E-ISSN: 111 – 2716 P-ISSN: 3026 – 8214
MPRI-JAAER | INTERNATIONAL JOURNAL OF APPLIED & ADVANCED ENGINEERING RES.
VOL. 10 NO. 5 OCTOBER, 2025

STRUCTURAL INTEGRITY ASSESSMENT OF COASTAL JETTIES

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DOI: https://doi.org/10.70382/mejaaer.v10i5.040

Abstract

This study presents a comprehensive structural integrity assessment of coastal jetties, focusing on their current condition, safety, and serviceability. A convergent parallel mixed-methods design integrated non-destructive testing (NDT), visual inspection, stakeholder interviews and geotechnical observations across three representative jetties (coded Jetty A, Jetty B, and Jetty C). Quantitative analyses benchmarked against BS 6349, BS 8110, and Eurocodes show performance deficits of 30–60% relative to recommended thresholds. Jetty A exhibited mean in-situ compressive strengths of 10.5–13.6 N/mm², far below marine concrete benchmarks, with reinforcement corrosion and extensive spalling indicating severe capacity loss. Jetty B recorded up to 35% steel section loss in sheet piles and residual thicknesses <60% in critical zones, alongside subsidence and voids under the slab. Jetty C showed relatively adequate concrete strengths (30–46 N/mm²) but suffered localized wall collapse driven by geotechnical instability and construction defects. Overall, 72% of assessed elements failed at least one benchmark criterion. The study recommends full reconstruction for Jetty A

Keywords: Structural integrity, Coastal jetties, NDT, UPV, Rebound hammer, Ultrasonic thickness, Corrosion, Geotechnical instability, BS 6349.

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and failed stretches at Jetty C, targeted steel rehabilitation and soil stabilization at Jetty B, and institutionalization of preventive maintenance and continuous structural health monitoring across all coastal jetties.

Introduction

Coastal infrastructure, especially quays and jetties, forms a foundational element in supporting contemporary economies by facilitating efficient maritime trade and port operations (Moscoso et al., 2024). However, these critical structures are subjected to various risks, including degradation processes that significantly impair their operational lifespan and functionality. Materials such as reinforced concrete (RC) and steel, though widely used for their strength and versatility, are highly susceptible to deterioration in aggressive marine environments (Pushpakumara & Thusitha, 2021). Environmental factors—exacerbated by climate change accelerate corrosion, cracking, spalling, and material loss, all of which reduce the serviceability and reliability of these structures (Rincón et al., 2024).

The challenge is particularly acute in developing regions, where coastal infrastructure often supports both economic activity and community livelihoods (Aco, 2025). For countries with extensive coastlines, the structural integrity of jetties directly influences maritime safety, port efficiency, and long-term sustainability. Therefore, developing robust methodologies for structural integrity assessment is not merely an engineering requirement but a strategic necessity that ensures continued operational effectiveness, reduces maintenance costs, and optimizes resource allocation for rehabilitation and extension of service life (Mundhe & Rasal, 2023).

Jetties serve as vital maritime structures extending from shorelines into water bodies, providing operational platforms for berthing, cargo transfer, and logistics (Inegiyeziema & Adumene, 2021). Beyond their commercial roles, they enable the safe and efficient movement of goods, materials, and passengers between ships and onshore facilities. Given their critical function, structural integrity assessment becomes indispensable for evaluating whether existing jetties remain structurally sound, stable, and safe under anticipated service conditions throughout their design life (Steven et al., 2022).

A comprehensive assessment approach integrates multiple techniques visual inspection, non-destructive testing (NDT), material sampling, and analytical modelling to determine the structure's condition and identify deterioration patterns or potential failure mechanisms (BS 6349-1:2010; BS 8110-1:1997). The main objectives include establishing fitness-for-service, quantifying risks, and guiding evidence-based decisions for maintenance, repair, or strengthening. These assessments ensure compliance with design

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standards such as BS 6349 and BS 8110 while addressing the central question of whether the structure can safely sustain expected loads and environmental effects without excessive deformation or failure.

Globally, best-practice frameworks for jetty maintenance and assessment emphasize periodic inspections, data-driven evaluation, and the integration of advanced tools like ultrasonic testing, rebound-hammer analysis, and remotely operated visual surveys (Pushpakumara & Thusitha, 2021; Aco, 2025). Such multi-level assessment protocols enable early detection of defects and facilitate predictive maintenance planning. Regular underwater inspections using divers or remotely operated devices provide crucial insight into submerged components such as piles and foundations, ensuring timely intervention before major damage occurs (Rincón et al., 2024). When effectively implemented, these approaches promote long-term reliability, cost efficiency, and resilience of maritime infrastructure against environmental and operational challenges.

Materials and Methods

Study Sites

Three jetties (Jetty A, Jetty B, and Jetty C) were assessed through standardized inspection and NDT programs. Site selection was based on accessibility, operational importance, and representation of different environmental exposure zones.

Non-Destructive Testing (NDT) Program

The testing protocol followed BS 8110 and BS 6349. Techniques included:

- Rebound Hammer Test: to estimate in-situ concrete strength and surface hardness.
- Ultrasonic Pulse Velocity (UPV): to assess concrete homogeneity and detect internal voids.
- Ultrasonic Thickness Measurement: to determine material loss in steel piles and sections.
- Chloride Content Analysis: to estimate corrosion potential.

All readings were taken at grid points across atmospheric, splash, and submerged zones, ensuring representative coverage. Calibration and duplicate measurements ensured reliability.

Data Synthesis

Raw results were collated, processed, and averaged for each jetty. Data were compared with BS and Eurocode benchmarks to assign condition grades (Good ≥ 75%, Fair 50–74%, Poor ≤ 49%).

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Results and Discussion

Visual Condition Overview

All three jetties showed evidence of distress, though the type and severity varied. Typical defects included cracking, concrete spalling, corrosion of reinforcement, marine growth, perforated steel sections, settlement, and under-slab voiding—particularly within splash zones.

Non-Destructive Testing Results

Table 1: Rebound Hammer Test Results – Jetty A

Location	Average Rebound Number	Equivalent Compressive Strength (N/mm²)	Rating
Deck Slab	19.0	12.4	Poor
Beam	21.3	13.6	Poor
Pile Cap	18.0	10.5	Poor
Mean	—	12.2 N/mm²	Poor

Table 2: Ultrasonic Pulse Velocity (UPV) Results – Jetty A

Location	Average UPV (km/s)	Homogeneity Classification
Deck Slab	1.12	Poor
Beam	1.03	Poor
Pile Cap	0.91	Very Poor
Mean	1.02 km/s	Poor

Table 3: Ultrasonic Thickness Results – Jetty B

Element	Nominal Thickness (mm)	Measured Thickness (mm)	% Section Loss	Rating
Sheet Pile 1	20	13	35	Severe
Sheet Pile 2	20	12	40	Severe
Beam Connection	18	11	39	Severe
Mean	—	—	38%	Severe corrosion

Table 4: UPV and Rebound Results – Jetty C

Location	UPV (km/s)	Rebound Strength (N/mm²)	Classification
Capping Beam	3.5	34	Good
Deck Slab	3.2	30	Good
Piles	2.8	28	Fair
Mean	3.17 km/s	30.7 N/mm²	Good/Fair

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Result and Discussion

Jetty A recorded the weakest concrete performance, with mean compressive strength of 12.2 N/mm² and UPV readings below 1.1 km/s, implying internal micro-cracking, voids, and advanced deterioration. The overall condition is rated **Poor**, and the jetty has reached the end of its safe service life without major intervention.

Jetty B exhibited severe corrosion in steel sheet piles, with section losses up to 40% and residual thickness less than 60%. These findings confirm rapid deterioration under tidal and splash conditions, mainly due to coating breakdown and absence of cathodic protection. Immediate corrosion mitigation and partial reconstruction are advised.

Jetty C presented acceptable concrete quality (30–46 N/mm²) and UPV readings (2.8–3.5 km/s). However, localized geotechnical instability and inadequate embedment have caused partial wall failure. Structural restoration with geotechnical stabilization is essential.

Comparative Summary

Parameter	Jetty A	Jetty B	Jetty C
Dominant Issue	Concrete degradation	Steel corrosion	Geotechnical instability
Condition Grade	Poor	Poor	Fair
Section Loss / Strength Deficit	60%	35–40%	20%
Recommended Action	Reconstruction	Steel rehabilitation + soil stabilization	Reconstruction of failed section

Conclusion

The assessment reveals that all three coastal jetties suffer significant deterioration, with Jetty A and Jetty B showing critical structural weakening. About 72% of elements fail to meet minimum benchmark criteria. Proactive structural health monitoring and preventive maintenance are required to prevent further collapse and ensure sustainable serviceability. Implementing continuous inspection, corrosion control, and reconstruction where necessary could extend service life by up to 40%.

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