GUJARAT TECHNOLOGICAL UNIVERSITY

5th Semester Civil Engineering – PDDC

Subject Code & Name: X50602 - Earthquake Engineering

Sr. No.	Course content
1.	**Earthquake Basics:** Earth interior, plate tectonics, faults, consequences of earthquake, Earthquake parameters, magnitude & intensity, scales, Seismic zones of India, damages caused during past earthquakes (worldwide).
2.	**Fundamentals of Earthquake Vibrations of buildings:** Static load v/s Dynamic load, (force control and displacement control), simplified single degree of freedom system modelling of buildings, natural frequency, resonance v/s increased response, responses of buildings to different types of vibrations like free and forced, damped and undamped vibration, response of building to earthquake ground motion, introduction to multi degree of freedom systems (mode shape).
3.	**Earthquake Loads on Building and Lateral load Analysis :** Philosophy of earthquake resistant design, earthquake proof v/s earthquake resistant design, Four virtues of earthquake resistant structures (strength, stiffness, ductility and configuration), Introduction to IS: 1893 (Part I), Seismic structural configuration. Seismic coefficient method – base shear and lateral force distribution along height, Load combinations, Concepts of ductile detailing of RC building Methods of Analysis: approximate method, matrix – computer method
4.	**Special topics:** Introduction to soil liquefaction, structural control & Seismic strengthening
5.	**Earthquake resistant Masonry features:** Un-reinforced Masonry, Basics of masonry: units of masonry, good construction practice, Earthquake resistant features: bands and vertical reinforcement IS-4326, IS-13827, IS-13828

Term Work : Term work shall consist of Seismic design of RC multi-storey frame building with ductile detailing in A3 CAD drawings, at least 25 problems based on the course under Earthquake Engineering and Preparation of various models of structural systems OR seminar/project.

IS Codes :

1. IS 1893 Part-I (2002) - Criteria for earthquake resistant design General provision & Building
2. IS 13920 (1993) - Code of Practice for Ductile Detailing of RC Structures
3. IS 4326 (1993) - Code of Practice for earthquake resistant design & Construction of buildings
4. IS 13827(1993) - Improving Earthquake Resistance of Earthen Buildings
5. IS 13828 (1993) - Guide lines for Improving Earthquake Resistance low strength masonry buildings

References Books:

1. A.K.Chopra : Dynamics of structures
2. Clough & Penzin : Dynamics of structures
3. Manish shrikhande & Pankaj Agrawal : Earth quake resistant design of structures
4. Park & Pauly : Behavior of RC structure
5. John M.Biggs : Introduction to Structural Dynamics
6. Mario Paz : Structural Vibrations - Theory

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GUJARAT TECHNOLOGICAL UNIVERSITY

PDDC - SEMESTER–V • EXAMINATION – SUMMER 2015

Subject Code: X50602 **Date:11/05/2015**

Subject Name: Earthquake Engg.

Time: 02:30 pm - 05:00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Use of IS 1893- 2002 (Part 1), IS 13920 (1993), IS 4326 (1993), IS 13828 (1993) is permitted.**

Q.1 **(a)** **Attempt following.(All)** **07**

1. Explain in detail - Over damped system comes to rest, faster than critically damped system or underdamped system
2. Differentiate - Ductility Vs Flexibility
3. Differentiate - Gravity load distribution Vs lateral load distribution1. Enlist required condition for liquefaction.
4. Give four virtue of good earthquake resistant design.
5. Explain in detail - Moment resisting Capacity of a column should be more than that of beam framing on it.
6. Differentiate - Seismograph Vs Seismogram
7. Explain logarithmic decrement.

(b) **State whether following statements are true or false with justification. (Any seven)** **07**

1. Soft storey & weak storey are same.
2. Damping can be neglected in the dynamic analysis of buildings.
3. Design philosophy for gravity loads & design philosophy for lateral loads due to earthquake are same.
4. Surat situated in South of Gujarat near sea coast has highest seismic risk.
5. P & S waves are responsible for maximum damage to structures.
6. Natural frequency of vibrating system will remain unchanged if damping level is Increased.
7. Energy released in an earthquake of magnitude 8, is double compared that released in magnitude 4 earthquakes.
8. Generally shallow focus earthquakes are more destructive compared to deep focus earthquakes of same magnitude.

Q.2 **(a)** A SDOF system consists of 6 m high column of 300 mm diameter which supports the heavy mass of 15 Ton at its top. The system is subjected to a harmonic force of 1500 Sin 50t N. Consider 10% damping & $E = 2 \times 10^5$ N/mm^2. Calculate the maximum dynamic amplitude. Also state whether system will have resonance or not? **07**

(b) Determine the magnification factor of forced vibration produced by an oscillator fixed at the middle of the beam at a speed of 500 rpm. The weight concentrated at the middle of the beam is W is equal to 5500 N and produces a static deflection of beam equal to (δ_{st}) 0.040 cm. Neglect the weight of beam and assume that the damping co efficient is equal to 20 N-S/m. **07**

OR

(b) A mass initially at rest is allowed to displaced through 25 mm and released to vibrate. Determine undamped and damped natural frequencies. Natural period and amplitude after 5 cycles. And Nos. Of cycles when amplitude reaches to 1 mm. Assume damping constant is equal to 10 N s/mm. (Figure.1) **07**

Q.3 **(a)** Calculate base shear in the critical direction only for building located in Ahmedabad with following data by static coefficient method. Assume damping by 10 percent. **07**

(a) No. of storey = 6 (b) No. of bay in x direction = 2
(c) No. of bay in y direction = 3 (d) storey height = 4.0 m
(e) Width of each bay = 4 m (f) Size of beam = 300 x 400 mm
(g) size of column = 300 x 600 m (h) LL = 4 kN/m^2
(i) Thickness of slab = 160 mm
Assume suitable data if required. Write all your assumptions & clauses of IS 1893 (2002).

(b) Ref Q 3 (a) Calculate lateral forces in the critical direction only at each floor Level. Also draw distribution of lateral force at each floor level. **07**

OR

Q.3 **(a)** **Attempt All** **07**

1. Enlist various codes of practice along with correct name related to Earthquake engineering.
2. Give very short answers for the following :
(i) Explain Shear Walls & its significance
(ii) Enlist component of seismograph
(iii) Can I make building earthquake proof?

(b) 1. Two pendulums are hanging on an ideal spring with equal mass. The period of vibration for the pendulums is 4 sec & 12 sec respectively. What is the stiffness of the second pendulum with respect to first? **07**

2. A SDOF system having the amplitude of vibration in successive cycle are 0.70, 0.35, 0.18, 0.09 units respectively. Determine damping ratio of the System. Also determine logarithmic decrement.

Q.4 **(a)** Derive expression for the response of free damped SDOF structural system. **07**

(b) Explain ductile detailing of column as per IS 13920 – 1993 **07**

OR

Q.4 **(a)** Explain mathematical modeling in detail. Draw mathematical model for any Three structural systems. **07**

(b) Explain in detail with suitable sketches., **07**
a) Pounding b) Storey Drift c) Floating Column.

Q.5 **(a)** Explain in details a.) Center of mass b.)Center of Stiffness **07**

(b) The figure as shown in plan of 6 m high hospital parking shed. Carry out lateral load distribution as per IS 1893(I)-2002. If recorded acceleration at roof level is 0.20 m/s^2. (Figure.2) **07**

OR

Q.5 **(a)** Discuss the preventive measures against liquefaction of soil. **07**

(b) For the two storey building frame having lumped masses 10 tonne at floor level having storey stiffness 100 kN/m. Perform free vibration analysis & draw all mode shapes. Calculate natural frequency. **07**

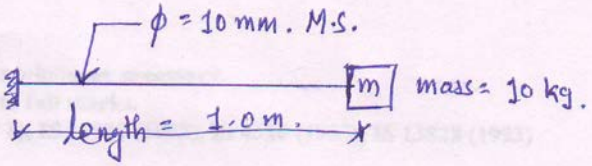
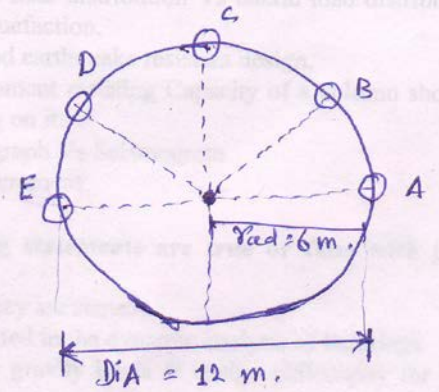


Figure. 1 [Q. 2 (B) optional]



Parking shed
Height = 6 m.

Figure. 2 [Q. 5 (B)]

Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

PDDC - SEMESTER–V • EXAMINATION – WINTER • 2014

Subject Code: X50602 **Date: 02-12-2014**

Subject Name: Earthquake Engineering

Time: 10:30 am - 01:00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **IS 1893 Part I (2002) & IS 13920 (1993) are allowed in the Examination.**

Q.1 **(a)** Derive the equation of motion for the free damped single degree of freedom system. **07**

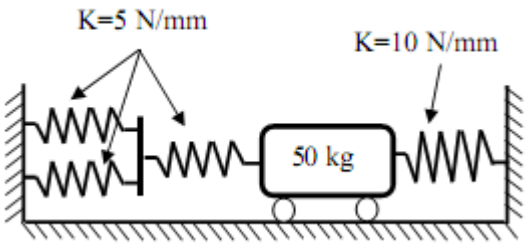
(b) Define (i) Iso-seismal (ii) soft storey (iii) epicenter (iv) magnitude (v) resonance (vi) seismogram (vii) Intensity **07**

Q.2 **(a)** Explain concept of ductile detailing & explain factor affecting the ductility of structures in detail. Explain ductile detailing of beam as per IS 13920 – 1993. **07**

(b) An empty elevated water tank is pulled by a steel cable by applying a 30 kN force. The tank is pulled horizontally by 5 cm. The cable is suddenly cut and the resulting free vibration is recorded. At the end of five complete cycles, the time is 2 seconds and the amplitude is 2 cm. Determine the damping ratio, natural period of undamped vibration, effective stiffness, effective weight and damping coefficient for the given data. **07**

OR

(b) Find the natural frequency of the system shown in the fig. below **07**



Q.3 **(a)** Calculate the base shear for a five storey hospital building having special moment resisting frame (SMRF) located in Ahmedabad on medium soil with following data using seismic coefficient method. **07**

(i) No. of bay in x and y-direction = 4
(ii) Width of each bay = 5m
(iii) Thickness of slab =150 mm
(iv) Storey height = 3 m
(v) Size of beam and column = 300 mm x 450 mm
(vi) Amount of damping = 10 % of critical damping
(vii) Live load = 4 kN/m2

Assume any additional data if required and neglect the weight of the infill wall panels.

(b) Calculate the lateral forces at each floor level of hospital building of Q.3.a using seismic coefficient method. **07**

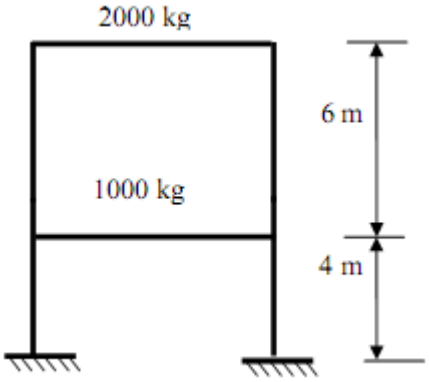
OR

Q.3 **(a)** What is the natural period of vibration of the second system with respect to first if both systems are identical except support condition? First system has hinge support & second system has fixed support **04**

(b) Explain four virtue of good earthquake resistant design. **05**

(c) Explain Base Isolation technique. **05**

Q.4 **(a)** What is mode shape? Plot the mode shapes for the frame shown in the fig. and indicate the fundamental mode. Take $EI_{column} = 1.5 \times 10^{12}$ N-mm, $EI_{beam} = \infty$. **14**

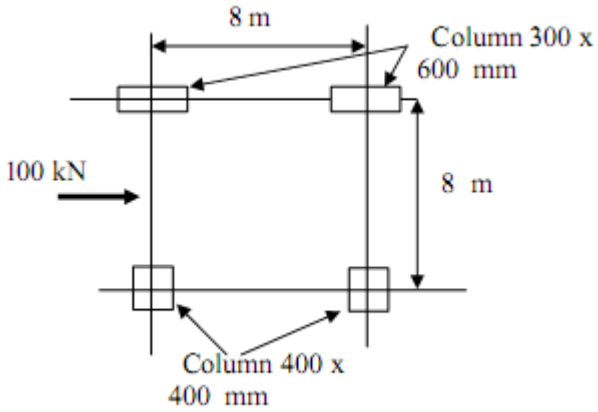


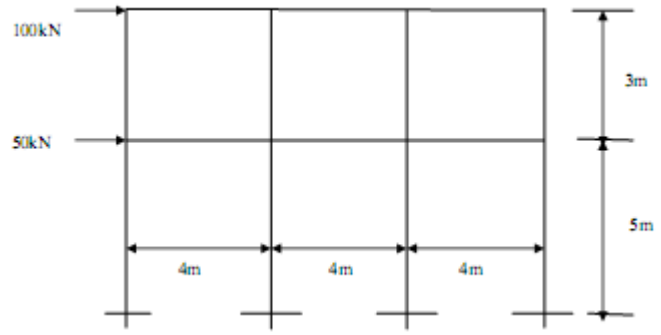
OR

Q.4 **(a)** State whether following statements are true or false. Give logical reason for your answer : **07**

1. Masonry structures offers less damping as compared to steel structures.
2. Code specifies lower value of R for building having better performance.
3. Dahod is having maximum earthquake risk.
4. Peak ground acceleration (PGA) & Zero period acceleration (ZPA) are same.
5. Two identical building to be constructed in zone IV & V. Building in zone IV should be designed for higher lateral load than building in zone V.
6. Any structure is designed as earthquake proof structure.
7. Liquefaction is only possible in clayey soil.

Q.4 **(b)** Find the lateral loads in the columns of a rigid floor shown in the fig. All columns are of same height and mass is uniformly distributed. **07**



Q.5 **(a)** 

07

Analyze the structure as shown in the figure. by portal method .

(b) Draw axial force, shear force & bending moment diagram for the RC frame given in Q 5 (a) **07**

OR

Q.5 **(a)** Explain failures of masonry structures observed in past earthquakes & how will you improve performance of masonry building. **07**

(b) Define & explain liquefaction. Also give remedial measures for the liquefaction. **07**

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Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

PDDC - SEMESTER–V • EXAMINATION – SUMMER • 2014

Subject Code: X50602 Date: 29-05-2014

Subject Name: Earthquake Engineering

Time: 02:30 pm - 05:00 pm Total Marks: 70

Instructions:

1. ***Attempt all questions.***
2. ***Make suitable assumptions wherever necessary.***
3. ***Figures to the right indicate full marks.***
4. ***IS 1893 Part I (2002) & IS 13920 (1993) are allowed in the Examination.***

Q.1 **(a)** Derive the expression for the dynamic load factor for the forced damped vibration with usual notations. **07**

(b) Explain four virtue of good earthquake resistant design. **07**

Q.2 **(a)** Explain concept of ductile detailing & explain factor affecting the ductility of structures in detail. Explain ductile detailing of column as per IS 13920 – 1993. **07**

(b) An elevated water tower tank with a capacity of 60000 litres of water has a natural period in lateral vibration of 1.5 sec when empty. When the tank is full of water, its period lengthens to 2.8 sec. Determine the lateral stiffness ‘k’ of the tower and the weight ‘W’ of the tank. Neglect the mass of the supporting column and damping. **07**

OR

(b) What is jacketing? Explain the jacketing of beams and column with illustrative sketches. **07**

Q.3 **(a)** A five storeyed building has size of 30m x 30m. It is located in Bhuj and resting on hard soil. The weights of floors and height of the floors are 2000kN, 2500kN, 2500kN, 2500kN and 2100kN AND 4.5m, 3.5m, 3.5m, 3.5m and 3.5m respectively from slab no.1 from bottom. Assuming the building as special moment resisting office building and 7% of critical damping, calculate the horizontal shear forces acting at the each slab level by equivalent lateral force method. **10**

(b) Discuss in detail the advantage of horizontal bands and vertical reinforcement in the masonry buildings. **04**

OR

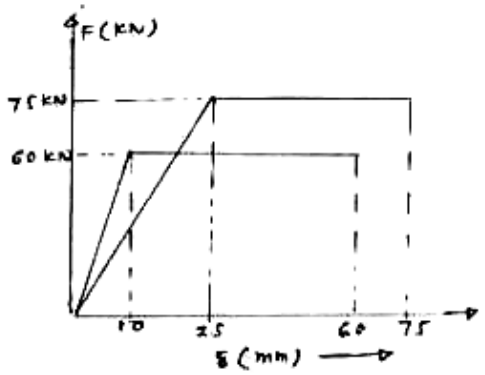
Q.3 **(a)** Define & explain liquefaction. Also give remedial measures for the liquefaction. **07**

(b) Explain Base Isolation technique. **07**

Q.4 **(a)** State whether following statements are true or false. Give logical reason for your answer : **07**

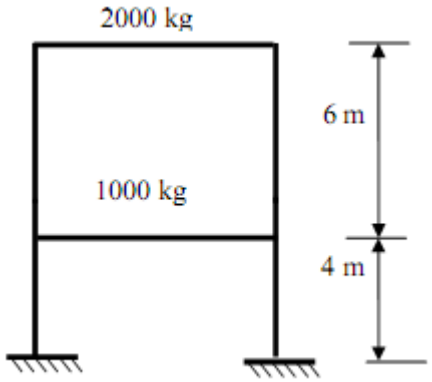
1. Masonry structures offers less damping as compared to steel structures.
2. Code specifies lower value of R for building having better performance.
3. Dahod is having maximum earthquake risk.
4. Peak ground acceleration (PGA) & Zero period acceleration (ZPA) are same.
5. Two identical building to be constructed in zone IV & V. Building in zone IV should be designed for higher lateral load than building in zone V.
6. Any structure is designed as earthquake proof structure.
7. Liquefaction is only possible in clayey soil.

Q.4 **(b)** Force deformation curve of two building is shown in Fig., calculate (i) Stiffness of building A and B (ii) Ductility factor of building A and B (iii) Energy absorption capacity of building A and B (iv) Maximum load capacity of building A **07**

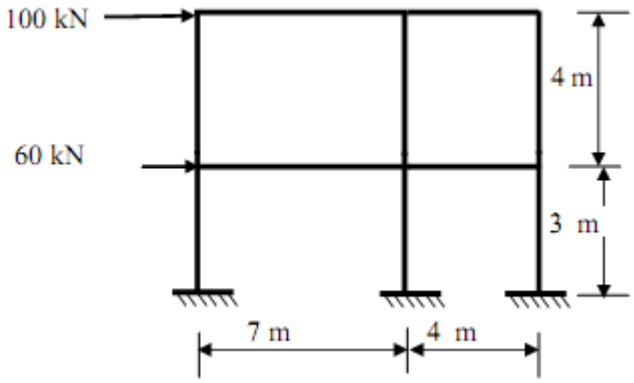


OR

Q.4 **(a)** What is mode shape? Plot the mode shapes for the frame shown in the fig. and indicate the fundamental mode. Take $EI_{column} = 1.5 \times 10^{12}$ Nmm^2, $EI_{beam} = \infty$. **14**



Q.5 **(a)** Enlist different approximate methods used for lateral load analysis. Analyze the frame shown in the fig. using an appropriate approximate method and construct BM,SF and axial force diagrams. Give the assumptions made in the analysis. All columns are of same cross section 300 x 300 mm . **14**



OR

Q.5 **(a)** Explain failures of masonry structures observed in past earthquakes & how will you improve performance of masonry building. **07**

(b) A SDOF vibrating system is having following parameters. m = 250 kg, k = 180 N/m, c = 50 N – sec / m. Determine (i) the damping factor (ii) the natural frequency of damped vibration (iii) logarithmic decrement (iv) the ratio of two successive amplitudes & (v) the number of cycles after which the original amplitude is reduced to 50%. **07**

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Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

PDDC - SEMESTER–V • EXAMINATION – WINTER 2013

Subject Code: X 50602 Date: 06-12-2013

Subject Name: Earthquake Engineering

Time: 10.30 AM - 01.00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Use of IS 1893- 2002 (Part 1), IS 13920 (1993), IS 4326 (1993), IS 13828 (1993) is permitted**

Q.1	**(a)**	Derive the equation of motion for the free damped single degree of freedom system using D-Alembert principle.	**07**
	(b)	Derive Equation for a torsional vibration for single degree of freedom for a vertical shaft, assume suitable data.	**07**
Q.2	**(a)**	Derive equation of motion for forced vibration of single degree of freedom system. Also mention resonant frequency, resonant frequency ratio and deformation response factor.	**07**
	(b)	A vertical cantilever beam of m.s. section is 3 m long and kept as shown in figure. This supports 5.5 kg weight And system has harmonic excitation of 1.0 kN amplitude and 5 Hz frequency. Assume Damping as 5% of critical. The M.S. section has 200 mm dia. And having wall thickness of 6 mm. Calculate maximum steady state displacement and bending stress in m.s. section.	**07**
		OR	
	(b)	A Spring mass model consists of 6 kg mass and spring with stiffness of 4.5 N/mm., was selected for viscous damped vibration. Two successive amplitudes are recorded as 1.6 & 1.35. Calculate 1. Logarithmic decrement 2. Natural frequency of undamped system 3. Damping ratio 4. Damping Coefficient and Damped natural Period.	**07**
Q.3	**(a.1)**	Explain Base Isolation technique. Comment whether it is active or passive type?	**07**
	(a.2)	Enlist various codes of practice along with correct name related to earthquake engineering.	
	(b.1)	Two pendulums are hanging on an ideal spring with equal mass. The period Of vibration for the pendulums is 4 sec & 10 sec respectively. What is the Stiffness of the second pendulum with respect to first?	**07**
	(b.2)	A SDOF system having the amplitude of vibration in successive cycle are 0.75, 0.40, 0.20, 0.10 units respectively. Determine damping ratio of the system.	
		OR	

Q.3 **(a)** Calculate base shear in the critical direction only for building in Vadodara with following data by static coefficient method. Assume suitable data if required. Write all your assumptions & clauses of IS1893 (2002). **07**

(a) No. of storey = 5 (b) No. of bay in x direction = 3
(c) No. of bay in y direction = 2 (d) storey height = 4.0 m
(e) Width of each bay = 4 m (f) Size of beam = 300 x 450 mm
(g) size of column = 300 x 600 m (h) LL = 5 kN/m^2
(i) Thickness of slab = 150 mm

(b) Ref Q 3 (a) Calculate lateral forces in the critical direction only at each floor level. Also draw distribution of lateral force at each floor level. **07**

Q.4 **(a)** State whether following statements are true or false. Give logical reason for your answer : (any Seven) **07**

1. Iso seismal & Meizo Seismal are same.
2. Code specifies lower value of R for building having better performance.
3. Concrete structures offer more damping as compared to steel structures.
4. Mumbai is located on sea coast, So it's having maximum earthquake risk.
5. Two identical building to be constructed in zone IV & V. Building in Zone V should be designed for lower lateral load than building in zone IV.
6. Masonry structures offers less damping as compared to steel structures.
7. Peak ground acceleration (PGA) & Zero period acceleration (ZPA) are same.
8. Performance of shear walls which are located near geometric centre of bldg. is good?

(b) Analyze the 3 bay two storey RC frame by any appropriate approximate method **07**
of analysis if 300 kN & 250 kN forces are acting at first & ground storey. Draw axial force, shear force & bending moment diagram.

OR

Q.4 **(a)** Explain following (Any three) **07**
(i) Explain in detail – Response Spectrum Method.
(ii) Plate tectonics
(iii) Seismic waves
(iv) Explain MCE & DBE with its importance.

(b) It was decided to retrofit ground storey such that soft story effect can be removed. Calculate the size & stiffness of shear wall need to be added at ground Storey. Draw mode shape & interpret the result. Give your valuable comment about the result. **07**

Q.5 **(a)** Discuss in detail the concepts of the ductile detailing in Beams. **07**

(b) Discuss the capacity design concept in ductile detailing. **07**

OR

Q.5 (a) Attempt following 07

1. Explain liquefaction with adequate mathematical expression of shear strength.
2. Give four virtue of good earthquake resistant design.
3. Differentiate - Soft storey & weak storey
4. Differentiate - Ductility Vs Flexibility
5. Differentiate - Gravity load distribution Vs lateral load distribution
6. What is PGA? Explain its importance.
7. Differentiate - Seismograph Vs Seismogram

(b) Attempt following any three 07

1. Explain mathematical modeling with two examples of SDOF & MDOF.
2. Explain the deficiencies of Fukushima Nuclear Site building (reactor)
   exposed in recent Japan earthquake.
3. Define & explain liquefaction along with remedial measures.
4. Enlist three latest great earthquake of the world after 2009.
   Name two Inter plate & two intra plate earthquakes of India.

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Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

PDDC - SEMESTER–V • EXAMINATION – SUMMER 2013

Subject Code: X50602 Date: 14-05-2013

Subject Name: Earthquake Engineering

Time: 02.30 pm - 05.00 pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **IS 1893 Part 1 2002 & IS 13920 – 1993 are allowed in the examinations**

Q.1 **(a)** Derive expression for the response of forced damped SDOF structural system. **07**

(b) Explain ductile detailing of beam as per IS 13920 – 1993 **07**

Q.2 **(a)** Differentiate Static DOF & Dynamic DOF. **07**
Explain assumptions to reduce dynamic DOF of multi-storey building.

(b) A single storey building frame is having slab supported on four columns at corners fixed at support. Following data are given **07**

Dimensions of slab = 4m x 6m
Thickness of slab = 100 mm
Storey height = 5 m
Damping = 5% of critical damping
Size of column = 300mm x 300mm
Grade of concrete = M 25

Determine (i) Natural frequency of damped vibration (ii) Peak displacement of first five cycle of vibration Also draw amplitude envelop for five cycle of vibration if the floor is displaced horizontally by 100mm & suddenly released.

OR

(b) Explain steady state & transient component of vibration. Explain the phenomenon of resonance.
A simply supported beam of negligible mass spanning 10 m supports a machine of 40 kN at center with an unbalanced rotor applying a vertical force of 40 sin 55t kN. The damping force is 0.4 kN-s/m & Flexural rigidity of beam is 20000 kN-m^2. Determine (i) Amplitude of vibration after 10 secs (ii) amplitude of vibration at resonance

Q.3 **(a)** Calculate base shear for building of Tata Motors in Sanad with following data by static coefficient method. **07**

(a) No. of storey = 4 (b) No. of bay in x direction = 3
(c) No. of bay in y direction = 3 (d) storey height = 5.0 m
(e) Width of each bay = 4 m (f) Size of beam = 300 x 450 mm
(g) size of column = 300 x 300 m (h) LL = 3 kN/m^2
(i) Thickness of slab = 100 mm

Assume suitable data if required. Write all your assumptions & clauses of IS 1893 (2002).

(b) Ref Q 3 (a) Calculate lateral forces at each floor level. Also draw distribution of lateral force at each floor level. **07**

OR

Q.3 **(a)** Attempt any two **07**

1. Explain mathematical modeling in detail. Draw mathematical model for any three structural system.

2. Explain liquefaction and give remedial measures for it.

(b) 1. Two pendulums are hanging on an ideal spring. The frequency of first pendulum is twice the frequency of second pendulum & the mass of first pendulum is four times the mass of second pendulum. What is the stiffness of the second pendulum with respect to first? **07**

2. A spring mass (k1, m1) system has a natural frequency f1. Calculate the value of stiffness of other spring which when connected to k1 in series decreases the frequency by 50%.

Q.4 (a) Explain following (Any three) **07**

(i) Philosophy of Earthquake resistant design.

(ii) Enlist various codes of practice along with correct name related to earthquake engineering.

(iii) Differentiate (i) Magnitude & Intensity (ii) Iso-seismal & Meizo-seismal (ii) Seismograph Vs Seismogram (iv) S wave & P wave

(iv) Elastic rebound theory

(b) Attempt **following (Any three)** **07**

1. Explain the deficiencies of building exposed in any recent earthquake after 2011. Also write remedial measures of each deficiency.
2. Enlist two major/great Indian intra-plate & two interpolate earthquake with usual details.
3. Explain earthquake resistant feature of masonry structure.
4. Differentiate :
   (a) Epicentre & hypocentre
   (b) Earthquake proof structure Vs earthquake resistant structure.
   (c) Soft storey & weak storey

OR

Q.4 (a) Analyze the 2 bay two storey RC frame by any appropriate approximate method of analysis if 1000 kN & 500 kN forces are acting at first & ground storey. Draw axial force, shear force & bending moment diagram. **07**

Q.4 (b) A 8 m high petrol pump is a single storey RC building having plan (SDOF) dimension 30 m x 15 m. Carry out lateral load distribution as per IS 1893 Part I 2002 if 5000 kN force is acting at floor level. Size of columns are 300 mm x 300 mm **07**

Q.5 (a) State whether following statements are true or false. Give logical reason for your answer : **07**

1. Masonry structures offers less damping as compared to steel structures.
2. Code specifies lower value of R for building having better perform ace.
3. Any structure is designed as earthquake proof structure.
4. Peak ground acceleration (PGA) & Zero period acceleration (ZPA) are same.
5. Two identical building to be constructed in zone IV & V. Building in zone IV should be designed for higher lateral load than building in zone V.
6. A building is located in the boundary of zone III & IV. It will be designed as if it is in zone III.
7. Performance of shear walls which are located near geometric centre of

building is better than the identical shear wall located on periphery.

(b) A mass of 2000 kg under SDOF with viscous damping of 40% has spring constant 6 MN/m. Calculate undamped & damped natural frequencies. Also calculate peak displacement of first two cycles provided initial displacement was 100mm & suddenly released. **07**

OR

Q.5 **(a)** For the two storey building frame having lumped masses 20 tonne at floor level having storey stiffness 60 kN/m. Perform free vibration analysis & draw all mode shapes. **07**

(b) **Ref Q 5(a) OR** **07**

It was decided to retrofit ground storey such that soft story effect can be removed. Calculate the size & stiffness of shear wall need to be added at ground storey. Draw mode shape & interpret the result. Give your valuable comment about the result.

Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

PDDC - SEMESTER – V • EXAMINATION – WINTER 2012

Subject code: X 50602 **Date: 17/01/2013**

Subject Name: Earthquake Engineering

Time: 02.30 pm - 05.00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **IS 1893 2002 Part I & IS 13920 1993 codes are allowed**

Q.1 **(a)** Derive expression for the response of free damped SDOF structural system. **07**

(b) Explain ductile detailing of column as per IS 13920 – 1993 **07**

Q.2 **(a)** Explain mathematical modeling in detail. Draw mathematical model for any three structural system. **07**

(b) A two bay single storey RCC plane frame in which lumped mass of 15 tonne is supported on three columns (AB, CD & EF) having fixed support. **07**

$L_{AB} = 0.5\ L_{CD} = 0.25\ L_{EF} = 10$ m

Calculate BM & SF at support for the RCC frame after five cycles of vibration if floor is displaced horizontally by 100mm & suddenly released. Assume rigid diaphragm action. Take fck = 25 MPa & size of column 500 mm x 500 mm. Assume suitable damping.

OR

(b) A SDOF system consists of 6 m high column of 400 mm diameter which supports the heavy mass of 15000 kg at its top. The system is subjected to a harmonic force of 1500 Sin 50t N. Consider 10% damping & E = 2 x 10^5 N/mm^2. Calculate the maximum dynamic amplitude. Also state whether system will have resonance or not?

Q.3 **(a)** Calculate base shear **in the critical direction only** for building in Bhuvaneshwar with following data by static coefficient method. **07**

(a) No. of storey = 5 (b) No. of bay in x direction = 3
(c) No. of bay in y direction = 2 (d) storey height = 4.0 m
(e) Width of each bay = 4 m (f) Size of beam = 300 x 450 mm
(g) size of column = 300 x 600 m (h) LL = 5 kN/m^2
(i) Thickness of slab = 150 mm

Assume suitable data if required. Write all your assumptions & clauses of IS 1893 (2002).

(b) Ref Q 3 (a) Calculate lateral forces **in the critical direction only** at each floor level. Also draw distribution of lateral force at each floor level. **07**

OR

Q.3 **(a)** Attempt any two **07**

1. Explain liquefaction and give remedial measures for it.
2. Explain Base Isolation technique.
3. Enlist various codes of practice along with correct name related to earthquake engineering.
4. Give very short answers for the following :
   (i) Name inter plate interaction
   (ii) Enlist component of seismograph
   (iii) Can my building withstand a magnitude 10 earthquake?

(b) 1. Two pendulums are hanging on an ideal spring with equal mass. The period of vibration for the pendulums is 3 sec & 9 sec respectively. What is the **07**

stiffness of the second pendulum with respect to first?

2. A SDOF system having the amplitude of vibration in successive cycle are 0.70, 0.35, 0.18, 0.09 units respectively. Determine damping ratio of the system.

Q.4 (a) Explain following (Any three) **07**

(i) Philosophy of Earthquake resistant design.
(ii) Plate tectonics
(iii) Seismic waves
(iv) Enlist two major/great Indian intra-plate & two interpolate earthquake with usual details.
(v) Elastic rebound theory

(b) Attempt **following** **07**

1. Explain the deficiencies of building exposed in any recent earthquake after 2009. Also write remedial measures of each deficiency.
2. Explain earthquake resistant feature of masonry structure.
3. Differentiate :
   (a) Epicentre & hypocentre
   (b) Earthquake proof structure Vs earthquake resistant structure.
   (c) Soft storey & weak storey

OR

Q.4 (a) Analyze the 3 bay two storey RC frame by any appropriate approximate method of analysis if 400 kN & 200 kN forces are acting at first & ground storey. Draw axial force, shear force & bending moment diagram. **07**

Q.4 (b) A single storey RC building having plan (SDOF) dimension 24 m x 12 m & height of 10 m. Carry out lateral load distribution as per IS 1893 Part I 2002 if 2000 kN force is acting at floor level. Size of columns are 600 mm x 600 mm **07**

Q.5 (a) State whether following statements are true or false. Give logical reason for your answer : **07**

1. Iso seismal & Meizo Seismal are same.
2. Liquefaction is only possible in clayey soil.
3. Code specifies lower value of R for building having better performance.
4. Any structure is designed as earthquake proof structure.
5. Concrete structures offer more damping as compared to steel structures.
6. Dahod is having maximum earthquake risk.
7. Two identical building to be constructed in zone IV & V. Building in zone V should be designed for lower lateral load than building in zone IV.

(b) A SDOF vibrating system is having following parameters. **07**
m = 50 kg, k = 180 N/m, c = 35 N – sec / m. Determine (i) the damping factor (ii) the natural frequency of damped vibration (iii) logarithmic decrement (iv) the ratio of two successive amplitudes & (v) the number of cycles after which the original amplitude is reduced to 80%.

OR

Q.5 (a) For the two storey building frame having lumped masses 10 tonne at floor level having storey stiffness 120 kN/m. Perform free vibration analysis & draw all mode shapes. **07**

(b) Ref Q 5(a) OR **07**
(a) Calculate natural frequency by approximate method.
(b) It was decided to retrofit ground storey & stiffness of ground storey increased by 50% due to retrofitting. Draw mode shape & interpret the result. Give your valuable comment about the result.

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Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

PDDC-Semester –V (May-2012) Examination

Subject code: X50602

Subject Name: Earthquake Engineering

Date:15/05/2012

Time: 10.30 am – 01.00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Attempt **following** **07**

1. Enlist required condition for liquefaction.
2. Give four virtue of good earthquake resistant design.
3. Differentiate - Iso-seismal & Meizo-seismal
4. Differentiate - Ductility Vs Flexibility
5. Differentiate - Gravity load distribution Vs lateral load distribution
6. Differentiate - Magnitude & Intensity
7. Differentiate - Seismograph Vs Seismogram

(b) **State whether following statements are true or false with justification.** **07**

1. Soft storey & weak storey are same.
2. Liquefaction is only possible in cohesive soil.
3. Design philosophy for gravity loads & design philosophy for lateral loads due to earthquake are same.
4. Chennai has least seismic risk.
5. P & S waves are responsible for maximum damage to structures.
6. Base isolation is preferred in high rise building.
7. As per IS 1893 2002, Gujarat is divided in Zone III, IV & V only.
8. Buildings in Gujarat can resist 9 magnitude earthquakes.

Q.2 **(a)** Derive expression for the response of SDOF free damped structural system. **07**

(b) A SDOF vibrating system is having following parameters. **07**
m = 100 kg, k = 180 N/m, c = 30 N – sec / m. Determine (i) the damping factor (ii) the natural frequency of damped vibration (iii) logarithmic decrement (iv) the ratio of two successive amplitudes & (v) the number of cycles after which the original amplitude is reduced to 50%.

OR

(b) Explain concept of ductile detailing & explain factor affecting the ductility of structures in detail. Explain ductile detailing of beam as per IS 13920 – 1993 **07**

Q.3 **(a)**

1. What is the natural period of vibration of the second system with respect to first if both systems are identical except support condition? First system has hinge support & second system has fixed support. **07**
2. The dimension of the column is 300 mm x 300 mm. If the these dimensions become doubled, what should be the increase in the lateral load carrying capacity of the column with respect to column with earlier dimension
3. Two separate pendulums are hanging on an ideal spring with equal mass. The period of vibration for the pendulums is 1.73 sec & 3 sec respectively. What is the stiffness of the second pendulum with respect to first?

(b) Attempt following any three **07**

1. Enlist three latest great earthquake of the world after 2009. Name two inter plate & two intra plate earthquakes of India.
2. Explain the deficiencies of building exposed in recent Japan earthquake. Also write remedial measures of each deficiency.
3. Define & explain liquefaction along with remedial measures.
4. Explain mathematical modeling with two examples:

OR

Q.3 **(a)** Calculate base shear **in the critical direction only** for a industrial building of Tata Motors in Sanand with following data by seismic coefficient method. **07**

(a) No. of storey = 5 (b) No. of bay in x direction = 4
(c) No. of bay in y direction = 1 (d) storey height = 3.5 m
(e) Width of each bay = 5 m (f) Total DL on roof = 12 kN/m^2 (g) Total DL on floor = 10 kN/m^2 (h) LL = 5 kN/m^2
(i) Thickness of slab = 150 mm

All columns having their longer side in X direction. Neglect weight of infill walls. Assume suitable data if required. Write all your assumptions & clauses of IS 1893 (2002). Building is provided with additional viscous dampers which will increase damping by 5%.

(b) Calculate lateral forces **in the critical direction only** at each floor level along with diagram of distribution of lateral force at each floor level. Refer data given in Q3 (a). Also discuss (only) following **07**

- If the same building is located in West Bengal, is there any change in design lateral force?
- The functional purpose of the building is changed & now it is used as training center having, what will be the change in design lateral force?

Q.4 **(a)** Calculate the forces in four columns located in corner due to lateral load of 1600 kN acting in X direction for the single storey building having slab dimension 10m x 6m. Intensity of loading is 12 kN/m^2 which is uniform. All columns are identical square column. Use all provisions of IS 1893 – 2002 Part-I including torsion provision. **07**

(b) If the half of the floor is used for storage purpose having intensity of loading is 15 kN/m^2, recalculate the forces in the columns. Intensity of loading in other half slab panel is 12 kN/m^2. **07**

OR

Q.4 **(a)** Analyze the two bay three storeys RC frame by any appropriate approximate method of analysis. Lateral force of 100 kN, 80 kN & 60 kN is acting at first, second & third floor respectively. Storey height = 4 m & bay width of each bay =.6 m. **07**

(b) Draw axial force, shear force & bending moment diagram for the RC frame given in Q 4 (a) OR **07**

Q.5 For the two storey building frame having lumped masses 15 tonne at floor level having first storey stiffness 90 kN/m & ground storey stiffness 25 kN/m. Draw all mode shapes, interpret the result of the mode shape & identify the deficiency. **14**

OR

Q.5 **(a)** A simply supported beam of negligible mass spanning 8 m supports a machine of 30 kN at center with an unbalanced rotor applying a vertical force of 60 sin 55t kN. The damping force is 0.4 kN-s/m & Flexural rigidity of beam is 30000 kN-m^2. Determine (i) maximum amplitude of vibration (ii) amplitude of vibration at resonance **07**

(b) Explain failures of masonry structures observed in past earthquakes & how will you improve performance of masonry building. **07**

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Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

PDDC SEM-V Examination-Nov-2011

Subject code: X50602 **Date: 22/11/2011**

Subject Name: Earthquake Engineering

Time: 2.30 pm -5.00 pm **Total marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 Calculate lateral forces **in the critical direction only** at each floor level for the office building in Junagadh with following data by seismic coefficient method. **14**

(a) No. of storey = 10 (b) No. of bay in x direction = 12

(c) No. of bay in y direction = 2 (d) storey height = 3.0 m

(e) Width of each bay = 7 m (f) No of occupants = 499

(g) Total DL on roof = 12 kN/m^2 (h) LL on floors = 5 kN/m^2

(i) Total DL on floors = 10 kN/m^2

Neglect weight of infill walls. Assume suitable data if required. **Write all your assumptions & clauses of IS 1893 (2002).** Also draw distribution of lateral force at each floor level.

Also discuss **(only)** following in short

- If the same building is located in Dahod, is there any change in design lateral force?
- The functional purpose of the building is changed & now it will used as residential house having 500 occupants, what will be the change in design lateral force?

Q.2 **(a)** Derive expression for the response of SDOF free damped structural system. **07**

(b) A SDOF vibrating system is having following parameters. **07**

m = 90 kg, k = 150 N/m, c = 20 N – sec / m. Determine (i) the damping factor (ii) the natural frequency of damped vibration (iii) logarithmic decrement (iv) the ratio of two successive amplitudes & (v) the number of cycles after which the original amplitude is reduced to 40%.

OR

(b) Explain concept of ductile detailing & explain factor affecting the ductility of structures in detail. Also explain ductile detailing of column as per IS 13920 – 1993 **07**

Q.3 **(a)** **State whether following statements are true or false & also justify your answer in short.** **07**

1. Liquefaction is only possible in cohesive soil.
2. Intensity will reduce & magnitude will increase near epicenter.
3. As per IS 1893 2002, Gujarat is divided in Zone III, IV & V only.
4. Ductile detailing is compulsory for RCC building located in Gujarat.
5. Buildings in Gujarat can resist 9 magnitude earthquakes.
6. Design philosophy for gravity loads & design philosophy for lateral loads due to earthquake are same.
7. A building is located in zone III but on the boundary of zone III & IV. It will be designed as if it is in zone IV.

(b) Attempt **any three** **07**

1. What is the natural period of vibration of the second system with respect to first if both systems are identical except support condition? First system has hinge support & second system has fixed support.
2. The dimension of the column is 300 mm x 300 mm. If the these dimensions become doubled, what should be the increase in the lateral load carrying capacity of the column with respect to column with earlier dimension
3. Explain four virtue of good earthquake resistant design.
4. Give your comment
   - Importance factor depends on performance of the building.
   - Base isolation is preferred in high rise building.

OR

Q.3 **(a)** **State whether following statements are true or false & also justify your answer in short.** **07**

1. Performance of shear walls which are located near geometric centre of building is better than the identical shear wall located on periphery.
2. Non structural wall will fail before structural wall.
3. IS 13920-1993 has given special detailing for beam-column joint.
4. Concrete structures offer less damping as compared to steel structures.
5. Code specifies higher value of R for building having better performance.
6. Any structure is designed as earthquake proof structure.
7. Mizoram is having least seismic risk.

(b) Attempt following any three **07**

1. Enlist three latest great earthquake of the world after 2007. Name two inter plate & two intra plate earthquakes of India.
2. Explain the deficiencies of building exposed in recent Japan earthquake. Also write remedial measures of each deficiency.
3. Define & explain liquefaction.
4. Differentiate : Ductility Vs Flexibility

Q.4 **(a)** Calculate the forces in four columns located in corner due to lateral load of 1600 kN acting in X direction for the single storey building having slab dimension 12m x 8m. Intensity of loading is 10kN/m^2 which is uniform. All columns are identical square column. Use all provisions of IS 1893 – 2002 Part-I including torsion provision. **07**

(b) If the half of the floor is used for storage purpose having intensity of loading is 15 kN/m^2, recalculate the forces in the columns. Intensity of loading in other half slab panel is 10 kN/m^2. **07**

OR

Q.4 **(a)**

1. Differentiate (i) Magnitude & Intensity (ii) Iso-seismal & Meizo-seismal (ii) Seismograph Vs Seismogram (iv) S wave & P wave **07**
2. Explain mathematical modeling with two examples.

(b) Analyze the two bay two storey RC frame by any appropriate approximate method of analysis & draw axial force, shear force & bending moment diagram. Lateral force of 100kN & 60 kN is acting at first & second floor respectively. Storey height = 4 m & bay width of each bay =.6 m. **07**

Q.5 For the three storey building frame having lumped masses 10 tonne at floor level having first & second storey stiffness 90 kN/m & ground storey stiffness 25 kN/m. Draw all mode shapes, interpret the result of the mode shape & identify the deficiency. **14**

OR

Q.5 **(a)** A simply supported beam of negligible mass spanning 8 m supports a machine of 40 kN at center with an unbalanced rotor applying a vertical force of 120 sin 40t kN. The damping force is 0.3 kN-s/m & Flexural rigidity of beam is 30000 kN-m^2. Determine (i) Maximum amplitude of vibration (ii) Amplitude of vibration at resonance. **07**

(b) Explain failures of masonry structures observed in past earthquakes & how will you improve performance of masonry building. **07**

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