



PART 2

Read the text below and answer questions 14–26.

INNOVATIONS IN INSPECTION, REPAIR, AND RENEWAL

A

As infrastructure ages, the most valuable innovations are often those that shift timing: detecting defects earlier, intervening before damage cascades, and upgrading assets to extend service life without full replacement. This “prevention-first” logic is partly technical and partly managerial. It requires inspection regimes that reveal hidden deterioration, decision systems that prioritise scarce budgets rationally, and repair strategies that target known failure modes such as corrosion, fatigue cracking, and joint degradation. In practice, renewal increasingly depends on integrating civil engineering with data science, because the objective is not simply to fix what is broken, but to manage risk across thousands of assets under uncertainty.

B

Inspection is moving from occasional site visits toward instrumented, continuous monitoring. Drones can survey bridges, towers, and elevated rail lines without lengthy closures, while robots can crawl through pipes or confined spaces where humans cannot safely enter. Embedded sensors measure strain, vibration signatures, crack propagation, temperature, moisture ingress, and corrosion potential, creating real-time evidence of changing condition. This produces continuous streams of information rather than periodic snapshots. The promise is earlier intervention and more precise diagnosis, but the benefit is realised only if agencies have the staff, calibration routines, and analytical competence to interpret signals correctly. Otherwise, monitoring can generate “data noise” that overwhelms decision-makers, leading either to false alarms or to missed warning signs.

C

Because budgets rarely match the scale of need, analytics now plays a central role in deciding what to repair first. Agencies increasingly use risk models that combine an asset’s condition and usage with the consequence of failure, so that repairs are prioritised not only by deterioration but also by the harm that failure would create. A water main beneath a hospital corridor, for example, is treated differently from a similar pipe under a quiet street, and a bridge on an evacuation route receives more attention than a low-volume crossing. Yet algorithmic prioritisation can reproduce inequity if the underlying datasets reflect historical neglect. When inspection frequency, complaint records, or maintenance histories are thinner in poorer neighbourhoods, the model may mistakenly infer “lower risk” where risk is simply less measured. This is why technical optimisation



has to be paired with governance: agencies must audit their data inputs and explicitly correct for bias rather than assuming that historical records are neutral.

D

Repair materials and methods are evolving to slow deterioration without major reconstruction. Self-healing concrete, for instance, uses microcapsules or mineral reactions that seal microcracks when water enters, limiting pathways for chlorides and oxygen and thereby slowing reinforcement corrosion. Fibre-reinforced polymers can be used to wrap columns and beams, increasing confinement and strength with minimal added weight, which is particularly useful where geometric clearance is limited. For metal structures, advanced coatings reduce exposure to moisture and salts, while cathodic protection applies controlled electrical currents to slow the electrochemical reactions that degrade steel. These interventions do not eliminate the need for renewal, but they can convert rapid decline into manageable ageing, buying time for planned replacement instead of emergency repair.

E

Not all renewal is purely physical. Digital twins—virtual models that are continuously updated with sensor feeds and inspection records—allow engineers to simulate loads, test scenarios, and estimate remaining life under alternative maintenance strategies. When integrated with maintenance logs and environmental exposure data, a twin can reveal which interventions extend life most cost-effectively and can help schedule closures to minimise disruption. However, twins can also create a false sense of certainty if they are treated as objective truth rather than as models dependent on assumptions. They require ongoing data cleaning, software upkeep, and periodic validation against real measurements. If the model is poorly maintained or if the inputs are incomplete, a twin can become an expensive dashboard that visualises error rather than reducing it.

F

Innovation can also be organisational and financial. Some cities are shifting from short-term, project-by-project grants toward multi-year maintenance programmes that fund inspection, repair, and workforce training as one package. This approach recognises that preventive systems depend on human capacity: technicians must be trained to install and maintain sensors, engineers must be able to interpret data, and crews must be available to act quickly when early warnings appear. “Fix-it-first” policies similarly aim to stabilise budgets by prioritising existing assets over new expansion, reducing the political tendency to favour ribbon-cutting over upkeep. While these reforms may sound administrative, they can determine whether technical tools actually translate into reduced failure rates.



G

A further driver of renewal is climate resilience. Assets are increasingly being redesigned for higher temperatures, heavier rainfall, and saltwater exposure, including drainage improvements, redesigned foundations, and the elevation of critical equipment in flood-prone zones. Yet retrofitting is disruptive: lanes close, services are interrupted, and residents may experience immediate inconvenience for benefits that appear only years later. This time mismatch can weaken political support even when the technical case is strong. The most effective strategies therefore connect climate adaptation to transparent prioritisation, showing why certain projects must occur now to avoid larger losses later, and how renewal choices distribute costs and benefits across communities.

Questions 14–17

Choose the correct heading for each paragraph.

List of Headings

- i Why virtual modelling requires constant maintenance to stay reliable
- ii When optimisation inherits bias from earlier underinvestment
- iii Repair materials and methods that slow deterioration
- iv Instrumented monitoring and the shift from snapshots to continuous evidence
- v Climate adaptation as the only solution for infrastructure decline
- vi Using dashboards to replace physical inspection
- vii The claim that drones eliminate the need for skilled staff
- viii When cost-benefit rules ignore consequences of failure
- ix Materials innovation as a substitute for budgeting reform

14 Paragraph B

15 Paragraph C

16 Paragraph D

17 Paragraph E

Questions 18–22

Complete the summary below. Choose **NO MORE THAN TWO WORDS** from the text for each answer.



Modern approaches to infrastructure renewal

Modern monitoring creates continuous **18** of information rather than occasional inspections. Risk models weigh asset condition and usage against the **19** of failure. One technique, known as **20**, uses a regulated electrical current to limit chemical damage to steel. Engineers use digital **21** to test scenarios and estimate remaining life. If poorly maintained, these systems can become an expensive **22**

Questions 23–26

The text has seven paragraphs, **A–G**. Which paragraph contains the following information? Choose the correct letter, **A–G**. **NB** You may use any letter more than once.

23 The warning that algorithmic prioritisation can mirror past neglect because records are uneven across districts.

24 The example of multi-year programmes that fund both maintenance work and skills development.

25 The point that retrofitting for climate risks causes disruption now while benefits may appear much later.

26 The idea that prevention-first renewal depends on integrating engineering with data science for risk management.

Answer Key

14. iv

15. ii

16. iii

17. i

18. streams

19. consequence

20. cathodic protection

21. twins

22. dashboard

23. C



24. F

25. G

26. A