INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500043

CIVIL ENGINEERING
QUESTIONBANK

Course Name	:	**EARTHQUAKE RESISTANT DESIGN OF BUILDINGS**
Course Code	:	BST206
Class	:	I M. Tech II Semester
Branch	:	Civil Engineering
Year	:	2017 - 2018
Course Coordinator	:	J S R Prasad, Professor
Course Faculty	:	J S R Prasad, Professor

OBJECTIVES

Most of the loss of life in past earthquakes has occurred due to the collapse of buildings, constructed in traditional materials like stone, brick, adobe and wood, which were not particularly engineered to be earthquake resistant.In view of the continued use of such buildings in most countries of the world, it is essential to introduce earthquake resistance features in their construction.

The primary objectives of this course are

1. To deal with the basic concepts involved in achieving appropriate earthquake resistance of buildings.
2. To analyze the factors that influence the collapse resistance of RC frames in earthquake based on seismic damage observed in the past earthquakes.
3. To discuss the methodologies to improve structural resistance with focus on global strength margin, global redundancy and global integration of the structural system.
4. To identify the issues that needs further research in earthquake resistant design.

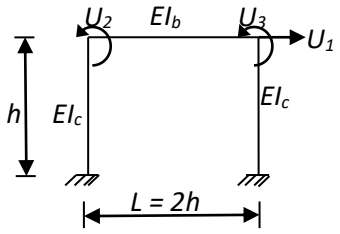
COURSE OUTCOMES

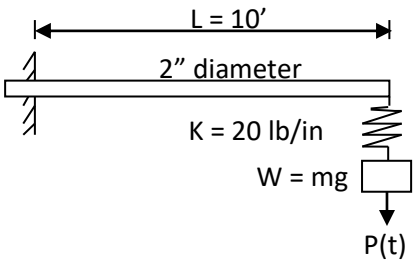
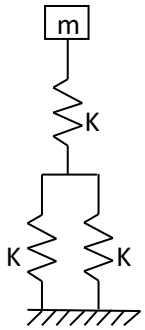
After completing this course, the student must demonstrate the knowledge and ability:

CBST206.01	To Understand the main cause of earthquakes in the earthquake prone regions
CBST206.02	To introducing the basic seismological concepts
CBST206.03	To learn Earthquake ground motion characteristics and seismic energy dissipation
CBST206.04	To provide an overall perspective of past Indian earthquakes and the interesting features of the same
CBST206.05	To have the correct perspective on earthquake magnitude and earthquake intensity
CBST206.06	To introduce basic principles and importance of structural dynamics and earthquake in civil engineering applications
CBST206.07	To investigate the seismic damages of RCC buildings from the experiences of past earthquakes.
CBST206.08	To know the behavior of structures under dynamic and earthquake excitations
CBST206.09	To have the general knowledge required for design and analysis
CBST206.10	To know sound earthquake-resistant architectural provisions
CBST206.11	To know the factors required for assessing the lateral design forces

CBST206.12	To understand the effect of transverse reinforcement
CBST206.13	To understand the seismic analysis procedure as per 1893 code
CBST206.14	To understand the equivalent force method
CBST206.15	To evaluate multistorey RCC buildings by mathematical modeling
CBST206.16	To understand the need and importance of ductility of a material, structural component
CBST206.17	To know the provisions of IS 13920:1993 and its revisions
CBST206.18	To know the Design steps of Core wall
CBST206.19	To understand the purpose of base shear
CBST206.20	To brief out the procedure to determine Structural ductility of any typical building
CBST206.21	To be able to identify deficiencies in existing masonry buildings
CBST206.22	To have knowledge on distribution of lateral loads in masonry buildings
CBST206.23	To have knowledge on strengthening aspects of masonry buildings
CBST206.24	To analyse and design one-storey and two-storey masonry buildings

S.No.	QUESTIONS	BLOOMS TAXONOMY LEVEL	COURSE OUTCOME
	UNIT-I **EARTHQUAKE GROUND MOTION AND STRUCTURAL DYNAMICS**		
Part A (Short Answer Questions)			
1.	Where do Earthquakes happen?	Knowledge	CBST206.01
2.	Where do over 90% of Earthquakes occur?	Remembering	CBST206.02
3.	Why do Earthquakes happen?	Remembering	CBST206.01
4.	What are the formulae for P and S velocity?	Remembering	CBST206.02
5.	Indicate the approximate radius of the earth, inner core, and outer core.	Remembering	CBST206.03
6.	What is a fault?	Remembering	CBST206.02
7.	What are different types of faults?	Understanding	CBST206.02
8.	What is intensity?	Remembering	CBST206.05
9.	Which type of seismic wave does not pass through a fluid?	Remembering	CBST206.02
10.	Enumerate the different peak amplitude parameters for an earthquake ground motion.	Understanding	CBST206.03
11.	Define seismology	Remembering	CBST206.02
12.	What do you mean by Epicentre and focus?	Knowledge	CBST206.02
13.	Define Degrees of Freedom.	Comprehension	CBST206.03
14.	Brief resonance and natural frequency.	Knowledge	CBST206.03
15.	Define response spectra.	Remembering	CBST206.03
16.	Define the term soil Amplification.	Knowledge	CBST206.05
17.	Define Mercalli intensity scale and Richter scale	Knowledge	CBST206.05
18.	Define micro-zonation	Knowledge	CBST206.03
19.	Write a short note on Seismic waves.	Knowledge	CBST206.02
20.	Write a short note on Plate Tectonic Theory	Application	CBST206.01
			Part B (Long Answer Questions)
1.	Distinguish between Rayleigh waves and Love waves.	Knowledge	CBST206.03
2.	Write short notes on Intensity of earthquake.	Knowledge	CBST206.05
3.	Differentiate between magnitude and Intensity of an earthquake.	Knowledge	CBST206.05
4.	At a recording station a difference in time of arrival between P waves and S waves was observed to be 1.5 seconds. What is the approximate distance from the station at which the event	Comprehension	CBST206.03

	occurred? Assume P wave velocity as 4 km/sec and S wave velocity as 2 km/sec.		
5.	During an earthquake the maximum amplitude recorded at a site by Wood- Anderson Seismograph is 20 cm. The maximum ground velocity recorded was 25 cm/sec. The site was found to be 75 km away from the epicenter. Determine the Magnitude and Intensity of the occurred earthquake.	Comprehension	CBST206.05
6.	The epi-central intensity of an earthquake that occurred in 1870 is estimated to be IX in MMI scale. Estimate the approximate magnitude of the earthquake.	Application	CBST206.05
7.	Estimate the moment magnitude of an event with rupture length of 100km, rupture width of 45km and slip of average fault slip of 3m. Take modulus of rigidity, m_u as 3.5 x 1010 N/m^2.	Knowledge	CBST206.05
8.	What is an attenuation relationship and What are the parameters that attenuation relations use as input?	Analysis	CBST206.05
9.	What is Gutenberg-Richter relationship?	Comprehension	CBST206.03
10.	Estimate the variation in mean peak ground acceleration with respect to distance for the attenuation relation proposed by Boore (1997) for a magnitude 7 event with reverse type mechanism. Use the values of closest distance to surface projection of rupture as 10km, 30km and 70km. Assume a V_s of 760m/s.	Knowledge	CBST206.02
11.	How is Earthquake Magnitudes Measured? How the magnitude of earthquake is related to energy released in an earthquake?	Knowledge	CBST206.05
12.	Write salient points on Seismo-tectonics of India and seismicity of India.	Knowledge	CBST206.01
13.	Explain the steps of seismic hazard analysis?	Application	CBST206.02
14.	i. List out the earthquake and explain it briefly. ii. Name the major plates of the earth.	Knowledge	CBST206.02
15.	i. Differentiate magnitude and intensity. ii. How will you measure magnitude and intensity? Explain the methods?	Knowledge	CBST206.05
16.	A SDOF system is subjected to a harmonic ground motion of $\ddot{x}_g(t) = x_o \sin \overline{w}\ t$ Determine the steady state response using time and frequency domain method and considering that the system starts from rest. The natural frequency and fraction of critical damping of SDOF system are and , respectively.	Application	CBST206.05
17.	Calculate the lateral stiffness for the frame shown in Figure below assuming the elements to be axially rigid. . 	Analysis	CBST206.04

18.	Derive the equation of motion of the weight w suspended from a spring at the free end of a cantilever steel beam shown in Figure below. For E = 29000 Ksi. Neglect the mass of the beam and spring. 	Comprehension	CBST206.04
19.	Derive an expression for damped frequency in case of single degree damped free vibration system.	Application	CBST206.03
20.	Find the local spring constant for motions about x=1 m for the nonlinear spring characteristic shown in Figure 1.7. The *f* axis is given in newtons and the x axis is in meters.	Evaluation	CBST206.03
21.	What is equivalent stiffness for the system illustrated in Figure below? 	Application	CBST206.03
22.	Show that the displacement response of an un-damped SDOF system subjected earthquake acceleration, $x(t)^{\cdot\cdot} = \ddot{x}e^{-\alpha t}$ is given by $$x(t) = -\frac{\ddot{x}_0}{a^2+\omega_0^2}\left[\frac{a}{\omega_0}\sin\omega_0 t - \cos\omega_0 t + e^{-at}\right]$$ where, w_o= natural frequency of the SDOF system; and a = parameter having the same unit as that of w_o.	Comprehension	CBST206.03
	UNIT-II **CONCEPT OF EARTHQUAKE RESISTANT DESIGN OF RCC STRUCTURE**		
Part A (Short Answer Questions)			
1.	Write short note on various load combinations to be considered for seismic resistant design of RCC structures.	Remembering	CBST206.06
2.	What are the special measures to make the masonry structures earthquake resistant?	Remembering	CBST206.07
3.	What are the objectives of earthquake resistant design of reinforced concrete structures?	Remembering	CBST206.06
4.	Explain Inertial force.	Remembering	CBST206.08
5.	Explain Response spectrum factor.	Remembering	CBST206.09
6.	Explain provisions for Torsion.	Remembering	CBST206.10
7.	What are the factors required for assessing the lateral design forces?	Remembering	CBST206.06

<table>
<tr><td>8.</td><td>Write notes on Bond between reinforcing bars and concrete</td><td>Remembering</td><td>CBST206.07</td></tr>
<tr><td>9.</td><td>What are the properties of construction materials required for earthquake resistance?</td><td>Remembering</td><td>CBST206.07</td></tr>
<tr><td>10.</td><td>What are the possible damages to RCC buildings in earthquake-prone region?</td><td>Understanding</td><td>CBST206.08</td></tr>
<tr><td>11.</td><td>Differentiate frame and shear wall.</td><td>Comprehension</td><td>CBST206.06</td></tr>
<tr><td>12.</td><td>What are the factors required for assessing the lateral design forces?</td><td>Understanding</td><td>CBST206.06</td></tr>
<tr><td>13.</td><td>What are the factors required for assessing the design response spectrum?</td><td>Understanding</td><td>CBST206.06</td></tr>
<tr><td>14.</td><td>Write the functions of base isolation and isolating devices.</td><td>Understanding</td><td>CBST206.06</td></tr>
<tr><td>15.</td><td>Discuss about the major damages occur in the RC structures during earthquake.</td><td>Comprehension</td><td>CBST206.07</td></tr>
<tr><td>16.</td><td>What are the possible damages to RCC buildings in earthquake-prone region?</td><td>Knowledge</td><td>CBST206.07</td></tr>
<tr><td>17.</td><td>Write notes on Bond between reinforcing bars and concrete</td><td>Knowledge</td><td>CBST206.09</td></tr>
<tr><td>18.</td><td>Write notes on Effect of transverse reinforcement</td><td>Knowledge</td><td>CBST206.09</td></tr>
<tr><td>19.</td><td>Difference between static and dynamic loading</td><td>Comprehension</td><td>CBST206.10</td></tr>
<tr><td colspan="4">Part B (Long Answer Questions)</td></tr>
<tr><td>1.</td><td>Is it desirable to have (a) high strength steel (b) high strength concrete in earthquake resistant design of reinforced concrete structures? Justify your answers.</td><td>Synthesis</td><td>CBST206.08</td></tr>
<tr><td>2.</td><td>What are the objectives of earthquake resistant design of reinforced concrete structures?</td><td>Comprehension</td><td>CBST206.10</td></tr>
<tr><td>3.</td><td>Enumerate the assumptions made in the analysis of earthquake-resistant design of structures.</td><td>Knowledge</td><td>CBST206.06</td></tr>
<tr><td>4.</td><td>What are the principles of earthquake-resistant design of RCC buildings?</td><td>Knowledge</td><td>CBST206.06</td></tr>
<tr><td>5.</td><td>A RCC beam of rectangular section has to carry a distributed live load of 20 kN/m in addition to its own weight and a dead load of 25kN/m. The maximum bending moment and shear force due to the earthquake are 60 kN-m and 40 kN respectively. Centre to Centre distance between supports is 6 m. Design the beam using M-20 grade concrete and Fe 415 steel.</td><td>Knowledge</td><td>CBST206.09</td></tr>
<tr><td>6.</td><td>Design the reinforcement for a column of size 450 mm x 450 mm, subjected to the following forces. The column has unsupported length of 3.0 m and is braced against sway in both directions. Use M-25 grade concrete and Fe grade steel.
<table>
<tr><td></td><td>Dead load</td><td>Live load</td><td>Seismic load</td></tr>
<tr><td>Axial load (kN)</td><td>1000</td><td>800</td><td>550</td></tr>
<tr><td>Moment (kNm)</td><td>50</td><td>40</td><td>100</td></tr>
</table></td><td>Understand</td><td>CBST206.09</td></tr>
<tr><td>7.</td><td>Write any two empirical formulae to estimate the time period of buildings.</td><td>Remember</td><td>CBST206.06</td></tr>
<tr><td>8.</td><td>An eight storeyed RC framed building with live load of 3kN/m^2 is to be constructed in Agra (Seismic zone=III). Work out seismic forces on the structure. All beams and columns may be assumed to be of 250 mm x 450 mm and 400 mm x 500 mm respectively.
The roof and floor slabs may be assumed as 150 mm thick. The wall is all round 120 mm thick. Solve the problem using IS</td><td>Understand</td><td>CBST206.09</td></tr>
</table>

	1893:2002 code.		
9.	Explain the principles of earthquake-resistant design of RCC buildings?	Remember	CBST206.06
10.	How to build earthquake proof buildings in India?	Understand	CBST206.07
11.	Explain seismic detailing of Intermediate and special moment frames of concrete	Understand	CBST206.08
12.	Give brief notes on General requirements of Concrete Detailing with reference to earthquake resistance of building components.	Knowledge	CBST206.08
13.	Write short notes on the following: (a) Bond between reinforcing bars and concrete (b) Effect of Transverse reinforcement (c) Buckling of reinforcing bars	Knowledge	CBST206.08
14.	Discuss briefly the following types of failures of RCC buildings (a) Ductile failure (b) Flexural failure (c) Failure of joints	Understand	CBST206.08
	UNIT-III **SEISMIC ANALYSIS AND MODELLING OF RCC STRUCTURES**		
Part-A (Short Answer Questions)			
1.	What are the factors required for assessing the lateral design forces?	Remembering	CBST206.11
2.	What are the factors required for assessing the design response spectrum?	Remembering	CBST206.11
3.	Distinguish between flexure beam model and shear beam models?	Remembering	CBST206.12
4.	Prepare the shear wall to resist lateral load.	Remembering	CBST206.12
5.	Show the failure mechanics of unfilled frame.	Remembering	CBST206.13
6.	What are the possible damages to RCC buildings in earthquake-prone region?	Remembering	CBST206.13
7.	Write notes on Bond between reinforcing bars and concrete	Remembering	CBST206.12
8.	Write notes on Effect of transverse reinforcement	Remembering	CBST206.12
9.	Write notes on buckling of reinforcing bars	Understanding	CBST206.15
10.	In what ways do stirrups help RCC beams	Understanding	CBST206.12
11.	Give reason for the Depth of beam should not be more than one-fourth of the clear span in RCC members subjected seismic forces	Understanding	CBST206.13
Part-B (Long Answer Questions)			
1.	A three storeyed symmetrical RC school building situated at Bhuj with following data: Plan dimension : 7 m Storey height : 3.5 m Total weight of beams in a storey : 130 kN Total weight of slab in a storey : 250 kN Total weight of columns in a storey : 50 kN Total weight of walls in a storey : 530 kN Live load : 130 kN Weight of terrace floor : 655 kN The structure is resting on hand rock. Determine the total base shear and lateral loads at each floor level for 5% of damping using seismic coefficient method.	Comprehension	CBST206.13

2.	Design a rectangular beam for 8m span to support a DL of 10kN/m and a LL of 12kNm? Inclusive of its own weight. Moment due to earthquake load is 1000kNm and shear force is 80kN. Use M20 grade concrete andFe415 steel.	Analysis	CBST206.13
3.	Briefly write a step by step procedure to analyze a frame by equivalent static lateral load method.	Comprehension	CBST206.14
4.	A four storey reinforced concrete frame building is situated at Roorkee. The height between the floors is 3 m and total height of building is 12 m. The dead load and normal live load is lumped at respective floor. The soil below the foundation is assumed to be hard rock. Assume building is intended to be used as a hospital. Determine the total base shear as per IS 1893 (Part 1):2002 and compare with the earlier IS: 1893 codes. Formulate the base shear along the height of the building.	Analysis	CBST206.15
5.	Explain the different types of shear wall with neat sketch.	Synthesis	CBST206.14
6.	Design the exterior column to of a multistorey building with size 400x500mm, axial load from analysis is 601.9 kN and moment from analysis is 176.6 kN-m with ductile detailing	Knowledge	CBST206.13
7.	Explain the principles of earthquake resistant design of RC members.	Comprehension	CBST206.13
8.	Evaluate the best strengthening techniques involved in RC building.	Knowledge	CBST206.15
9.	Write the design procedure for a flexure member with an example	Comprehension	CBST206.11
10.	Design a R.C.C building frame of your own as per IS 1893:2002.	Analysis	CBST206.13
11.	Examine types of shear wall and what do you prefer for high rise building? Explain it.	Comprehension	CBST206.15
12.	Write the step by step procedure to find lateral displacement using software.	Understand	CBST206.13
13.	Explain capacity based design and detailing for RC building with example.	Synthesis	CBST206.13
14.	Examine the philosophy of earthquake resistant design of RC buildings.	Knowledge	CBST206.13
15.	Design a rectangular beam for 8m span to support a DL of 10kN/m and a LL of 12kNm? Inclusive of its own weight. Moment due to earthquake load is 1000kNm and shear force is 80kN. Use M20 grade concrete and Fe415 steel.	Comprehension	CBST206.14
16.	Briefly write a step by step procedure to analyze a frame by equivalent static lateral load method.	Knowledge	CBST206.14
	UNIT-IV **EARTHQUAKE RESISTANT DESIGN OF RCC STRUCTURES**		
Part A (Short Answer Questions)			
1.	Define ductility of a material, structural component	Understanding	CBST206.16
2.	What is ductile detailing?	Understanding	CBST206.16
3.	When do you need Ductility Detailing?	Remembering	CBST206.17
4.	Do you need ductile detailing in the basements?	Understanding	CBST206.16
5.	What about IS13920:1993 and its revisions?	Understanding	CBST206.17
6.	Explain storey drift.		CBST206.19
7.	Examine the factors affecting ductility.	Understanding	CBST206.16
8.	Explain assessment of ductility.	Understanding	CBST206.16
9.	Illustrate vertical distribution of base shear	Understanding	CBST206.19

10.	Analyze shear beam model.	Understanding	CBST206.19
11.	What do you infer from capacity based design?	Understanding	CBST206.20
12.	Write the design steps of core wall.	Understanding	CBST206.18
13.	Summarize the principle base shear.	Understanding	CBST206.19
14.	Which Indian code is based on lateral strength as well as deformability and ductility capacity of structure with limited earthquake damage but no collapse?	Comprehension	CBST206.17
15.	What are special provisions of design of buildings with soft storey	Knowledge	CBST206.17
Part B (Long Answer Questions)			
1.	What are the provisions given in IS 13920: 1993 for ductile detailing in the members of Reinforced Concrete buildings?	Synthesis	CBST206.17
2.	What are the ductile detailing provisions for beams (for flexure and shear)?	Synthesis	CBST206.17
3.	What is meant by special confining reinforcement in columns of ductile frames?	Synthesis	CBST206.17
4..	What are the important factors affecting ductility of a structure?	Synthesis	CBST206.16
5.	Explain the use of ductility factors in estimating seismic forces.	Evaluation	CBST206.20
6.	Explain the impact of ductility on the structural behaviour when it is subjected to earthquake force using Single degree of Freedom system	Comprehension	CBST206.17
7.	What are the design requirements to achieve a ductile structure?	Comprehension	CBST206.20
8.	Discuss the procedure to determine Displacement ductility of a member/element using sketches.	Synthesis	CBST206.18
9.	Discuss the procedure to determine Structural ductility of a any typical building.	Application	CBST206.20
10.	How to evaluate ductility of a structure using curvature ductility ratio of structural elements?	Synthesis	CBST206.16
11.	What are the important factors affecting ductility of a structure?	Synthesis	CBST206.16
UNIT-V **EARTHQUAKE RESISTANT DESIGN OF MASONRY STRUCTURES**			
Part A (Short Answer Questions)			
1.	Define diaphragm discontinuity.	Remembering	CBST206.21
2.	Write about flexible diaphragm.	Remembering	CBST206.22
3.	Define rigid diaphragm.	Remembering	CBST206.22
4.	What is pounding of buildings?	Remembering	CBST206.21
5.	Explain the concept of floating column	Remembering	CBST206.21
6.	What kind of damage occurs in staircase due to earthquake?	Understanding	CBST206.21
7.	Explain plan and mass irregularity damage.	Remembering	CBST206.21
8.	Outline the role of lintel bands in masonry buildings	Remembering	CBST206.23
9.	Brief about Killari earthquake.	Understanding	CBST206.21
10.	Discuss the reasons for poor performance of masonry buildings	Understanding	CBST206.21
11.	Illustrate the height to thickness correction factors as per IS 1905.	Understanding	CBST206.22
12.	Does grouting increase the earthquake resistance capacity? Justify your answer	Synthesis	CBST206.23
13.	How to calculate the base shear in masonry buildings	Synthesis	CBST206.22
14.	Give some data's about Jabalpur earthquake.	Comprehension	CBST206.21
15.	Analyse the stress strain curve for brickwork in compression.	Comprehension	CBST206.22

16.	Compare flexible and rigid diaphragm	Comprehension	CBST206.22
17.	What will happen if the rigidity modulus affects the masonry structure? Justify.	Synthesis	CBST206.21
18.	Differentiate structural and non-structural damages in masonry building.	Application	CBST206.21
19.	Write the formula for modal mass.	Synthesis	CBST206.24
20.	Write the principle for the design of infill walls.	Synthesis	CBST206.24
Part B (Long Answer Questions)			
1.	Give the reasons for the poor performance of masonry buildings to resist earthquakes.	Synthesis	CBST206.21
2.	Classify the different types masonry buildings according to IS 4326:1993.	Synthesis	CBST206.24
3.	Explain the behaviour of unreinforced masonry walls	Synthesis	CBST206.21
4.	Compare and contrast the behaviour of reinforced and unreinforced masonry walls.	Synthesis	CBST206.22
5.	Brief about the behaviour of infill walls	Evaluation	CBST206.22
6.	How to improve the seismic capacity of masonry buildings	Comprehension	CBST206.24
7.	Describe the performance of RC buildings during earthquake and explain its damages?	Comprehension	CBST206.22
8.	Specify the methods for strengthening of masonry buildings and explain in detail with neat sketches.	Synthesis	CBST206.24
9.	Write the effects of earthquake on pre stressed and steels buildings when compared to masonry buildings.	Application	CBST206.21
10.	Illustrate the design specifications of different types of shear walls	Synthesis	CBST206.23
11.	Examine the plan configuration problems that affect the performance of masonry buildings during earthquake.	Synthesis	CBST206.22
12.	Analyze the limitations of equivalent lateral force and response spectrum analysis procedures	Synthesis	CBST206.24
13.	Explain in detail about seismic design spectrum.	Synthesis	CBST206.24
14.	Write the various factors in seismic analysis	Synthesis	CBST206.24

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