

STRUCTURAL HEALTH ASSESSMENT MANUAL

For existing schools and health facilities in Pakistan

Staged assessment • Testing • Evaluation • Decision • Reporting



SITE ASSESSMENT



DAMAGE MAPPING



TESTING



SAFETY



EVALUATION



REPORTING



Document control

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Abbreviations

Term	Meaning
AHJ	Authority Having Jurisdiction
ASCE/SEI	American Society of Civil Engineers / Structural Engineering Institute
FEMA	Federal Emergency Management Agency
BCP-2021	Building Code of Pakistan 2021
BSE-1E / BSE-2E	Basic Safety Earthquake 1 and 2 for existing buildings (ASCE/SEI 41-17)
CP / LS / IO	Collapse Prevention, Life Safety and Immediate Occupancy structural performance levels
DCR	Demand-capacity ratio
EMIS / HMIS	Education / Health Management Information System
MCE ^R	Risk-targeted Maximum Considered Earthquake
NDT / DT	Non-destructive testing / destructive testing
PEC	Pakistan Engineering Council
RC	Reinforced concrete
Risk Category I-IV	Occupancy-based risk classification, BCP-2021 §1604.5 and Table 1604.5
S_s / S_1	Mapped 0.2-second and 1-second spectral response accelerations
URM / CM / RM	Unreinforced / confined / reinforced masonry
κ	Knowledge factor (ASCE/SEI 41-17 Table 6-1)

Definitions

Term	Definition
Structural health assessment	The staged process by which the structural condition and adequacy of an existing building are established and converted into a documented decision.
Index building	A representative building characterized in engineering detail, whose findings are applied to other buildings of the same typology, construction era and condition.
Knowledge factor (κ)	A reduction factor applied to component capacity to reflect the reliability of as-built data, assigned per component from ASCE/SEI 41-17 Table 6-1.
Demand-capacity ratio	The ratio of the demand on a component or action under the governing load combination to the corresponding capacity, computed under linear procedures.
Deformation-controlled action	A ductile action evaluated against a permissible deformation, with capacity modified by an m-factor.
Force-controlled action	A brittle or limited-ductility action that must remain elastic; no ductility modification is permitted.
Performance objective	A target structural performance level associated with a defined seismic hazard level.
Gate condition	A finding designated as an automatic referral. A Class 1 gate condition routes the assessment directly to the decision stage; a Class 2 gate condition raises the screening outcome. Both apply irrespective of any other finding. The gate conditions are listed at Clause 8.3.1.
Trigger event	An earthquake, flood, fire, landslide or observation of new damage that requires an assessment to be reopened.

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1 Introduction, Scope and Application

Public schools and health facilities in Pakistan are occupied by children and patients, are relied upon as places of refuge after a damaging event, and exist in very large numbers; their structural condition is unknown. The Manual converts information on structural condition into a documented, defensible engineering decision.

1.1 Purpose

The Manual provides a structured procedure for assessing the structural condition and adequacy of existing public schools and health facilities subject to earthquakes, flood, wind, landslide, fire and material deterioration. It converts field evidence into a decision an owner can act on, a financier can fund, and an independent reviewer can check.

1.1.1 An assessment carried out under this Manual shall produce a decision-ready record. The record shall identify the asset, state the applicable performance objective, document the evidence collected and its limitations, and connect the findings to a repair, retrofit, replacement, relocation or monitoring decision.

1.2 Application and limits

This Manual governs the assessment of existing buildings only. It neither governs the design of new construction nor supersedes the material design standards adopted in BCP 2021.

1.2.1 This Manual shall not be applied to justify a lower level of safety than that stipulated by the adopted code, the Authority Having Jurisdiction, the financing agreement or the owner's requirements. Where a project requirement is more stringent, the more stringent requirement governs.

1.2.2 This Manual structures engineering judgement by requiring evidence, assumptions, limitations and decisions to be stated explicitly. It does not remove the responsibility of the assessing engineer to determine whether the procedures are adequate for the building under assessment.

1.3 Instruction hierarchy

Assessment practice combines legal obligation, professional recommendation, engineering judgement, and owner-imposed requirements. This Manual keeps the four distinct.

Instructions are also carried in boxed callouts. A REQUIREMENT box states a requirement and is binding in the same way as a numbered clause. A KEY DECISION box states a matter reserved to engineering judgement. A CAUTION box identifies a misapplication to be avoided, and a NOTE box explains the reason for a provision. CAUTION and NOTE boxes are explanatory and are read with the clause they accompany; they do not create a separate requirement.

Table 1-1 Instruction Hierarchy and Requirements for Departure

Instruction	Meaning	Departure
Requirement	A numbered clause using “shall”. Required for work claiming conformance with this Manual.	Only where the governing authority or contract requires a different approach; record the reason.
Recommended practice	Guidance using “should”. Defines normal professional practice.	Permitted with a documented engineering reason accepted by the reviewer.
Engineering judgement	A decision reserved to the competent assessing engineer.	State the basis, the alternatives considered, and the limitations.
Owner requirement	A requirement imposed by the client, authority or custodian above the minimum.	Governs where more stringent; identify it explicitly.

1.4 Evidence discipline

- 1.4.1** A technical citation, legal provision, standard test method, material value or reported condition shall be traced to a primary source. Where a value cannot be established from a primary source, the assessment shall state the requirement in performance terms rather than adopt an unsupported number.
- 1.4.2** Photographs, test results, finite element model output and official placards presented as project evidence shall be genuine records of the facility assessed. Generic illustrations shall be captioned as such and shall not be presented as project evidence.

1.5 How to use this Manual

Chapter 2 outlines the assessment workflow and the point at which each stage may terminate. Chapters 3 to 5 establish the legal, typological and performance basis. Chapters 6 to 12 investigate the building. Chapters 13 to 15 analyze and evaluate it. Chapters 16 to 19 convert the result into a decision, a report, a monitoring regime and a portfolio action.

Table 1-2 Guide to the Structure and Use of the Manual

Question	Chapter
What is the assessment process and where may it stop?	2
What legal and code basis governs the assessment?	3
What structural typology is the building?	4
What performance objective applies?	5
What information is collected before and during the site visit?	6 to 9
Which test is justified and how is the result interpreted?	10 to 12
Does the building require an analytical model and a tiered evaluation?	13 and 14
How is risk expressed and prioritized across many buildings?	15 and 19
What decision is made, and how is it reported and certified?	16 and 17
What happens after the report is issued?	18 and 19

1.6 Safeguarding, consent and assessor safety

Every assessment under this Manual is carried out in an occupied school or health facility, with children, patients and staff present. The obligations below apply to every stage and to every person attending site, and are additional to any safeguarding policy of the commissioning organization, which governs where it is more stringent.

- 1.6.1** The head of the facility, or the officer in charge, shall be notified before entry and the purpose, extent and expected duration of the visit explained. Access to occupied teaching, treatment or residential spaces shall be arranged so that it does not require children or patients to be photographed, questioned or displaced.
- 1.6.2** No photograph, video or record made under this Manual shall show an identifiable child or patient. Where a person appears incidentally in a required photograph, the image shall be reframed or retaken. Clause 9.6.1 is satisfied by photographing the element and the finding, not the occupants.
- 1.6.3** Assessors shall not enter a building or a part of a building where collapse or falling material is judged imminent, where a partial collapse has already occurred and is unshored, or where access is by a structure whose adequacy has not been established. Where entry is refused on those grounds, the condition shall be recorded as a finding and the facility referred under Chapter 8.
- 1.6.4** Personal protective equipment appropriate to the work shall be worn on every visit: at a minimum, a safety helmet, protective footwear and eye protection, with fall protection for any roof or elevated access. Roof access shall not be taken where the roof structure or covering has not been assessed from below.
- 1.6.5** No assessor shall work alone at a facility. Testing under Chapters 10 and 11 shall be carried out with the occupied areas cleared of the immediate work zone and made good under Clause 11.3.3 before the area is returned to use.

2 The Structural Health Assessment Framework

This chapter outlines the workflow on which every following chapter depends. The workflow has fourteen stages, each with a stated criterion for termination, executed under the authority of the Building Code of Pakistan 2021.

2.1 Basis of the framework

A Pakistani engineer assessing an existing building works within an established legal and technical structure. The Building Code of Pakistan 2021 sets the Risk Category, the seismic and wind load demand and the load combinations against which any evaluation is checked. Appendix A of BCP 2021, “Guidelines for Seismic Evaluation and Retrofit of Existing Buildings,” adopts the tiered evaluation and retrofit procedure of ASCE/SEI 41-17, so the tiered method used in Chapters 13 and 14 is part of the national code and not an alternative to it.

The BCP 2021, however, does not provide guidance on the decision to select buildings for tiered evaluation. This is the contribution of the staged workflow provided below.

Table 2-1 Legal, Technical and Process Basis of the Assessment Framework

Layer	Instrument	Role
Legal authority	BCP 2021	Risk Category (§1604.5, Table 1604.5); seismic demand (§1613.2.1 and Appendix C); wind demand (§1609.3); load combinations (Chapter 16); masonry (Chapter 21).
Evaluation procedure	BCP-2021 Appendix A, adopting ASCE/SEI 41-17	Tier 1 screening (§A106), Tier 2 deficiency-based evaluation and retrofit (§A107), Tier 3 systematic evaluation and retrofit (§A108), repair and retrofit guidance (§A109).
Process discipline	ISO 13822	Staged, iterative assessment of existing structures: establish what is known, test the gaps, and stop when the evidence supports a decision.

2.2 The fourteen-stage workflow

Each stage below is elaborated in one chapter of this Manual. The final column states the condition under which an assessment may terminate at that stage with a justified decision.

Table 2-2 The fourteen stages of assessment and their termination criteria

Stage	Ch.	Activity	Termination criterion
1. Asset identification	6	Unique asset identifier, ownership, use, location and block inventory recorded.	Never terminal. Establishes the register that later stages write back to.
2. Desktop study	7	Drawings, construction era and available hazard information assembled.	Terminal only where the asset is to be demolished or decommissioned for reasons unrelated to structural condition.

Stage	Ch.	Activity	Termination criterion
3. Rapid visual screening	8	Standardized visual screen against structural signs and site hazards.	Terminal where the outcome is SAFE and no trigger event has occurred. This is the exit point for the majority of the stock.
4. Detailed visual assessment	9	Systematic block-by-block, element-by-element survey; crack mapping and damage-state assignment.	Terminal where every finding is a component deficiency with an unambiguous prescriptive remedy.
5. Non-destructive testing	10	Indirect measurement of mechanical properties of the material and reinforcement arrangement.	Terminal where calibrated results confirm materials consistent with the design assumption and no other deficiency exists.
6. Destructive testing	11	Direct measurement by core extraction or load testing.	Not terminal. Feeds Stage 7.
7. Material characterization	12	Test data converted to design values; knowledge factor assigned per component.	Not terminal. Sets parameters on which Stages 8 and 9 depend.
8. Structural modelling	13	Numerical model of the building as it exists, where earlier stages have not resolved the question.	Not terminal. Required only where the performance question is still unresolved.
9. Performance evaluation	14	Tiered evaluation to a demand-capacity ratio and a performance level.	Terminal. Always yields a decision-ready result.
10. Risk assessment	15	Multi-hazard result placed in a risk frame, including compounding failure modes.	Terminal. Yields prioritization.
11. Decision	16	Repair, retrofit, reconstruct or relocate selected against stated criteria.	Terminal. Every assessment reaches this stage.
12. Reporting	17	Assessment report and signed certificate issued.	Mandatory in every case irrespective of the termination stage.
13. Monitoring	18	Re-screening intervals, trigger events and, where justified, instrumentation or other monitoring tools.	Continuing.
14. Portfolio management	19	The register used to sequence investment across many facilities.	Continuing.

2.2.1 An assessment shall proceed to the next stage only where the termination criterion of the current stage is not met.

2.2.2 A Class 1 gate condition identified at any stage shall route the assessment directly to Stage 11 without completing the intervening stages. A Class 2 gate condition shall raise the screening outcome under Clause 8.3.1 without terminating the assessment. The gate conditions of each class are listed at Clause 8.3.1.

CAUTION DECISION

The standard is not maximum investigation; it is sufficient justification for the decision being made. Over-assessment consumes public resources that are needed elsewhere in stock; under-assessment produces unsafe decisions. Cost and disruption are engineering parameters, not grounds for omitting an indicated stage: a stage is skipped because its termination criterion is met, never because it is inconvenient.

2.3 Iteration and trigger events

- 2.3.1** Ambiguous evidence within a stage shall cause the assessment to proceed to the next stage rather than to a decision made on an unresolved basis. A test result inconsistent with the record shall be resolved by further testing, not by assumption in either direction.
- 2.3.2** A trigger event shall cause a facility carrying a terminal SAFE or MONITOR outcome to re-enter the workflow at Stage 3. Re-entry is not at Stage 1: the asset register and desktop study already exist and are not repeated.
- 2.3.3** Material characterization performed for one purpose shall be reused for any later purpose on the same component. A knowledge factor once earned for a component through testing does not revert to a lower value on a later assessment of the same building.

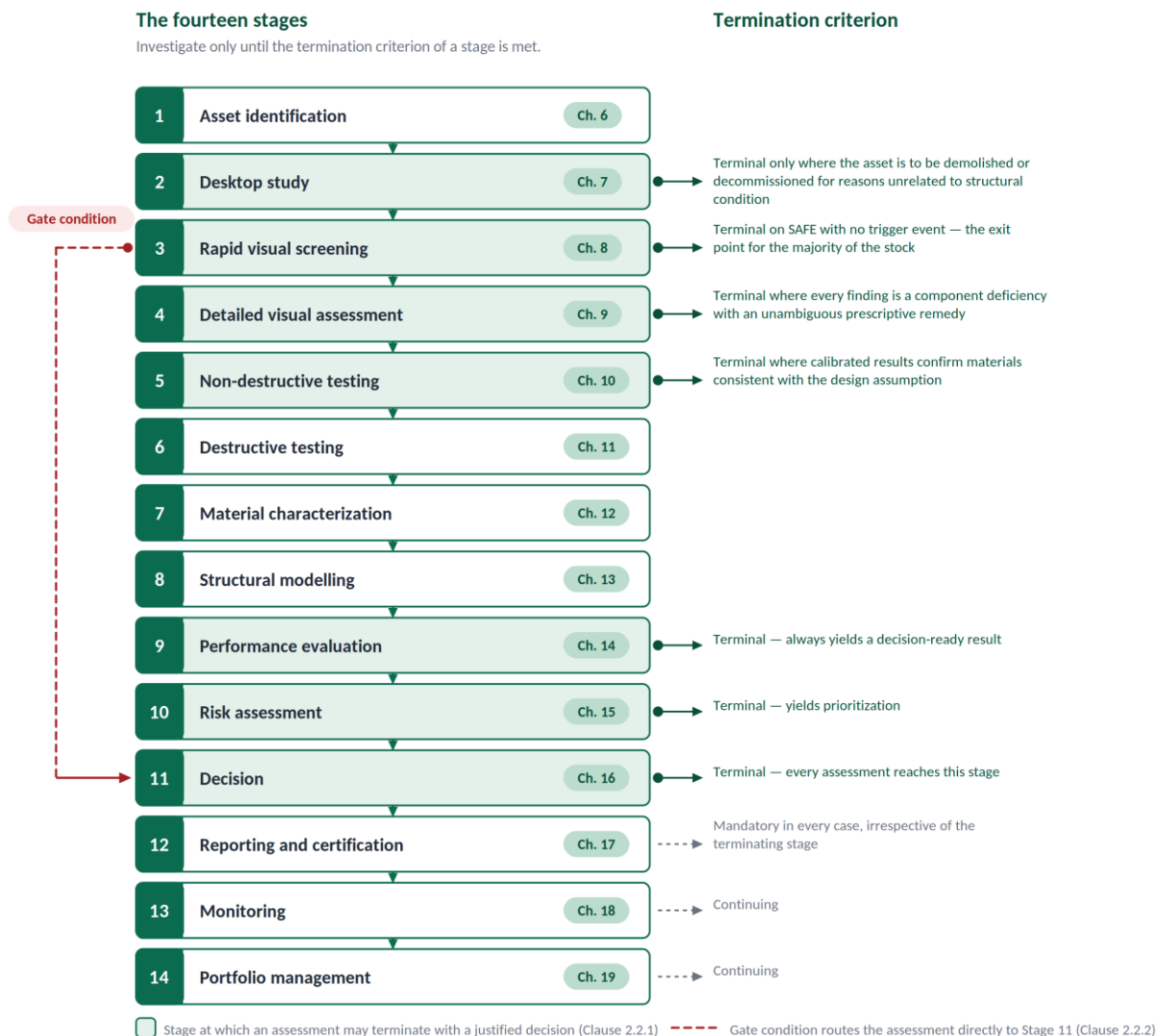


Figure 2-1 Sequence of assessment stages

3 Legal, Code and Institutional Basis

3.1 The Building Code of Pakistan

BCP 2021 is the primary code basis for this Manual. It is derived from the International Building Code and uses that numbering: Chapters 1 to 34 followed by Appendices A, B and C. Citations in this Manual are to that structure.

Table 3-1 BCP-2021 Provisions Relevant to Structural Health Assessment

Subject	Provision
Risk Category	§1604.5 and Table 1604.5
Basic design wind speed	§1609.3
Mapped earthquake acceleration parameters S_s and S_1	§1613.2.1, Figures 1613.2.1(1) and 1613.2.1(2), and Appendix C
Load combinations and structural design	Chapter 16
Masonry	Chapter 21
Seismic evaluation and retrofit of existing buildings	Appendix A
Flood-resistant construction	Appendix B

CAUTION

References to a BCP 2021 “Annex” or “Part” do not correspond to any division of the Code and shall not be used. Seismic ground-motion parameters are obtained from the maps at Figures 1613.2.1(1) and 1613.2.1(2), read at the site coordinates; the Code does not contain a district-by-district table of acceleration values. A mapped value read from those figures is not a design value: it becomes one only after the site class adjustment required by Clause 7.4.2.

3.2 Legal status and professional duty

The Building Code of Pakistan (Seismic Provisions – 2007) was given legal effect through the Pakistan Engineering Council. Statutory Notification S.R.O. 971(1)/2008 of 8 September 2008, made under section 25 of the Pakistan Engineering Council Act 1975, inserted bye-law 10 into the Pakistan Engineering Council (Conduct and Practice of Consulting Engineers) Bye-laws 1986. That bye-law provides that the provisions of the Building Code apply to the engineering design of buildings and related components, that construction in violation of the Code constitutes a violation of professional engineering work under section 2(xxv) of the Act, and that the Code is to be revised by the Council every five years or earlier as circumstances require. The 2021 edition is the revision issued by the Council under that requirement.

- 3.2.1** The assessment shall record the code edition in force at the facility's location, confirmed with the Authority Having Jurisdiction (AHJ), together with any local amendment.

- 3.2.2** A finding or decision made under this Manual shall be issued under the signature of a named Professional Engineer registered with the Pakistan Engineering Council. An organizational signature does not discharge the professional duty of care that attaches to the assessment.

3.3 The Authority Having Jurisdiction (AHJ)

Several determinations are reserved to the Authority Having Jurisdiction (AHJ): the code edition in force, acceptance of a knowledge factor different from the tabulated value, and acceptance of a departure from the cost limit of BCP-2021 Appendix A §A105.2. The AHJ is not a single office across Pakistan; it is the provincial or municipal body holding building-control jurisdiction over the site.

- 3.3.1** Every facility record shall identify the Authority Having Jurisdiction by name and office, so that determinations reserved to it can be sought from the correct authority.

3.4 Institutional context

Assessment at program scale serves institutions as well as individual owners. Provincial education and health departments hold the asset registers and the maintenance budgets; disaster management authorities hold the event history that establishes trigger events; and financing institutions require a portfolio-level prioritization before capital can be allocated. Chapter 19 sets out what the assessment record must contain to serve those needs.

4 Building Typologies

Assessment at the scale of a national building stock is applied to typologies, not to individual buildings considered from first principles. A small number of index buildings is characterized in engineering detail for each typology, and the result is applied, with stated limitations, to buildings classified under that typology.

4.1 Typology register

Table 4-1 Pakistani Structural typology register

Code	Typology	Group
A	Adobe, earthen or unfired-block construction	Masonry, un-engineered
URM	Unreinforced masonry in fired brick or block	Masonry
SM-R	Stone masonry, random rubble	Masonry
SM-D	Stone masonry, dressed	Masonry
CM	Confined masonry	Masonry, confined
RM	Reinforced masonry	Masonry, reinforced
DD	Dhajji-Dewari, timber-braced masonry infill	Composite / timber
C1	Reinforced-concrete moment resisting frame	RC frame
C2	Reinforced-concrete shear wall or dual system	RC wall
C3	Reinforced-concrete frame with infill masonry shear walls	RC frame with infill
S1	Steel moment frames	Steel
S2	Steel braced frames	Steel
S3	Metal building frames	Steel

- 4.1.1** Every building assessed under this Manual shall be assigned one primary structural typology from Table 4-1. Where a building combines two typologies in different directions or storeys, the governing typology in each direction and at each storey shall be assigned from Table 4-1 and each recorded, and the assessment carried out against the more vulnerable of them.
- 4.1.2** Where a finding is established at index-building resolution and applied across a typology under Clause 16.5.1, not fewer than three index buildings shall be characterized for each combination of typology and construction-era band, and not fewer than one for each district in which that combination occurs. Index buildings shall be selected to span the range of condition observed at screening rather than by convenience of access, and the selection basis shall be recorded. A facility shall be assessed individually, and shall not inherit an index-building finding, where it carries a gate condition, where its storey count, plan configuration or lateral system differs from the index building, where it has been extended or altered since construction, or where its damage state is more severe than that of any index building.

4.2 Typology characteristics

4.2.1 Masonry without confinement

Adobe and earthen construction have no engineered lateral system, very low out-of-plane bending capacity and a high susceptibility to total collapse under strong shaking. Unreinforced masonry performance is governed by mortar bond strength and by the presence or absence of through-wall ties at corners and wall intersections. Stone masonry behaves similarly, with additional vulnerability from irregular unit geometry and, in random rubble construction, poor interlock between wythes where through-stones are absent.

4.2.2 Confined and reinforced masonry

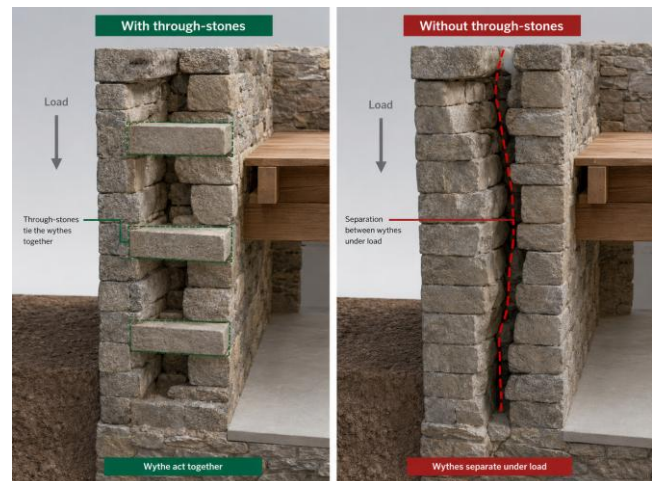
Confined masonry places reinforced-concrete tie-columns at wall corners, intersections and openings and tie-beams at every floor and roof level, cast after the masonry panel so that the confining elements bond to it. Confinement substantially improves ductility and post-cracking integrity relative to unreinforced masonry. Reinforced masonry instead places vertical and horizontal reinforcement within the units and behaves closer to a ductile shear-wall system. Masonry design and construction requirements are given in BCP-2021 Chapter 21.

4.2.3 Dhajji-Dewari

Dhajji-Dewari is a timber-braced masonry infill system used across northern Pakistan and Kashmir: a timber frame, diagonally braced at each panel, infilled with brick or stone. The timber frame provides ductility and redistributes load even where the brittle infill cracks, and the system is reported to have performed comparatively well in the 2005 Kashmir earthquake relative to adjacent unreinforced masonry.



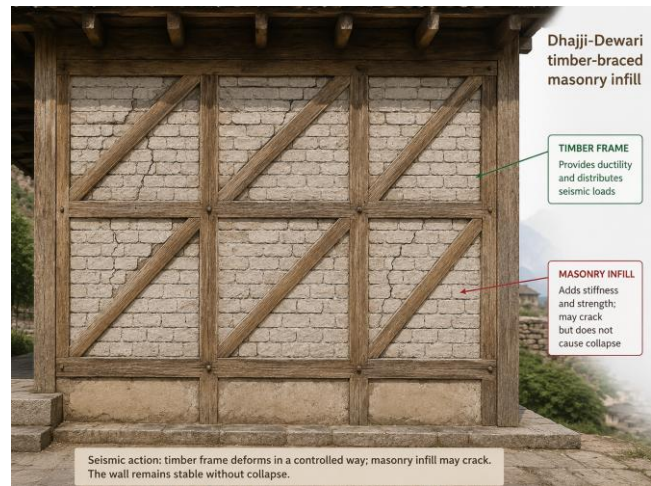
Masonry without confinement with diagonal cracks originating from the openings



Stone masonry



Confined masonry



Dhajji-dewari, timber-braced masonry infill

Figure 4-1 Masonry typologies - what distinguishes them in the field

4.2.4 Reinforced-concrete frames

Frames detailed for ductile behavior under current provisions are classified as C1. Shear wall and dual systems (C2) generally perform markedly better than an equivalent bare frame. Frames with unreinforced masonry infill (C3) are distinguished because the infill panel changes the frame's response, and a partial-height panel leaving a window opening below the beam produces a short-column condition.

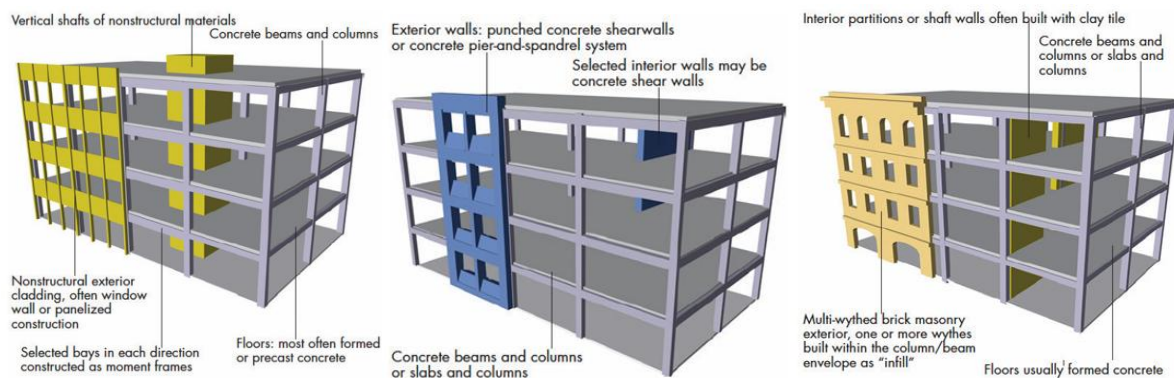


Figure 4-2 Reinforced-concrete frame typologies

4.2.5 Steel and light-frame construction

Steel moment and braced frames are uncommon in the public building stock relative to masonry and concrete but occur in newer administrative and health facilities. Metal frame buildings are increasingly used for single-storey annexes.

4.3 Relationship to international taxonomies

Where a facility is also recorded in a national or donor exposure database using an international classification such as the Global Library of School Infrastructure (GLOSI), both classifications shall be recorded and cross-referenced.

Table 4-2 Cross-reference of Table 4-1 codes to the Global Library of School Infrastructure

Code	GLOSI correspondence	Basis of the correspondence
A, URM, SM-R, SM-D	Corresponding GLOSI masonry class	Direct
CM, RM	Corresponding GLOSI confined and reinforced masonry class	Direct
C1, C2, C3	Corresponding GLOSI concrete class	Conditional. The infill configuration and the design level shall be observed on site before a correspondence is established.
DD, S1, S2, S3	None	Absent. Recorded under the Table 4-1 code with the constituent parameters described.

5 Performance Objectives and Acceptance Criteria

5.1 Risk Category

BCP-2021 Table 1604.5 assigns every building to Risk Category I, II, III or IV according to the nature of its occupancy and the consequence of failure. The provisions relevant to schools and health facilities are reproduced below in the conditional form in which the Code states them.

Table 5-1 Risk Category triggers relevant to schools and health facilities (BCP-2021 Table 1604.5)

Facility condition	Risk Category
Group E (educational) occupancy with an occupant load of 250 or fewer	II - the default category for buildings not listed in Categories I, III and IV
Group E occupancy with an occupant load greater than 250	III
Educational occupancy for students above the 12th grade with an occupant load greater than 500	III
Group I-2, Condition 2 occupancy without emergency surgery or emergency treatment facilities	III
Group I-2, Condition 1 occupancy with 50 or more care recipients	III
Group I-2, Condition 2 occupancy with emergency surgery or emergency treatment facilities	IV
Ambulatory care facility with emergency surgery or emergency treatment facilities	IV
Any building designated an earthquake, hurricane or other emergency shelter	IV

- 5.1.1** Risk Category shall be assigned from BCP-2021 Table 1604.5 on the basis of the recorded occupancy of the facility and its formal designation, and not by facility type alone. Risk Category shall never be inferred from school level, facility tier or administrative classification.
- 5.1.2** Where a building contains occupancies falling in more than one Risk Category, the highest category shall govern, in accordance with BCP-2021 §1604.5.1. Where portions are structurally separated, each portion may be classified separately, except that a portion providing required access or egress to, or sharing life-safety components with, a portion of higher category takes the higher category.

REQUIREMENT

A school designated as an emergency shelter is Risk Category IV under Table 1604.5 irrespective of its occupant load. Where a provincial or district authority designates schools for post-disaster shelter use, that designation is a structural requirement and not an operational convenience. The asset register (Chapter 6) shall record the designation.

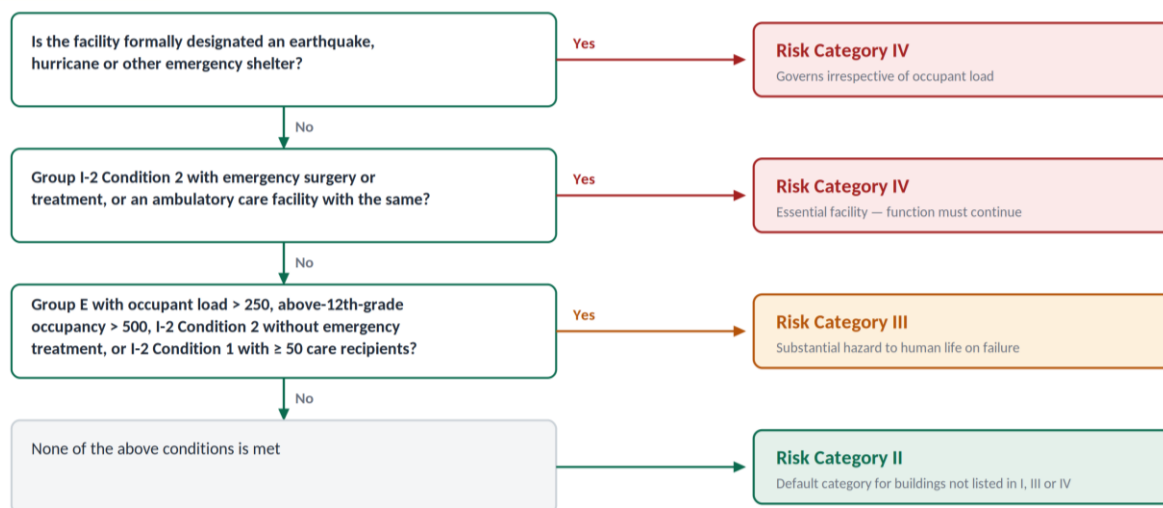


Figure 5-1 Assigning Risk Category under BCP-2021 Table 1604.5

5.2 Performance levels

Structural performance level describes the extent of damage a building may sustain at a given hazard level. Five levels are used in this Manual, as defined in ASCE/SEI 41-17 and adopted through BCP-2021 Appendix A. Damage Control and Limited Safety are ranges between the three named levels and are required by the Risk Category III pairing of Table 5-3.

Table 5-2 Structural Performance Levels

Level	Description
Immediate Occupancy (S-1)	Damage is limited; the building remains safe to occupy and its essential functions continue.
Damage Control (S-2)	A range of damage between Immediate Occupancy and Life Safety. Damage is greater than that permitted at Immediate Occupancy but is repairable, and function can be restored without replacement of the structure.
Life Safety (S-3)	Significant damage may occur but the structure retains a margin against collapse and the risk of life-threatening injury is low.
Limited Safety (S-4)	A range of damage between Life Safety and Collapse Prevention. The margin against collapse is reduced relative to Life Safety, and continued occupancy is not assumed without repair.
Collapse Prevention (S-5)	The structure remains standing but is on the verge of partial or total collapse; continued occupancy is not assumed.

- 5.2.1** The performance objective shall be assigned from Table 5-3 according to the Risk Category determined under Section 5.1. A single performance level assigned without its paired hazard level does not constitute a performance objective.
- 5.2.2** A facility formally designated an emergency shelter, and any facility whose loss of function during the recovery period would itself constitute a secondary hazard, shall be assigned the Risk Category IV pairing of Table 5-3 irrespective of its occupancy.
- 5.2.3** The Basic Performance Objective for Existing Buildings of Table 5-3 is the default objective under this Manual. Where the owner, the financing institution or the Authority Having

Jurisdiction requires performance equivalent to new-building standards, the corresponding objective checked at the BSE-1N and BSE-2N hazard levels applies instead, and Clause 1.2.1 governs where the two differ.

5.3 Hazard levels and paired objectives

A target performance level is meaningful only when paired with a defined seismic hazard level. In accordance with ASCE/SEI 41-17, the seismic evaluation and retrofit of existing buildings are governed by paired hazard levels anchored to the risk-targeted maximum considered earthquake (MCE_R) spectral accelerations mapped under BCP-2021 §1613.2.1. The lower level represents a more frequent, moderate event (BSE-1E); the upper level represents a severe, rare event (BSE-2E), capped at BSE-2N.

5.3.1 A performance objective is a coupled target: a structural performance level (S-1 to S-5) and a non-structural performance level (N-A to N-E), each evaluated at a defined hazard level, as established in the Basic Performance Objective for Existing Buildings of ASCE/SEI 41-17. A dual-level objective requires compliance at both hazard levels; adequacy demonstrated at one hazard level only does not satisfy a paired performance objective.

5.3.2 BSE-1E is the lower hazard level of the pair and BSE-2E the upper. Both shall be determined in accordance with ASCE/SEI 41-17 §§2.4.1.3 and 2.4.1.4, using the mapped spectral response acceleration parameters S_s and S_1 from BCP-2021 §1613.2.1 read at the site coordinates, and adjusted for site class in accordance with Clause 7.4.2. In no case shall the spectral response parameters for BSE-1E or BSE-2E be taken greater than those of the corresponding new-building hazard levels, BSE-1N and BSE-2N respectively.

Table 5-3 Performance objective by Risk Category (Basic Performance Objective for Existing Buildings, assigned in accordance with ASCE/SEI 41-17)

Risk Category	At BSE-1E, the lower hazard level	At BSE-2E, the upper hazard level
I and II	Life Safety structural performance (S-3); Life Safety non-structural performance (N-C)	Collapse Prevention structural performance (S-5); Hazards Reduced non-structural performance (N-D)
III	Damage Control structural performance (S-2); Position Retention non-structural performance (N-B)	Limited Safety structural performance (S-4); Hazards Reduced non-structural performance (N-D)
IV	Immediate Occupancy structural performance (S-1); Position Retention non-structural performance (N-B)	Life Safety structural performance (S-3); Hazards Reduced non-structural performance (N-D)

Clause 5.3.1 requires the objective to be satisfied at both hazard levels. How that is demonstrated depends on the tier applied under Chapter 14. A Tier 3 systematic evaluation checks each hazard level explicitly. At Tier 1 and Tier 2, ASCE/SEI 41-17 does not require the structural performance at BSE-1E to be evaluated explicitly for Risk Categories I to III; Risk Category IV requires the BSE-1E structural check at every tier. The non-structural performance levels of both hazard levels apply irrespective of

the tier. The scope of assessment shall be taken from ASCE/SEI 41-17 for the tier being applied, and the assessment shall record which hazard levels were checked explicitly and which were deemed satisfied. Non-structural performance levels are applied under Clause 9.4.2.

5.4 Acceptance criteria

Acceptance criteria are the component-level deformation, force or strain limits against which the evaluation of Chapter 14 checks the building. They are set by component type and performance level in ASCE/SEI 41-17 Chapters 7 to 12, applied by material. This Manual does not reproduce those tables; they are applied directly from the standard so that the criteria used remain traceable to a single controlled source.

6 Asset Identification and the Facility Register

Asset identification is never a terminal stage. Every later stage depends on a register that is complete, uniquely keyed and stable across repeat visits.

6.1 Unique identification

- 6.1.1** Every facility shall be identified by its Education or Health Management Information System facility code in addition to its name, so that the register remains reconcilable against the systems the facility already reports into. A facility name is not a unique identifier: names duplicate across districts and are not stable under renaming or upgrading.
- 6.1.2** Latitude and longitude shall be recorded for every facility. This is the field that allows the seismic and wind parameters of BCP-2021 and the available flood and landslide information to be read at the facility rather than at district resolution.

6.2 Minimum register content

Table 6-1 Minimum Facility Register Information

Group	Content
Identification	Facility code, name, facility type mapped to the occupancy group used in Chapter 5, province, district, address, coordinates, year of construction; site class, whether determined or defaulted, its source and the site coefficients applied.
Accountability	Custodian or focal person, department, designation, and the date and author of the record.
Occupancy	For schools: enrolment by sex, teaching and support staff, learners with disabilities, classroom count, storeys and covered area. For health facilities: outpatient throughput, inpatient beds, whether 24-hour emergency or labor-room services are provided, staffing, and patients unable to evacuate unaided.
Designation	Formal designation as an emergency shelter, and the authority making the designation.
Block inventory	One record per structurally distinct block: identifier, plan shape, storeys, primary use, floor area and a dimensioned sketch.
Authority	The Authority Having Jurisdiction by name and office.

- 6.2.1** Occupant load and emergency-shelter designation shall be recorded for every facility, because both determine Risk Category under Chapter 5.
- 6.2.2** Every stage of this Manual shall be applied per structurally distinct block where a facility comprises more than one. A masonry block built in the 1990s and a concrete-frame block built in 2018 on the same campus are two assessment problems that share an address.

6.3 Findings that do not enter the structural workflow

A facility survey records more than structural condition. Maintenance defects, site safety hazards and accessibility or sanitation deficiencies are recorded in the same register but are routed to different responses. Only structural findings engage the workflow of Chapter 2.

Table 6-2 Classification and Routing of Facility Survey Findings

Finding class	Examples	Route
Structural signs	Wide, long or cross-element cracks; out-of-plumb or bulging walls; sagging roof, beam or floor; visible foundation movement.	Engages this Manual at Stage 3.
Maintenance and repair	Flood watermarks, persistent damp or leaks, loose or missing roof sheeting, unsecured rooftop plant.	Maintenance program.
Site safety	Scour or undermining, slope instability, blocked or inward-opening egress, exposed or damaged electrical wiring.	Immediate corrective action by the owner.
Accessibility, sanitation and inclusion	Absent or non-compliant ramps and handrails; toilets not wheelchair-usable; no separate lockable facilities for girls and women; unlit egress routes; inadequate water supply.	Inclusion and facilities planning.

6.3.1 A finding recorded outside the structural class shall not by itself engage the structural workflow, and shall not be closed by a structural assessment. A structurally adequate building with a blocked exit or no usable toilet for a child with a disability has not been made safe.

6.4 Register requirements for program use

A register serving a financing institution must answer three questions that a single facility file cannot: (a) which facilities need investment first, (b) what an intervention will cost at portfolio scale, and (c) whether an investment already made has had its intended effect. Those requirements are met by keying the register to a stable asset identifier, recording block-level area and construction data, and preserving the record across repeat visits rather than recreating it at each visit.

7 Desktop Study and Archival Review

Desktop study prepares the site visit; it does not duplicate it. Before an engineer reaches the facility, the following four questions should be answered:

- (a) What was built and when?
- (b) Which side of the seismic-detailing transition does the building fall on?
- (c) What remote imagery shows that a ground survey may not cover?
- (d) What does the available hazard information already reveal about the site?

7.1 Drawings and records

7.1.1 Where original structural drawings exist, they shall be reviewed before the site visit, and the register cross-checked against them for year of construction and storey count. A discrepancy shall be resolved on site and not by silently preferring one source.

Original drawings are the exception rather than the rule for the older and incrementally extended parts of the public building stock. Their absence is the normal working condition and is not itself a deficiency finding, but it increases the weight carried by construction-era inference and by the field survey.

7.2 The seismic-detailing transition

The Building Code of Pakistan (Seismic Provisions - 2007) was the first nationally notified seismic design provision in Pakistan, given effect by S.R.O. 971(1)/2008 following the 8 October 2005 Kashmir earthquake. Year of construction is therefore the strongest desktop indicator of whether a concrete frame is likely to have been detailed for ductility.

7.2.1 A facility recorded as constructed before 2007 shall be provisionally treated as non-ductile until site observation confirms or revises the classification. Year of construction alone is not conclusive: buildings constructed after 2007 without engineering supervision exist, as do pre-2007 buildings that have since been retrofitted.

7.3 Imagery review

7.3.1 Available satellite or aerial imagery shall be reviewed before the site visit for the number and footprint of blocks actually present, checked against the block inventory; for site topography and drainage context; and for proximity to adjacent structures relevant to pounding.

Imagery is a cross-check on the register, not an independent source. Where imagery shows a block or site condition that is not shown in the register, the discrepancy is resolved on site: imagery can also be out of date.

7.4 Hazard information

Seismic ground-motion parameters are read from BCP-2021 Figures 1613.2.1(1) and 1613.2.1(2) at the site coordinates, with Appendix C giving the mapped acceleration parameters. Basic design wind

speed is taken from §1609.3. Flood hazard is assessed for compliance with requirements of BCP-2021 §1612 and Appendix B together with any flood hazard mapping published for the district. Landslide and ground-instability exposure is assessed from terrain and published geological information.

- 7.4.1** The desktop study shall record which hazard information was consulted, its version or date, and the finding relevant to the site. Externally maintained hazard information shall be cited rather than transcribed, so that a superseded value is not carried forward.
- 7.4.2** The site class shall be determined for every facility and recorded. Mapped spectral response acceleration parameters read from BCP-2021 §1613.2.1 are bedrock-referenced and are not design values. Site class shall be determined in accordance with ASCE 7-16 Chapter 20, §20.3 and Table 20.3-1, and the site coefficients F_a and F_v taken from ASCE 7-16 Tables 11.4-1 and 11.4-2. The site class adjustment to the BSE-1E and BSE-2E hazard levels shall be made under ASCE/SEI 41-17 §2.4.1.6.
- 7.4.3** Where the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used as the default in accordance with ASCE 7-16 §11.4.3, and F_a shall not be taken less than 1.2 for a defaulted site class. The default shall not be used where conditions indicating Site Class E or F are present or reasonably suspected, including soft or deep clay, high-plasticity clay, peat or highly organic soil, liquefiable sand, and collapsible, quick or sensitive soil. Such conditions are common in the alluvial deposits of the Indus plain, in the Peshawar valley and in coastal Sindh, and the exclusion shall be applied on its merits at each site rather than treated as a formality.
- 7.4.4** Where a site-specific ground motion hazard analysis is required by ASCE 7-16 §11.4.8 and none is available, the assessment shall not proceed on an assumed value. The facility shall be referred for geotechnical investigation, the limitation recorded in the assessment and on the certificate, and the performance evaluation of Chapter 14 held until the required parameters are established.
- 7.4.5** The site class, whether determined or defaulted, its source, the site coefficients applied and the resulting hazard levels shall be recorded in the desktop study, in the facility register and on the assessment certificate. Where the default is used and the decision is sensitive to the site class, the assessment shall state the effect of one class either side.

Table 7-1 Desktop Study and Hazard Review Procedure

Step	Action
1	Review original structural drawings and as-built records.
2	Place the facility against the 2007 seismic-detailing transition.
3	Review satellite or aerial imagery against the block inventory.
4	Read S_s and S_1 at the site coordinates and record the basic design wind speed.
5	Determine the site class and the site coefficients, and derive the BSE-1E and BSE-2E hazard levels (Clauses 7.4.2 to 7.4.4).
6	Establish flood, landslide and ground-condition exposure from available mapping and terrain.
7	Record the source, version and finding for each item consulted.

8 Rapid Visual Screening

Rapid visual screening is the stage at which the majority of the public building stock is resolved. It is deliberately fast and inherently conservative, designed to establish which buildings warrant detailed engineering rather than the engineering condition of any one of them.

8.1 Purpose and conduct

Screening is a structured visual examination carried out from the ground and from accessible interior spaces, without opening up construction and without testing. It is performed by a trained engineer registered with the Pakistan Engineering Council, using a standard record sheet so that results are comparable across a stock. The screening record covers the structural system and its condition, the configuration features known to concentrate damage, the condition of non-structural elements that can fall, and the site hazards that act on the building.

8.1.1 The following competence shall apply to each stage of this Manual. Rapid visual screening shall be performed by a trained engineer registered with the Pakistan Engineering Council. Detailed visual assessment shall be performed by an engineer registered with the Pakistan Engineering Council. Testing under Chapters 10 and 11 shall be planned and interpreted by an engineer registered with the Pakistan Engineering Council and may be conducted by trained staff under that engineer's supervision. Structural modelling under Chapter 13 and Tier 3 evaluation under Chapter 14 shall be performed by a structural engineer, meaning a Professional Engineer in civil engineering with not less than five years of experience in structural design or structural assessment. The assessment certificate shall be signed by a Professional Engineer registered with the Pakistan Engineering Council.

8.1.2 Supervision means that the supervising engineer has specified the work to be done and the record to be made, is contactable throughout, reviews the record before it is submitted, and signs it. Work carried out without a supervising engineer identified by name and registration number is not supervised for the purposes of this Manual.

The approach follows the tiered logic adopted by BCP-2021 Appendix A §A106 for Tier 1 screening and the international practice on which it is based, including FEMA P-154. Screening establishes a priority, not a verdict on structural adequacy.

8.2 What screening records

Table 8-1 Information Recorded During Rapid Visual Screening

Group	Recorded
Structural system	Typology from Table 4-1; number of storeys; year of construction; evidence of extension or alteration; apparent lateral system in each direction.
Structural signs	Crack width, length, orientation and location; out-of-plumb or bulging walls; sagging or deflected roof, beam or floor; separation at wall intersections; foundation movement.
Configuration	Open, soft or weak storey; vertical or plan irregularity; setbacks; short or captive columns from partial-height infill; inadequate separation from adjacent buildings.

Group	Recorded
Non-structural hazards	Unrestrained parapets and gable walls; heavy roof elements; unsecured water tanks, solar frames and rooftop plant; ceilings and light fittings over occupied areas.
Site hazards	Flood watermarks and drainage; scour and erosion; slope condition above and below the building; ground movement indicators; fire and egress conditions; material deterioration.

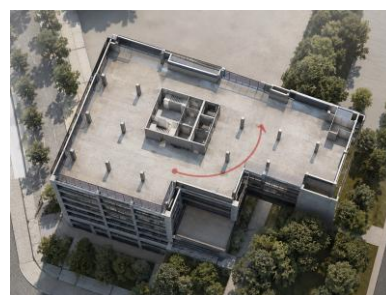
Fire and egress conditions recorded under this Section are screened against the Building Code of Pakistan (Fire Safety Provisions 2016), which governs egress provision, travel distance and the protection of escape routes. A deficiency found against those provisions is recorded and routed under Table 6-2; it is not resolved by the structural assessment.



Soft/Weak Storey



Setback & Vertical Irregularity



Plan Irregularity & Torsion



Short/ Captive Column



Inadequate Separation/ Ponding



Unrestrained Non-Structural Elements

Figure 8-1 Configuration features that concentrate damage

8.3 Screening outcomes

Screening resolves each facility to one of four outcomes. A gate condition, listed at Clause 8.3.1, is a finding designated as an automatic referral and applies irrespective of any other finding recorded at screening.

Table 8-2 Screening outcomes and their consequences

Outcome	Meaning and next step
SAFE	No gate condition identified. Terminal under Chapter 2 unless a trigger event subsequently occurs. The facility returns to the routine re-screening interval of Chapter 18.
MONITOR	A condition is present that is not currently a deficiency but could become one. Handed to Chapter 18 for a shortened re-screening interval directed at the specific condition observed.
REMEDiate TO COMPLY	A deficiency with a prescriptive remedy has been identified. Handed to Chapter 9; if the detailed visual assessment confirms the deficiency is a component deficiency with an

Outcome	Meaning and next step
	unambiguous remedy, the assessment terminates at Stage 4 and the remedy is executed.
PROCEED TO DETAILED ASSESSMENT	Screening could not resolve the question within its own scope. The facility enters the workflow from Stage 4 onward, with no presumption at handover of which later stage will resolve it.

8.3.1 The following findings are gate conditions. Class 1, which routes the assessment directly to Stage 11 under Clause 2.2.2: partial collapse, or displacement, buckling or loss of section in a primary vertical element such that collapse is judged imminent; a floor or roof no longer supported at a bearing; and a site condition under Clause 16.3 that no building-level intervention can make acceptable, including a building standing in a floodway or on an actively moving slope. Class 2, which raises the screening outcome to PROCEED TO DETAILED ASSESSMENT: a soft or weak storey; a captive or short-column condition arising from partial-height infill; a discontinuity in the lateral load path; a diaphragm without positive connection to its supporting walls; a wall out of plumb or bulging; evidence of active foundation movement or settlement; an active crack recorded under Clause 9.2.1 in a primary structural element; separation at wall intersections in unconfined masonry; inadequate separation from an adjacent building relative to the expected drift; and an unrestrained parapet, gable wall or heavy roof element over an occupied area or an egress route.

8.3.2 A record in which any required item is unanswered is an incomplete record. No outcome shall be issued on an incomplete record, and an unanswered item shall never be read as the absence of a finding or as a SAFE outcome. Every screening and assessment record shall carry the name and Pakistan Engineering Council registration number of the assessor, the date, and the assessor's signature; a record without those entries is incomplete.

8.4 What a screening outcome does not establish

8.4.1 A SAFE outcome shall not be read as a certification that the facility will suffer no damage in a future event, nor as equivalent to the result of a performance evaluation under Chapter 14. It records that a rapid, conservative screen found no gate condition.

8.4.2 An outcome of PROCEED TO DETAILED ASSESSMENT shall not be read as a finding that the facility is unsafe. It records that screening could not resolve the question - the expected outcome for a meaningful fraction of any building stock.

8.5 Overriding a screening outcome

8.5.1 A SAFE outcome may be raised to PROCEED TO DETAILED ASSESSMENT where the assessing engineer identifies a condition the screening record does not capture - a site-specific adjacency, a material condition outside the standard categories, or information post-dating the screening visit. The override and its basis shall be recorded against the facility record and signed by the overriding engineer.

8.5.2 An outcome shall not be lowered in priority without completing the assessment that the original outcome called for.

9 Detailed Visual Assessment

Detailed visual assessment is a systematic survey, closer than screening, undertaken once a facility carries an outcome of REMEDIATE TO COMPLY or PROCEED TO DETAILED ASSESSMENT. It terminates the assessment where every finding is a component deficiency whose remedy is prescriptive and unambiguous.

9.1 Survey procedure

9.1.1 The survey shall proceed block by block and, within each block, element by element - foundation and plinth, vertical elements, horizontal elements and non-structural elements - and not as an unstructured walk-through. An element omitted because it appeared satisfactory from a distance has not been surveyed.

The survey is conducted against the provisional typology carried forward from the desktop study and screening and is the point at which that classification is confirmed or corrected against what is actually built. Where construction documents exist, the survey verifies general conformance with them, identifies alterations and supplements incomplete records, consistent with BCP-2021 §A106.2.1.

9.2 Crack classification

Cracking is classified by mechanism and severity. By mechanism: flexural cracking, typically near-vertical at the tension face of a bending member; shear cracking, typically diagonal; settlement cracking, following a differential-movement pattern and often stepped in masonry; thermal cracking, following expansion-joint spacing and orientation; and corrosion-induced cracking, following the line of embedded reinforcement and frequently accompanied by rust staining.

9.2.1 Every crack recorded shall be measured rather than estimated by eye, and its width, length, orientation, location and activity recorded. A crack is active where it is still opening, evidenced by monitoring or by fresh un-weathered faces.

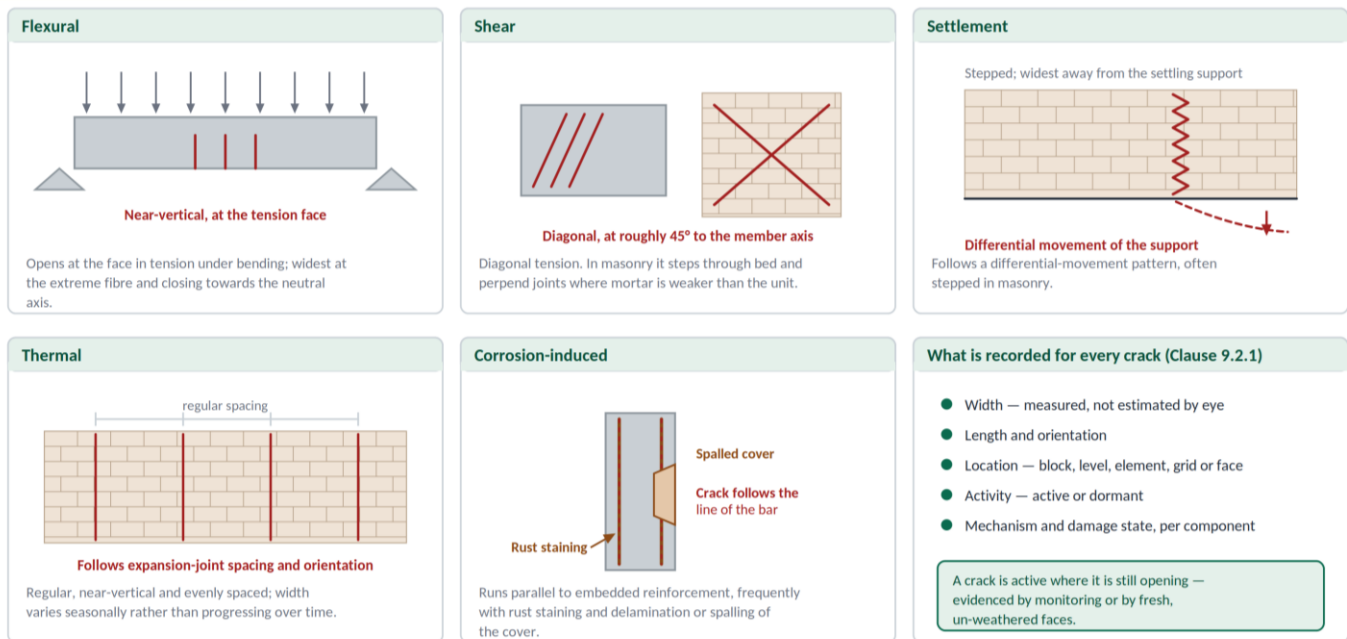


Figure 9-1 Crack classification by mechanism

9.3 Damage states

Damage is recorded as a progression of states per component and per failure mechanism - insignificant, slight, moderate, heavy and severe - each tied to what is physically observed rather than to a single numeric threshold. This is the progression established by FEMA 306 for concrete and masonry wall buildings, and it is used here so that a damage state recorded in the field is legible to any engineer working from that literature.

9.3.1 A damage state shall be recorded per component and per mechanism. For instance, a column may exhibit both light flexural cracks and moderate shear cracks. Documenting only the most severe condition would omit information necessary for Chapters 12 and 14.

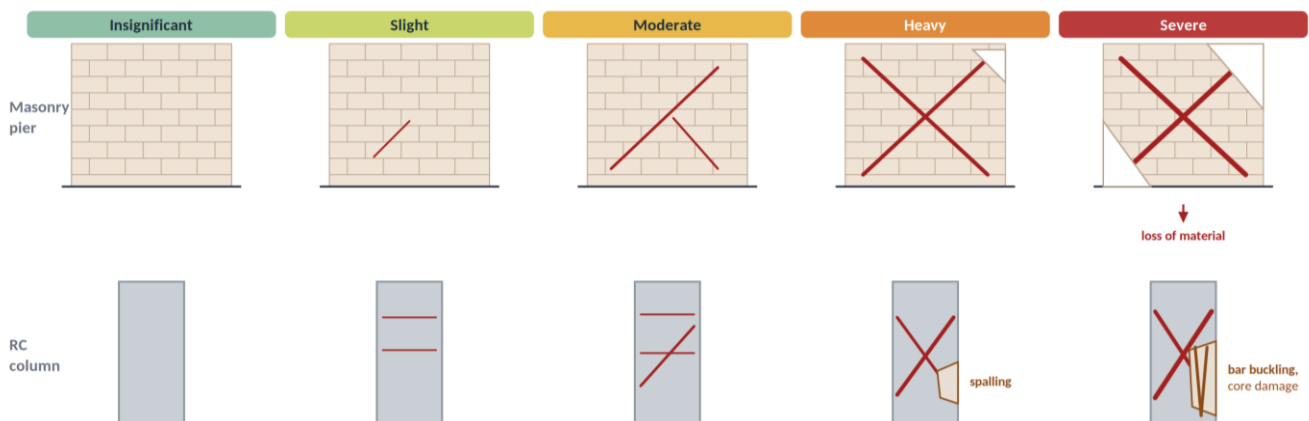


Figure 9-2 Damage-state progression, per component and per mechanism

9.4 Component and global deficiency

A component deficiency refers to damage or a defect limited to a single element, with a specific remedy that is independent of the behavior of the remaining structure. Examples include an

unrestrained parapet, a corroded balcony railing, or a blocked exit. In contrast, a global deficiency affects the load path or the lateral system, such as a soft storey, a captive column condition, or a diaphragm lacking a positive connection to its supporting walls. A global deficiency cannot be addressed at this stage, as its resolution is contingent upon the response of the entire structure.

9.4.1 Each finding shall be classified as a component or global deficiency before this stage is exited, and the classification documented. A global deficiency shall not be treated as resolved by a component-level remedy applied to one visible symptom: re-plastering a wall that is cracking because of a soft-storey mechanism does not address the soft storey.

9.4.2 A non-structural finding recorded at screening under Table 8-1 - an unrestrained parapet or gable wall, a heavy roof element, an unsecured water tank, solar frame or rooftop plant, or a ceiling or light fitting over an occupied area or an egress route - shall be classified under Table 9-1 in the same way as any other finding, and where it is a component deficiency with an unambiguous prescriptive remedy the assessment may terminate at this stage. Where the performance objective assigned under Table 5-3 carries a non-structural performance level of Position Retention, the acceptance criteria for that level shall be applied from ASCE/SEI 41-17 for the components concerned; this Manual does not reproduce those criteria.

Table 9-1 Component and Global Deficiency Classification

Finding	Example	Consequence
Component deficiency	Unrestrained parapet; corroded railing; single spalled cover zone.	Assessment may terminate at this stage; prescriptive repair follows.
Global deficiency	Soft or weak storey; load-path discontinuity; unanchored diaphragm.	Assessment proceeds to testing, modelling and evaluation.

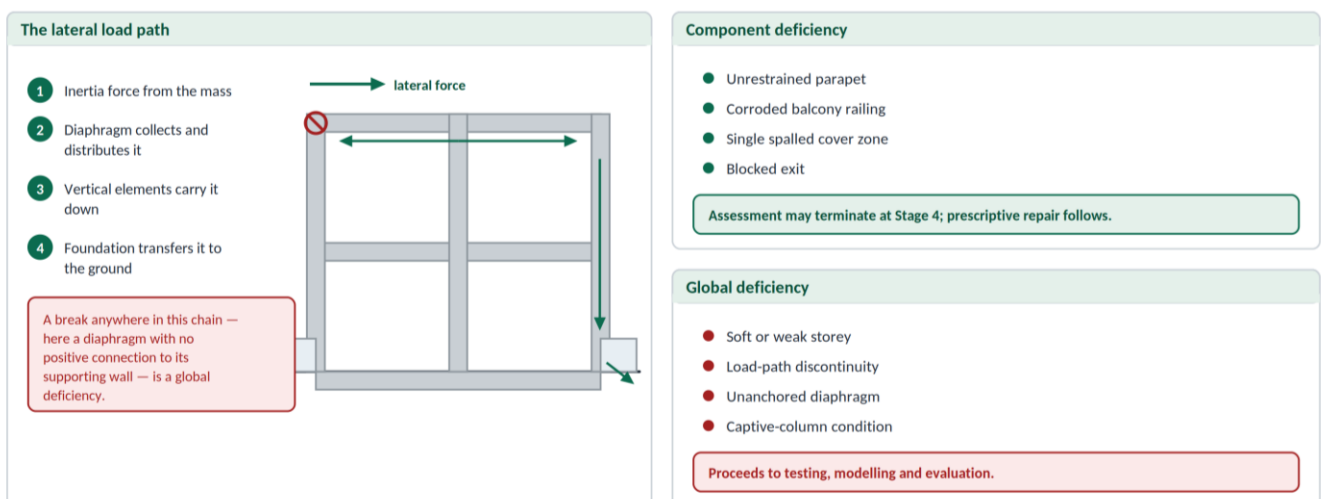


Figure 9-3 The lateral load path, and the difference between a component and a global deficiency

9.5 Post-event evaluation

Rapid safety evaluation immediately after a damaging event is a different procedure answering a different question at a different speed. Its purpose is to triage a large number of potentially affected

buildings for immediate occupancy restriction, and its outcome is a posting of the building as inspected, restricted or unsafe.

9.5.1 The post-event placard procedure is not covered by this Manual. A post-event safety evaluation shall be carried out in accordance with ATC-20-1, and its outcome shall not be substituted for the detailed visual assessment procedure of this chapter: a building posted as inspected after an event has not thereby completed an assessment under this Manual. Clause 18.2.1 governs what follows, the event being a trigger that returns the facility to the workflow at Stage 3.

9.6 Photographic record

9.6.1 Every finding shall be photographed with a scale reference in frame. Each photograph shall have a caption identifying the block, element and finding so that it can be matched to the written record independently of file order.

One contextual photograph should show the element within the building, and one detailed photograph should show the finding itself.

10 Non-Destructive Testing

Non-destructive testing (NDT) is applied where the visual assessment leaves a material or condition question that inspection alone cannot resolve. NDT methods provide indirect measurements used for strength estimation or for evaluation of concrete in structures.

10.1 Methods

Table 10-1 Non-Destructive Testing Methods, Working Basis and Limitations

Method	Standard	What is measured	Principal limitation
Rebound number	ASTM C805	Surface hardness of concrete, correlated to compressive strength.	The instrument displays a strength-like number that is not a strength. A correlation must be established for the concrete under test.
Ultrasonic pulse velocity	ASTM C597	Transit time of a stress pulse through the section; lower velocity indicates porosity, voiding or micro-cracking.	Correlates to strength only through a site- or mix-specific calibration.
Cover meter or ground-penetrating radar	Manufacturer's calibration procedure	Reinforcement location, orientation, spacing and cover.	Congested reinforcement, overlapping bar layers and embedded conduit can be misread. Requires verification against exposed bars.
Half-cell potential	ASTM C876	Electrical potential of embedded reinforcement relative to a reference electrode, indicating probability of active corrosion.	A probability indicator, not a measure of section loss. Sensitive to moisture condition and concrete resistivity at the time of test.
Carbonation depth	Phenolphthalein indicator on a freshly broken or cored face	Depth from the surface to the colour-change front.	Meaningful only when compared with the measured cover depth.
Chloride profiling	ASTM C1152 or ASTM C1218	Chloride content against depth, from powdered samples.	A single bulk value is not usable; a depth profile is required.
Infrared thermography	ACI 228.2R. No consensus test method is adopted for this application in buildings.	Subsurface delamination, voiding or moisture from differential heating and cooling rates.	A screening tool over a large area. Sensitive to weather, surface finish and time of day.

10.2 Interpretation

10.2.1 Rebound number and pulse velocity results shall be recorded as comparative measurements

- suitable for identifying variability across a structure and for selecting locations for

confirmatory coring - and shall not be reported as compressive strength unless a correlation to core strength has been established for the concrete being tested.

- 10.2.2** Cover survey results shall be verified by physical exposure of reinforcement at not fewer than one location per structural element type surveyed before the survey is relied upon across the structure.
- 10.2.3** A half-cell survey shall be interpreted as identifying zones of elevated corrosion probability for targeted verification, and not as a stand-alone basis for a repair or retrofit decision.
- 10.2.4** Carbonation depth and chloride content shall be reported against the measured cover depth. The governing question is whether the carbonation front or the chloride threshold has reached reinforcement, not what the value is at the surface.
- 10.2.5** No single method shall be relied upon alone to terminate the assessment at this stage. Each result shall be read together with an independent method or with the visual record, and the corroborating method shall be identified before the testing campaign is planned rather than improvised after an ambiguous result.

CAUTION

Reporting a rebound-hammer or pulse-velocity reading as concrete strength, without the correlation required by Clause 10.2.1, is a misapplication of the method. The displayed or derived value shall not be treated as compressive strength unless the required correlation has been established.

11 Destructive and Semi-Destructive Testing

Destructive testing provides the direct measurement that the indirect methods of Chapter 10 defer to. It is undertaken only where a specific, named question remains unresolved and where a design value is required that non-destructive methods cannot responsibly supply. This stage is never terminal: every result feeds the material characterization of Chapter 12.

11.1 Methods

Table 11-1 Destructive and Semi-Destructive Testing Methods

Method	Standard	Application
Core extraction	ASTM C42	The most direct measurement of in-place concrete compressive strength, and the anchor point for any rebound or pulse-velocity correlation.
Pull-out test	ASTM C900	Force to extract a post-installed insert together with the attached concrete fragment, correlated to compressive strength.
Pull-off test	ASTM C1583	Direct tensile force to detach a surface disc; the method for bond or surface tensile strength, including the bond of a repair mortar or overlay to its substrate.
Single flat-jack	ASTM C1196	In-situ compressive stress state in masonry, from the stress relief measured when a horizontal slot is cut and the pressure required to restore the original condition.
Double flat-jack	ASTM C1197	Deformability and, where carried to failure, compressive strength of masonry between two parallel slots.
In-situ load test	ACI 437	Controlled load applied directly to a floor or roof element, with deflection and recovery measured.

NOTE

Pull-out (ASTM C900) and pull-off (ASTM C1583) are readily confused by name. Pull-out measures bulk compressive strength; pull-off measures bond or surface tensile strength. ASTM C1583 has no application to reinforcement location.

11.2 Conduct and interpretation

11.2.1 Core diameter, length-to-diameter ratio, moisture condition at test and the presence of embedded reinforcement within the core shall be recorded, and the corrections of ASTM C42 applied. A core containing a bar or taken at an out-of-tolerance length-to-diameter ratio is neither a discarded result nor a directly comparable one.

11.2.2 Flat-jack testing shall be the preferred method for establishing in-situ masonry stress and stiffness in confined, unreinforced and stone masonry, in preference to assuming literature values for an unconfirmed masonry composition. Masonry properties vary substantially with local unit and mortar characteristics that a generic table cannot represent.

11.3 Justification and making good

- 11.3.1** Destructive testing shall be undertaken only where non-destructive methods have been applied and have left a specific, named question unresolved - a design value that Chapter 12 or Chapter 14 requires. A test plan without a stated question shall not proceed.
- 11.3.2** Destructive testing shall not be undertaken where a global deficiency has already been established whose remedy does not depend on the value the test would supply. A confirmed soft-storey mechanism does not require a core strength result before the decision stage can be engaged.
- 11.3.3** Every test location shall be repaired to restore section and weather resistance - core holes filled with a compatible non-shrink repair mortar, flat-jack slots re-pointed, pull-out and pull-off locations patched - and the repair recorded against the same location reference used for the test, so that a later assessment does not mistake a repaired test location for a defect.

KEY DECISION

Each method discussed in this chapter incurs a cost that a school or clinic must subsequently address or rectify, such as a hole in a column, a slot in a load-bearing wall, or a floor rendered unusable. This cost is justified when it provides an answer that influences the decision at Stage 11. Conversely, it is unjustified when the test is conducted merely due to the availability of equipment.

12 Material Characterization and the Knowledge Factor

This stage converts test data into the two inputs the evaluation requires: a design value for each material property, and a knowledge factor that discounts component capacity for uncertainty in how well that property is known. An evaluation performed with an assumed material value and no stated knowledge factor has not satisfied this stage by other means.

12.1 From test data to design values

12.1.1 Where multiple test results exist for a property, the design value shall be a statistically appropriate characteristic or lower-bound value and not the simple mean, unless the applicable material standard permits the mean to be used directly.

12.1.2 An individual result shall be excluded as an outlier only where a physical explanation or a recognized statistical test supports the exclusion, applied equally to high and low values. ASCE/SEI 41-17 §6.2.4.4.1 permits such exclusion only where results are available at six or more locations for the specific material application and identifies ACI 214R for concrete cores and ASTM E178 as an acceptable statistical procedure.

Conversion of core compressive strength to an equivalent standard-cylinder value requires the corrections that ACI 214R specifies for length-to-diameter ratio, moisture condition and drilling direction relative to casting.

12.2 The knowledge factor

ASCE/SEI 41-17 Table 6-1 establishes the knowledge factor based on the actual methods used to obtain the material properties for evaluation, rather than on a general assessment of the building's documentation quality.

BCP-2021 §A107.2.6 states the requirement for deficiency-based evaluation in its simplest form: the knowledge factor shall be 0.75 unless data collection complies with the requirements for a factor of 1.0 in ASCE/SEI 41-17 §6.2.4.

Table 12-1 Knowledge factor by data-collection basis (ASCE/SEI 41-17 Table 6-1)

Level of knowledge	Basis on which properties were obtained	K
Minimum	Design drawings available and confirmed by visual condition assessment; no material testing	0.90
Minimum	No design drawings; default material values assumed	0.75
Usual	Design drawings, or field survey drawings prepared in their absence, together with usual testing	1.00
Comprehensive	Design drawings, or field survey drawings prepared in their absence, together with comprehensive testing	1.00

12.2.1 The knowledge factor shall be selected on an individual component basis, according to the level of knowledge obtained for that component. One building may correctly carry different

factors for different components; a single building-wide value shall not be assumed for convenience.

- 12.2.2** Where a representative visual examination has not been completed for a material or construction type, $\kappa = 0.75$ shall govern for that type irrespective of what Table 12-1 would otherwise indicate. Visual confirmation is a minimum condition for any factor above 0.75.
- 12.2.3** A factor of 1.00 may also be taken where the building meets the benchmark requirements of ASCE/SEI 41-17 Table 3-2, or where inspection or testing records are available that substantiate the design drawings.
- 12.2.4** In no case shall the knowledge factor exceed 1.00. A value different from the tabulated value requires supporting data and the approval of the Authority Having Jurisdiction, in accordance with ASCE/SEI 41-17 §6.2.4.4.2.
- 12.2.5** Where an analysis is performed before data collection using an assumed factor, the assumed value shall be substantiated by data collection before retrofit is implemented. Where an analysis using an assumed value results in no required retrofit, the value shall be substantiated before the evaluation is finalized.

NOTE

A factor of 1.0 is earned through testing, not through possession of drawings. A building with original drawings, confirmed visually but not tested, and meeting neither the benchmark condition nor the substantiating-records condition, is limited to 0.90: documentation describes what was designed, not the condition the material is in today.

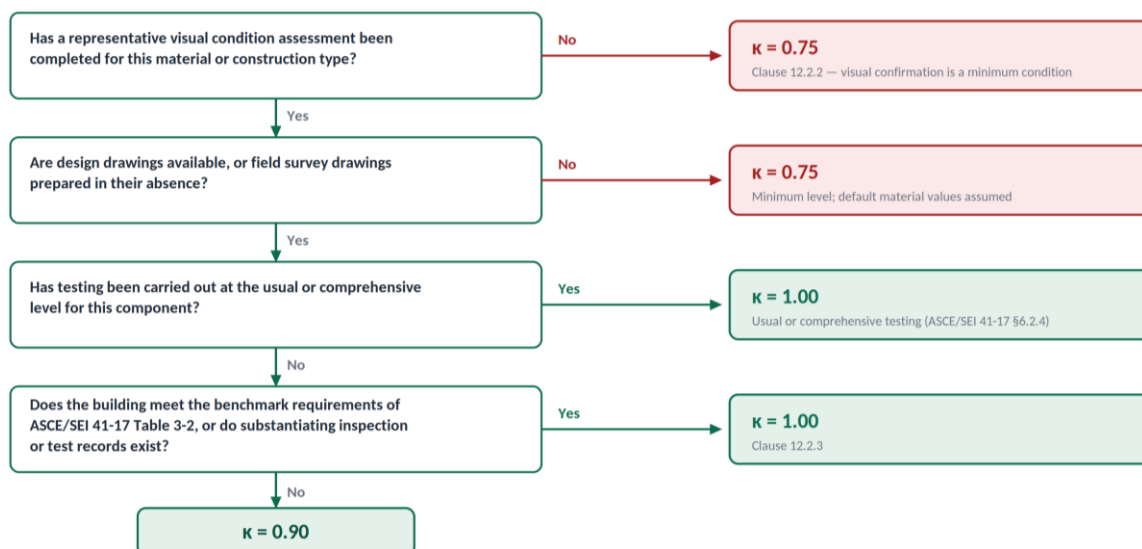


Figure 12-1 Assigning the knowledge factor, per component

13 Structural Modelling of Existing Buildings

A finite element model is built only where the earlier stages have not resolved the performance question. Most of the public building stock should never reach this stage. This chapter fixes how a model is built for the buildings that do.

13.1 Modelling what exists

13.1.1 A model constructed in accordance with this chapter shall accurately reflect the surveyed building, incorporating actual member dimensions, material design values, and knowledge factors, as well as the current damage states. It shall not rely on drawing dimensions or nominal material grades when these are contradicted by field data.

This is the most consequential modelling decision in the chapter and the easiest to get quietly wrong. A model built from the original drawings, with field findings treated as a check applied afterwards, is a model of a different building that happens to share the drawings.

13.2 Stiffness

Reinforced concrete cracks under service load well below ultimate capacity. A model built on gross section properties overestimates stiffness, shortens the computed period of the structure and can materially misstate both drift demand and the distribution of forces between members of different size.

13.2.1 Effective, cracked-section stiffness shall be used for concrete components, applying the modifiers of ASCE/SEI 41-17 by component type and axial load level. Gross section stiffness shall not be used without a stated justification.

13.3 Infill walls and configuration

13.3.1 A model of a frame with unreinforced masonry infill shall represent the stiffness contribution of the infill over its actual height, and where the infill is partial-height shall explicitly capture the short-column condition it creates.

CAUTION

Omitting infill walls for simplicity is not a conservative simplification for an infilled frame. It removes the stiffness irregularity and, where the infill is partial-height, the short-column mechanism. Such features make the typology distinction meaningful. The result can be unconservative compared with the actual behavior of the building.

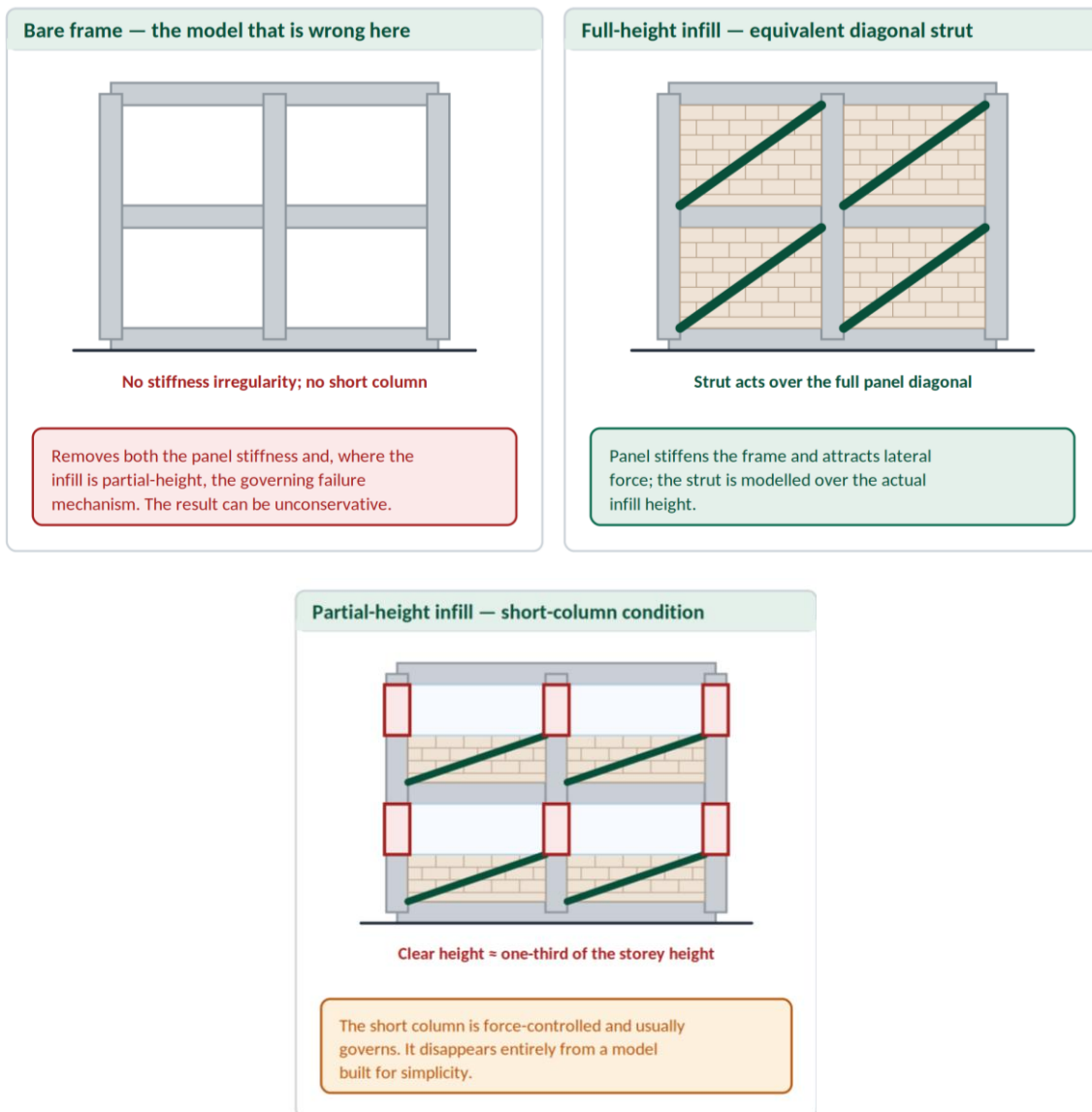


Figure 13-1 Modelling an infilled frame, and the short-column condition

13.3.2 A storey identified as a soft- or weak-storey candidate during the visual assessment shall be modelled with the stiffness and infill configuration observed at that storey, and not with the properties assumed for typical storeys elsewhere.

13.4 Foundations and deteriorated members

13.4.1 Where site-specific geotechnical information is unavailable, the foundation fixity assumption shall be stated explicitly and its sensitivity checked by comparing a fixed-base case with a reasonable soil-spring alternative, rather than adopted by software default. This clause governs the foundation fixity assumption in the model; it does not relieve the requirement of Clause 7.4.4 where a site-specific ground motion hazard analysis is required.

13.4.2 A member with confirmed section loss shall be modelled with its as-surveyed reduced properties and the design values and knowledge factor assigned to it under Chapter 12.

14 Performance Evaluation

This is the stage at which every path through the preceding chapters converges. It applies the tiered evaluation procedure adopted by BCP-2021 Appendix A to the typology, performance objective and material properties already established, and yields a demand-capacity ratio and a performance level. It always produces a decision-ready result.

14.1 The three tiers

Table 14-1 The tiered evaluation procedure

Tier	Procedure	Basis	Proceed to the next tier where
Tier 1	Checklist-based screening using the evaluation statements and quick checks of ASCE/SEI 41-17 Chapter 4, selected for the performance level and level of seismicity.	BCP-2021 §A106	the checklists identify a non-compliant or unknown condition.
Tier 2	Deficiency-based evaluation of the specific items identified at Tier 1, by simplified calculation rather than a full building model.	BCP-2021 §A107	simplified calculation cannot resolve the deficiency.
Tier 3	Systematic evaluation of the whole building using linear or nonlinear procedures on the model of Chapter 13.	BCP-2021 §A108	Tier 3 is the final tier.

14.1.1 An evaluation shall proceed to Tier 2 only where Tier 1 identifies a deficiency, and to Tier 3 only where Tier 2 cannot resolve it. Proceeding to Tier 3 when an earlier tier has already resolved the question is not conservative practice; it is unaffordable practice at programme scale.

14.1.2 Where a Tier 2 deficiency-based retrofit is performed, the resulting building including the strengthening measures shall comply with Tier 1 screening or with a Tier 2 evaluation for all potential deficiencies identified, in accordance with BCP-2021 §A107.4.

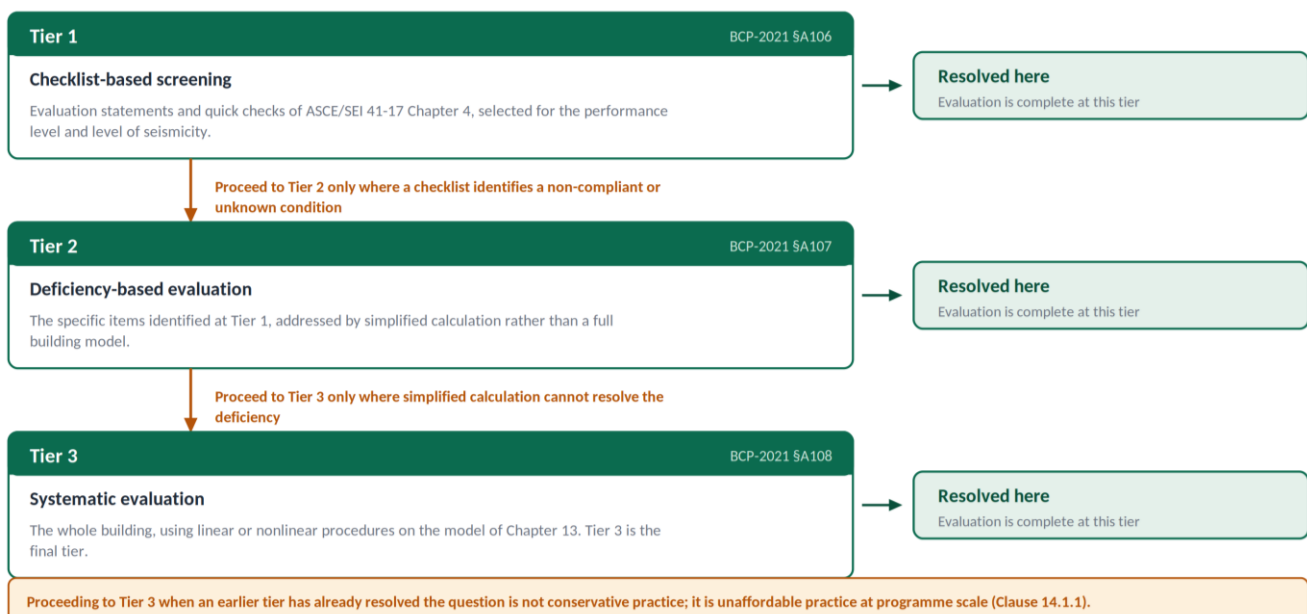


Figure 14-1 The tiered evaluation procedure of BCP-2021 Appendix A

14.2 Component classification and the demand-capacity ratio

Under linear procedures, component adequacy is expressed as a demand-capacity ratio. Capacity is computed differently according to whether the action is deformation-controlled - ductile behavior, capacity expressed as a permissible deformation modified by an m-factor reflecting expected ductility - or force-controlled - brittle or limited-ductility behavior, capacity taken at expected or lower-bound strength with no ductility modification, because there is no reserve deformation capacity beyond first exceedance.

14.2.1 Every component shall be classified as deformation-controlled or force-controlled before a demand-capacity ratio is computed. A force-controlled component shall never be assigned an m-factor.

CAUTION

A short column failing in shear is the canonical force-controlled case in this building stock. It has essentially no ductile reserve once shear capacity is exceeded, unlike a well-detailed flexural member. Treating it as deformation-controlled credits the component with ductility it cannot provide.

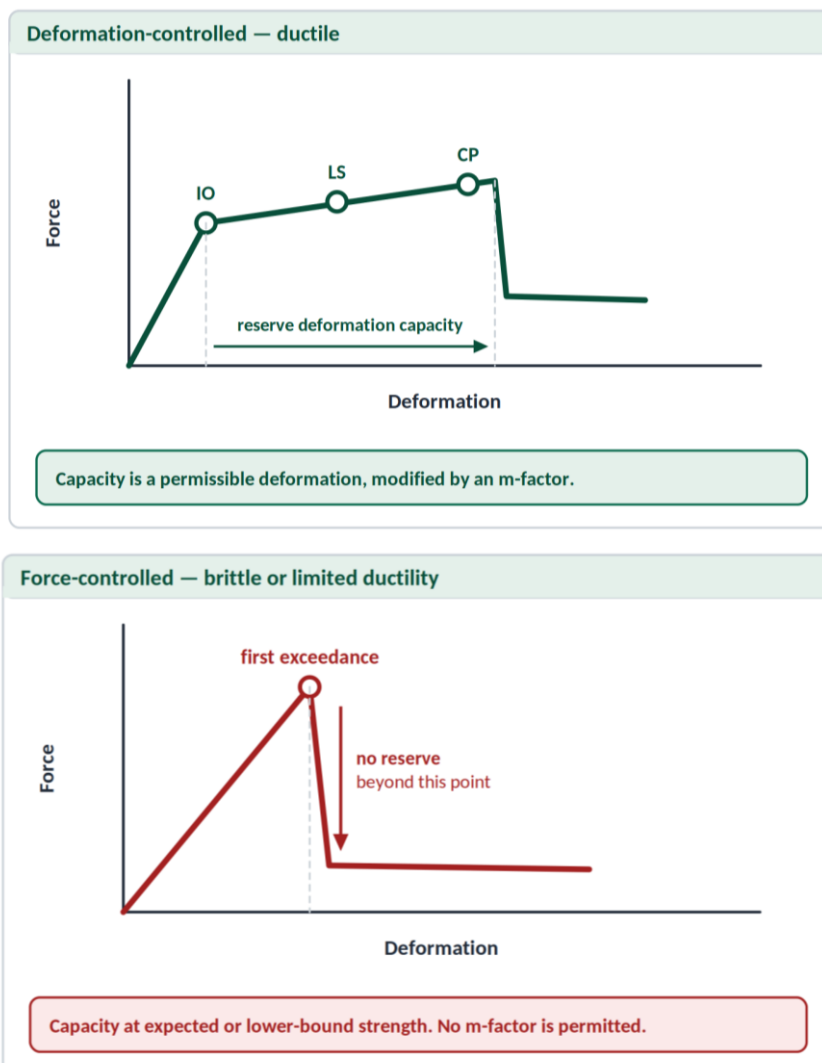


Figure 14-2 Deformation-controlled and force-controlled actions

14.3 Nonlinear procedures and the knowledge link

Nonlinear static analysis incrementally displaces the structure under a prescribed lateral load pattern, tracing the force-deformation response past first yield to a target displacement representing the design demand. Nonlinear dynamic analysis applies ground-motion time histories directly. Both require a model that captures inelastic component behavior.

14.3.1 Nonlinear procedures shall not be used where the data-collection basis corresponds only to the minimum level of knowledge. ASCE/SEI 41-17 §6.2.4.2 permits minimum-knowledge data collection for linear procedures only; §6.2.4.3 requires the usual or comprehensive level for nonlinear procedures. Where a nonlinear procedure is used before that data has been collected, the required testing shall be performed before retrofit is implemented or, where no retrofit is required, before the evaluation report is finalized.

14.3.2 The restriction is on the quality of the input data, not on analytical capability. When proposing a nonlinear evaluation for a component at the minimum knowledge level, an engineer should initially enhance the data-collection basis for that component instead of relying on assumptions at the minimum level.

14.4 Acceptance criteria

Acceptance criteria, such as the demand-capacity ratio, m-factor or deformation limit that a component type must satisfy at a given performance level, are set by material in ASCE/SEI 41-17 Chapters 8 to 12 and applied directly from the standard. This Manual does not reproduce those tables: a separately maintained copy of a numeric acceptance table is a source of citation drift.

14.5 Probabilistic performance assessment

14.5.1 Probabilistic seismic performance assessment expressing results as repair cost, repair time and casualty distributions may be applied to Risk Category IV facilities where the tiered evaluation does not provide sufficient resolution for the decision at hand. It is a supplementary method for the highest-consequence facilities and not a replacement for the tiered procedure.

15 Risk Assessment

The evaluation yields a demand-capacity ratio and a performance level per component. This chapter places those results in a risk frame: it combines hazards rather than treating each in isolation, accounts for failure modes that appear only where two hazards interact and produces the prioritization that portfolio management requires.

15.1 Risk frame

This Manual adopts the risk management structure of ISO 31000 - identification, analysis, evaluation and treatment - as the frame within which engineering results become a risk statement.

Table 15-1 Risk Assessment Framework

Step	Application
Identification	Typology, hazards screened and deficiencies found (Chapters 4 to 14).
Analysis	Likelihood and consequence combined, per hazard and across hazards.
Evaluation	The analyzed risk compared against the performance objective assigned in Chapter 5.
Treatment	The decision of Chapter 16.

15.1.1 Risk shall be evaluated against the performance objective actually assigned to the facility, and not against a generic risk scale that does not distinguish between facility types.

15.2 Multi-hazard integration

15.2.1 The risk statement shall integrate the result of every hazard applicable to the site and not only the hazard that produced the governing demand-capacity ratio. A facility with a marginal seismic result and a severe flood result is not adequately described by its seismic result.

Extreme heat is assessed in addition to the hazards screened, where it affects occupant safety in facilities without adequate passive cooling or ventilation, and where it accelerates material deterioration mechanisms.

15.3 Compounding failure modes

Some of the most consequential failure modes occur at the interaction of two hazards rather than within either hazard considered alone.

Table 15-2 Compounding failure modes

Mode	Why single-hazard assessment misses it
Scour undermining a foundation before seismic demand arrives	A foundation whose bearing has been reduced by scour has a different, and typically worse, seismic performance than the same foundation intact.
Fire following earthquake	Shaking damages suppression, gas and electrical systems and obstructs egress at the moment ignition risk is highest.

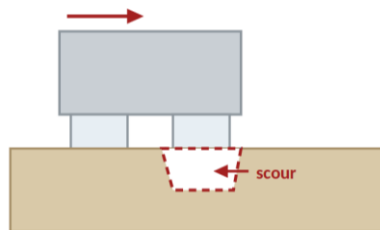
Mode	Why single-hazard assessment misses it
Deterioration reducing capacity against every hazard	A corroded or carbonation-affected member has reduced capacity against every action that loads it, not only the action under which the deterioration was first observed.
Wind-driven rain following envelope breach	Loss of a roof element changes internal pressure and admits water simultaneously, so the structural and durability consequences compound.

15.3.1 Where a finding affects a structural property relied upon by more than one hazard check, the revised property shall be applied consistently across every check it affects, and not only the check under which the finding was originally made.

Scour before seismic demand arrives

Flood + Earthquake

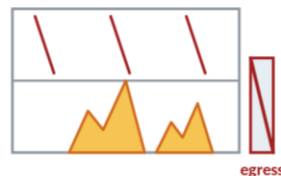
A foundation whose bearing has already been reduced by scour has a different, and typically worse, seismic performance than the same foundation intact.



Fire following earthquake

Earthquake + Fire

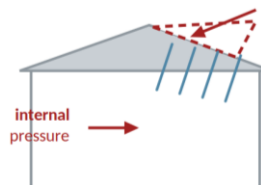
Shaking damages suppression, gas and electrical systems and obstructs egress at the moment ignition risk is highest.



Wind-driven rain following envelope breach

Wind + Rain

Loss of a roof element changes internal pressure and admits water simultaneously, so the structural and durability consequences compound.



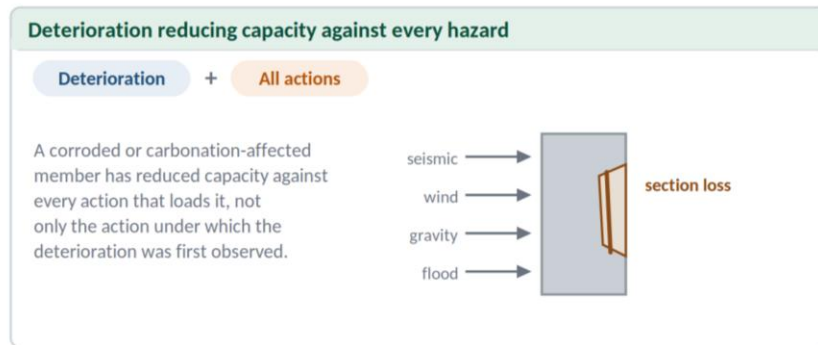


Figure 15-1 Compounding failure modes at the interaction of two hazards

15.4 Future climate conditions

Where the assessment supports a decision with a long service life, the hazard exposure used should reflect the conditions expected over that life and not only the present-day condition. Rainfall intensity, flood level, extreme heat and coastal water level are the variables for which change is material in Pakistan.

- 15.4.1** Where a future-condition allowance is applied to a design action, the assessment shall record the baseline value and its source, the dataset and scenario used, the design horizon, the transformation from climate variable to design action, the resulting value and the sensitivity of the decision to that value. An allowance shall not be applied as a generic percentage uplift without that record.
- 15.4.2** Where the available evidence does not support a defensible numerical allowance, the assessment shall rely on robust siting and detailing, sensitivity analysis and monitoring, and shall record that no numerical allowance was adopted and why.

15.5 Portfolio prioritization

- 15.5.1** Where risk is assessed across more than one facility, prioritization shall be based on the full multi-hazard, compounding-aware risk statement, so that a facility with a moderate result in isolation but a severe compounding condition is not under-prioritized relative to a facility with a worse single-hazard result.

16 The Decision

Every facility assessed under this Manual reaches this chapter, regardless of which earlier stage it exited from. Four outcomes are available. This chapter fixes the criteria that separate them.

16.1 The four outcomes

Table 16-1 Decision outcomes

Outcome	Criterion
REPAIR	Damage or deterioration is present, but the structural system as built is adequate for the performance objective once the damage is made good and its cause is controlled.
RETROFIT	The structural system as built is inadequate for the demand, the deficiency can be corrected, and the ratio R does not exceed the limit of Clause 16.2.2.
RECONSTRUCT	The deficiency cannot be corrected by retrofit, or the ratio R exceeds the limit of Clause 16.2.2, or the site is unsuitable but an acceptable alternative site is available.
RELOCATE	The site is unsuitable and cannot be made acceptable by any site-level intervention, and no alternative site is available to the custodian at the existing location.

The outcomes are tested in a fixed order, so that a site exclusion is settled before a cost comparison is attempted.

Tested in this order, so that a site exclusion is settled before a cost comparison is attempted (§16.1)

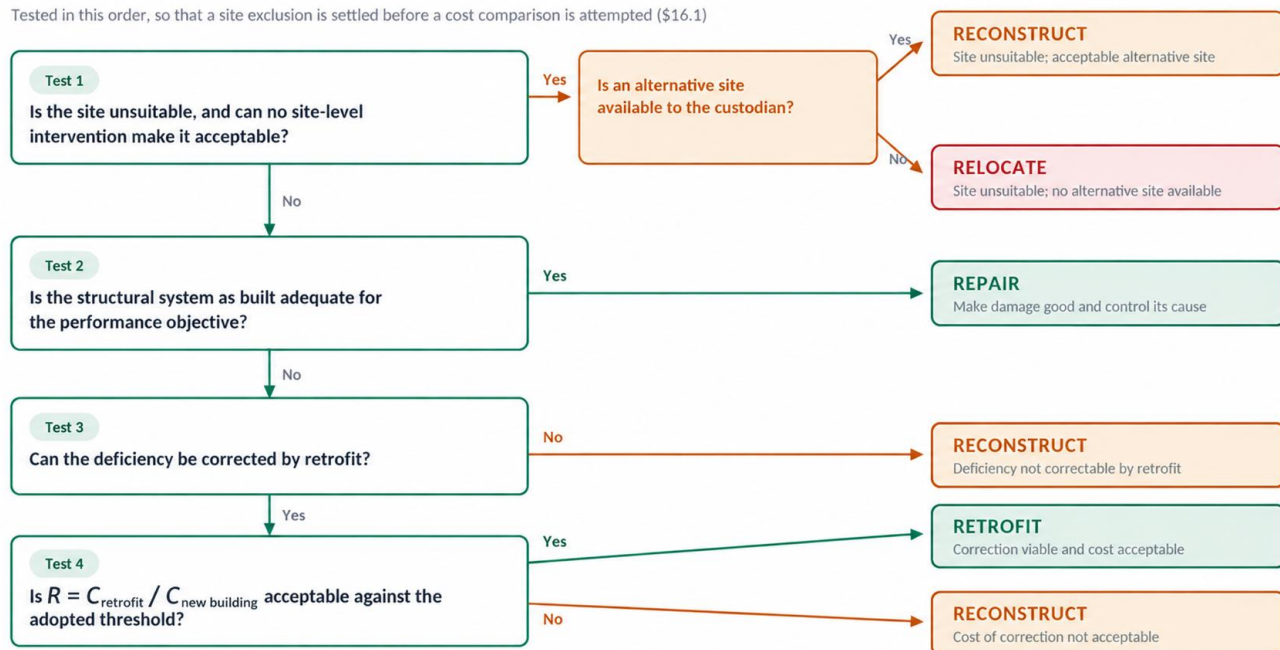


Figure 16-1 Order in which the decision criteria are tested

16.1.1 The decision shall be made on the evidence available at the stage at which the assessment terminated under Table 2-2. Where the assessment proceeded to Stages 9 and 10, the decision shall not be made until the performance evaluation and the risk assessment are complete.

16.1.2 Where the assessment terminated at screening with a SAFE outcome, the decision is that no intervention is required on the evidence available, and the facility returns to the re-screening

interval of Chapter 18. Where it terminated at Stage 4 with a component deficiency, the decision is REPAIR limited to that deficiency. In each case the decision, its basis and the stage at which the assessment terminated shall be stated in the report and on the certificate, and the decision shall not be expressed in terms that imply a performance evaluation was carried out.

16.2 Cost comparison

Where retrofit is technically viable, whether it is also the correct decision depends on its cost relative to the cost of a new building at the same site. The comparison is expressed as a ratio.

$$R = C_{\text{retrofit}} / C_{\text{new building}} \quad (16.1)$$

- 16.2.1** The ratio shall be assembled on the basis required by BCP-2021 Appendix A §A105.2. The cost of retrofit shall include the measured scope and rates with the price date; design, investigation and supervision; temporary accommodation and service continuity during the works; a risk allowance; and the cost of refurbishment of the building to a condition equal to or better than a new building at the same site. The replacement value shall be the cost of a new building at the same site of equivalent scope. A ratio quoted without that basis is not comparable between facilities and shall not be used to rank them.
- 16.2.2** BCP-2021 Appendix A §A105.2 provides that the cost of a retrofitted building should not exceed 40% of the cost of a new building at the same site. A ratio exceeding 0.40 shall therefore be reported as indicating reconstruction. The Code states this as a suggestion, so it is a recommended practice under Table 1-1 and a departure requires a documented engineering reason; a more stringent requirement imposed by the owner, the financing institution or the Authority Having Jurisdiction governs under Clause 1.2.1. The ratio, the threshold applied and any departure from it shall be recorded in the assessment and on the certificate.
- 16.2.3** The threshold sits well below unity because a retrofit corrects a stated deficiency in a building whose remaining components retain their existing age and condition, whereas a replacement building delivers a full design life and current code compliance. As the ratio approaches 0.40, that difference outweighs the saving, and above it reconstruction is indicated. The ratio is applied by the owner or the financing institution; it is not a determination made by the facility custodian.

16.3 Site suitability

A site is unsuitable where its hazard exposure cannot be reduced to an acceptable level by any building-level intervention. Examples include a site subject to continuing slope instability that no foundation or retaining measure addresses at reasonable cost, or a site within a floodway rather than a floodplain, where the hazard is the passage of water itself rather than its depth.

- 16.3.1** Land tenure or ownership constraints preventing reconstruction on the existing site shall be documented as a site finding and not as an adjustment to the cost threshold.

16.4 Non-engineering factors

16.4.1 BCP-2021 Appendix A §A105.2 exempts buildings of cultural or historical importance from the cost limit. Confirmed heritage value, or displacement of a school for more than one academic year with no alternative accommodation, may therefore justify departing from the threshold. Any such departure requires the approval of the owner or the financing institution, and the value adopted, the reason and the approving authority shall be recorded in the assessment and on the certificate. It shall not be applied at the deciding engineer's discretion alone.

16.5 Applying the decision across a typology

16.5.1 The technical viability finding and the cost comparison may be established at index-building resolution and applied to facilities of the same typology, construction era and condition. An individual facility shall depart from the index-building decision only where a facility-specific finding applies to it and not to the index building.

17 Reporting and Certification

Reporting is mandatory in every case irrespective of the terminating stage. A facility that exited at screening is reported as thoroughly, within its scope, as one carried to a full evaluation.

17.1 Report structure

Table 17-1 Assessment report structure

Section	Content
1. Facility identification	Asset identifier, location and coordinates, typology, Risk Category, taken from the register and not re-entered.
2. Terminating stage and outcome	The stage at which the assessment terminated and the reason why, including a screening exit, shall be stated as a positive finding rather than as an absence of further work.
3. Findings by stage reached	Every finding made from desktop study through the stage reached, not only the findings that drove the decision.
4. Evaluation and risk	Where reached: demand-capacity ratios, performance level, and the risk statement including any compounding condition.
5. Decision and rationale	The outcome and the specific criterion that produced it, including the cost ratio and its basis where applicable.
6. Recommendations	The intervention shall be described in sufficient detail for the design engineer to proceed, with the cost band and the portfolio priority assigned.
7. Certificate	As Section 17.2.
8. Appendices	Photographic records, test data and calculation records are sufficient for an independent engineer to follow the reasoning.
9. Inclusion and accessibility	The inclusion and accessibility findings recorded under Table 6-2 and Annex B.4, stated separately from the structural findings and routed to inclusion and facilities planning. The section shall appear even where no finding was made.

17.1.1 Every section shall appear even where it is brief because the assessment terminated early.

17.1.2 The recommendations section shall state the outcome, the cost basis and the portfolio priority together, so that the reader is not required to assemble them from separate sections.

17.1.3 Where a finding requires action before the recommended intervention can be carried out, the assessing engineer shall state the interim risk-reduction measures in the report, addressed to the custodian and expressed as instructions that can be acted on without further engineering input. These include securing or removing unrestrained parapets, water tanks, solar frames and rooftop plant; clearing and unlocking egress routes; and relocating occupancy out of a block or storey pending intervention. The measures shall be dated and the custodian's receipt of them recorded.

17.2 The assessment certificates

Table 17-2 Assessment Certificate Information and Source

Field	Source
Asset identifier and facility identification	Chapter 6
Terminating stage	Chapter 2
Typology assigned	Chapter 4
Risk Category and performance objective	Chapter 5
Knowledge factors applied, by component	Chapter 12
Demand-capacity ratio and performance level, where reached	Chapter 14
Decision outcome	Chapter 16
Cost ratio, the limit applied under Clause 16.2.2, and any departure with its approving authority	Chapter 16
Residual risk and monitoring requirement	Chapters 15 and 18
Assessing engineer, registration number, date and signature	Chapter 17
Inclusion review carried out, and findings recorded	Chapters 6 and 17

- 17.2.1** The certificate shall be signed by a Professional Engineer registered with the Pakistan Engineering Council taking personal professional responsibility for the finding. It shall not be issued unsigned or under an organizational signature in place of a named individual.
- 17.2.2** A field that does not apply because the corresponding stage was not reached shall be marked “not reached” rather than left blank.

18 Monitoring

A building does not remain in the state in which it was found. This chapter fixes what happens between assessments.

18.1 Re-screening intervals

18.1.1 The interval before re-screening shall be set by the outcome the facility currently carries and by its Risk Category. A “MONITOR” outcome shall carry a shorter interval than a “SAFE” outcome, directed at the specific condition that produced it.

18.1.2 A Risk Category IV facility shall be re-screened no less frequently than a facility of lower Risk Category carrying the same outcome, because the consequence of missed deterioration is greater even where its probability is unchanged.

18.2 Trigger events

18.2.1 An earthquake, flood, fire, landslide or observation of new damage shall reopen the assessment at Stage 3 irrespective of where the facility currently sits in its re-screening interval.

18.2.2 An owner-reported observation matching any structural sign of Chapter 6 shall itself be treated as a trigger event, whether or not a named hazard event is known to have occurred. New damage observed without an identified cause is not exempt from re-screening.

18.3 Crack monitoring

18.3.1 A crack recorded as active shall be fitted with a crack monitor or an equivalent dated reference at the time the finding is made, and not retrospectively at the next scheduled visit.

18.4 Instrumentation

Continuous instrumentation produces decision-relevant data for a narrow set of facilities and an expensive record that changes no decision for most others. The difference is not the technology but whether a stated decision depends on the data.

18.4.1 Instrumentation shall not be installed unless a specific decision, named at the time it is proposed, depends on the data it would produce, and that decision could not be adequately supported by periodic monitoring at lower cost.

18.4.2 Where instrumentation is justified, it shall be prioritized by portfolio risk ranking and not by facility visibility or funding convenience.

19 Portfolio Management

Chapters 6 to 18 are written from the perspective of a single facility. On the portfolio scale the question is no longer what should be done to this building, but in what order across the whole stock, given a finite budget.

19.1 The register as a management instrument

A stable asset identifier and recorded coordinates allow the findings for every facility included in it to be queried and compared across the portfolio. Block-level inventory allows investment to be costed at the resolution at which work is actually procured. Persistence with the identifier across repeat visits allows the register to show whether an investment already made has had its intended effect, and not only what condition a facility is in today.

19.2 Investment prioritization

19.2.1 Prioritization shall rank facilities by the risk statement of Chapter 15. Cost-efficiency and ease of implementation shall be applied only to sequence facilities of comparable risk relative to one another, and not to promote a lower-risk, cheaper or more convenient facility ahead of a higher-risk one.

19.2.2 Not less than 5% of screened blocks, and not fewer than one per district batch, shall be re-screened blind by a different assessor who has not seen the first record, and the agreement rate reported against the batch. Where agreement falls below 90%, the batch screened by that assessor shall be re-screened in full.

KEY DECISION

A capital program under budget and schedule pressure will always find it easier to complete ten cheap, low-risk repairs than one expensive, high-risk reconstruction, and can report ten completed interventions as more progress than one. Clause 19.2.1 exists because that reporting incentive is real and points in the opposite direction to risk management.

19.3 Information system requirements

This Manual does not specify a software platform. It states what an information system supporting the register must do, so that any system built or procured can be assessed against a stated requirement.

Table 19-1 Minimum Information System Requirements

Requirement
Query and filter the register by asset identifier, typology, Risk Category, outcome and risk rank.
Display facility locations against the hazard information used in Chapter 7.
Version each facility's assessment history against a persistent identifier rather than overwrite the prior record.
Generate the report structure and certificate of Chapter 17 directly from register data.

Requirement

Track re-screening intervals and trigger-event status, and flag facilities due or overdue.

Export a ranked investment list consistent with Clause 19.2.1, rather than a table the user may re-sort by any column.

19.4 Closing the cycle

The workflow closes where it began. Completed interventions are recorded against the asset identifier, the facility returns to the monitoring interval set by its new outcome, and the portfolio ranking is updated so that the next allocation of capital is made against current evidence.

Annex A Assessment Report and Certificate Template

The template below follows Chapter 17. It is issued blank. No entry shall carry a facility identity, finding, outcome, engineer's name, registration number, signature or date except as part of a completed and signed assessment.

A.1 Report section register

Table A-1 Report section register

Order	Section	Entered from
1	Facility identification	Chapter 6 register
2	Terminating stage and outcome	Chapter 2
3	Findings by stage reached	Chapters 7 to 12
4	Evaluation and risk assessment	Chapters 14 and 15
5	Decision and rationale	Chapter 16
6	Recommendations	Chapter 16
7	Assessment certificate	Table A-2
8	Appendices - photographs, test data, calculations	Chapters 9 to 14

A.2 Certificate

Table A-2 Assessment certificate

Field	Entry
Facility name and asset identifier	
Location and coordinates	
Authority Having Jurisdiction	
Typology	
Risk Category and performance objective	
Terminating stage	
Knowledge factors applied, by component	
Demand-capacity ratio and performance level	
Decision outcome	
Cost ratio, the limit applied under Clause 16.2.2, and any departure with its approving authority	
Residual risk and monitoring requirement	
Assessing engineer - name, PEC registration number	
Signature and date	
Inclusion review carried out, and findings recorded	

Annex B Field Record Sheets

The sheets below are the minimum field records required by Chapters 6, 9, 10 and 11. They are reproduced blank and may be reformatted for a project provided the recorded fields are preserved.

B.1 Facility and block record

Table B-1 Facility and block record

Field	Entry
Facility code (EMIS / HMIS) and name	
Province, district, address	
Latitude, longitude	
Facility type and occupancy group	
Year of construction; recorded alterations	
Occupant load; emergency-shelter designation	
Custodian - name, designation, department	
Block identifier, plan shape, storeys, use, floor area	
Assessor - name, PEC registration number, date and signature	
Supervising engineer, where the record was made under supervision (Clause 8.1.2)	

B.2 Observation and damage record

Table B-2 Observation and damage record

Field	Entry
Block, level, element identifier and grid or face	
Observation reference and date	
Neutral description of what is observed	
Crack width, length, orientation; active or dormant	
Mechanism and damage state, per component	
Component or global deficiency	
Photograph references - context and detail	
Immediate action taken and notified to	
Assessor - name, PEC registration number, date and signature	

B.3 Test record

Table B-3 Test record

Field	Entry
Question the test is intended to answer	
Method and standard; equipment and calibration status	
Location, element and orientation	
Environmental and surface conditions at test	
Raw reading and units	
Corrections applied and reference	
Corroborating method and result	
Making good - material, date, verified by	
Assessor - name, PEC registration number, date and signature	

B.4 Inclusion and accessibility record

Table B-4 Inclusion and accessibility record

Field	Entry
Ramps and handrails - provided, compliant, condition	
Doorways and circulation usable by a wheelchair user	
Toilets - wheelchair-usable; separate lockable facilities for girls and women	
Egress routes - unobstructed, outward-opening, lit	
Water supply - available, accessible	
Learners or patients unable to evacuate unaided - number and provision made	
Finding routed to	
Recorded by - name, PEC registration number, date and signature	

Annex C Worked Examples

The examples below illustrate the application of Chapters 5, 12, 14 and 16. All inputs are assumed for illustration. They are not records of any facility and shall not be transferred to a project.

C.1 Risk Category and performance objective

A government girls' high school comprises two blocks. Block A is a single-storey confined masonry classroom block; Block B is a two-storey reinforced-concrete frame block built in 1998. Recorded enrolment is 480 pupils with 22 teaching and support staff. The district administration has formally designated the school as a flood shelter.

Table C-1 Risk Category determination - illustrative

Step	Determination	Basis
1	Test the shelter designation first. The school is a designated emergency shelter, so Risk Category IV applies irrespective of occupant load.	BCP-2021 Table 1604.5, Risk Category IV
2	Note that the occupant load of 502 would in any case have produced Risk Category III as a Group E occupancy with occupant load greater than 250. The higher category governs.	BCP-2021 §1604.5.1
3	Assign Immediate Occupancy as the governing performance level, because the facility is Risk Category IV and is a designated shelter.	Clause 5.2.1
4	Apply the paired hazard check: Immediate Occupancy at the lower hazard level with the corresponding upper-level check for the Risk Category.	Clause 5.3.1
5	Assess each block separately: the two blocks are structurally separate and are different typologies.	Clause 6.2.2

NOTE

The shelter designation, not the enrolment, is what raises this school to the highest Risk Category and to an Immediate Occupancy objective. A designation recorded only in a district circular and not in the facility register would have produced a Risk Category III assessment and a materially weaker performance objective.

C.2 Assigning the knowledge factor

For Block B, the following data were obtained. The knowledge factor is assigned per component.

Table C-2 Knowledge factor assignment - illustrative

Component	Data obtained	K	Basis
Ground-storey columns	Cores extracted and tested; cover meter survey verified by exposure at three locations; visual condition assessment complete.	1.00	Usual testing
Upper-storey beams	Original design drawings available and confirmed by visual condition assessment; no testing.	0.90	Minimum level, drawings available
Foundations	No drawings; not exposed; no testing; default values assumed.	0.75	Minimum level, default values

Component	Data obtained	κ	Basis
Infill masonry	No representative visual examination completed for this material type.	0.75	Clause 12.2.2 - no representative visual examination

The building correctly carries three different values simultaneously. Because the minimum level of knowledge applies to some components, linear procedures govern the evaluation unless the data-collection basis for those components is raised.

C.3 Component classification

Block B has full-height masonry infill in the transverse direction and partial-height infill with a continuous window band in the longitudinal direction, leaving a clear column height of approximately one-third of the storey height.

Table C-3 Component classification - illustrative

Component	Classification	Consequence
Transverse frame beams in flexure, with confined detailing	Deformation-controlled	Evaluated against a permissible deformation with an m-factor from the relevant material chapter.
Longitudinal columns in shear over the clear height above the window band	Force-controlled	No m-factor. Capacity taken at expected or lower-bound strength; the component must remain elastic.
Diaphragm-to-wall connection	Force-controlled	Connection capacity governs; failure is brittle.

CAUTION

Modelling this block as a bare frame would remove both the transverse stiffness contribution and the longitudinal short-column mechanism. The short column is the governing component, and it disappears from a model built for simplicity.

C.4 Cost comparison at the decision stage

The evaluation of Block B identifies a correctable deficiency. Costs are assembled on the basis required by Clause 16.2.1.

Table C-4 Cost comparison - illustrative

Item	Included in	Amount (assumed)
Measured retrofit works at current rates	Cost of retrofit	1.00 unit
Design, investigation and supervision	Cost of retrofit	0.12 unit
Temporary accommodation during the works	Cost of retrofit	0.15 unit
Risk allowance	Cost of retrofit	0.13 unit
Refurbishment to a condition equal to or better than a new building at the same site (BCP-2021 \$A105.2)	Cost of retrofit	0.35 unit
Total cost of retrofit		1.75 unit

Item	Included in	Amount (assumed)
New building at the same site, equivalent scope	Cost of a new building	2.60 unit
Total cost of a new building at the same site		2.60 unit
Ratio R = cost of retrofit / cost of a new building at the same site		0.67

The ratio is reported together with its basis. At 0.67 it exceeds the 40% limit of BCP-2021 Appendix A §A105.2, so reconstruction is indicated under Clause 16.2.2. Note that the demolition and disposal of the existing building does not enter the denominator: §A105.2 compares against the cost of a new building at the same site, and the refurbishment of the existing building to an equal or better condition enters the numerator. A departure from the limit would require the approval of the owner or the financing institution under Clause 16.4.1, and the reason recorded.

References

Documents are listed in the form in which they are relied upon in this Manual. Where a specific provision is cited in the text, that provision is identified at the point of use.

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