

Element-Level Inspection Fundamentals (MBEI)

Element-level inspection breaks a bridge into elements and records how much of each is in each condition state. NBIS requires it for NHS bridges per the AASHTO MBEI. This course covers element types, condition states and quantity rules.

Learning objectives

- Explain element types: NBEs, BMEs and ADEs
- Assign condition states 1 through 4
- Quantify defects in the correct units
- Use protective-system and wearing-surface elements

Why element-level data

Component ratings (0–9) summarize an entire deck or superstructure in one number. Element data records *quantity by condition state*, which supports deterioration modeling, preservation planning and cost estimates in bridge management systems. 23 CFR 650.315(a) requires element data for NHS bridges collected per the MBEI (2nd Ed., 2019).

Element types

- **National Bridge Elements (NBEs)** — primary structural components such as decks/slabs, girders, trusses, columns, abutments, piles, bearings, culverts.
- **Bridge Management Elements (BMEs)** — components typically managed by agencies: joints, approach slabs, wearing surfaces, protective coatings, deck/slab protection systems.
- **Agency Developed Elements (ADEs)** — custom elements an agency defines for its own needs, usually as subsets of NBEs/BMEs.

Elements are measured in units appropriate to the element: area (sq ft) for decks and wearing surfaces, length (ft) for girders, joints and railings, and each (ea) for bearings, columns and piles.

Condition states

Each element uses four condition states: **CS1 Good**, **CS2 Fair**, **CS3 Poor**, **CS4 Severe**. The MBEI provides defect-specific language for each material. CS4 generally indicates the defect is affecting strength or serviceability, or warrants structural review. The total quantity of an element must equal the sum of quantities in CS1–CS4.

Defects (e.g., corrosion, cracking, delamination/spall/patched area, efflorescence, section loss, settlement, scour) are recorded as child entries under the element with their own quantities and condition states.

Protective systems and wearing surfaces

Wearing surfaces and protective systems (coatings, sealers) are recorded as separate elements tied to the parent element. A deck with an asphalt overlay records the wearing surface condition separately; the deck's own condition must still be

estimated from the underside and other evidence. A steel girder's paint system is a protective-system element with its own condition states, distinct from the steel's section loss.

Quantity practice and common errors

- Do not double-count: one area of the deck belongs in one condition state for that element.
- Condition state is assigned by the *worst applicable defect* at that location.
- Use consistent units: girders in linear feet per girder line, not span length.
- Patched areas are recorded as defects; sound patches may be CS2 per MBEI language.
- Photo-document CS3 and CS4 quantities with location references.

Example: a 4,000 sq ft deck with 120 sq ft of spalls and delaminations (CS3), 300 sq ft of sound patches (CS2) and the rest CS1 records 3,580 / 300 / 120 / 0.

Part A — From one number to a condition profile

For most of the NBIS program's history, the condition of a bridge was summarized by four numbers: deck, superstructure, substructure (or a single culvert rating), each on a 0–9 scale. Those component ratings are simple and useful for screening, but they compress a lot of information. A superstructure rated 5 could be eight girders with uniform light corrosion, or seven pristine girders and one girder with heavy section loss at a bearing. The repair strategies, costs and risks are very different.

Element-level inspection answers the question "how much of what is in what condition?" The bridge is broken into defined **elements** — a reinforced concrete deck, steel girders, elastomeric bearings, a concrete pier cap — and each element's total quantity is distributed across four **condition states**. The AASHTO *Manual for Bridge Element Inspection* (MBEI) defines the elements, units, condition states and defects. MAP-21 required element data for bridges on the NHS, and the NBIS and SNBI build on that requirement.

What element data enable

- **Deterioration modeling.** Bridge management systems use the movement of quantities between condition states over time to estimate how fast elements deteriorate.
- **Cost estimating.** If 1,200 sq ft of deck is in condition state 3, a patching estimate follows directly from a unit cost.
- **Preservation planning.** Treatments like sealing, joint replacement and spot painting are most cost-effective when applied while quantities are in states 1–2. Element data show when that window is open.
- **Prioritization across an inventory.** Element data allow owners to compare like with like — all steel girders, all strip seal joints — and plan programs.

The component rating and element data are complementary. Inspectors still assign component ratings for federal reporting; the element data explain and quantify them.

Part B — Element families and examples

The MBEI organizes elements into three families:

Family	Purpose	Examples
National Bridge Elements (NBEs)	Primary structural components; required for federal reporting on applicable bridges	Decks and slabs, girders, trusses, arches, cables, floor beams, stringers, columns, pier walls, abutments, caps, piles, culverts, bearings, bridge rails
Bridge Management Elements (BMEs)	Components that are typically managed by agencies for preservation, such as joints, wearing surfaces and protective systems	Expansion joints, wearing surfaces, protective coatings, approach slabs
Agency-Developed Elements (ADEs)	Elements an agency defines for its own needs, following MBEI conventions	Agency-specific items such as particular joint types, sign structures attached to bridges, or subdivisions of NBEs

Common element numbers

Element numbers are a shared vocabulary. A few common ones (verify against the edition your owner uses):

No.	Element	Unit
12	Reinforced concrete deck	sq ft
107	Steel open girder/beam	ft
109	Prestressed concrete open girder/beam	ft
205	Reinforced concrete column	each
215	Reinforced concrete abutment	ft
234	Reinforced concrete pier cap	ft
300	Strip seal expansion joint	ft
310	Elastomeric bearing	each
331	Reinforced concrete bridge railing	ft
510	Wearing surfaces	sq ft
515	Steel protective coating	sq ft

Units matter

Elements are measured in square feet (decks, slabs, wearing surfaces, coatings), linear feet (girders, caps, abutments, joints, railings), or each (columns, bearings, piles in some cases). Using the wrong unit — for example, counting girders as "each" — makes the data unusable for comparison and modeling. Always check the MBEI unit for the element.

Worked example 1 — Element totals for a simple bridge

A single-span, 80 ft long, 40 ft wide (out-to-out) bridge with five prestressed I-girders, an RC deck with an asphalt overlay, two RC abutments 40 ft long, ten elastomeric bearings, two strip seal joints across the 40 ft width, and RC barrier rails both sides.

Element	Calculation	Total quantity
12 RC deck	80 × 40	3,200 sq ft
510 Wearing surface	Curb-to-curb area (e.g., 80 × 37)	2,960 sq ft

Element	Calculation	Total quantity
109 PS girder	5×80	400 ft
215 RC abutment	2×40	80 ft
310 Elastomeric bearing	5×2	10 each
300 Strip seal joint	2×40 (or curb-to-curb per owner)	80 ft
331 RC railing	2×80	160 ft

Follow your owner's guidance for measuring details such as whether joint length is out-to-out or curb-to-curb and whether deck area excludes overhangs. Consistency across inspections is more important than the convention chosen.

Part C — Condition states and defects

Each element quantity is distributed among four condition states:

CS	Name	General meaning
1	Good	No or minor defects
2	Fair	Defects present but not affecting strength or serviceability in a significant way
3	Poor	More significant defects; may require repair; strength or serviceability may be affected
4	Severe	Defects affecting strength or serviceability to an extent that warrants structural review

The MBEI gives specific descriptions for each defect within each condition state — for example, crack widths for reinforced concrete cracking, the extent of delamination or spalling, the presence of exposed reinforcing with or without section loss, and for steel, freckled rust versus section loss. Inspectors must use the definitions in the MBEI (and any owner supplements), not generic adjectives.

Defect-level recording

The current MBEI also records *defects* within an element — the quantity in each condition state attributable to each defect type (e.g., for an RC deck: delamination/spall/patched area, exposed rebar, cracking, efflorescence). The element condition state totals equal the sum of the defect quantities in each state, with the remainder in CS1. This allows a management system to know not just that 300 sq ft is in CS3, but why.

The "worst defect governs" rule for overlapping defects

When defects overlap on the same area — say, cracking with efflorescence over a delaminated area — the area is counted once, in the most severe applicable condition state, assigned to the governing defect. Double-counting overlapping areas makes element totals exceed the element quantity, a common data error that management systems reject.

Worked example 2 — Distributing an RC deck

Deck element 12 total = 3,200 sq ft. The inspector finds (from the underside, since the top is covered by an overlay):

- Cracking with efflorescence over 400 sq ft, crack widths in the MBEI CS2 range → CS2 (cracking).
- Delamination found by sounding over 90 sq ft, not yet spalled → CS3 under typical definitions (delamination).
- Spalls with exposed rebar, no measurable section loss, over 60 sq ft → CS3 (exposed rebar).

None of the areas overlap. Result: CS1 = 3,200 – 400 – 90 – 60 = 2,650; CS2 = 400; CS3 = 150; CS4 = 0. Total 3,200 ✓. Check the condition-state definitions in the edition your owner uses — some owners place small delaminations in CS2.

Part D — Steel elements in practice

Steel girders, stringers, floor beams and truss members are measured in linear feet. The main defects are corrosion (with or without section loss), cracking, connection problems, distortion and, for some members, damage from impact.

Typical steel condition-state logic

Observation	Typical CS
No corrosion, coating functioning	1
Freckled rust, corrosion without measurable section loss	2
Section loss present but not warranting structural review	3
Section loss or cracking that warrants structural review	4
Arrested crack (drilled, no growth) — owner rules vary	2 or 3
Active fatigue crack in a primary member	3 or 4 (often 4)

Protective coating as a separate element

The steel member and its coating are recorded separately: element 107 for the steel girder (linear feet, condition of the steel) and element 515 for the protective coating (square feet, condition of the coating). A girder can be in CS1 (no corrosion of the steel) while its coating is in CS3 (substantial coating failure). This separation is valuable for preservation: coating condition tells the owner when to paint before the steel itself starts losing section.

Worked example 3 — Steel girder and coating

Six steel plate girders, 120 ft each = 720 ft (element 107). Coating surface area estimated from girder geometry: approximately 7.5 sq ft per ft of girder (both web faces plus flange surfaces) × 720 = 5,400 sq ft (element 515). Observations:

- All six girders: coating failed with surface rust within 8 ft of each end (expansion joint leakage) = 6 × 2 × 8 = 96 ft of girder; coating area 96 × 7.5 = 720 sq ft.
- Of that, G1 and G6 (fascias) at the east end have section loss on the bottom flange over 6 ft each = 12 ft, measured loss up to 15%, judged not to warrant structural review.
- Elsewhere the coating is chalking and faded, but intact, over the remaining area.

Element	CS1	CS2	CS3	CS4	Total
107 Steel girder (ft)	624	84	12	0	720
515 Coating (sq ft)	0	4,680	720	0	5,400

Here the coating's fading and chalking puts most of it in CS2 under typical definitions, and the failed areas at the ends in CS3. Exact coating CS definitions vary by edition — check them. The pattern tells the owner: fix the joints and spot-paint the girder ends now; plan a full repaint later.

Weathering steel

Weathering steel is designed to form a protective patina and is usually not coated. In that case the protective system element for weathering steel patina is used per the MBEI edition, recording whether the patina is protective (tight, fine-grained) or non-protective (flaking, laminar rust, often caused by persistent wetness or salt). FHWA Technical Advisory T 5140.22 gives guidance on uncoated weathering steel performance.

Part E — Concrete and prestressed elements

Reinforced concrete

Concrete decks, slabs, girders, caps, columns and abutments share common defects: delamination and spalling, exposed reinforcing, cracking, efflorescence and rust staining, abrasion, and damage from impact. For decks, the defects are often only visible from below when an overlay covers the top surface; sounding from the top or NDE (GPR, impact echo, infrared thermography) may supplement visual inspection. Course BR-N01 covers concrete NDE.

Prestressed concrete

Prestressed girders add defects specific to prestressing: exposed or corroded strands, and cracking patterns related to prestress (end-region cracking, longitudinal cracking along strands, flexural cracking in tension zones that should be precompressed). Because prestressed members are designed to be crack-free under service loads in many cases, flexural cracks or cracks along strand lines with rust staining are important warning signs and push quantities into higher condition states.

Worked example 4 — Prestressed girder distribution

Element 109, five girders × 80 ft = 400 ft. Observations:

- G1 (fascia): impact damage at midspan with spalled bottom flange concrete exposing two strands over 4 ft; strands appear intact with surface corrosion.
- G1 and G5: hairline longitudinal cracks along the bottom flange at the ends, no staining, 6 ft each end.
- Other girders: no defects.

CS1	CS2	CS3	CS4	Total
372	24	4	0	400 ft

The 4 ft of exposed strands goes in CS3 (exposed prestressing without section loss under typical definitions); the hairline end cracks (4 locations × 6 ft = 24 ft) go in CS2. If any strand were severed, the area would likely be CS4 with a structural review, and potentially a critical finding.

Part F — Substructure, bearings and joints

Substructure

Abutments and pier caps are measured in linear feet; columns and some pile types in each. Movement-related defects (settlement, rotation, scour-related undermining) are recorded as well as material deterioration. A cap with a 6 ft long spall exposing rebar is recorded as 6 ft in CS3 — not the whole cap.

Bearings

Bearings are counted each. Typical defects include movement beyond design limits (rockers tilted excessively, elastomeric bearings with excessive shear deformation or walking), corrosion, loss of bearing area, deterioration of elastomer (cracking, bulging, splitting), and debris restricting movement. An elastomeric bearing with excessive shear deformation and splitting may be CS3; a bearing that has lost seat support is CS4 and likely a critical finding.

Joints

Joints are measured in linear feet. Leakage, seal damage or loss, debris impaction, adjacent deck or header deterioration, and metal damage are typical defects. Joint condition drives deterioration below: a leaking joint over a pier cap shows up years later as cap spalling and bearing corrosion. Joints are among the most cost-effective items to maintain.

Worked example 5 — Bearings and joints

Ten elastomeric bearings (element 310). Two bearings at the east abutment have walked 1 in. out from under the sole plate edge and show surface splits; the other eight are in good condition. Distribution: CS1 8, CS3 2 (owner definitions), total 10 each.

Two strip seal joints, 40 ft each = 80 ft (element 300). The east joint gland is torn over 12 ft and leaking; the remaining 28 ft of that joint is debris-filled but sealing. The west joint is in good condition. Distribution: CS1 40, CS2 28, CS3 12, total 80 ft.

Part G — Wearing surfaces and the deck

The wearing surface (element 510) is the riding surface — an asphalt overlay, a concrete overlay, or, for bare decks, the top surface of the deck itself per MBEI conventions. Recording the wearing surface separately from the deck is important because the wearing surface can be replaced without replacing the deck, and because its condition (and whether it hides the deck) affects how the deck is evaluated.

Practical issues

- **Hidden deck top.** When an overlay covers the deck, the inspector rates the deck from the underside and any NDE or cores available; potholes in the overlay that expose deck concrete give clues. Record that the top of the deck was not visible.
- **Patches.** Patched areas in the wearing surface or deck are recorded per the MBEI defect definitions — sound patches are not automatically CS1.
- **Area basis.** Wearing surface area is generally the riding surface area, which may differ from the deck element area.

Worked example 6 — Overlay over a deck

A 3,200 sq ft deck with a 2,960 sq ft asphalt wearing surface. The overlay has 180 sq ft of alligator cracking and 40 sq ft of potholes. Underside of deck shows 120 sq ft of efflorescence cracking and 30 sq ft of spalled concrete. Distribution (illustrative): wearing surface CS1 2,740, CS2 180, CS3 40; deck CS1 3,050, CS2 120, CS3 30. Note in the report that deck top surface is concealed by the overlay; recommend deck NDE before the next overlay replacement.

Part H — Relating element data to component ratings

Inspectors assign NBI component ratings (0–9) and element condition states on the same visit. They should tell a consistent story, but there is no fixed formula converting one to the other — the component rating reflects the inspector's judgment of the overall component, including the significance of where defects are, not just how much area they cover.

Worked example 7 — Same element data, different ratings

Bridge	Element 107 distribution	Location of CS3/CS4	Reasonable superstructure rating
A	CS1 650 / CS2 50 / CS3 20 / CS4 0 (720 ft)	Bottom flange section loss at ends of fascia girders, low stress region, rating unaffected	6
B	CS1 650 / CS2 50 / CS3 0 / CS4 20	Web section loss at bearings of interior girder, warrants structural review of shear/bearing capacity	4

The quantities in poor-or-worse states are equal (20 ft), but bridge B's defect is in a critical location and warranted structural review, so the component rating is lower. Element data are about extent; component ratings incorporate significance.

Consistency checks

- A component rated 7 with large CS3 quantities needs an explanation.
- A component rated 4 with almost everything in CS1 suggests either a localized but significant defect (explain it) or an inconsistent rating.
- A CS4 quantity usually means a structural review was warranted — the report should say whether one was requested and its outcome.

QC reviewers commonly use these checks to catch errors before data are submitted.

Part I — Quantity practice and common errors

Error	Consequence	Fix
Element total changes between inspections without a physical change	Deterioration models misread the change	Compute totals once from plans; carry forward unless the bridge changes
Wrong units (girders counted each, deck in linear feet)	Data unusable; rejected by system	Check MBEI unit for every element
Overlapping defects double-counted	CS totals exceed element total	Count each area once in its worst state
Whole element put in the worst state found	Grossly overstates deterioration and cost	Measure and distribute actual extents
Coating condition recorded in the steel element	Loses preservation signal	Record coating separately (515)
Generic descriptions instead of MBEI definitions	Inconsistent CS assignments between inspectors	Carry MBEI definitions in the field; calibrate team
No notes on access limitations	Unseen areas assumed CS1	Record areas not inspected and why

Estimating versus measuring

Element quantities are measurements, but practical inspection involves estimating. A reasonable approach: measure significant defects (CS3/CS4) directly with tape or from photos with scale, and estimate CS2 extents by span or bay. Record the method. Consistency over time matters more than false precision — if the last inspector estimated deck cracking to the nearest 50 sq ft, recording 437 sq ft this time gives a false impression of change.

Worked example 8 — Spotting a data problem

Inspection history for a deck element (3,200 sq ft):

Year	CS1	CS2	CS3	CS4	Total
2020	2,900	250	50	0	3,200
2022	2,700	380	120	0	3,200
2024	3,050	100	50	0	3,200

The 2024 record shows the deck "improving" with no repair recorded. Either repairs were done and not documented, or the 2024 inspector applied definitions differently. QC should resolve it before the data are submitted — otherwise the management system's deterioration model learns that decks heal themselves.

Part J — Field workflow for element inspection

- Before the trip:** review the previous inspection's element list and quantities, photos and notes; confirm element totals against the plans.
- On site, systematically:** work element by element and span by span, in the same order every time (for example, deck top, wearing surface, joints, railings, then underside span by span: deck underside, girders, bearings, substructure).
- Record defects as found:** location, defect type, extent and CS; mark significant areas on a framing plan sketch.
- Photograph:** each CS3/CS4 area with a scale; representative CS2 conditions.
- Before leaving:** sum each element's condition states and check they equal the total; compare with the last inspection and explain significant changes.
- In the office:** enter data, run consistency checks against component ratings, and flag any element needing structural review.

Tablet tools

Many owners use tablet software that enforces totals and units and pre-loads previous data. These tools reduce arithmetic errors, but the inspector still needs to know the MBEI definitions — software will happily accept a wrong condition state.

Part K — Using element data for preservation

The payoff of element data comes when owners use it to decide what to do and when. The FHWA *Bridge Preservation Guide* (FHWA-HIF-18-022) describes preservation as actions that prevent, delay or reduce deterioration — cyclical activities like washing and sealing, and condition-driven activities like joint repair and spot painting.

Worked example 9 — Turning element data into a work list

Element data	Preservation action	Quantity basis
300 Strip seal: CS3 12 ft (torn gland, leaking)	Replace gland	12 ft (or whole joint per practice)
515 Coating: CS3 720 sq ft at girder ends	Spot/zone painting	720 sq ft plus overlap
12 Deck: CS2 400 sq ft cracking	Crack sealing or penetrating sealer	Deck area per treatment
12 Deck: CS3 150 sq ft delam/spall	Partial-depth patching	150 sq ft plus margin
310 Bearings: CS3 2 each	Reset/replace bearings	2 each

With unit costs, this becomes a cost estimate. Across a whole inventory, management systems compare the cost of acting now with the cost of deferring, using deterioration models derived from historical element data.

Part L — Timber, masonry, culverts and railings

Timber

Timber elements (decks, stringers, caps, piles) carry defects such as decay, insect or marine borer damage, checks and splits, crushing, abrasion and connection deterioration. Decay often starts hidden — inside a pile top or at a stringer bearing — so sounding and probing are part of the element assessment. A pile with hollow sounding and reduced sound shell found by boring may be CS3 or CS4 depending on remaining section and owner definitions.

Masonry

Stone masonry arches, abutments and walls appear on older bridges. Defects include mortar loss, displaced or missing stones, cracking, bulging, and vegetation. A bulge in a masonry spandrel wall indicates fill pressure and may warrant structural review.

Culverts

Culvert elements are measured in linear feet along the barrel. Defects differ by material: for corrugated metal, corrosion and perforation (especially at the invert), deformation and seam problems; for concrete boxes and pipes, cracking, spalling, joint separation and settlement. Also record conditions at the ends — headwalls, wingwalls, scour at outlets — per owner practice.

Railings

Bridge railings are measured in linear feet. Impact damage, missing or loose anchor bolts, corrosion and concrete deterioration are typical. A damaged railing section that no longer provides containment at a drop-off may be a critical safety finding as well as CS4.

Worked example 10 — CMP culvert

A 72 ft long, 8 ft diameter corrugated metal pipe. The invert shows heavy corrosion with perforations over the bottom quarter of the barrel for 18 ft at the outlet end; 30 ft shows rust without perforation; the rest is galvanized and sound. Distribution: CS1 24 ft, CS2 30 ft, CS3 or CS4 18 ft (CS4 if soil loss or deformation warrants structural review). Total 72 ft. Recommend invert paving or lining evaluation.

Part M — Comprehensive exercise

A two-span continuous steel bridge, each span 90 ft, deck 36 ft wide out-to-out (34 ft curb-to-curb), four plate girders, concrete deck with no overlay, two strip seal joints at the abutments, eight elastomeric bearings at the abutments plus four at the pier, RC abutments 36 ft long, RC pier cap 36 ft long, three RC columns, RC barrier rail both sides. Coated steel girders. Assume coating area 7 sq ft per ft of girder.

Step 1 — Totals

Element	Total
12 Deck	$180 \times 36 = 6,480$ sq ft
510 Wearing surface (bare deck top)	$180 \times 34 = 6,120$ sq ft (per owner practice for bare decks)
107 Steel girder	$4 \times 180 = 720$ ft
515 Coating	$720 \times 7 = 5,040$ sq ft
300 Strip seal	$2 \times 36 = 72$ ft
310 Bearings	12 each
215 Abutments	$2 \times 36 = 72$ ft
234 Pier cap	36 ft
205 Columns	3 each
331 Railing	$2 \times 180 = 360$ ft

Step 2 — Observations

- Deck top: 300 sq ft of cracking in CS2 range; 80 sq ft of spalls with exposed rebar (CS3).
- Girders: coating failed at both abutment ends of all girders for 10 ft (8 girder-ends $\times$ 10 = 80 ft of girder); steel corrosion without section loss there (CS2). 6 ft of G1 at the south abutment has measurable section loss, no structural review warranted (CS3).
- Joints: north joint leaking full length (36 ft CS3); south joint good.
- Pier cap: an 8 ft long spall exposing rebar from an old impact (the bridge is continuous over the pier, so there is no joint there) — 8 ft CS3.
- Bearings: all good.

Step 3 — Distribution

Element	CS1	CS2	CS3	CS4
Deck top (510 wearing surface for bare deck, or deck per owner)	5,740	300	80	0
107 Girder	640	74	6	0
515 Coating	4,480	0	560	0
300 Joints	36	0	36	0
234 Pier cap	28	0	8	0
310 Bearings	12	0	0	0

Check: girder $640 + 74 + 6 = 720$ ✓; coating $4,480 + 560 = 5,040$ ✓ ($80 \text{ ft} \times 7 \text{ sq ft/ft} = 560 \text{ sq ft}$ failed); deck surface $5,740 + 300 + 80 = 6,120$ ✓.

Part N — Calibration and QC for element data

Element data are only as useful as they are consistent. Two inspectors looking at the same girder should produce similar distributions. Programs achieve consistency through:

- **Training on the MBEI definitions** with photo examples of each defect in each condition state.
- **Calibration exercises:** multiple teams inspect the same bridge independently and compare results; large differences point to definition misunderstandings.
- **Office QC:** automated checks for totals, units and changes between inspections, plus reviewer checks of photos against assigned states.
- **Field QA:** independent re-inspection of a sample of bridges.

Worked example 11 — Interpreting a calibration result

Three teams inspect the same 3,200 sq ft deck. CS3 quantities: Team A 150 sq ft; Team B 160 sq ft; Team C 900 sq ft. Team C counted all cracked areas with efflorescence as CS3 rather than CS2. The calibration session reviews MBEI definitions for cracking versus delamination/spall and the effect of efflorescence; Team C's understanding is corrected before they inspect the next set of bridges.

Part O — FAQ, glossary and summary

Do element data replace component ratings?

No. Both are required for applicable bridges; they serve different purposes.

Must every bridge have element data?

Federal requirements apply element data to NHS bridges, and the SNBI defines element data reporting; many owners collect element data on all bridges. Follow your owner's policy.

Can I create my own elements?

Owners can define agency-developed elements following MBEI conventions; individual inspectors use the owner's element list.

What if I can't see part of an element?

Record the limitation. Do not assume unseen quantities are CS1 without a note; follow owner guidance on how to code them.

Term	Meaning
Element	A defined bridge component with a unit of measure
Condition state (CS)	One of four levels: good, fair, poor, severe
Defect	A specific type of deterioration or damage recorded within an element
NBE / BME / ADE	National bridge element / bridge management element / agency-developed element

Term	Meaning
Protective system	Coatings, sealers or patina protecting an element; recorded separately

Key points

- Element data quantify how much of each element is in each condition state.
- Use MBEI units and definitions exactly; count overlapping areas once in the worst state.
- Record protective systems and wearing surfaces separately — they drive preservation.
- Element data and component ratings should tell a consistent story; the rating adds significance.
- Consistency over time is essential for deterioration modeling.

Part P — How management systems use your data

Most bridge management systems (for example, AASHTOWare BrM, which many States use) model element deterioration with transition probabilities: for each element and environment, the probability that a unit of quantity in one condition state moves to the next worse state in a given period. These probabilities are estimated from historical inspection data — your element quantities.

Worked example 12 — A simple deterioration projection

Assume (illustrative numbers only) that for a deck element in a given environment, over a two-year cycle, 8% of CS1 moves to CS2, 10% of CS2 moves to CS3, and 6% of CS3 moves to CS4. Start with a 3,200 sq ft deck at CS1 2,650 / CS2 400 / CS3 150 / CS4 0.

Cycle	CS1	CS2	CS3	CS4
Now	2,650	400	150	0
+2 yr	2,438	572	181	9
+4 yr	2,243	710	227	20

Calculation for the first step: CS1 loses $0.08 \times 2,650 = 212 \rightarrow 2,438$. CS2 gains 212 and loses $0.10 \times 400 = 40 \rightarrow 572$. CS3 gains 40 and loses $0.06 \times 150 = 9 \rightarrow 181$. CS4 gains 9.

The model then compares scenarios: patch and seal now (moving CS3 quantity back to CS1 and slowing CS1 $\rightarrow$ CS2) versus defer. The comparison only means something if the input data are consistent — which is why the quantity practices in this course matter.

Part Q — Case study: element data changing a decision

A district has two similar 1980s steel girder bridges, both with superstructure rated 6. Budget allows painting one this year.

Data	Bridge X	Bridge Y
Superstructure rating	6	6
Coating (515) CS3+CS4	8% of area	42% of area
Girder (107) CS2	5%	18%

Data	Bridge X	Bridge Y
Girder (107) CS3	0%	1%
Joints (300) CS3	0 ft	40 ft (both leaking)

The component ratings are identical, but the element data show bridge Y's coating has largely failed and steel corrosion is spreading, driven by leaking joints. The district repairs Y's joints and paints Y first; bridge X gets washing and spot treatment. Without element data, the decision might have been made on traffic volume or simply on which bridge was next on a list.

Wrap-up

Element-level inspection turns a bridge visit into a quantified condition profile that drives preservation, programming and modeling. Mastering the units, the condition-state definitions and disciplined quantity practice is what makes that profile trustworthy. Course BR-I05 covers the companion skill — consistent 0–9 component ratings.

Part R — Integrating NDE results into element data

Visual inspection sees the surface. For concrete decks especially, a large share of deterioration is hidden: delamination at the top mat of reinforcing under an overlay, or corrosion activity that has not yet cracked the cover. Nondestructive evaluation (NDE) — chain drag and hammer sounding, ground-penetrating radar (GPR), infrared thermography, impact echo, half-cell potential (ASTM C876) — can map these conditions.

How NDE results map to condition states

- Sounded or thermography-detected delaminations are recorded as delamination defect quantities in the appropriate condition state.
- GPR deterioration maps indicate likely corrosion-related deterioration zones; owners decide how to translate attenuation thresholds into element quantities, often with verification cores.
- Half-cell potentials indicate probability of active corrosion, not damage itself; they inform preservation timing rather than directly assigning condition states.

Worked example 13 — Updating a deck with NDE

Visual-only deck data: CS1 3,050 / CS2 120 / CS3 30 (underside observations). An infrared and GPR survey of the top of the deck (beneath the overlay) identifies 420 sq ft of delamination, verified by sounding through cores at three locations. Of that, 30 sq ft coincides with the area already in CS3 from below. Updated distribution: $CS3 = 30 + 390 = 420$; CS2 remains 120 (assume no overlap); $CS1 = 3,200 - 120 - 420 = 2,660$. Record the NDE method and date in the notes so later inspectors know why CS3 jumped — otherwise it looks like rapid deterioration in a deterioration model.

Part S — Photo standards for element inspection

Photos make element data verifiable. A practical photo standard:

Photo	When	Content
Bridge overview	Every inspection	Elevation and roadway views
Representative CS1/CS2	Every inspection, per element	Typical condition so trends can be compared

Photo	When	Content
CS3/CS4 areas	Every occurrence	Context photo + close-up with scale and location label
Changes since last inspection	When observed	Same angle as previous photo if possible
Access limitations	When applicable	Show what could not be reached

Name photos by element and location (e.g., "107_G1_S1_E-end_section-loss.jpg") so they can be matched to quantities later. Repeat-angle photos are especially valuable: placing this cycle's photo beside the previous one is the fastest way for a reviewer to confirm that a change in CS quantities is real.

Part T — Practice problems with answers

1. **A 40 ft prestressed box beam span has five beams. What is the element total?** $5 \times 40 = 200$ ft.
2. **A deck has 90 sq ft of spall that sits inside a 250 sq ft cracked area. How much goes in CS3 and how much in CS2 for those areas?** CS3 90 sq ft (the spall), CS2 160 sq ft (the remaining cracked area). Never count the 90 sq ft twice.
3. **A bearing is tipped beyond its design limits but still supporting the girder. Which state?** Usually CS3; CS4 if the inspector judges it warrants structural review, for example if loss of support is possible.
4. **Coating has failed on 15% of a 6,000 sq ft girder coating area, with active corrosion beneath. How many sq ft are in CS3 or worse?** 900 sq ft ($0.15 \times 6,000$), assigned per the protective-system definitions.
5. **The previous inspection showed CS3 = 40 ft on a joint. This cycle the joint was replaced. What happens?** The element is now CS1 for its full length; note the replacement date so the improvement is explained in the history.
6. **Why are condition states recorded on wearing surfaces separately from the deck?** Because overlays deteriorate and are replaced on their own cycle; mixing them with the structural deck would hide deck condition and distort deterioration models.
7. **The deck element shows 30% CS3, but the deck component rating is 7. What should the reviewer do?** Question the inconsistency. Widespread CS3 deterioration usually supports a lower rating, so either the quantities or the rating needs to be rechecked against photos and notes.
8. **An inspector cannot reach the bearings at the center pier. How should they be recorded?** Report the access limitation, use previous data or owner-directed coding as the policy requires, and recommend access (a lift or snooper) for the next inspection.

If you answered at least six correctly, you are ready for the course quiz. If not, review the earlier parts on units, condition-state definitions and quantity rules before you take it.

Common mistakes to avoid

- Totals that do not match the element quantity, often after a widening or a deck replacement that nobody updated in the inventory.
- Defaulting unseen areas to CS1 without any note.
- Copying last cycle's quantities forward when the field notes describe new damage.
- Recording a protective-system failure only on the steel element and leaving the coating element at CS1.
- Using the wrong units: linear feet for decks, or square feet for girders.
- Leaving no location detail, so the next inspector cannot find the CS3 area to compare it.

Each of these makes the data less useful to the management system and harder to trust in the next review. A quick self-check of totals and notes before you submit catches most of them. Many owners build these checks into their data-entry software, but the software can only flag arithmetic and missing fields. Whether a quantity is in the right condition state is still the inspector's judgment, backed by photos, measurements and clear notes that a reviewer can follow.

Key takeaways

- Element data is required on NHS bridges per MBEI 2nd Ed.
- NBEs, BMEs and ADEs; units of sq ft, ft or each.
- Four condition states: Good, Fair, Poor, Severe.
- Quantities in CS1–CS4 must sum to the element total.

References

1. AASHTO, Manual for Bridge Element Inspection, 2nd Edition, 2019
2. FHWA, Bridge Inspector's Reference Manual (BIRM), FHWA-NHI-12-049, 2012 (as revised)

Study text only; the final quiz is taken online. Verify all references against the edition your agency has adopted.