

Building Resilience: Seismic Safety and Strengthening

Section A – Scenario-Based MCQs

Q1.

Following an Mw 7.1 earthquake, a 12-storey RC moment-resisting frame designed before modern ductile detailing provisions exhibits extensive cracking at beam-column joints, while columns remain largely undamaged. The owner intends to restore occupancy rapidly without significantly increasing the building's lateral stiffness.

Which retrofit strategy is most consistent with this objective?

- A. RC jacketing of all first-storey columns
- B. Addition of RC shear walls at the building perimeter
- C. Local strengthening of beam-column joints using CFRP/UHPFRC-based techniques while restoring joint confinement
- D. Providing steel cross bracings at few locations as per design

Q2.

A municipal authority evaluates two existing hospitals for seismic upgrading.

Hospital A:

- Designed to modern ductile standards
- Located on soft alluvial soil
- Minor structural deterioration

Hospital B:

- Designed before seismic detailing requirements
- Located on rock
- Moderate corrosion of beam-column joints

Assuming identical seismic hazard levels, which facility is likely to require the more comprehensive structural intervention?

- A. Hospital A because site amplification dominates structural performance
- B. Hospital B because detailing deficiencies and deterioration reduce deformation capacity
- C. Both require identical strengthening because hazard is identical
- D. Neither requires retrofit since both have survived previous earthquakes

Q3.

An engineer proposes adding reinforced concrete shear walls symmetrically to improve seismic resistance of a 15-storey office building. Subsequent nonlinear analysis shows substantially reduced roof displacement but significantly increased foundation demand.

The most appropriate explanation is:

- A. Increased stiffness reduced lateral displacement while attracting larger seismic forces
- B. Shear walls add more dead weight in structure
- C. Increased stiffness reduces both displacement and base shear simultaneously
- D. Foundation demand depends only on gravity loading

Q4.

An earthquake reconnaissance team observes two apparently identical RC apartment buildings. Building X develops extensive diagonal cracking in masonry infills but limited structural damage. Building Y experiences severe column damage and partial storey collapse while infill damage is comparatively minor.

The most probable explanation is:

- A. Building X possessed superior energy dissipation through intended structural mechanisms
- B. Building Y experienced lower earthquake intensity
- C. Masonry infills always prevent column damage
- D. Column damage indicates stronger beam behaviour than expected

Q5.

A four-storey school building is being assessed for retrofit. Large classrooms at the ground floor require removal of several masonry infill walls to improve functionality.

Which seismic concern becomes most critical after this modification?

- A. Increased torsional mass
- B. Soft-storey mechanism due to abrupt reduction in lateral stiffness
- C. Reduction in gravity load
- D. Increase in floor diaphragm rigidity

Q6.

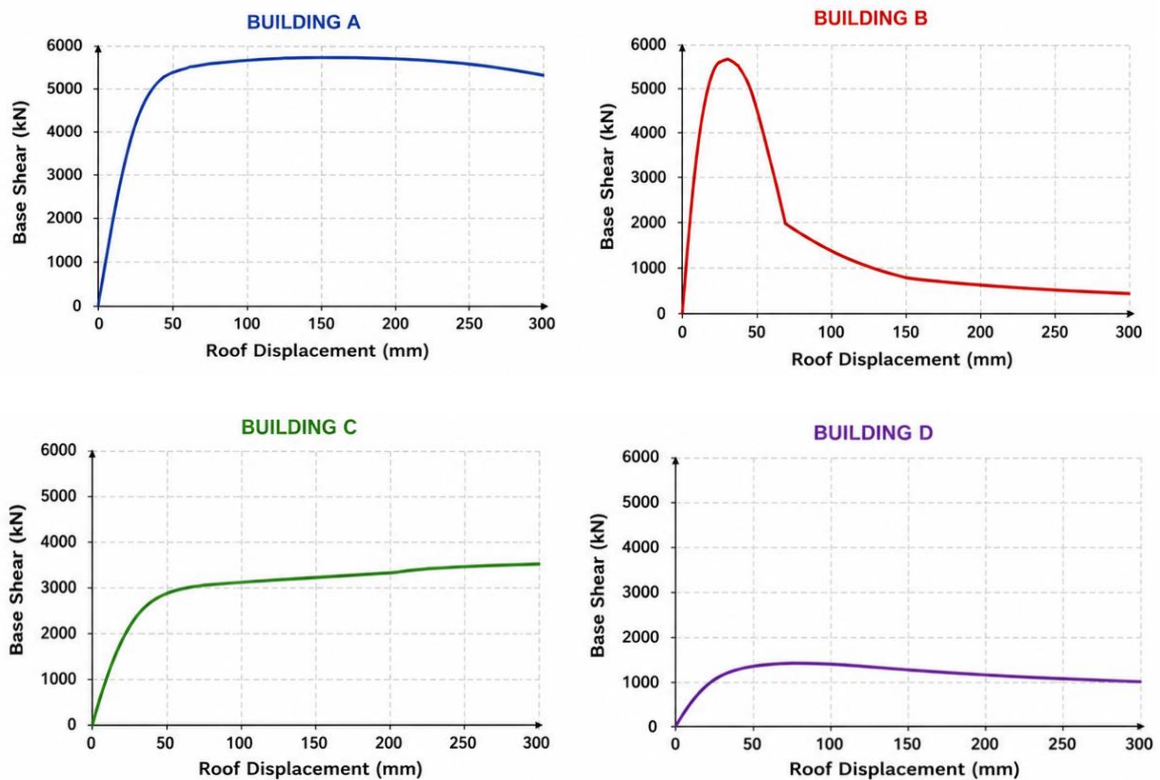
Following an earthquake, an RC bridge pier exhibits yielding near its base but maintains vertical load-carrying capacity and no noticeable concrete crushing.

From a performance-based perspective, the structure has most likely achieved:

- A. Collapse
- B. Immediate Occupancy
- C. Life Safety
- D. Operational Performance with zero damage

Q7.

The figures attached below show the pushover curves of four nos. Reinforced Concrete (RC) buildings obtained from nonlinear static pushover analysis.



Based on these curves, which building is expected to exhibit the best overall seismic performance under strong earthquake shaking, considering lateral strength, displacement ductility and energy absorption?

- A. Building A
- B. Building B

C. Building C

D. Building D

Q8.

Two residential buildings possess identical strength but different stiffness.

Building A:

Fundamental period = 0.45 s

Building B:

Fundamental period = 1.60 s

Both are subjected to the same earthquake record.

Which statement is generally correct?

A. Buildings with identical strength will always experience the same base shear during an earthquake

B. Dynamic response depends upon interaction between structural period and earthquake frequency content

C. Longer-period buildings always experience larger accelerations

D. Shorter-period buildings never sustain earthquake damage

Q9.

An existing RC frame has severe reinforcement corrosion concentrated only within the plastic hinge regions of columns.

Which consequence is expected to influence seismic performance most significantly?

A. Increased flexural ductility

B. Reduced confinement effectiveness leading to brittle failure

C. Increase in damping ratio sufficient to compensate for strength loss

D. Improved energy dissipation due to steel section reduction

Q10.

A city intends to improve seismic resilience of its emergency response network under limited financial resources.

Which investment is likely to provide the greatest improvement in post-earthquake functionality?

A. Architectural renovation of emergency buildings

B. Strengthening hospitals, emergency operation centres, bridges, Elevated Water Reservoirs and utility lifelines according to performance objectives

C. Increasing parking capacity around public buildings

D. Installing modern energy-efficient lighting and HVAC systems in public buildings

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Section B – Indian Standards (IS 1893, IS 13920 & IS 13935)

Q11.

A structural engineer is analysing a 22-storey reinforced concrete office building with significant plan irregularity. The building exhibits closely spaced translational and torsional modes, with no single mode contributing 90% of the participating mass. Which approach is most consistent with the intent of IS 1893?

- A. Use only the first mode because it has the largest modal mass participation.
- B. Include sufficient modes so that the cumulative modal mass participation satisfies the code requirement before combining modal responses.
- C. Ignore torsional modes if translational modes are dominant.
- D. Use equivalent static analysis because modal participation is distributed.

Q12.

An engineer proposes using the Equivalent Static Method for a vertically irregular 18-storey reinforced concrete building located in a high seismic zone. According to the philosophy of IS 1893, the primary concern with this proposal is that:

- A. Equivalent static analysis cannot represent the influence of higher modes in irregular tall buildings.
- B. Equivalent static analysis always produces unconservative base shear.
- C. Equivalent static analysis is prohibited for reinforced concrete buildings.
- D. Response Spectrum Analysis generally predicts lower storey drifts.

Q13.

According to IS 1893 (Part 1): 2016, accidental eccentricity shall be considered by shifting the centre of mass by:

- A. $\pm 2\%$ of the building dimension perpendicular to the seismic force
- B. $\pm 5\%$ of the building dimension perpendicular to the seismic force
- C. $\pm 10\%$ of the building dimension parallel to the seismic force
- D. $\pm 5\%$ of the building dimension parallel to the seismic force

Q14.

During construction, the site engineer proposes relocating lap splices of longitudinal reinforcement to the beam-column joint to simplify reinforcement placement. From the perspective of IS 13920, why is this proposal unacceptable?

- A. Beam-column joints are expected to undergo high cyclic inelastic demands, making splice performance unreliable.
- B. Lap splices increase concrete compressive strength.
- C. Lap splices increase beam stiffness excessively.
- D. Beam-column joints are designed only for gravity loading.

Q15.

According to IS 13920:2016, lap splices in longitudinal reinforcement of columns shall not be provided:

- A. At the middle half of the clear height
- B. Within the beam-column joint
- C. In columns carrying axial load less than $0.2A_g f_{ck}$
- D. Above the roof level

Q16.

During peer review of a ductile moment-resisting frame, it is found that the calculated flexural strength of several columns at a joint is lower than that of the framing beams.

Which seismic failure mechanism is IS 13920 primarily intended to prevent?

- A. Beam yielding before column yielding.
- B. Strong-column weak-beam mechanism.
- C. Weak-column strong-beam mechanism leading to storey instability.
- D. Flexural cracking in slabs.

Q17.

Following a moderate earthquake, an existing RC office building exhibits widespread cover concrete spalling, corrosion of exposed reinforcement, and moderate flexural cracking in beams. No measurable permanent tilt or foundation distress is observed.

According to the philosophy of IS 13935, the first engineering priority should be:

- A. Demolish the entire structure.
- B. Perform a systematic condition assessment and determine whether repair or strengthening is required before selecting intervention measures.
- C. Immediately increase the building height.
- D. Replace all architectural finishes before structural evaluation.

Q18.

According to IS 13935, structural cracks in reinforced concrete members that affect load-carrying capacity should primarily be repaired using:

- A. Cement slurry brushing
- B. Epoxy injection after proper assessment
- C. White cement putty
- D. Polymer paint

Q19.

A design review identifies significant stiffness irregularity at the first storey due to open parking. Rather than modifying the architectural layout, the engineer proposes enhanced ductile detailing alone. Which statement best reflects the combined philosophy of IS 1893 and IS 13920?

- A. Proper detailing completely eliminates the adverse effects of structural irregularities.
- B. Ductile detailing improves deformation capacity but does not remove the need to address adverse structural configuration.
- C. Structural irregularities influence only wind loading.
- D. Soft-storey effects are governed only by foundation design.

Q20.

A 30-year-old reinforced concrete hospital was designed before modern seismic detailing provisions. Assessment indicates inadequate transverse reinforcement, corrosion in critical columns, and increased seismic demand due to revised hazard provisions.

Which strategy is most consistent with the collective intent of IS 1893, IS 13920, and IS 13935?

- A. Repair visible cracks only because the building has not collapsed.
- B. Assess seismic performance, identify structural deficiencies, and implement strengthening measures that improve both strength and ductility to achieve the required performance objective.
- C. Increase live load capacity without modifying lateral-force-resisting elements.
- D. Replace only non-structural partitions while leaving structural deficiencies unchanged.

Answer Key

Q	Answer
1	C
2	B
3	A
4	A
5	B
6	C
7	A
8	B
9	B
10	B
11	B
12	A
13	B
14	A
15	B
16	C
17	B
18	B
19	B
20	B