ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2023
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR CIVIL ENGINEERING

Date	: October 7, 2023
Total Marks	: 100
Writing Time	: 150 minutes (2.5 hours)
Reading Time	: 15 minutes (prior to writing time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is provided to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
   - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
     Part II - 4 Short Answer Questions

     All questions under SECTION A are COMPULSORY.
   - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part in a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **13 printed pages**, including this instruction page.

GOOD LUCK

SECTION A

PART I: Multiple Choice Questions (30 marks)

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. Formation of small patches of plaster, swelling out beyond the plastered surface is known as
   a) Blistering
   b) Cracking
   c) Crazing
   d) Flaking

2. IS 456-2000 recommends to provide certain minimum steel in RCC beam to
   a) ensure compression failure.
   b) avoid rupture of steel in case a flexural failure occurs.
   c) hold the stirrup steel in position.
   d) provide enough ductility to the beam.

3. The shape of clay particle is usually
   a) Angular
   b) Flaky
   c) Tubular
   d) Rounded

4. Sand and drain are used to
   a) reduce the settlement.
   b) accelerate the consolidation.
   c) increase the permeability.
   d) transfer the load.

5. Bitumen felt
   a) is used as water proofing material.
   b) is used as damp proofing material.
   c) is made of bitumen and hessian fibres.
   d) All of the above

6. Hydrographic survey deal with the mapping of
   a) large water bodies.
   b) mountainous region.
   c) canal system.
   d) movement of clouds.

7. The principle of surveying is to work
   a) from part to the whole.
   b) from whole to the part.
   c) from higher level to the lower level.
   d) from lower level to the higher level.

8. In a mortar, the binding material is
   a) Cement
   b) Sand
   c) Surkhi
   d) Cinder

9. _____is the method of surveying in which the field observations and plotting proceed simultaneously.
   a) Chain surveying
   b) Compass surveying
   c) Plan table surveying
   d) Tacheometric surveying

10. To improve the earthquake resistance of a building, provide_____.
    a) roof band
    b) plinth band
    c) lintel band
    d) All of the above

11. For quality control of Portland Cement, the essential test done is
    a) setting time
    b) soundness
    c) consistency
    d) All of the above

12. M20 grade of concrete approximates
    a) 1 : 1: 2 mix
    b) 1: 1.5 : 3 mix
    c) 1: 3: 6 mix
    d) None of the above

13. Permissible compressive strength of M250 concrete grade is
    a) 100 kg/cm^2
    b) 150 kg/cm^2
    c) 200 kg/cm^2
    d) 250 kg/cm^2

14. Workability of concrete is measured by
    a) Vicat apparatus test
    b) Minimum void method
    c) Talbot richard test
    d) Slump test

15. _____is the process of proper and accurate measurement of concrete ingredients for uniformity of proportion.
    a) Batching
    b) Curing
    c) Grading
    d) None of the above

16. The lateral earth pressure on a retaining wall is
    a) equal to mass of the soil retained.
    b) proportional to the depth of the soil.
    c) proportional to the internal friction of the soil.
    d) None of the above

17. A combine footing is adopted when
    a) there is only one column.
    b) number of columns is two and they are spaced close to each other.
    c) number of columns is more than two and they are spaced far apart.
    d) number of columns is two and they are spaced far apart.

18. In a cantilever of length L carrying a load whose intensity varies uniformly from zero at the free end to w per unit run at the fixed end, the maximum bending moment (BM) is
    a) $wl^2/8$
    b) $wl^2/4$
    c) $wl^2/12$
    d) $wl^2/6$

19. The maximum net pressure intensity causing shear failure of soil, is known as
    a) Safe bearing capacity
    b) Net safe bearing capacity
    c) Net ultimate bearing capacity
    d) Ultimate bearing capacity

20. The steel generally used in R.C.C works, is
    a) Stainless
    b) Mild steel
    c) High carbon steel
    d) High tension steel

21. _____is the ratio of shearing stress to the shearing strain within elastic limit.
    a) Modulus of elasticity
    b) Bulk modulus of elasticity
    c) Tangant modulus of elasticity
    d) Shear modulus of elasticity

22. In rolled steel beams, shear force is mostly resisted by
    a) Web only
    b) Flanges only
    c) Web and flanges together
    d) None of the above

23. Unit of kinematic viscosity is
    a) newton sec/m^2
    b) m^2/sec
    c) newton sec/m^3
    d) kg sec/m^2

24. To measure very low pressure, we use
    a) Barometers
    b) Piezometers
    c) Manometers
    d) Differential manometers

25. The item of steel work which is measured in square metre (sq.m) is
    a) Collapsible door
    b) Rolling shutters
    c) Steel doors
    d) All of the above

26. In a compaction test, as the compaction effort is increased, the optimum moisture content
    a) Decrease
    b) Remains same
    c) Increases
    d) Increases first and thereafter decreases

27. The point of contraflexure is the point where
    a) bending moment changes sign.
    b) bending moment is maximum.
    c) bending moment is minimum.
    d) shear force is zero.

28. The foundation are placed below ground level, to increase
    a) Strength
    b) Stability of the structures
    c) Workability
    d) All of the above

29. The foundation in which a cantilever beam is provided to join two footings, is called as
    a) Strip footing
    b) Strap footing
    c) Combined footing
    d) Raft footing

30. The brick laid with its breath parallel to the face of a wall, is known as
    a) Header
    b) Stretcher
    c) Closer
    d) None of the above

PART II – Short Answer Questions [20 marks]

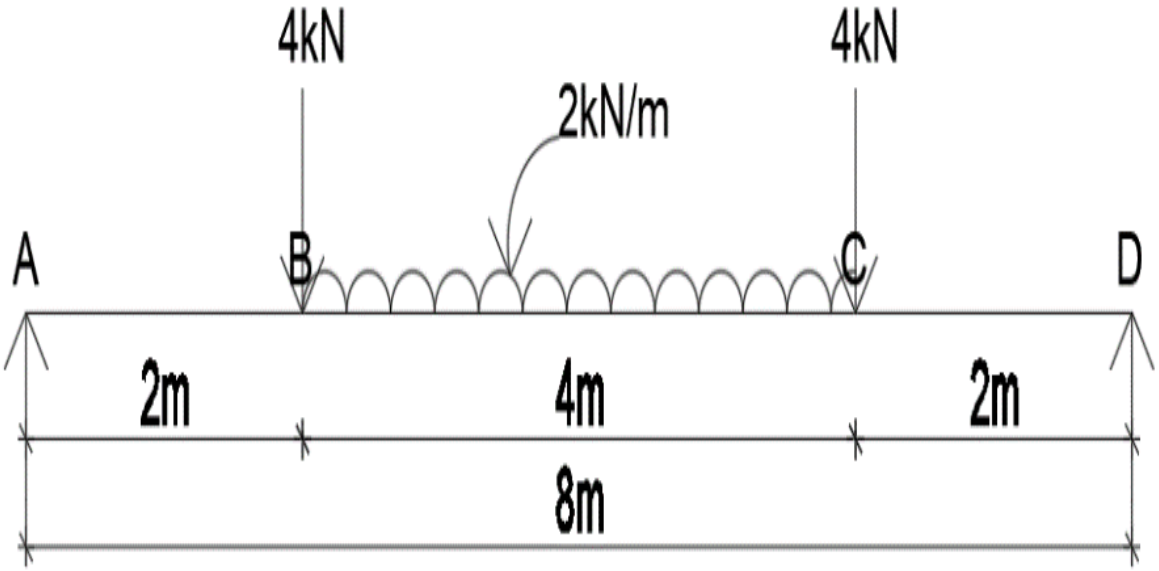
This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.

1. What are the differences between red bricks and Autoclaved Aerated Cement (AAC) blocks?

2. What is concrete curing and describe briefly the various methods of concrete curing? Why the concrete curing is important?

3. What are the steps involved in the concreting process and explain each steps?

4. Determine the values of reactions at support A and D, maximum bending moment and draw the bending moment diagram (BMD) & shear force diagram (SFB) of the figure given below-



SECTION B: Case Study [50 marks]

Choose either CASE I OR CASE II from this section. Each case study carries 50 marks. Mark for each sub-question is indicated in the brackets.

CASE I

You are assigned to analyze a four multi- storied special RC building located in a seismic zone IV with equivalent static lateral force method. The followings are the assumed preliminary data for the analysis of the frame-

1.	Type of structure	Special RC moment resisting frame
2.	Seismic zone	IV
3.	Number of stories	4 (G+3)
4.	Floor to floor height	3.5 m
5.	Materials	Concrete (M20) and Reinforcement (Fe 500)
6.	Column Sizes	250x450mm
7.	Beam Sizes	250mm x 400 mm in Longitudinal & 250mmx350mm in transverse direction
8.	Slab depth	100 mm
9.	Specific weight of RCC	25 kN/m^3
10.	Specific weight of infill	20 kN/m^3
11.	Type of soil	Rock
12.	Infill wall thickness	250 mm
13.	Imposed Load on 1^{st}, 2^{nd}, 3^{rd} floor	3.5 kN/m^2
14.	Imposed Load on roof	0.0
15.	Response Spectra	As per IS 1893 (Part 1):2016

1. Convert the given weight (weight of the 1^{st} floor is 632.43 kN, 2^{nd} floor is 632.43kN, 3^{rd} floor is 632.43kN and weight of roof floor = 363.82 kN) of the each floor into masses and Calculate the seismic weight of the building. **[5 marks]**

2. Determine the Fundamental Natural Period. **[7 marks]**

3. What is Base Shear of the structure and what does the base shear acting on a building depend on? **[8 marks]**

4. Determine the value of the Design Seismic Base Shear. **[10 marks]**

5. Determine the design lateral forces at various floor level and draw the loading diagram and shear diagram. **[20 marks]**

CASE II

1. Suppose a design for a five storied RCC building was already completed, however the client was proposing for one additional floor, i.e. 6 storied, and the foundation need to be redesign before execution of the construction works, and so you as a civil engineer, you are assigned to re-determine the size and depth of the isolated square footing with the following given data. Check for One way and two way shear. **[25 marks]**

   Serviceable axial load- 2500 kN

   Moment about z-axis, M_z =100 kNm

   Moment about x-axis, M_x = 120 kNm

   Load factor for ultimate strength is 1.5

   Column Size = 600 mm x 600 mm

   Unit weight of the soil = 18 kN/m^3

   Compressive strength of concrete, f_{ck} = M20MPa

   Yield strength of steel reinforcement, F_y = Fe 500MPa

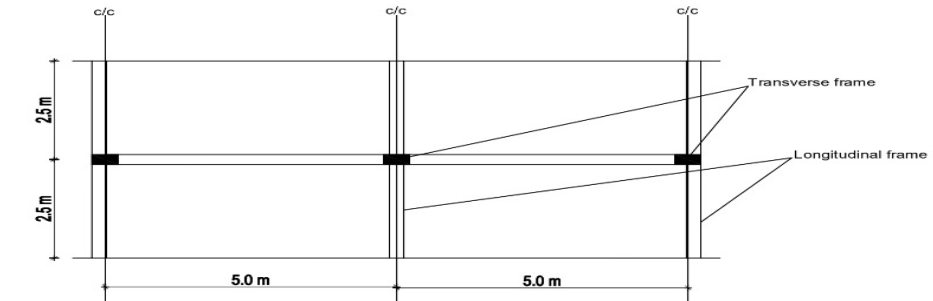
   Safe bearing capacity = 150 kN/m^2

   Shear strength of concrete in punching, τ_c = $\boxed{0.25\sqrt{fck}}$ and design shear strength of concrete is given below-

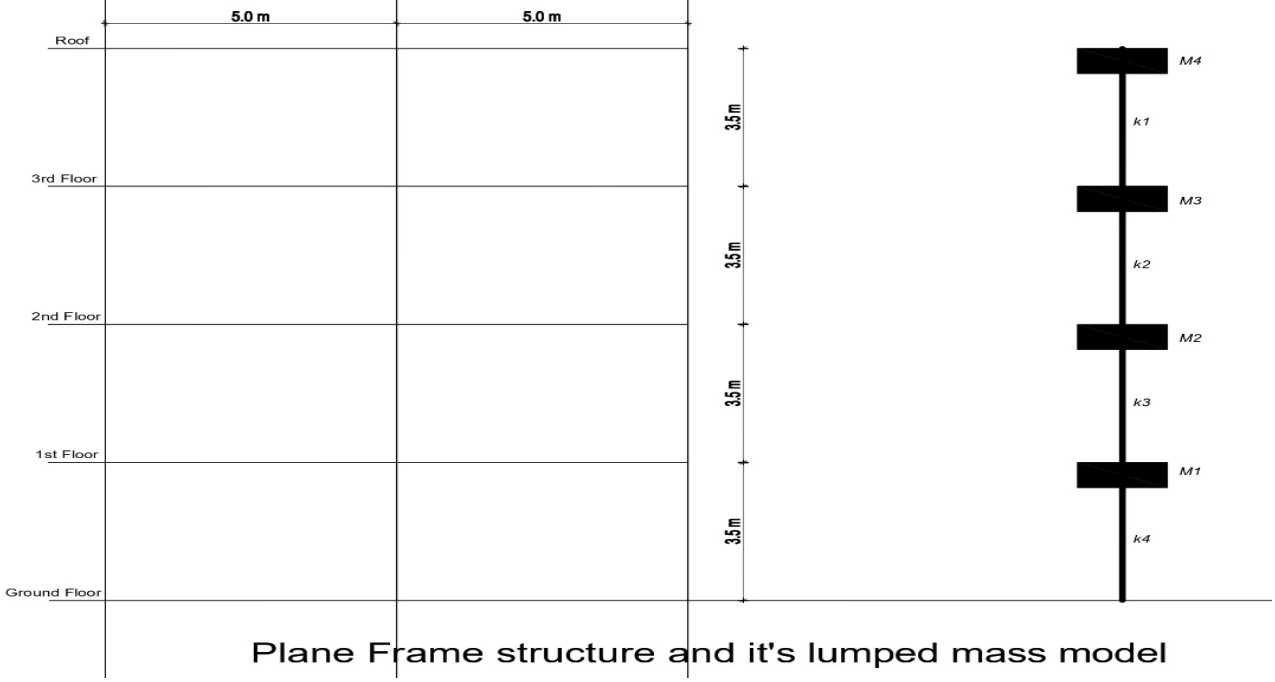
$100A_s/bd$	≤0.15	0.25	0.5	0.75	1.0	1.25	1.5	1.75	2.0	2.25	2.5≥
τ_c	0.28	0.36	0.48	0.56	0.62	0.67	0.72	0.75	0.79	0.81	0.82

2. A cantilever retaining wall is required to retain earth 3.8 metre high above the ground level. Determine the depth of the foundation, width of the footing and thickness of the base slab, & stem. Also check for the stability-factor of safety (FOS) against sliding, FOS against overturning. Sketch the retaining wall with dimensions.

   Assume the unit weight of soil (γ_s) as 18 kN/m^3, angle of repose of soil (Ø) as 30º, the backfill surface is inclined (Θ) at 15º, coefficient of friction (μ) as 0.5, the safe bearing of the soil (q_0) as150 kN/m^2, f_{ck}=M20MPa and f_y=Fe 500MPa**. [25 marks]**



Plan showing the column and beams at floor levels of the plane frame



Plane Frame structure and it's lumped mass model

240
250
415
480
500
f_{ck}
20

TABLE 2 FLEXURE — REINFORCEMENT PERCENTAGE, p_t FOR SINGLY REINFORCED SECTIONS

f_{ck} = 20 N/mm²

M_u/bd^2, N/mm²	f_y, N/mm²					M_u/bd^2, N/mm²	f_y, N/mm²				
	240	250	415	480	500		240	250	415	480	500
0·30	0·146	0·140	0·085	0·073	0·070	2·22	1·253	1·203	0·725	0·627	0·602
0·35	0·171	0·164	0·099	0·086	0·082	2·24	1·267	1·216	0·733	0·633	0·608
0·40	0·196	0·188	0·114	0·098	0·094	2·26	1·281	1·230	0·741	0·640	0·615
0·45	0·222	0·213	0·128	0·111	0·106	2·28	1·295	1·243	0·749	0·647	0·621
0·50	0·247	0·237	0·143	0·123	0·119	2·30	1·309	1·256	0·757	0·654	0·628
0·55	0·272	0·262	0·158	0·136	0·131	2·32	1·323	1·270	0·765	0·661	0·635
0·60	0·298	0·286	0·172	0·149	0·143	2·34	1·337	1·283	0·773	0·668	0·642
0·65	0·324	0·311	0·187	0·162	0·156	2·36	1·351	1·297	0·781	0·675	0·648
0·70	0·350	0·336	0·203	0·175	0·168	2·38	1·365	1·311	0·790	0·683	0·655
0·75	0·376	0·361	0·218	0·188	0·181	2·40	1·380	1·324	0·798	0·690	0·662
0·80	0·403	0·387	0·233	0·201	0·193	2·42	1·394	1·338	0·806	0·697	0·669
0·85	0·430	0·412	0·248	0·215	0·206	2·44	1·408	1·352	0·814	0·704	0·676
0·90	0·456	0·438	0·264	0·228	0·219	2·46	1·423	1·366	0·823	0·711	0·683
0·95	0·483	0·464	0·280	0·242	0·232	2·48	1·438	1·380	0·831	0·719	0·690
1·00	0·511	0·490	0·295	0·255	0·245	2·50	1·452	1·394	0·840	0·726	0·697
1·05	0·538	0·517	0·311	0·269	0·258	2·52	1·467	1·408	0·848	0·734	0·704
1·10	0·566	0·543	0·327	0·283	0·272	2·54	1·482	1·423	0·857	0·741	0·711
1·15	0·594	0·570	0·343	0·297	0·285	2·56	1·497	1·437	0·866	0·748	0·719
1·20	0·622	0·597	0·359	0·311	0·298	2·58	1·512	1·451	0·874	0·756	0·726
1·25	0·650	0·624	0·376	0·325	0·312	2·60	1·527	1·466	0·883	0·764	0·733
1·30	0·678	0·651	0·392	0·339	0·326	2·62	1·542	1·481	0·892	0·771	0·740
1·35	0·707	0·679	0·409	0·354	0·339	2·64	1·558	1·495	0·901	0·779	0·748
1·40	0·736	0·707	0·426	0·368	0·353	2·66	1·573	1·510	0·910	0·786	0·755
1·45	0·765	0·735	0·443	0·383	0·367	2·68	1·588	1·525	0·919	0·794	
1·50	0·795	0·763	0·460	0·397	0·382	2·70	1·604	1·540	0·928		
1·55	0·825	0·792	0·477	0·412	0·396	2·72	1·620	1·555	0·937		
1·60	0·855	0·821	0·494	0·427	0·410	2·74	1·636	1·570	0·946		
1·65	0·885	0·850	0·512	0·443	0·425	2·76	1·651	1·585	0·955		
1·70	0·916	0·879	0·530	0·458	0·440	2·78	1·667	1·601			
1·75	0·947	0·909	0·547	0·473	0·454	2·80	1·683	1·616			
1·80	0·978	0·939	0·565	0·489	0·469	2·82	1·700	1·632			
1·85	1·009	0·969	0·584	0·505	0·484	2·84	1·716	1·647			
1·90	1·041	1·000	0·602	0·521	0·500	2·86	1·732	1·663			
1·95	1·073	1·030	0·621	0·537	0·515	2·88	1·749	1·679			
2·00	1·106	1·062	0·640	0·553	0·531	2·90	1·766	1·695			
2·02	1·119	1·074	0·647	0·559	0·537	2·92	1·782	1·711			
2·04	1·132	1·087	0·655	0·566	0·543	2·94	1·799	1·727			
2·06	1·145	1·099	0·662	0·573	0·550	2·96	1·816	1·743			
2·08	1·159	1·112	0·670	0·579	0·556	2·98	1·833	1·760			
2·10	1·172	1·125	0·678	0·586	0·562						
2·12	1·185	1·138	0·685	0·593	0·569						
2·14	1·199	1·151	0·693	0·599	0·575						
2·16	1·212	1·164	0·701	0·606	0·582						
2·18	1·226	1·177	0·709	0·613	0·588						
2·20	1·239	1·190	0·717	0·620	0·595						

NOTE — Blanks indicate inadmissible reinforcement percentage (*see* Table E).

Table 1 Percentage Increase in Net Bearing Pressure and Skin Friction of Soils
(*Clause* 6.3.5.2)

Sl No. (1)	Soil Type (2)	Percentage Increase Allowable (3)
i)	*Type A:* Rock or hard soils	50
ii)	*Type B:* Medium or stiff soils	25
iii)	*Type C:* Soft soils	0

NOTES

1 The net bearing pressure shall be determined in accordance with IS 6403 or IS 1888.

2 Only corrected values of N shall be used.

3 If any increase in net bearing pressure has already been permitted for forces other than seismic forces, the increase in allowable bearing pressure, when seismic force is also included, shall not exceed the limits specified above.

4 The desirable minimum corrected field values of N shall be as specified below:

Seismic Zone	*Depth* (m) *below Ground Level*	*N Values*	*Remarks*
III, IV and V	≤ 5	15	For values of depths between 5 m and 10 m, linear interpolation is recommended
	≥10	25	
II	≤ 5	10	
	≥10	20	

If soils of lower N values are encountered than those specified in the table above, then suitable ground improvement techniques shall be adopted to achieve these values. Alternately, deep pile foundations should be used, which are anchored in stronger strata, underlying the soil layers that do not meet the requirement.

5 Piles should be designed for lateral loads neglecting lateral resistance of those soil layers (if any), which are liable to liquefy.

6 Indian Standards IS 1498 and IS 2131 may be referred for soil notation, and corrected N values shall be determined by applying correction factor C_N for effective overburden pressure σ'_{vo} using relation $N = C_N N_1$, where $C_N = \sqrt{P_a/\sigma'_{vo}} \leq 1.7$, P_a is the atmospheric pressure and N1 is the uncorrected SPT value for soil.

7 While using this table, the value of N to be considered shall be determined as below:

a) Isolated footings — Weighted average of N of soil layers from depth of founding, to depth of founding plus twice the breadth of footing;

b) Raft foundations — Weighted average of N of soil layers from depth of founding, to depth of founding plus twice the breadth of raft;

c) Pile foundation — Weighted average of N of soil layers from depth of bottom tip of pile, to depth of bottom tip of pile plus twice the diameter of pile;

d) Group pile foundation — Weighted average of N of soil layers from depth of bottom tip of pile group, to depth of bottom tip of pile group plus twice the width of pile group; and

e) Well foundation — Weighted average of N of soil layers from depth of bottom tip of well, to depth of bottom tip of well plus twice the width of well.

Table 2 Classification of Types of Soils for Determining Percentage Increase in Net Bearing Pressure and Skin Friction
(*Clause* 6.3.5.2)

Sl No. (1)	Soil Type (2)	Remarks (3)
i)	**Type A** Rock or hard soils	Well graded gravel (GW) or well graded sand (SW) both with less than 5 percent passing 75 mm sieve (Fines) Well graded gravel — sand mixtures with or without fines (GW-SW) Poorly-graded sand (SP) or Clayey sand (SC), all having N above 30 Stiff to hard clays having N above 30, where N is corrected standard penetration test value
ii)	**Type B** Medium or stiff soils	Poorly graded sands or poorly graded sands with gravel (SP) with little or no fines having N between 10 and 30 Stiff to medium stiff fine-grained soils, like silts of low compressibility (ML) or clays of low compressibility (CL) having N between 10 and 30
iii)	**Type C** Soft soils	All soft soils other than SP with N<10. The various possible soils are: Silts of intermediate compressibility (Ml); Silts of high compressibility (MH); Clays of intermediate compressibility (Cl); Clays of high compressibility (CH); Silts and clays of intermediate to high com-pressibility (MI-MH or CI-CH); Silt with clay of intermediate compressibility (MI-CI); and Silt with clay of high compressibility (MH-CH).
iv)	**Type D** Unstable, collapsible, liquefiable soils	Requires site-specific study and special treatment according to site condition (*see* **6.3.5.3**)

Table 3 Seismic Zone Factor *Z*
(*Clause* 6.4.2)

Seismic Zone Factor (1)	II (2)	III (3)	IV (4)	V (5)
Z	0.10	0.16	0.24	0.36

6.4.3 Effects of design earthquake loads applied on structures can be considered in two ways, namely:

a) Equivalent static method, and
b) Dynamic analysis method.

In turn, dynamic analysis can be performed in three ways, namely:

1) Response spectrum method,
2) Modal time history method, and
3) Time history method.

In this standard, Equivalent Static Method, Response Spectrum Method and Time History Method are

Table 7 Minimum Design Earthquake Horizontal Lateral Force for Buildings
(*Clause* 7.2.2)

Sl No.	Seismic Zone	ρ Percent
(1)	(2)	(3)
i)	II	0.7
ii)	III	1.1
iii)	IV	1.6
iv)	V	2.4

7.2.3 *Importance Factor (I)*

In estimating design lateral force V_B of buildings as per **7.2.1**, the importance factor I of buildings shall be taken as per Table 8.

Table 8 Importance Factor (*I*)
(*Clause* 7.2.3)

Sl No.	Structure	*I*
(1)	(2)	(3)
i)	Important service and community buildings or structures (for example, critical governance buildings, schools), signature buildings, monument buildings, lifeline and emergency buildings (for example, hospital buildings, telephone exchange buildings, television station buildings, radio station buildings, bus station buildings, metro rail buildings and metro rail station buildings), railway stations, airports, food storage buildings (such as warehouses), fuel station buildings, power station buildings, and fire station buildings), and large community hall buildings (for example, cinema halls, shopping malls, assembly halls and subway stations)	1.5
ii)	Residential or commercial buildings [other than those listed in Sl No. (i)] with occupancy more than 200 persons	1.2
iii)	All other buildings	1.0

NOTES

1 Owners and design engineers of buildings or structures may choose values of importance factor I more than those mentioned above.

2 Buildings or structures covered under Sl No. (iii) may be designed for higher value of importance factor I, depending on economy and strategy.

3 In Sl No. (ii), when a building is composed of more than one structurally independent unit, the occupancy size shall be for each of the structurally independent unit of the building.

4 In buildings with mixed occupancies, wherein different I factors are applicable for the respective occupancies, larger of the importance factor I values shall be used for estimating the design earthquake force of the building.

7.2.4 *Damping Ratio*

The value of damping shall be taken as 5 percent of critical damping for the purposes of estimating A_h in the design lateral force V_B of a building as per **7.2.1**, irrespective of the material of construction (namely steel, reinforced concrete, masonry, or a combination thereof of these three basic materials) of its lateral load resisting system, considering that buildings experience inelastic deformations under design level earthquake effects, resulting in much higher energy dissipation than that due to initial structural damping in buildings. This value of damping shall be used, irrespective of the method of the structural analysis employed, namely Equivalent Static Method (as per **7.6**) or Dynamic Analysis Method (as per **7.7**).

7.2.5 *Design Acceleration Spectrum*

Design acceleration coefficient S_a/g corresponding to 5 percent damping for different soil types, normalized to peak ground acceleration, corresponding to natural period T of structure considering soil-structure interaction, irrespective of the material of construction of the structure. S_a/g shall be as given by expressions in **6.4.2**.

7.2.6 *Response Reduction Factor (R)*

Response reduction factor, along with damping during extreme shaking and redundancy: (a) influences the nonlinear behaviour of buildings during strong earthquake shaking, and (b) accounts for inherent system ductility, redundancy and overstrength normally available in buildings, if designed and detailed as per this standard and the associated Indian Standards.

For the purpose of design as per this standard, response reduction factor R for different building systems shall be as given in Table 9. The values of R shall be used for design of buildings with lateral load resisting elements, and NOT for just the lateral load resisting elements, which are built in isolation.

7.2.7 *Dual System*

Buildings with dual system consist of moment resisting frames and structural walls (or of moment resisting frames and bracings) such that both of the following conditions are valid:

a) Two systems are designed to resist total design lateral force in proportion to their lateral stiffness, considering interaction of two systems at all floor levels; and

b) Moment resisting frames are designed to resist independently at least 25 percent of the design base shear.

7.3 Design Imposed Loads for Earthquake Force Calculation

7.3.1 For various loading classes specified in IS 875 (Part 2), design seismic force shall be estimated using

full dead load plus percentage of imposed load as given in Table 10. The same shall be used in the three-dimensional dynamic analysis of buildings also.

Table 9 Response Reduction Factor *R* for Building Systems
(*Clause* 7.2.6)

Sl No. (1)	Lateral Load Resisting System (2)	R (3)
i)	**Moment Frame Systems**	
	a) RC buildings with ordinary moment resisting frame (OMRF) (*see* Note 1)	3.0
	b) RC buildings with special moment resisting frame (SMRF)	5.0
	c) Steel buildings with ordinary moment resisting frame (OMRF) (*see* Note 1)	3.0
	d) Steel buildings with special moment resisting frame (SMRF)	5.0
ii)	**Braced Frame Systems** (*see* Note 2)	
	a) Buildings with ordinary braced frame (OBF) having concentric braces	4.0
	b) Buildings with special braced frame (SBF) having concentric braces	4.5
	c) Buildings with special braced frame (SBF) having eccentric braces	5.0
iii)	**Structural Wall Systems** (*see* Note 3)	
	a) Load bearing masonry buildings	
	1) Unreinforced masonry (designed as per IS 1905) without horizontal RC seismic bands (*see* Note 1)	1.5
	2) Unreinforced masonry (designed as per IS 1905) with horizontal RC seismic bands	2.0
	3) Unreinforced masonry (designed as per IS 1905) with horizontal RC seismic bands and vertical reinforcing bars at corners of rooms and jambs of openings (with reinforcement as per IS 4326)	2.5
	4) Reinforced masonry [*see* SP 7 (Part 6) Section 4]	3.0
	5) Confined masonry	3.0
	b) Buildings with ordinary RC structural walls (*see* Note 1)	3.0
	c) Buildings with ductile RC structural walls	4.0
iv)	**Dual Systems** (*see* Note 3)	
	a) Buildings with ordinary RC structural walls and RC OMRFs (*see* Note 1)	3.0
	b) Buildings with ordinary RC structural walls and RC SMRFs (*see* Note 1)	4.0
	c) Buildings with ductile RC structural walls with RC OMRFs (*see* Note 1)	4.0
	d) Buildings with ductile RC structural walls with RC SMRFs	5.0
v)	**Flat Slab – Structural Wall Systems** (*see* Note 4)	
	RC building with the three features given below:	3.0
	a) Ductile RC structural walls (which are designed to resist 100 percent of the design lateral force),	
	b) Perimeter RC SMRFs (which are designed to independently resist 25 percent of the design lateral force), and preferably	
	c) An outrigger and belt truss system connecting the core ductile RC structural walls and the perimeter RC SMRFs (*see* Note 1).	

NOTES
1 RC and steel structures in Seismic Zones III, IV and V shall be designed to be ductile. Hence, this system is not allowed in these seismic zones.
2 Eccentric braces shall be used only with SBFs.
3 Buildings with structural walls also include buildings having structural walls and moment frames, but where,
a) frames are not designed to carry design lateral loads, or
b) frames are designed to carry design lateral loads, but do not fulfill the requirements of 'Dual Systems'.
4 In these buildings, (a) punching shear failure shall be avoided, and (b) lateral drift at the roof under design lateral force shall not exceed 0.1 percent.

7.3.2 For calculation of design seismic forces of buildings, imposed load on roof need not be considered. But, weights of equipment and other permanently fixed facilities should be considered; in such a case, the reductions of imposed loads mentioned in Table 10 are not applicable to that part of the load.

Table 10 Percentage of Imposed Load to be Considered in Calculation of Seismic Weight
(*Clause* 7.3.1)

Sl No. (1)	Imposed Uniformity Distributed Floor Loads kN/m^2 (2)	Percentage of Imposed Load (3)
i)	Up to and including 3.0	25
ii)	Above 3.0	50

7.3.3 Imposed load values indicated in Table 10 for calculating design earthquake lateral forces are applicable to normal conditions. When loads during earthquakes are more accurately assessed, designers may alter imposed load values indicated or even replace the entire imposed load given in Table 10 with actual assessed load values, subject to the values given in Table 7 as the minimum values. Where imposed load is not assessed as per **7.3.1** and **7.3.2**,

a) only that part of imposed load, which possesses mass, shall be considered; and

b) lateral earthquake design force shall not be calculated on contribution of impact effects from imposed loads.

7.3.4 Loads other than those given above (for example, snow and permanent equipment) shall be considered appropriately.

7.3.5 In regions of severe snow loads and sand storms exceeding intensity of 1.5 kN/m^2, 20 percent of uniform design snow load or sand load, respectively shall be included in the estimation of seismic weight. In case the minimum values of seismic weights corresponding to these load effects given in IS 875 are higher, the higher values shall be used.