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Rehabilitation and Strengthening of Old Piles in Different Bridges in Jharkhand

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Abstract

A significant portion of Jharkhand's bridge stock predates modern design, construction, and durability standards. Aging pile foundations are increasingly exposed to higher monsoon discharges, local scour aggravated by sediment mining, abrasion from bed-load, and material degradation. This paper presents a practical, step-by-step framework for assessing, rehabilitating, and strengthening existing bridge piles in Jharkhand. It synthesizes current Indian and international practice into a workflow covering diagnostics, option development (jacketing, micro- piles, foundation enlargement, cathodic protection, and scour countermeasures), design checks, construction methods, quality assurance, risk management, and lifecycle considerations. The focused scenarios illustrate the approach for finding crakes. Deep inspection of Piles and pile caps in bridges, stiff movement in bearings.

Keywords: Bridge rehabilitation, pile strengthening, scour, jacketing, micro- piles, underwater concreting, bearings, lifecycle costing.

1. Introduction

Jharkhand's road network spans plateau terrain cut by alluvial river valleys (e.g., Subarnarekha, Damodar, Koel, Barakar). Many bridges were founded on bored cast- in- situ RCC piles or well foundations designed to historical hydrology and scour estimates. Over the last two decades, changing flood regimes, riverbed degradation from sand mining, and heavier vehicular loads have increased distress in substructures and foundations. Rehabilitation of old piles—rather than full replacement—can often be the most economical and least disruptive path if integrity and capacity can be assured.

This paper focuses on RCC pile foundations supporting simply supported and continuous girder bridges prevalent on state and national highways in Jharkhand. Recommendations target owners (Road Construction Department, SHAJ), consultants, and contractors preparing DPRs, repair designs, and method statements.

2. Common Distress Mechanisms in Existing Piles

1. **Hydraulic actions**
   - **General and local scour** at piers and abutments lowering effective embedment; exposure of pile groups; undermined pile caps.
   - **Abrasion and impact** from bed-load, boulders, floating debris during spates.
2. **Material degradation**
   - **Carbonation, chloride/sulfate ingress**, leading to reinforcement corrosion; cracking, spalling; loss of section.
   - **Alkali–silica reaction (ASR)** and freeze–thaw are less common but should be screened, especially in older mixes.
3. **Construction defects / aging**
   - Honeycombing, necking, segregation; defects at cold joints or at the toe from improper tremie operations.
   - Low cover and poor compaction leading to early corrosion in the splash zone.
4. **Geotechnical issues**
   - **Settlement / lateral spreading** due to local liquefaction-prone layers or softening of clays.
   - **Negative skin friction** from consolidating backfill.
5. **Demand-side changes**
   - **Higher traffic loads**, widened carriageways, seismic detailing gaps in older assets.

3. Condition Assessment & Investigation Methodology

3.1 Desk Study and Risk Screening

- Collect drawings, as- built pile records, geotechnical reports, historical HFLs, flood/siltation records, traffic projections, and any earlier repair dossiers.
- Screen the bridge with a risk matrix considering age, waterway geometry, river behavior, and visible signs of foundation distress (cracks, settlement, tilt, vibration, unusual expansion joint movements).

3.2 Field Reconnaissance and Visual/Underwater Inspection

- **Pier, pile cap, and exposed pile** survey for spalling, corrosion, abrasion, impact damage.
- **Underwater inspection** using trained divers or ROVs; measure remaining cover, pitting, marine growth, and defects; photo/video log.
- **Hydrographic/bathymetric survey** to map thalweg position, scour holes, and compare with previous campaigns.
- **River hydraulics**: cross- sections, velocities, bed material sampling (D50/D84), bank conditions.

3.3 Geotechnical & Hydrological Investigations

- **Boreholes** near piers to refusal; SPT/CPT, undisturbed sampling for lab tests (shear strength, compressibility, sulfate/chloride content, resistivity).
- **Scour assessment** (design / check) for current waterway using codal procedures; determine design scour level and required embedment.

Figure no 3.1. Damodar bridge in Bokaro district

INSPECTION & TESTING REPORT, BRIDGE "Inspection of Damodar Bridge as major bridges for assessment of effects, damages and deficiencies including in-depth inspection of Bearings, Expansion Joints and other deterioration of concrete surfaces Inspection of pavement quality and estimation of repair works required for major bridge, Approach Road, Service Road and cross road at the bridge. Damodar Bridge (Length of Bridge 6 x 24m) & preparation of Detail Project Report & Detail Estimate regarding repair, rehabilitation and strengthening of the bridge over Damodar river near PO Office Ashok OCP under Piparwar area, Ranchi district in Jharkhand state Submission of report summarizing all the findings and observations as mentioned above.

3.4 Non- Destructive Testing (NDT) and Load Testing of Piles

- **Low- strain integrity (PIT/SE)** on accessible piles to screen for major defects, necking, or pile length anomalies.
- **Crosshole Sonic Logging (CSL)** for cast- in- situ piles with installed access tubes; tomographic analysis where indicated.
- **High- strain dynamic testing (PDA)** on select piles to estimate capacity distribution (shaft/toe) and structural integrity; consider **static load testing** where feasible for calibration.
- **Rebar corrosion mapping & cover survey** on exposed sections; half- cell potential and resistivity.

3.5 Data Synthesis and Load Rating

- Establish **as- is capacity** (axial compression/tension, lateral, and combined) at pile and pile- group levels using site- specific soil parameters.
- Evaluate **demand**: factored DL + LL combinations, braking, collision forces, streamflow- induced hydrodynamic loads, and seismic.
- Identify **capacity shortfalls** or durability triggers that require intervention.

4. Strategy Selection: Repair vs Strengthening vs Enlargement

The following factors might necessitate the strengthening and repair during the life time of a bridge.

1. Increase in the traffic load and intensity
2. Damage and loss of cross section due to environmental attacks, e.g. corrosion
3. Damage due to fatigue
4. Change in the design codes
5. Errors in design of the structure
6. Errors in construction of the structure
7. Additional safety requirements
8. Improving traffic conditions, for example changing the geometry and increasing clearances
9. Environmental concerns.

4.1 Decision Framework

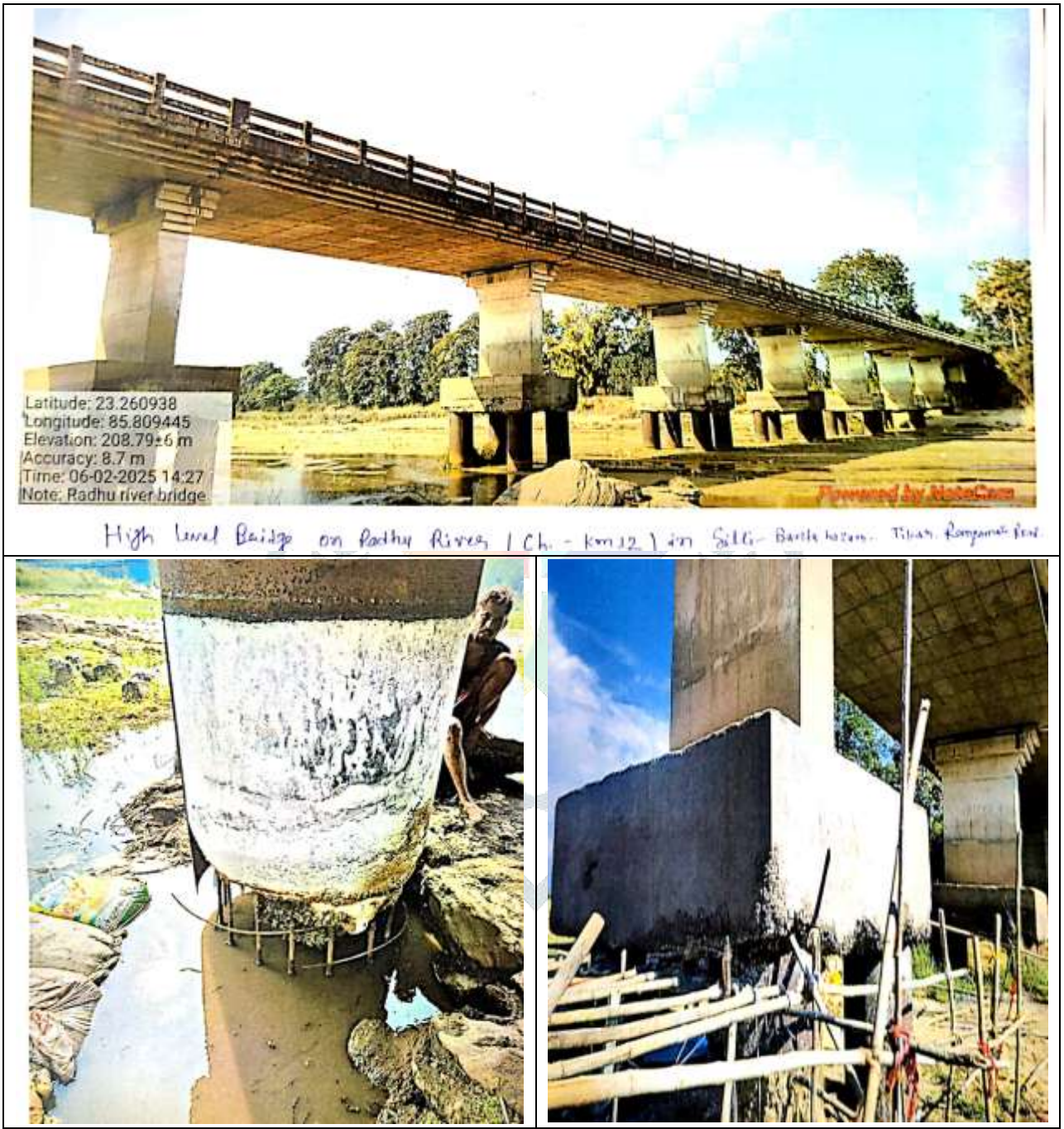
1. **Durability repair only** (no capacity deficit): surface patching, crack injection, coatings, cathodic protection, sacrificial anodes.
2. **Member- level strengthening**: jackets (RCC/steel/FRP), collars in splash or below waterline; confinement to restore or enhance axial and flexural capacity.
3. **Foundation- level upgrade**: micro- piles tied into an enlarged pile cap, underpinning, or new auxiliary piles/columns bridged to existing cap.
4. **Hydraulic countermeasures**: rip- rap/launching aprons, gabions, spurs/guide bunds, sheet- pile cut- offs, collar- type scour arrestors, bed armoring.

Figure no 4.1. Khuti bridge in Khuti district

INSPECTION & TESTING REPORT, BRIDGE "Inspection and testing of major bridges

for assessment of effects, damages and deficiencies including in-depth inspection of Bearings, Expansion Joints and other deterioration of concrete surfaces Inspection of pavement quality and estimation of repair works required for major bridge, Approach Road, Service Road and cross road at the bridge. Submission of report summarizing all the findings and observations as mentioned above.

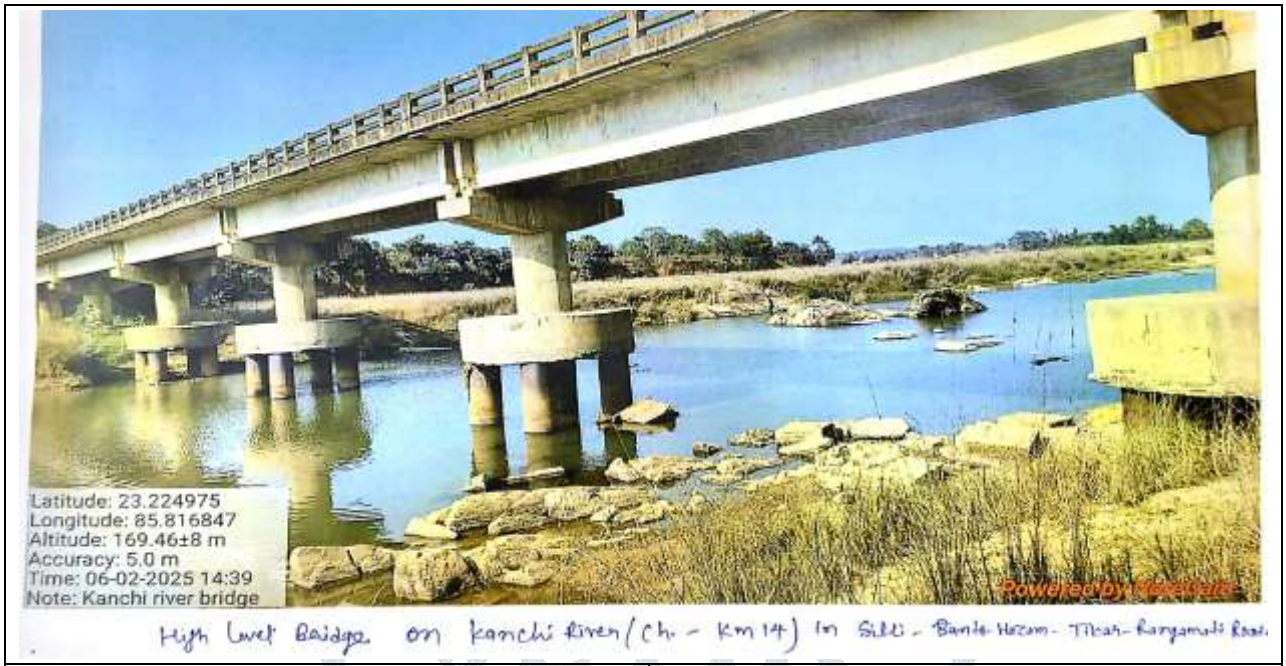
Figure no 4.3. Radhu River bridge in Ranchi Jharkhand

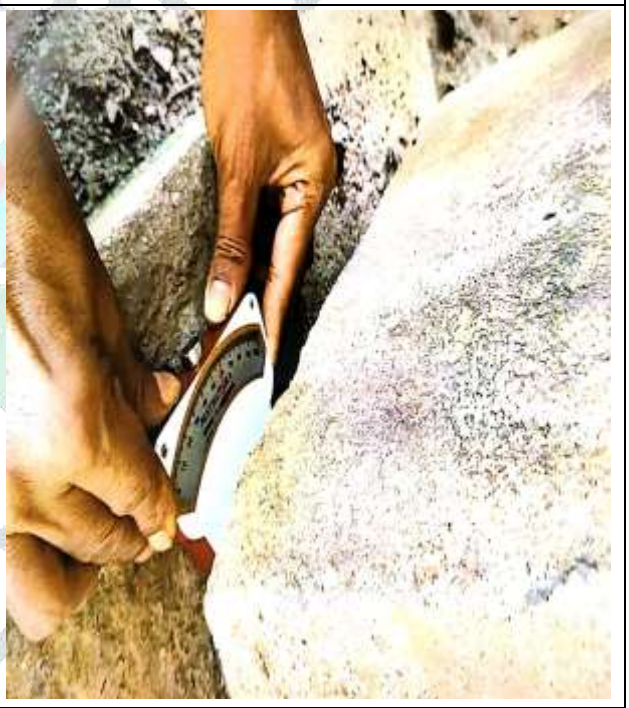


INSPECTION REPORT: "Inspection and testing of major bridges for assessment of effects, damages and deficiencies including in-depth inspection of Bearings, Expansion Joints and other deterioration of concrete surfaces Inspection of pavement quality and estimation of repair works required for Radhu river bridge, the slab of bridge is fully damaged the effective cover of the slab and piles are fully damage, the reinforcement in the piles are almost at severe condition hence diagnosis required. The Submission of report summarizing all the findings and observations as mentioned above in figure no

4.3.

Figure no 4.4. Kanchi River bridge in Ranchi Jharkhand





INSPECTION & TESTING REPORT, BRIDGE "Inspection and testing of major bridges for assessment of effects, damages and deficiencies including in-depth inspection of Bearings, Expansion Joints and other deterioration of concrete surfaces Inspection of pavement quality, repair works required for Bridge Bearings, Most of the piles and pile caps are damage and top of the shaft cap were found with multiple crack in the bridge. Submission of report summarizing all the findings and observations as mentioned above.

4.2 Typical Solutions and Design Notes

- **RCC Jacketing** (circular or rectangular):
  - Increases confinement and section; suitable for abrasion zones and moderate corrosion.
  - Detailing: shear connectors/dowels, continuous transverse reinforcement (close spacing), tremie- placed micro- concrete; maintain minimum cover and durable binder systems.
- **Steel Jacketing / Clamp Jackets**:
  - Rapid installation; good for tidal/splash zones; require corrosion protection (metalizing, epoxy/PU systems) and periodic maintenance.
- **FRP Composites** (wraps or stay- in- place jackets):
  - High corrosion resistance and rapid curing; effective for confinement and to seal cracks; design for axial- flexural interaction; ensure UV protection above water and long- term bond under wet service.
- **Collars and Pile- shoe Extensions** at the bed level to mitigate local scour around individual piles.
- **Micro- piles (≥100–250 mm dia)** and **cap enlargement**:
  - Effective when global capacity is deficient or when scour has reduced fixity/embedded length; design for group action and compatible stiffness; consider drilling through existing cap with post- grouting.
- **Underpinning/New Auxiliary Piles** tied via capping beams when pile groups are compromised.
- **Cathodic Protection (ICCP/Galvanic)** for severe corrosion environments; alternative is corrosion inhibitors and re- alkalization treatments.
- **Grout Injection** (cement/microfine/chemical) to seal voids, improve surrounding soil, or restore section under jackets.
- **River Training & Bed Protection**: guide bunds, spurs, bank revetments, and launching aprons designed for site hydraulics; armor sizing from bed material and design velocity.

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5. Design Checks and Detailing Essentials

- **Load combinations and factors** consistent with relevant bridge design codes; check **ultimate** and **serviceability** states for axial, lateral, and combined actions.
- **Jacket design** for confinement (hoop stress), axial load sharing, and bending; ensure development length of dowels and adequate shear transfer at interfaces (use of epoxy bonding agents and shear keys).
- **Durability**: minimum cover, sulfate- resistant cement where needed, low w/c ratio, air- entrainment if exposure warrants, and protective coatings in splash/atmospheric zones.
- **Seismic**: improve ductility with close stirrup spacing in plastic hinge zones; check group fixity in soils susceptible to strength loss.
- **Scour resilience**: confirm embedment and fixity depth post- rehabilitation; design armoring and aprons to self- launch to the maximum predicted scour depth.
- **Constructability**: cofferdams vs. dry work; tremie concreting procedures; access for divers/ROVs; staging and traffic management.

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6. Construction Methodology and QA/QC

6.1 Site Preparation and Temporary Works

- Seasonal planning to avoid peak monsoon; cofferdams/sheet- piles with adequate embedment; dewatering plan; diversion bunds as needed.
- Working platforms, barge access, safety zones, and navigation control.

6.2 Jacketing Works (RCC/Steel/FRP)

- **Surface preparation**: remove loose concrete, marine growth; grit blasting; expose sound substrate and reinforcement; treat corrosion; replace missing bars with couplers where practical.
- **Formwork/jacket system**: circular split forms or prefabricated stay- in- place jackets; seal joints for underwater concreting.
- **Shear connectors**: stainless/epoxy- coated anchor studs or dowels; proof pull- out tests.
- **Placement**: pumpable micro- concrete or tremie concrete; continuous pour; monitor rise in formwork; temperature control for mass effects.
- **Curing & Protection**: wet cure where possible; apply protective coatings above water; ensure UV shield for FRP.

6.3 Micro- piles and Cap Enlargement

- **Drilling** through/around existing cap with minimal vibration; casing where needed; post- grouting to mobilize bond.
- **Reinforcement**: threaded bars/tubes as per design; corrosion protection systems for permanent micropiles.
- **Load testing**: proof tests on a percentage of micro- piles; verification tests per project specs.
- **Cap works**: staged enlargement with dowel connection to existing cap; ensure adequate development and shear friction checks.

6.4 Scour and River Training Works

- **Bed armoring**: graded rip- rap with filter/geo- textile and launching aprons; underwater placement by tremie baskets or GPS- guided dump.
- **Bank protection**: gabions/fascia pitching; spurs/guide bunds per hydraulic model where warranted.

6.5 QA/QC and Acceptance

- Inspector checklists for pre- pour, during pour, and post- pour; cube/cylinder tests; core extraction where specified.
- NDT/monitoring: repeat PIT/CSL on rehabilitated elements where applicable; corrosion probes; bathymetry re- survey post- works.

6.6 Health, Safety, and Environment (HSE)

- Diving standards and permits; standby rescue; turbidity control; spill containment; noise and dust management; safe lifting and barge operations.

7. Two Jharkhand- Focused Scenarios (I

Scenario A: Scour- Compromised Pile Group on a Plateau River

- **Context**: Two- lane simply supported RCC girder bridge over a steep- gradient tributary with boulder bed; post- monsoon survey shows 1.5–2.0 m deeper thalweg with exposed pile cap toe.
- **Diagnostics**: Bathymetry confirms local scour; PIT indicates intact piles; corrosion minimal.
- **Intervention**: Install collar at bed level around each pile; RCC jacket for abrasion resistance over 2 m height; launching apron of graded rip- rap (with filter) designed to the predicted maximum scour; periodic hydrographic monitoring.

Scenario B: Capacity Upgrade for Widening on Alluvial River

- **Context**: Widening from 2- lane to 4- lane on a meandering alluvial reach; existing pile group lacks axial reserve for added dead/live loads.
- **Diagnostics**: CSL reveals acceptable shaft; PDA shows marginal capacity; soils permit micro- piles.
- **Intervention**: Cap enlargement with 8–12 micro- piles per pier tied into new cap; targeted FRP confinement on splash- zone segments; bank revetment to stabilize approach embankments.

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8. Procurement, Specifications, and Measurement

- Include performance- based durability targets (cover, permeability, chloride threshold) and method statements for underwater concreting, jacketing, and micro- pile drilling.
- Specify pre- qualification of diving subcontractors and NDT agencies; require test plans (ITP) and sample NDT reports.
- **Measurement & Payment** examples:
  - RCC jacketing: per square metre of finished surface including shear connectors, formwork, micro- concrete, and coatings.
  - FRP wraps/jackets: per metre height per pile including surface prep and resin systems.
  - Micro- piles: per running metre in strata with separate items for drilling, casing, grouting, reinforcement, and testing.
  - Rip- rap and launching aprons: per cubic metre including filter layers and placement.

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9. Lifecycle, Cost, and Risk Management

- Compare do- minimum, repair, strengthening, and replacement on NPV and whole- life carbon basis.
- Plan inspection intervals (annual visual, post- monsoon bathymetry, detailed underwater every 5 years or after major floods).
- Maintain a risk register: flood exceedance, cofferdam instability, underwater concreting defects, traffic incidents, supply chain for specialized jackets/FRP, and monsoon stoppages.

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10. Conclusions

Rehabilitation and strengthening of old bridge piles for Damodar river bridge, Khuti bridge, Radhu bridge & Kanchi river Bridge in Jharkhand demands a hydraulics- aware, geotechnically sound, and construction- practical approach. In inspection of major bridges for assessment of effects, damages and deficiencies including in-depth inspection of Bearings, Expansion Joints and other deterioration of concrete surfaces Inspection of pavement quality, repair works required for Bridge Bearings, most of the piles and pile caps are damage and top of the shaft cap were found with multiple crack in the bridge. Minor settlement (~20 mm) observed at right approach, the longitudinal cracks in approach road pavement were found, Wing walls intact, slight erosion near right-side retaining wall, fair condition, rutting visible near expansion joints, Hairline cracks at different piers & shaft, spalling at abutments.

The workflow presented—starting from disciplined diagnostics through judicious selection of jacketing, micro- piles, cathodic protection, and river training—offers owners and engineers a predictable path to safe, durable service life extension, with measured costs and manageable risk.

Appendices

Appendix A – Investigation & Data Checklist

- Drawings, as- builts, pile logs, concrete mix details, rebar schedules.
- Historic HFLs, discharge series, sediment sizes, river training works history.
- Visual/underwater inspection sheets with photo logs.
- Bathymetry (pre- and post- monsoon) and cross- sections.
- Borehole/CPT logs; chemical tests (chloride, sulfate), resistivity.
- NDT plans and reports (PIT/CSL/PDA), static load test results if any.

Appendix B – Typical Detail Notes (Jacketing & Cap Enlargement)

- Minimum cover; stirrup spacing; shear connector spacing and edge distances.
- Formwork sealing and concrete rise vents for underwater pours.
- Dowel lengths and development; epoxy bonding and surface roughening class.
- Galvanic anode locations for localized cathodic protection.

Appendix C – Specimen BoQ Skeleton (to be adapted)

1. Cleaning, surface preparation and removal of unsound concrete (m^2)
2. Corrosion treatment of reinforcement (kg/m^2)
3. RCC jacketing with micro- concrete, including shear connectors and formwork (m^2)
4. FRP composite wrapping/jacket (m)
5. Steel clamp jacket, fabricated and installed (m)
6. Micro- piles: drilling, reinforcement, grouting, and testing (m)
7. Pile cap enlargement (m^3)
8. Rip- rap/launching apron with filter layers (m^3)
9. Gabion revetment (m^3)
10. Underwater inspection and videography (l.s.)
11. Cofferdam/sheet- piling and dewatering (l.s.)
12. Bathymetric surveys (pre- and post- works) (l.s.)

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References to IRC Codes & Standards

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2. **IRC:SP:40** – Guidelines on Repair, Strengthening and Rehabilitation of Concrete Bridges.
3. **IRC:SP:51** – Guidelines for Load Testing of Bridges.
4. **IRC:83 (Part I & II)** – Code of practice for road bridges (bearings).
5. **IRC:78** – Road Bridge Code (Foundations and Substructures).
6. **IRC:89** – Guidelines for Design and Construction of River Training and Control Works.
7. **IRC:SP:37** – Guidelines for Evaluation of Load Carrying Capacity of Bridges.
8. **IRC:112** – Code of Practice for Concrete Road Bridges.
9. **MoRTH Specifications** – Sections on maintenance, rehabilitation, and repair materials.