. [12]



b) Explain the ductility and ductile detailing in RC structures. [4]

5. a) A six storied reinforced concrete hospital building with story height of 3.4 meters must be a special moment resisting frame located in Kathmandu. The lumped weight due to dead load is 14 kN/m^2 on floor and 10 kN/m^2 on roof. The floors are subjected to live loads of 3 kN/m^2 and 1.5 kN/m^2 on the roof. Determine the design seismic load on the structure as per NBC105: 2020 code if plan area of floor and roof are 160 m^2 and 130 m^2 respectively. [10]

   b) Explain the various methods of retrofitting of RCC structures with sketches. [6]

6. Write short notes on: (Any Two) [2×4]

   a) Global Stiffness Matrix in 3-D frame

   b) Explain the concept of regular buildings for earthquake resistant design

   c) Response spectrum of earthquakes

   d) Intensity of earthquakes

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: -Earthquake Resistance Design of Structure *(Elective II) (CE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Describe plate tectonic theory. Explain different types of seismic waves. [2+4]

   b) An earthquake causes an average of 3m strike slip displacement over 100km long, and 40km deep of a transform fault. Assuming the rock along the fault had average rupture strength of 180kPa, estimate the seismic moment and moment magnitude of an earthquake. [6]

2. a) Explain liquefaction with schematic sketches and its causes. [3+3]

   b) Define seismic hazard analysis. Explain how probabilistic seismic hazard analysis is carried out with steps. [1+5]

3. a) Determine displacement and lateral force at each storey at time 't' due to all modes of vibrations, during an earthquake when the response integral for a three-storey building is as shown below. Determine the peak values due to all modes using SRSS method. [12]

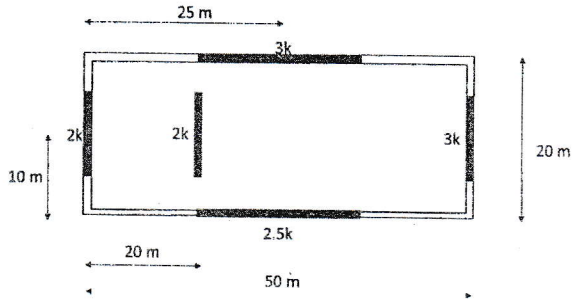
$$[m] = \begin{bmatrix} 1000 & 0 & 0 \\ 0 & 2000 & 0 \\ 0 & 0 & 3000 \end{bmatrix} kg \quad [\emptyset] = \begin{bmatrix} 1.00 & 1.00 & 1.00 \\ 0.55 & -1.50 & -6.50 \\ 0.20 & -0.90 & 11.0 \end{bmatrix}$$

$$[\omega] = \begin{Bmatrix} 11.5 \\ 25.2 \\ 45.5 \end{Bmatrix} rad/sec$$

Pseudo velocity response, $\{S_v$ at time t$\}$=$\begin{Bmatrix} 0.61 \\ -0.14 \\ 0.26 \end{Bmatrix} m/sec$

   b) Explain different failure mechanisms of masonry structures. [4]

4. a) A one storey building of size 50m x 20m has wallsof thickness 350 mm. The storey height is 4 m and the floor consists of cast in situ reinforced concrete. The building is subjected to lateral load of 350kN due to earthquake excitation in either directions. Calculate the design lateral forceson the walls. [12]



   b) Explain the term torsionally coupled and uncoupled systems. [4]

5. a) A three story reinforced concrete hospital building with the total height of 12 meters and story height of 4 meters must be special moment resisting frame located in seismic zone -V. The lumped weight due to dead load is 12 kN/m^2 on floor and 8 kN/m^2 on roof. The floors are subjected to live loads of 4 kN/m^2 and 2 kN/m^2 on the roof. If the plan area for floor and roof is 250 m^2 each, determine the design seismic load on the structure as per IS 1893part I code. [10]

   b) Explain the problems associated with soft and weak stories in buildings. [6]

6. Write short notes on:(Any Two) [2×4]
   a) Faults and fault mechanism

   b) Measures of earthquakes

   c) Modal mass and modal participation factor

   d) Ductility and energy absorption capacity in structures

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2079 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

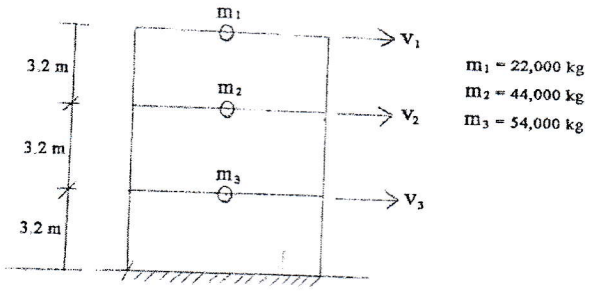
Subject: - Earthquake Resistance Design of Structure *(Elective II) (CE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Use of IS 1893-2002/2016 part-I is allowed.***
- ✓ *Assume suitable data if necessary.*

1. a) How is the intensity of an earthquake different from its magnitude? Estimate the Moment magnitude Mw due to an earthquake which causes an average slip of 4m over a 200 km long and 50 km deep transform fault if the rock had an average rupture strength of 250 kPa. [2+4]

   b) Why seismic hazard analysis is carried out for a site? Explain the information required for seismic hazard analysis. Explain the procedure for probabilistic seismic hazard analysis of a site. [2+3+5]

2. a) A three storey building shown in figure below has the following vibration properties.



$$[\phi] = \begin{bmatrix} 1.00 & 1.00 & 1.00 \\ 0.51 & -1.50 & -6.24 \\ 0.20 & -0.87 & 14.12 \end{bmatrix}$$

$$\{w\} = \begin{Bmatrix} 4.89 \\ 8.50 \\ 14.20 \end{Bmatrix} \text{rad/secs}$$

and pseudo spectral velocity responses

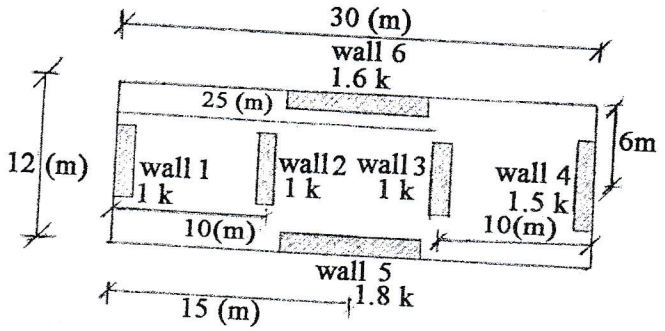
$$\{Sv\} = \begin{Bmatrix} 0.65 \\ -0.24 \\ 0.37 \end{Bmatrix} \text{m/secs}$$

Determine for each made of vibration, the maximum displacement, lateral force, shear force and overturning moments at each storey level. Also determine total maximums due to all modes using SRSS method. [12]

b) Enlist the different types of irregularity developed in building configuration system. Explain how these irregularities are developed and their effects on the building. [4]

3. a) Explain in brief with example the portal frame and cantilever method of lateral load analysis of frame. [6]

b) The one storey building with vertical resisting elements and their stiffness are shown in the figure below. The roof diaphragm is rigid in its plane and mass is distributed uniformly in the roof. Calculate the lateral force in the walls due to a lateral seismic force of 400 kN in the Y direction acting at the roof level. Assume that the wall takes the load only in its plane. Ignore the thickness of walls and their out-of-plane contribution. [10]



4. a) Explain the strength of masonry in shear and flexure with examples. [4]

b) A 3-storey RC public building with a height of 12 m and storey height of 4 m is to be designed as a special reinforced concrete moment resisting frame (SMRF). The building is situated in Kathmandu (seismic zone V). The soil type is soft. The lumped weight on floors due to dead load is 10 kN/m^2 and 6 kN/m^{2}on the roof. The live load on the floors were 5 kN/m^2. Neglect the live load on the roof. If the area of the floor is 400 m^2, determine the base shear and seismic forces on the storey levels as per (IS 1893:2016). Considering a bare frame structure i.e $T = 0.075h^{0.75}$. Draw the distribution of shear forces in the building.

5. Write short notes on: (Any Four) [12]

[4×4]

a) Failure mechanism of masonry walls
b) Soft storey and its mitigations measures
c) Ductile detailing of Reinforced concrete structures
d) Advantages of SMRF over OMRF in the design of multistoried building
e) Response spectrum of earthquakes
f) Characteristics of ground metres parameters.

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Earthquake Resistance Design of Structure *(Elective II) (CE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Use of IS 1893-2002(part I), NBC 105:2020 and IS 1893-2016 is allowed.***
- ✓ *Assume suitable data if necessary.*

1. a) Explain how magnitude of earthquake differs from intensity? Describe in brief about faults and its types. [2+4]

   b) A maximum ground displacement of 18 mm is recorded by a seismograph located at 1150 km from epicenter for the surface wave having period of 22.5 secs. Based on the data, determine surface wave magnitude. [4]

   c) Explain ground motion parameters. [3]

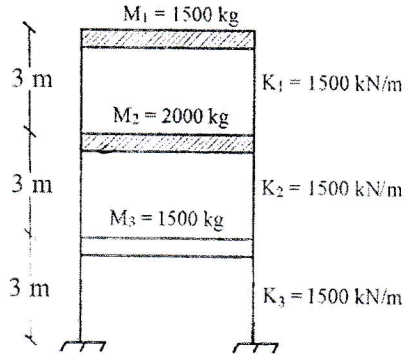
2. a) Define seismic hazard analysis and explain how probabilistic seismic hazard is carried out? [2+6]

   b) For a building shown in figure below with the mass matrix and vibration properties, determine the displacements, overturning moments and shear force at each storey at time t_1 during an earthquake when the response integrals for the three modes are: [16]

$$\{V(t_1)\} = \begin{Bmatrix} 0.42 \\ -0.15 \\ 0.23 \end{Bmatrix} \text{ m/s}$$

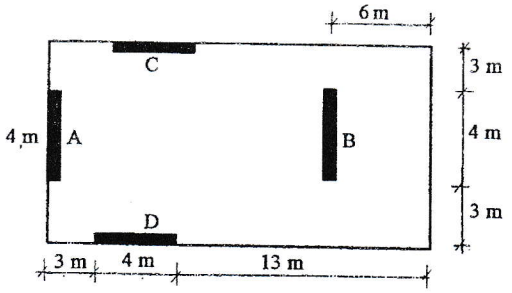
$$\{\omega\} = \begin{Bmatrix} 0.42 \\ -0.15 \\ 0.23 \end{Bmatrix} \text{ rad/s}$$

$$[\phi] = \begin{bmatrix} 1.0 & 1.0 & 1.0 \\ 0.80 & 0.56 & -2.25 \\ 0.44 & -1.25 & 1.8 \end{bmatrix}$$

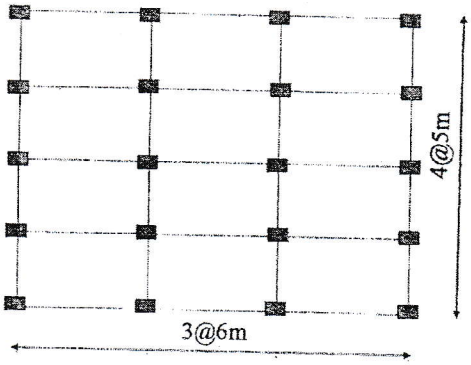


3. a) What is an irregular building? How does the irregularity affect the seismic performance of any building? [2+4]

   b) Plan of a building having four shear walls A, B, C and D is shown in figure below. All the four walls are of M20 grade concrete and 230 mm in thickness. Determine the design lateral forces on different shear walls of one storey building. The seismic force on the building is 400 kN in Y direction. Determine the design lateral force for different shear walls. [10]



4. a) The figure shown in below shows a plan of 6-storey RC framed structures to be constructed in Kathmandu. Height of each storey is 3.5 m. All columns are of 300 × 450 mm and all beams of 300 × 500 mm. Slab thickness is 150 mm. Masonry wall around is 230 mm thick. [12]



The soil below the foundation is hard and the building is located in Kathmandu. Assume live load on all floors is 4 kN/m^2 and in roof is 2 kN/m^2. Determine the seismic forces and shears at different floor levels in both directions. Assume relevant data if required as per IS1893 (part-I) – 2016.

b) Explain, how do you evaluate torsional response in an unsymmetric building? [3]

5. Write short notes on: (Any Three) [3×4]

a) Soft storey and its mitigation measures
b) Capacity design procedure
c) Duhamel's Integral for SDOF for earthquake ground motion
d) Failure mechanism of masonry buildings
e) Ductility in concrete structures

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2077 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

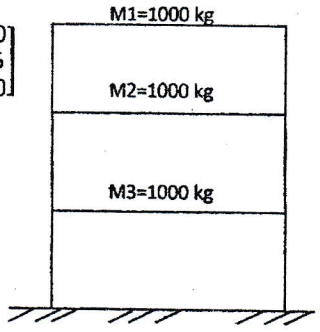
Subject: - Earthquake Resistance Design of Structure *(Elective II) (CE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Use of IS 1893-2002(part I), NBC 105:2020 and IS 1893-2016 is allowed.***
- ✓ *Assume suitable data if necessary.*

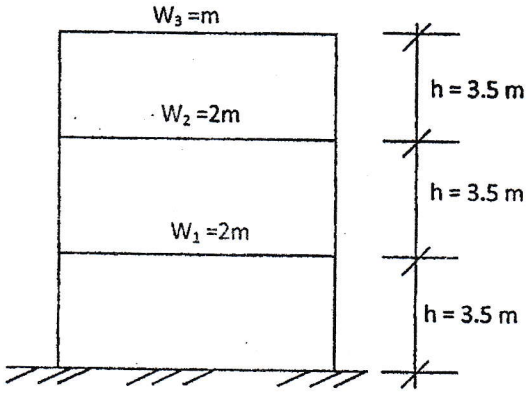
1. a) Estimate the moment magnitude of an event with rupture length of 110 km, rupture width 35 km and slip of average fault of 2.5m. Take modulus of rigidity as 3.5×10^{10} N/m^2. [6]
   b) Discuss the main characteristics of seismic waves. [5]
   c) Define magnitude and intensity of Earthquake. What is the difference in energy released due to earthquake of magnitude 6 and 7? [3+2]
2. a) A three storey building shown in figure below has the following vibration properties. [10]

$$[\phi]=\begin{bmatrix}1.00 & 1.00 & 1.000\\ 0.548 & -1.522 & -6.26\\ 0.198 & 0.872 & 12.10\end{bmatrix}$$

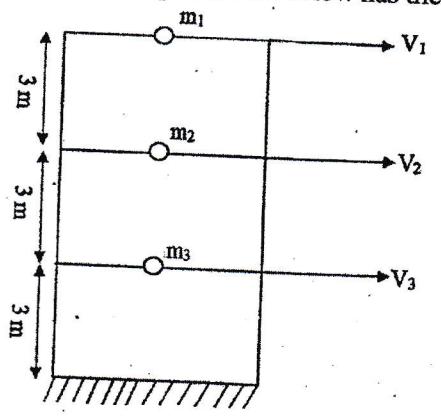
$$\{\omega\}=\begin{Bmatrix}11.62\\ 27.5\\ 45.9\end{Bmatrix}\ \text{rad/sec}$$



   b) Differentiate the DSHA and PSHA. Also, write down the procedure for obtaining the response spectrum curve. [6]
3. For the three storied RCC residential SMRF building located on medium soil and situated in zone V. The seismic weights on the floor are as shown in figure below. Given, m = 20 kN
   The free vibration results are: natural periods $\{T_n\}$ = {0.40 0.18 0.125}s and mode shapes $\{\phi_1\}$={0.314 0.686 1.00}, $\{\phi_2\}$={-0.50 -0.50 1.00} and $\{\phi_3\}$={1.00 -0.686 0.313}. Determine the seismic forces for each story using Equivalent static procedure and Response spectrum analysis procedure as per IS 1893:2016. Also compare the base shear obtained above with NBC 105:2020. [4+6+6]



4. a) A three storey shear building as shown below has the following dynamic properties.



$m_1 = 20{,}000$ kg
$m_2 = 38{,}000$ kg
$m_3 = 50{,}000$ kg

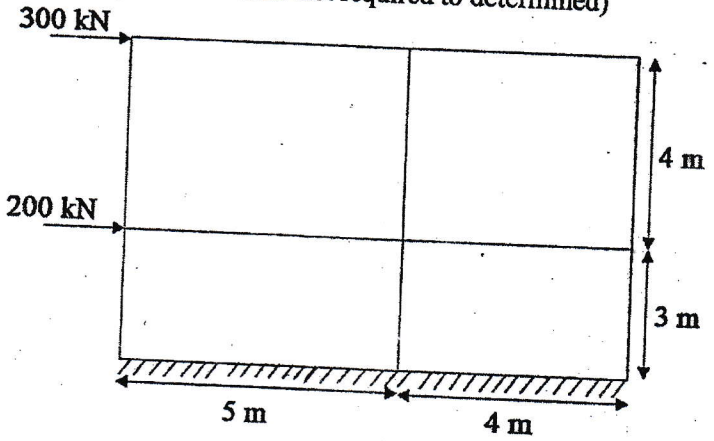
$$[\phi] = \begin{bmatrix} 1.00 & 1.00 & 1.00 \\ 0.52 & -1.51 & -6.24 \\ 0.17 & -0.84 & 12.14 \end{bmatrix}$$

$$\{\omega\} = \begin{Bmatrix} 4.12 \\ 7.32 \\ 12.32 \end{Bmatrix} \text{rad/secs}$$

$$\{V(t_1)\} = \begin{Bmatrix} 0.42 \\ -0.15 \\ 0.22 \end{Bmatrix} \text{m/sec}$$

Determine the displacements, lateral load, overturning moment and base shear due to all modes of vibration at a time t_1 during an earthquake. [11]

b) For the given portal frame, draw the AFD from using portal frame method and cantilever method. (SFD and BMD not required to determined) [5]



5. Write short notes on: (Any Four) [4×4]

a) In-plane and out-of-plane behaviour of masonry structures
b) Ductility and energy absorption in building
c) Ductile detailing for earthquake resistant design
d) Response spectrum of earthquakes
e) Failure mechanisms of masonry wall

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Bhadra

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Earthquake Resistant Design of Structure *(Elective II) (CE 76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Use of IS 1893 (part 1) – 2002 / 2016 is allowed.***
- ✓ ***Use proper and consistent unit system.***
- ✓ *Assume suitable data if necessary.*

1. a) Explain the plate tectonic theory and its mechanism. [6]

   b) Describe the fault and fault mechanism. [5]

   c) An earthquake causes an average 2.6m strike slip displacement over 70 km long, 22 km deep portion of transformed fault. Assuming the average rupture strength along the fault as 170 kPa, estimate the seismic moment and moment magnitude of earthquake. [5]

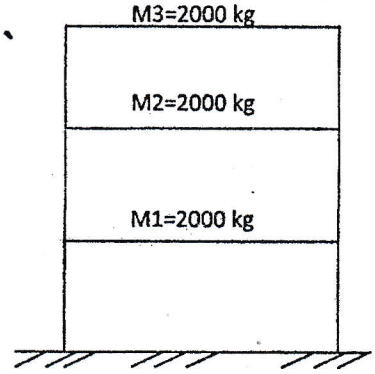
2. a) Explain the steps of probabilistic seismic hazard analysis to be carried out in site. [3]

   b) Define the liquefaction. What are the factors that affect liquefaction? [3]

   c) A theory storey building shown in figure below has the following vibration properties. [10]

$$[\phi]=\begin{bmatrix}0.34 & -1.16 & 2.51\\ 0.76 & -0.80 & -2.43\\ 1.0 & 1.00 & 1.00\end{bmatrix}$$

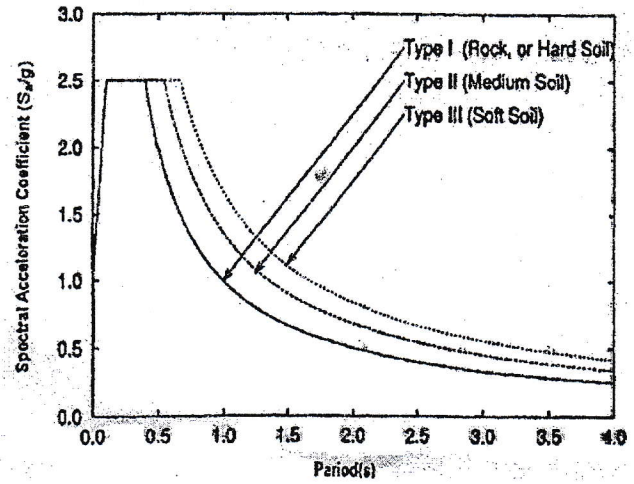
$$\{w\}=\begin{Bmatrix}43.87\\ 120.15\\ 167.00\end{Bmatrix}\ \text{rad/sec}$$



Determine the displacement, overturning moments, shear force at each storey and base shear at time t during an earthquake using the response spectrum method when the modal spectral displacement values are: $Sd_1=0.01902$m, $Sd_2=0.0023$m, $Sd_3=9.77\times10^{-4}$m.

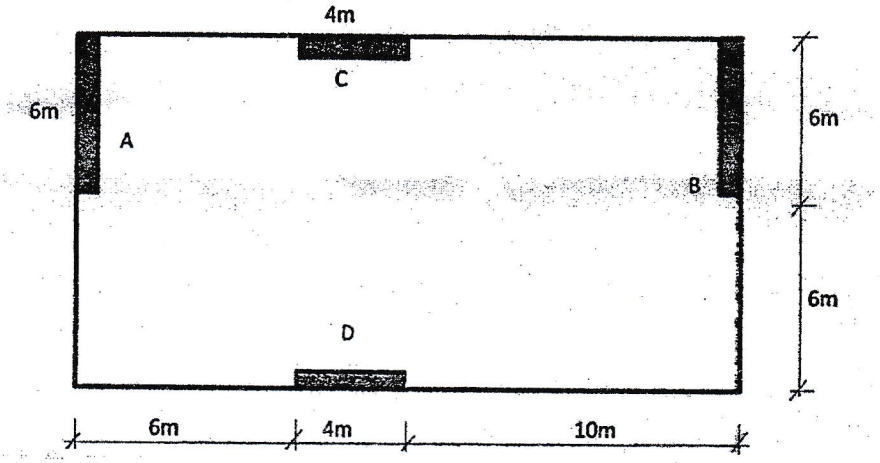
3. For the three storey building frame, the seismic weights on the floor are: weight of first floor (W_1)=1176 kN, weight of second floor (W_2)=784 kN, weight of third(top) floor (W_3) 392 kN. The building is founded on medium stiff soil and situated in zone V according to IS 1893:2002 and considering Z=0.36, I=1, R=5.

   The free vibration results are: natural periods $\{T_n\}$ = {0.883 0.404 0.302}s and mode shapes $\{\phi_1\}$={0.25 0.79 1.00},$\{\phi_2\}$={-1.00 0.00 1.00}, and $\{\phi_3\}$={0.25 -0.79 1.00}. Determine the seismic force by dynamic analysis procedure codal provision. [16]



4. a) Building constructed in seismic zones, the irregularities in the distribution of their mass, stiffness and strength are not desirable. Discuss how these irregularities are developed and their effects on the building. [6]

   b) Plan of a building having four shear walls A, B, C and D is shown in figure. All the four walls are of M25 grade concrete and 250mm in thickness. Determine the design lateral forces on different shear walls, if the storey height is given 4.0m and the seismic force on the building is 200 kN in either direction. [10]



5. Write short notes on: ***(Any Four)*** [4×4]

   a) Drift evaluation and verification
   b) Ductility and energy absorption in building
   c) Effect of infill masonry walls on frames
   d) Confinement of concrete for ductility
   e) Response spectrum of earthquakes

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05 A TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2075 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Earthquake Resistance Design of Structure *(Elective II) (CE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ ***Attempt <u>All</u> questions.***
- ✓ ***The figures in the margin indicate <u>Full Marks</u>.***
- ✓ ***<u>Use of IS 1893-2002(part I) is allowed.</u>***
- ✓ ***Assume suitable data if necessary.***

1. a) Briefly explain the plate tectonic theory. Define a magnitude of an earthquake. How is its different from intensity of an earthquake? [3+3]

   b) Estimate the moment magnitude of an earthquake with rupture length of 100 km rupture width of 50 km and slip of average fault slip of 3.20 m. Take modulus of rigidity as 3.5×10^{10} N/m^2. [6]

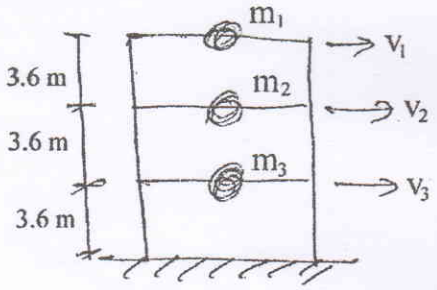
2. a) Lists the different Attenuation relationship model with mathematical expressions for PGA. [3]

   b) Using a appropriate Attenuation law, estimate PGA at a site which is 220 km from MCT(3.3) with a = 6.2, b = 0.8 having 10% probability of an exceedance in 50 years. [7]

   c) Explain the information required for Seismic Hazard Analysis. Also explain in stepwise how probabilistic seismic hazard analysis of a site is carried out. [9]

3. a) Compare the seismic coefficient method and response spectrum method in the design of multi storeyed buildings. [4]

   b) A three storey building as shown in figure below has the following vibration properties.



$m_1 = 21{,}000$ kg
$m_2 = 42{,}000$ kg
$m_3 = 58{,}000$ kg

$$[\phi] = \begin{bmatrix} 1.00 & 1.00 & 1.00 \\ 0.530 & -1.53 & -6.36 \\ 0.190 & -0.86 & 13.12 \end{bmatrix}$$

$$\{w\} = \begin{Bmatrix} 4.86 \\ 8.36 \\ 13.56 \end{Bmatrix} \text{rad/secs}$$

and

Pseudo velocity responses

$$\{Sv\} = \begin{Bmatrix} 0.64 \\ -0.23 \\ 0.35 \end{Bmatrix} \text{m/secs}$$

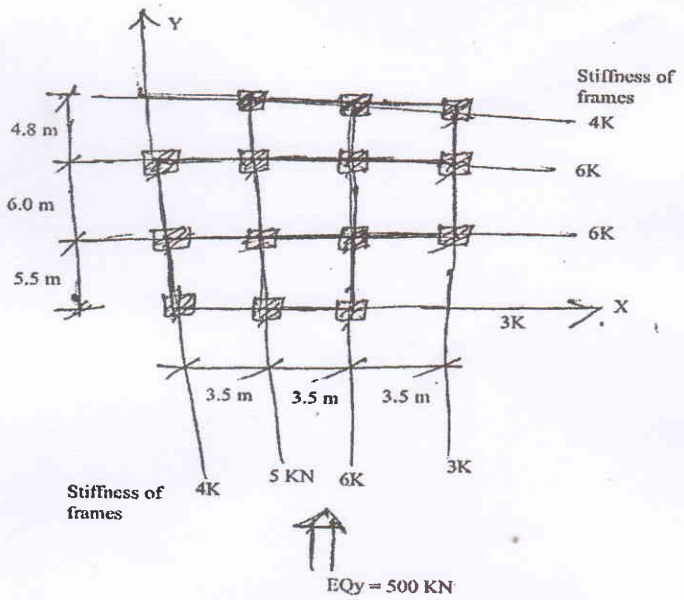
(i) Determine the displacement for each storey level due to all modes of vibrations

(ii) Determine the lateral load at each level for each mode of vibrations and also determine its maximum value due to all modes using SRSS method.

(iii)Determine the base shear due to all modes using also SRSS method. Also determine the mode participation factor, effective modal masses and the number of modes upto which the analysis to be considered as defined in IS 1893-2002. [15]

4. a) A three storey RCC residential building with a total height of 9.0m and a storey height of 3.0m each has to be designed in SMRF. The proposed building is located in seismic zone - V and soil condition as soft soil. The lumped weight due to dead loads is 6 KN/m^2 on floors and 5.0 KN/m^2 on roof. The floors are subjected to live load of 2.0 KN/m^2 and the roof to 1.5 KN/m^2. If the floor and roof at each level have area of 120 sq.m, determine the design seismic load on the building as per IS 1893-2002 (Part-I) [8]

b) The figure given below shown the plan of an one storey buildings which could be considered as composed of 2-D frames along the orthogonal directions. The roof diapharm is rigid in its own plane and mass of the roof is uniformly distributed. The building is subjected to a lateral load of 500 KN due to earthquake in Y-direction and passing through the centre of mass of the building. Calculate the lateral forces in the 2-D frames. [12]



5. a) What are advantages of SMRF over OMRF in the design of multi-storeyed building? What is the provision for drift evaluation in IS 1893-2002. [4]

b) Describe in a brief the Global stiffness matrix for a 3 - D moment resisting frames in reference with local stiffness matrix of plane frames of the same building. [6]

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05A TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2074 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Earthquake Resistant Design of Structures *(Elective II) (CE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1 (a) What is tectonic theory? Explain in brief the elastic rebound theory. Define the magnitude of an earthquake as given by Charles Richter. (6)

(b) Calculate the moment magnitude of an earthquake with the rupture area dimensions of length 35km, width 15km and slip 1meter. Assume modulus of rigidity, $\mu = 3.5 \times 10^{10}$ N/m^2. (6)

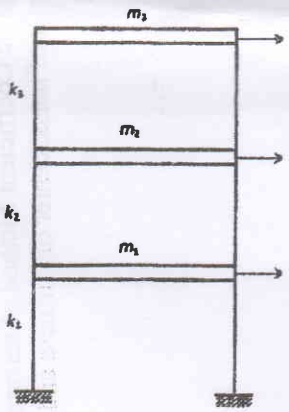
(c) What are the major steps of the Deterministic Seismic Hazard Analysis (DSHA)? What is the principle of Probabilistic Seismic Hazard Analysis (PSHA)? (4)

2 (a) What is response spectrum? Write down the relationship among pseudo velocity response, spectral displacement and pseudo acceleration response. (6)

(b) A three-story building is modeled as 3-DOF system and rigid floors as shown in Figure shown below. Determine the top floor maximum displacement and base shear due to El-Centro, 1940 earthquake ground motion using the response spectrum method. The El-Centro earthquake response spectrum is presented in the figure below. Take the inter-story lateral stiffness of floors i.e. $k_1 = k_2 = k_3 = 16357.5 \times 10^3$ N/m and the floor mass $m_1 = m_2 = 10000$ kg and $m_3 = 5000$ kg. The results of the free vibration analysis are also given below. (10)

$$\{\phi_1\} = \begin{Bmatrix} 1 \\ 1.732 \\ 2.0 \end{Bmatrix} \quad \{\phi_2\} = \begin{Bmatrix} 1 \\ 0 \\ 1 \end{Bmatrix} \quad \{\phi_3\} = \begin{Bmatrix} 1 \\ -1.733 \\ 2.0 \end{Bmatrix}$$

$$\omega_1 = 20.937\,rad/sec \quad \omega_2 = 57.2\,rad/sec \quad \omega_3 = 78.13\,rad/sec$$



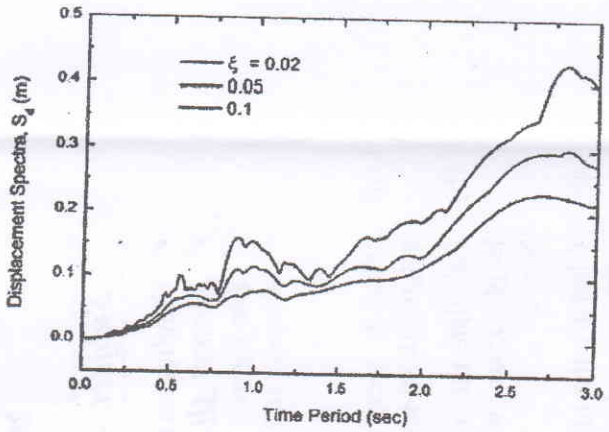
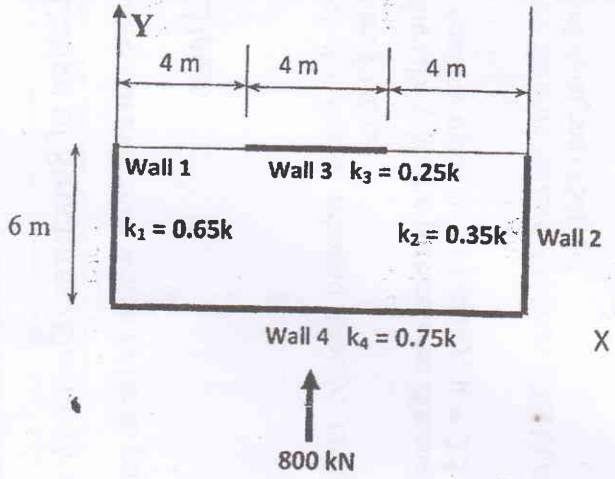


Figure: Displacement response spectra of El-Centro, 1940 earthquake ground motion.

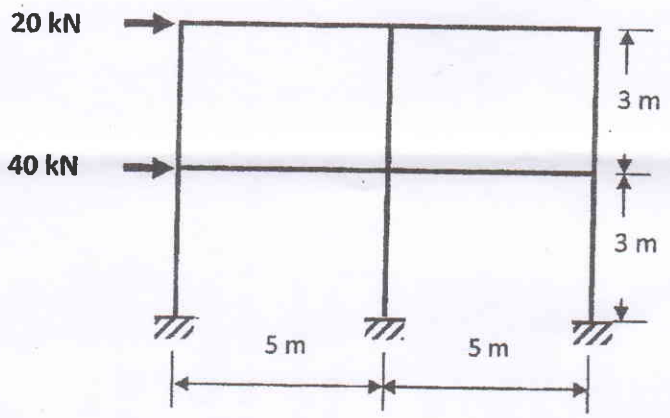
3 (a) Define rigid floor diaphragm. What is center of stiffness? Describe how the center of stiffness is determined with a simple example. (6)

(b) The figure given below shows the plan of a one-storey building, supported on four shear walls with the lateral stiffnesses as indicated, and oriented as shown. The roof diaphragm is rigid in its own plane, and the mass of the roof is uniformly distributed. The building is subjected to a lateral load of 800 kN, due to earthquake, in y-direction and passing through the center of mass of the building. Calculate the lateral forces in the walls. (10)



4(a). What is a moment resisting frame? Describe in brief the Global stiffness matrix for a 3-D moment resisting frame in reference with Local stiffness matrices of plane frames of the same building. (6)

(b) Analyze the frame shown in the figure given below using Portal method and construct Bending Moment diagram. Give the assumptions made in the analysis. All columns are of same cross section 300 x 300 mm. (10)



5. Write in brief the principles and concepts of (any three only) (4x4)

(a) Types of faults
(b) DOF and global stiffness matrix of 3-D moment resisting frames
(c) Lateral stiffness matrix of a solid shear wall with consideration of rocking of footing.
(d) Response spectrum analysis of a MDOF frame.
(e) Seismic Coefficient Method of seismic analysis
(f) Center of mass, center of stiffness and torsionally coupled system

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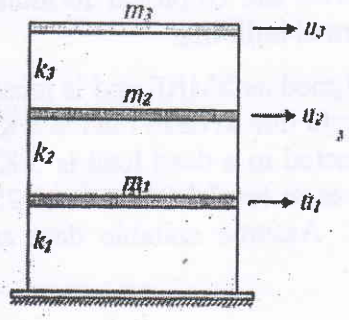
5 A TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

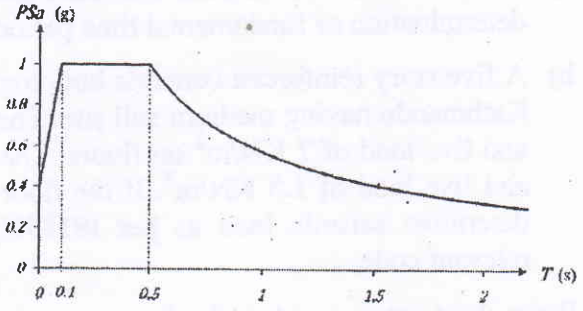
Subject: - Earthquake Resistance Design of Structure *(Elective II) (CE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Use of IS 1893-2002 (part-I) is allowed.***
- ✓ *Assume suitable data if necessary.*

1. a) Discuss about the seismic hazards with suitable examples. [6]
   b) Define Richter scale. [2]
   c) Find the spectral pseudo-velocity and spectral displacement of a structure, which has a natural frequency of vibration 7 Hz and a damping ratio of $\xi = 0.03$, corresponding to a spectral acceleration of 14 m/sec^2. [4]
   d) An Earthquake causes an average of 4m strike-slip displacement over 120 km long, 40 km deep portion of a transform fault. Assuming that the rock along faulty had average rupture strength of 180 kpa, estimate the seismic moment and moment magnitude of the Earthquake. [4]
2. A three story building is modeled as 3-DOF system with rigid floors as shown in the figure (a). Determine the top floor maximum displacement and shear due to the earthquake ground motion using the response spectrum (given in figure b) method. Assume $K_3=K_2=3K_1$ and $m_3=1.5m_2=m_1$, where $K_1=200$ kN/m and $m_1=2500$ kg. [16]



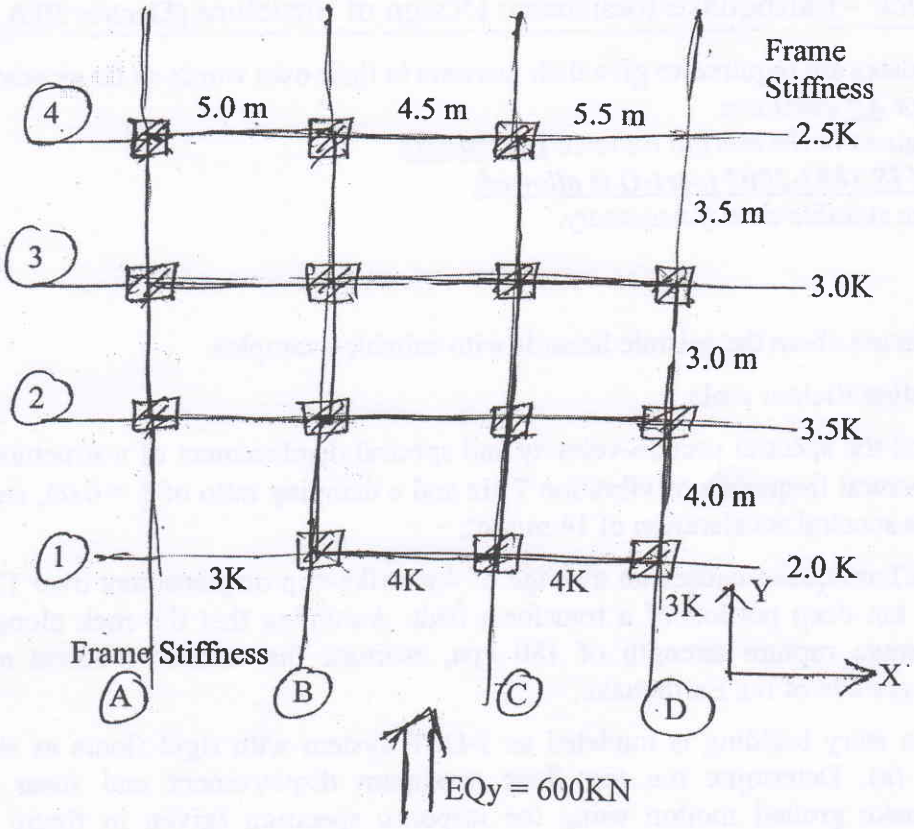
(a)



(b)

3. a) Define the torsionally uncoupled and torsionally coupled system of buildings. Also described how the lateral loads are distributed among the vertical members. [4]

b) For one storey building with rigid floor diagram. 600 KM lateral load acts at storey level along Y-direction as shown in figure. All the column of equal sizes as square type. Distribution of frame stiffness are as shown and assume uniform distribution of load in the floor, calculate the lateral force in the individual frames and sketches the 2-D frame along Y-direction. [12]



4. a) Define seismic coefficient and base shear. Write down the empirical formulae for determination of fundamental time period of a RC framed building. [4]

b) A five story reinforced concrete building is to be designed as SMRF and is located to Kathmandu having medium soil site. The lumped weight due to dead load is 8 KN/m^2 and live load of 7 KN/m^2 on floors. The roof is subjected to a dead load is 5 KN/m^2 and live load of 1.5 KN/m^2. If the floor and roof at each level have area of 250m^2, determine seismic load as per IS1893(part I)-2002. Assume suitable data as per relevant code. [12]

5. Write short notes on: (Any four) [4×4]

a) Approximate method for lateral load analysis of plane frame structures
b) Concept of Moment resisting frames
c) Ductile detailing of RCC structures
d) Failure Mechanisms of Masonry buildings
e) Seismic waves

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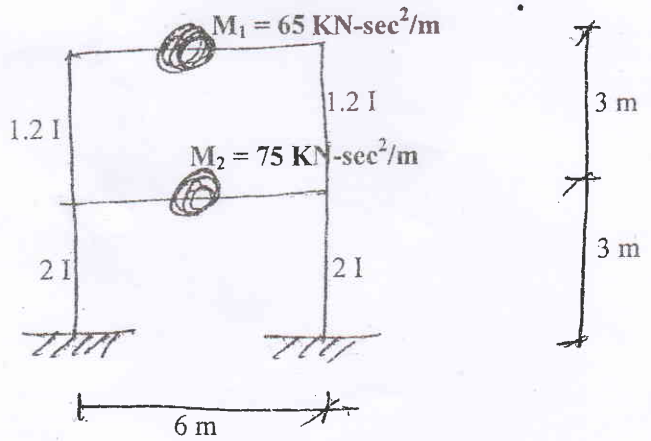
5A TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

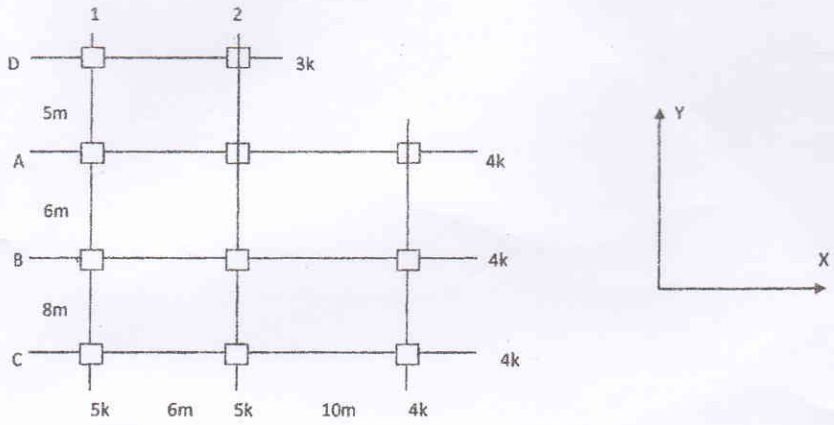
Subject: - Earthquake Resistance Design of Structure *(Elective II) (CE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
  Use of IS 1893-2002 (part-I) is allowed.
- ✓ *Assume suitable data if necessary.*

1. a) What is a fault? Explain each type of fault with a neat figure. [4]
   b) Estimate the moment magnitude of an event with rupture length of 120 km, rupture width of 40 km and slip of average fault slip of 3m. Take modulus of rigidity, as 3.5×10^{10} N/m^2. [8]
   c) What is an attenuation relationship? What are the main parameters of earthquake sources on which attenuation of the ground motion parameter depends? [4]
2. a) Define Seismic Hazard at a site. Explain in stepwise how deterministic seismic Hazard analysis of a site is carried out. [8]
   b) Write down the Rienter- Gutenberg Recurrence law. Explain how probabilistic density function of magnitude is obtained. [3]
   c) The main central Thrust (MCT-3.0) having a = 6.2 and b = 1.0 can produce maximum size of earthquake magnitude of 6.0 Richter scale. Calculate the Return period of the earthquake. [5]
3. The acceleration response spectrum values for a two storey shear building, as shown in the figure below, are given as $S_a = \begin{Bmatrix} 0.546 \\ 0.835 \end{Bmatrix} m/sec^2$. Calculate for each mode of vibration, the maximum displacement, shear force and over turning moment at each storey level. Also determine total manimums for each of the response quantities of the above. [16]



4. a) The figure shown below shows the plan of one-storey buildings, which may be considered as composed of 2-D frames along the orthogonal directions. The roof diaphragm is rigid in its own plane, and the mass of the roof is uniformly distributed. The building is subjected to a lateral load of 800 KN, due to earthquake, in Y-direction and passing through the centre of mass of the building. Calculate the lateral forces in the 2-D frames. [11]



b) Describe in brief the portal method of lateral load analysis of frame. [5]

5. Write short notes on: (Any four) [4×4]

a) Rigid Diaphragm effect
b) Probabilistic Seismic Hazard Analysis (PSHA)
c) Ground motion parameters
d) Seismic zoning
e) Failure mechanisms of masonry wall

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05A TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Ashwin

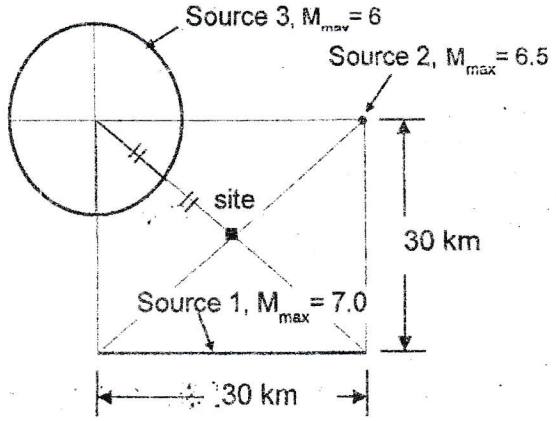
Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Earthquake Resistance Design of Structure *(Elective II) (CE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

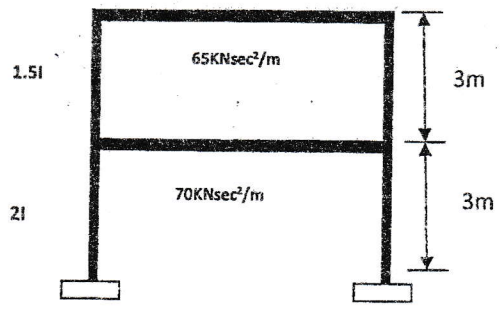
1. a) What are tectonic plates and explain tectonic theory. [2+2]
   b) Discuss the seismic hazards. [4]
   c) An earthquake causes an average of 3 m strike-slip displacement over 90km long, 40km deep portion of a transform fault. Assuming that the rock along the fault had average rupture strength of 180kPa, estimate the seismic moment and moment magnitude of the Earthquake. [8]
2. a) What is seismic hazard curve? Write down the process for developing it for a site? [4]
   b) Using DSHA compute the PHA for the site below. Use the following attenuation relationship. [12]

$$\ln \text{PHA (gals)} = 6.74 + 0.859\,M - 1.8 \ln (R+25) \qquad \text{(note : } R \text{ in km)}$$

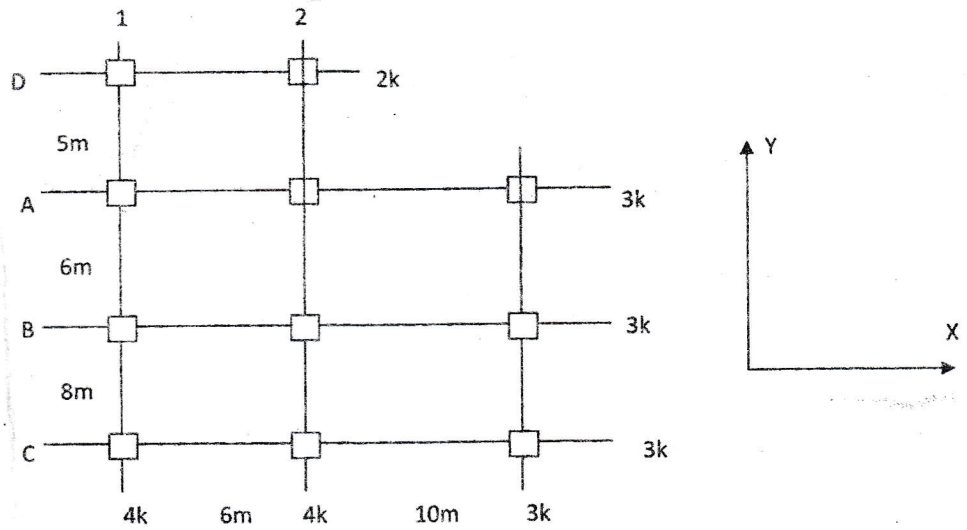


3. For the two-storey shear building as shown in the figure below, Calculate for each mode vibration, the maximum displacement, shear force and overturning moment at each storey level. Also determine total maximums for each of the response quantities of above. The acceleration response spectrum values as: [16]

$$S_a = \begin{bmatrix} 0.30 \\ 0.25 \end{bmatrix} m./s^2$$



4. a) The figure shown below shows the plan of one-storey buildings, which may be considered as composed of 2-D frames along the orthogonal directions. The roof diaphragm is rigid in its own plane and the mass of the roof is uniformly distributed. The building is subjected to a lateral load of 500KN due to earthquake, in X-direction and passing through the center of mass of the building. Calculate the lateral forces in the 2-D frames. [12]



b) Write down the approximate method for lateral load analysis of plane frame structures and their suitability. [4]

5. Write short notes on: (any four) [4×4]

i) Factors influencing ground motion parameters at a site.
ii) Failure mechanism of mosonry building
iii) Ductile detailing of reinforced concrete structure
iv) Global stiffness matrix of 3-D framed building
v) Provision for torsion

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05A TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2072 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Earthquake Resistance Design of Structure *(Elective II) (CE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) What are the causes of earthquake? State theory of plate tectonics. [4]

   b) An earthquake causes an average of 3.5 m strike- slip displacement over a 70 Km long, 221 Km deep portion of a transform fault. Assuming that the rock along the fault has an average rupture strength of150 KPa, estimate the seismic moment (M_o) and moment magnitude (Mw) of the earthquake. [8]

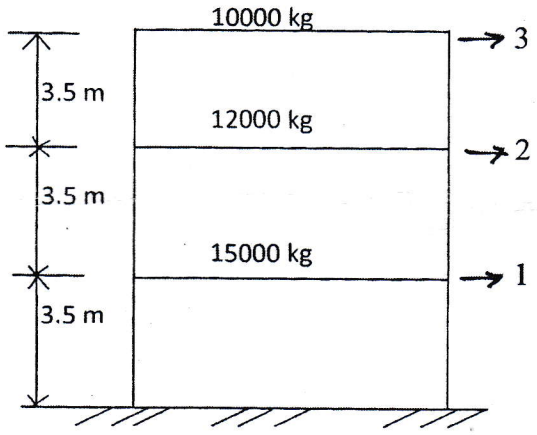
   c) Find the spectral pseudo-velocity and spectral displacement of a structure, which has a natural frequency of vibration 5Hz and a damping ratio of $\zeta = 0.05$, corresponding to a spectral acceleration of 12.57 m/sec^2. [4]

2. a) What is a seismic fault? Explain the types of faults. [4]

   b) A three storey building shown in figure below has the following vibration properties. [12]

$$[\phi]=\begin{bmatrix}1.000 & 1.000 & 1.000\\ 1.698 & 0.430 & -1.095\\ 2.027 & -0.629 & 1.498\end{bmatrix}$$

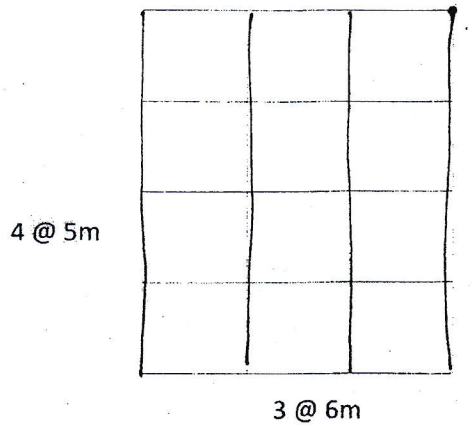
$$\{w\}=\begin{Bmatrix}0.907\\ 2.901\\ 4.912\end{Bmatrix}\text{ rad/sec}$$



Determine the displacement, overturning moments, shear force at each storey and the base shear at time t during an earthquake when the earthquake response integrals for three modes are

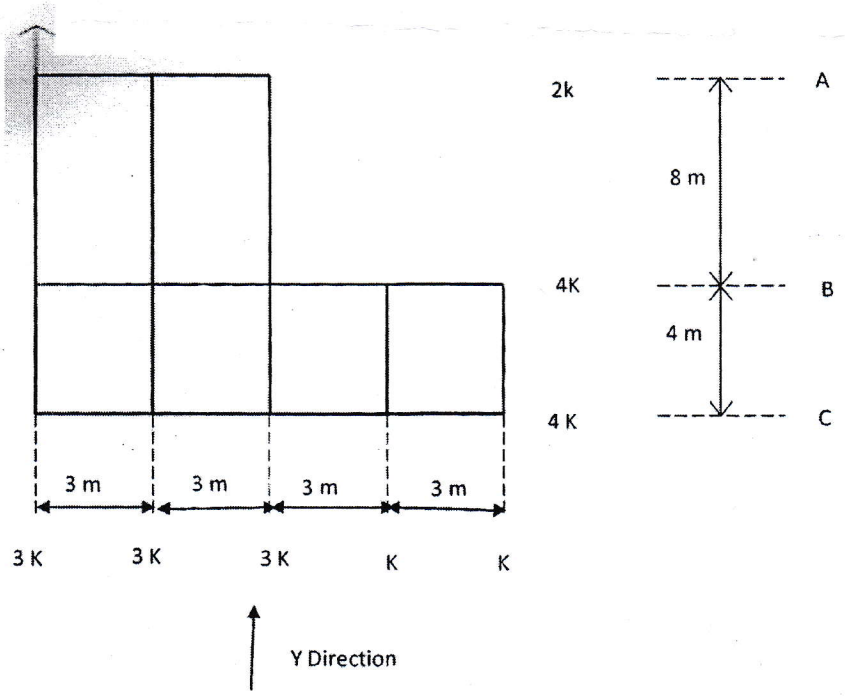
$$\{V(t)\}=\begin{Bmatrix}0.3\\ 0.55\\ 0.67\end{Bmatrix}\text{ m/sec}$$

3. The figure shown in below shows a plan of 6-storey RC framed structure to be constructed in Kathmandu. Height of each storey is 3.5 m. All columns are of 300×450mm an all beams of 300×500mm. Slab thickness is 150mm. Masonry Wall around is 230mm thick. [16]



The soil below the foundation is hard and the building is located in Kathmandu. The time period of building is determined by using $T = \frac{0.09h}{\sqrt{d}}$ .Assume live load on all floor is 4KN/m^2 and in roof is 2KN/m^2. Determine the seismic forces and shears at different floor levels in both directions. Assume relevant data if required as per IS1893(part I) -2002.

4. a) Describe the in-plane and out-of plane behavior of slabs. Define rigid floor diagram. [4]
   b) The figure given below shows the plan of one storey building which could be considered as composed of 2-D frames along the orthogonal directions. The roof diagram is rigid in its own plane, and mass of the roof is uniformly distributed. The building is subjected to a lateral load of 1500 kN due to earthquake in Y direction and passing through the center of mass of the building. Calculate the lateral forces in the 2D frame along X as well as Y directions. [12]



5. Write short notes on: (any four) [4×4]
   a) Magnitude and Intensity of earthquakes
   b) Response Spectrum Analysis
   c) PSHA (probabilistic Seismic Hazard Analysis)
   d) Lateral stiffness of shear wall resting on rigid foundation
   e) Earthquake Ground Motion Parameters