# Marine Infrastructure Needs Lasting Durability, Not Repeated Repair Cycles.


A strategic technical white paper on ***Steelike UHPC (Ultra High Performance Composite)*** for durability-led rehabilitation, lifecycle extension and operational continuity in marine, coastal and dual-use critical infrastructure.

# Contents

# 1. Executive Summary

**CNT Plus,** powered by **STEELIKE**, is the authorised EU platform for **Steelike UHPC**. This white paper positions **Steelike UHPC** as a targeted infrastructure resilience system for marine, coastal, and dual-use critical infrastructure, with an emphasis on durability-led rehabilitation, lifecycle extension, and operational continuity.

Ports, quays, coastal terminals, Ro-Ro ramps, access bridges and marine logistics assets are exposed to a degradation environment that combines chlorides, salt water, wet-dry cycles, abrasion, impact, freeze-thaw action and heavy operational loading. In these conditions, the strategic issue is not only structural capacity at handover. It is the ability of an asset to remain available under long-term exposure.

Conventional repair logic often treats deterioration as a discrete event. Marine infrastructure rarely behaves that way. The more common pattern is a recurring cycle: ingress, corrosion, cracking, local failure, repair, operational restriction and renewed degradation. The cost of the material is only one component. The higher operational costs are often downtime, reduced berth capacity, constrained terminal throughput, repeat mobilisation, and risk to continuity.

Steelike UHPC should therefore be evaluated not as a generic, stronger material, but as a high-performance composite system for zones where exposure severity, repair frequency, and downtime consequences justify a higher-performance rehabilitation strategy. The objective is targeted use, not universal adoption.

| Decision question | White paper position |
|---|---|
| **What is the infrastructure problem?** | *Marine assets degrade under combined chemical, mechanical and operational exposure while remaining critical to logistics capacity.* |
| **Why do conventional repairs struggle?** | *They may restore local geometry or strength but fail to sufficiently reduce ingress, abrasion and repeated intervention cycles.* |
| **Which Steelike parameters matter?** | *High compressive strength, dense-matrix behaviour, low absorption, chloride resistance, freeze-thaw durability, bond potential, and suitability for rapid return to service.* |
| **What is the operational impact?** | *Reduced repair frequency, shorter intervention windows, lower downtime exposure and stronger asset availability planning.* |
| **What is the lifecycle advantage?** | *Evaluation shifts from initial repair cost to lifecycle value, service interval extension and continuity of critical operations.* |
| **Where is validation required?** | *Every structural, defence-adjacent, coastal, or high-load application requires project-specific engineering design, testing, approvals, and, where applicable, certification.* |

***For port infrastructure, availability is capacity. For critical logistics, availability is continuity. For military mobility, availability is readiness.***

## 2. Infrastructure Problem: Marine Assets Degrade as Operational Systems

Marine infrastructure ages differently from most inland assets. Road slabs, industrial floors, and other inland structures primarily experience structural loads and environmental exposure. A quay wall, berth edge, Ro-Ro ramp, port pavement, coastal bridge, breakwater, or exposed marine asset works under structural loads, salt, moisture, chlorides, abrasion, impact, wet-dry cycles, freeze-thaw exposure, and continuous operational pressure.

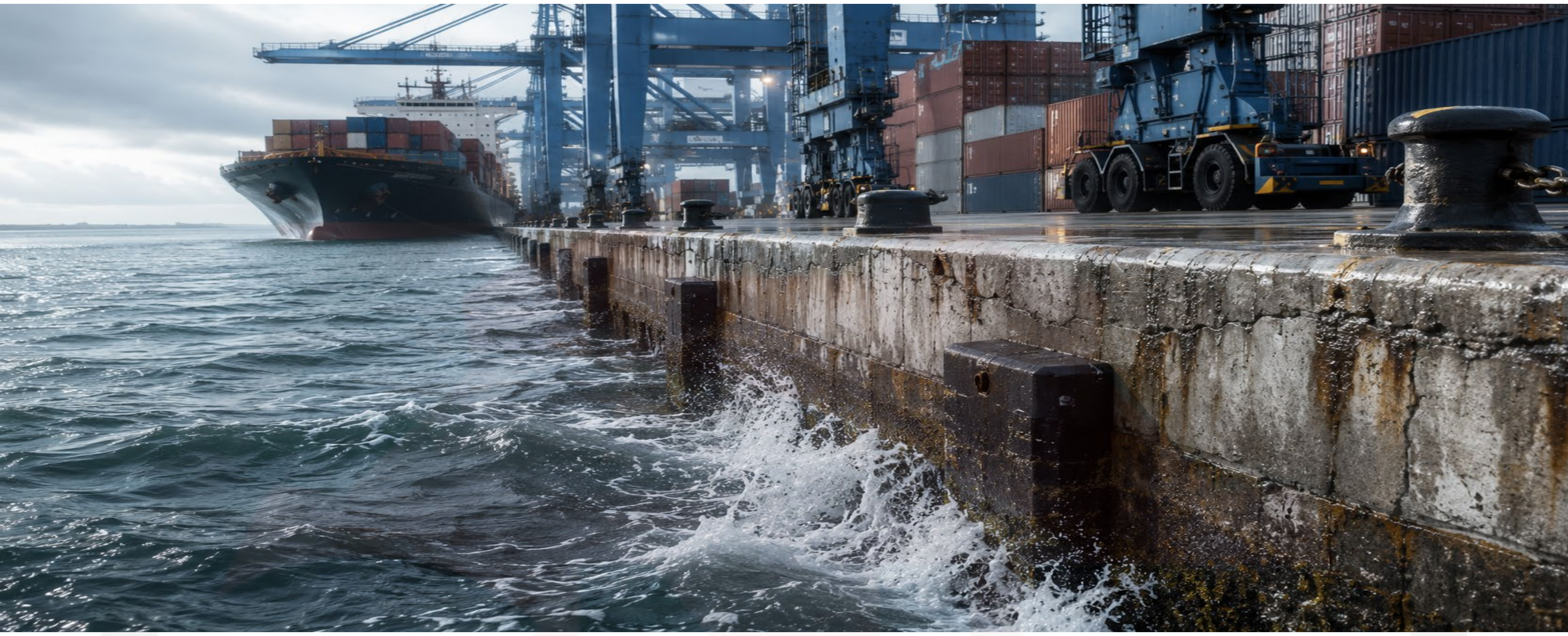
The technical risk is cumulative. Chloride ingress and moisture movement initiate durability-driven deterioration. Abrasion and impact accelerate surface loss. Heavy vehicles, container-handling equipment, and concentrated wheel loads increase fatigue and local stress demands. Operational availability requirements reduce the repair time window and increase the consequences of each intervention.

The result is a recurring degradation cycle rather than a single failure event. A repair that restores damaged concrete without materially changing exposure resistance may simply reset the clock until the next repair campaign.

### The asset-management problem

**Port infrastructure is not passive civil inventory.** It is an operating system for trade, energy, defence logistics, industrial supply chains and regional economic continuity. If a berth edge, loading slab, ramp, bridge approach, or terminal route is partially unavailable, the consequences extend beyond repair costs. It can affect vessel scheduling, terminal throughput, cargo movement, safety planning, emergency response and military mobility.

Accordingly, the repair question should not be limited to "How much does the repair cost?" The more useful question is: How much does the next repair cycle cost when downtime, repeat mobilisation, restricted capacity and risk to continuity are included?



## 3. Why Conventional Repair Logic Struggles in Marine Exposure

Many repair strategies are technically valid in moderate environments, but become less effective in assets exposed to high chloride loading, abrasion, mechanical damage and limited closure windows. In such environments, the primary challenge is not only restoring strength. It is reducing the drivers of future degradation.

Conventional materials and repair methods may struggle when the deterioration mechanism is dominated by permeability, chloride ingress, poor bond at the repair interface, differential movement, abrasion loss, thin cover, inadequate curing windows or repeated impact. A repaired area can quickly become the next weak point if the repair material does not address exposure, interface performance and operational demand together.

In marine and coastal assets, compressive strength alone is an incomplete performance indicator. The relevant decision parameters include permeability, absorption, chloride resistance, freeze-thaw durability, abrasion resistance, bond performance, crack control, curing behaviour, constructability and return-to-service timing.

A change in repair logic:

- ***Not only rebuild, but also protect the exposed zone.***
- ***Not only restore local capacity, but also reduce ingress and recurring degradation.***
- ***Not only complete the repair, but also shorten the operational restriction window.***
- ***Not only compare unit cost, but also compare lifecycle value and service interval.***

## 4. Material Logic: What Matters in Steelike UHPC

Steelike UHPC should be assessed as an Ultra-High-Performance Composite system for targeted high-consequence infrastructure zones. Its relevance to marine and coastal infrastructure should be evaluated through material behaviour that directly addresses exposure, durability and operational continuity.

Documented Steelike and CNT Plus materials indicate a high-performance profile. Steelike test documentation for UHPC with 2% steel fibre includes compressive strength results at 28 and 42 days, rapid chloride permeability testing, freeze-thaw testing, scaling resistance, abrasion resistance, tensile-related tests, bond-related tests and surface resistivity testing. CNT Plus laboratory reports indicate an average compressive strength of 157.5 MPa (up to 168 MPa) and a water absorption of 1.31% for the tested samples. These Steelike-and CNT Plus-specific results should be kept separate from the general UHPC literature and verified against the latest project-specific documentation before specification.

General UHPC literature and ***FHWA*** (U.S. Federal Highway Administration) guidance describe UHPC as a cementitious composite with optimised granular constituents, a low water-to-cementitious material ratio, and discontinuous internal fibre reinforcement, with mechanical and durability properties that can exceed those of conventional concrete. That general literature supports the category logic, but it does not replace Steelike-specific documentation for project claims.

### Performance parameters that matter in marine rehabilitation

| Parameter | Why it matters | Infrastructure consequence |
|---|---|---|
| **Dense matrix / low ingress** | *Reduces the pathways for water and chloride movement.* | *Supports durability in splash zones, on exposed surfaces, and in chloride-prone repairs.* |
| **Low absorption** | *Limits moisture uptake in cyclic wet-dry and freeze-thaw exposure.* | *Improves the resilience of thin overlays and repair zones.* |
| **High compressive strength** | *Supports high-load, impact-prone and thin-section applications when properly designed.* | *Enables targeted strengthening and thin-layer rehabilitation concepts.* |
| **Fibre-reinforced composite behaviour** | *Improves post-cracking behaviour relative to brittle cementitious matrices, subject to mix design and fibre orientation.* | *Supports crack-control logic in overlays, joints and repair interfaces.* |
| **Bond and interface performance** | *Critical where UHPC is applied to existing substrates.* | *Determines whether rehabilitation behaves as an integrated system or a surface repair.* |
| **Rapid return-to-service potential** | *Can shorten closure windows when curing, logistics and QA/QC are aligned.* | *Reduces operational disruption in ports and terminal facilities.* |

**Important limitation:** *no CNT Plus / Steelike claim should be made for structural certification, fire classification, blast resistance, ballistic resistance, STANAG performance or defence-standard compliance unless confirmed by CNT Plus / Steelike-specific certification and project-specific testing.*

## 5. Operational Impact: Availability, Downtime and Return-to-Service

In port and coastal infrastructure, the operational value of a material is measured by more than its laboratory performance. It is measured by its effects on closure duration, work sequencing, the risk of repeat repair, and confidence in asset availability.

Steelike UHPC may be relevant where asset owners face a high cost of disruption: berth closures, ramp restrictions, reduced terminal throughput, limited access to critical assets, constrained military mobility routes or complex marine work windows. In such cases, the repair material and application method should be evaluated as part of an operating strategy.

Rapid return-to-service is not a generic promise. It depends on mix behaviour, temperature, curing regime, thickness, substrate preparation, QA/QC, logistics, site access, load reopening criteria and engineering sign-off. The strategic point is that UHPC can be assessed for repair approaches that compress intervention windows while improving durability compared with lower-performance repair cycles.


### Operational value chain

- Reduced permeability and chloride ingress pathways can reduce the probability of repeated corrosion-driven repairs.
- High early performance potential can support shorter closure windows when validated by project testing.
- Thin-section capability can reduce demolition depth and speed up rehabilitation in selected zones.
- Improved durability can reduce inspection escalation, emergency repairs and repeat mobilisation.
- Longer service intervals can improve predictability for port operators and infrastructure owners.

## 6. Lifecycle Advantage: From Repair Cost to Asset Value

Traditional procurement often compares repair options based on initial cost, quantity, and programme. For high-exposure critical assets, this is incomplete. The more relevant comparison is lifecycle value: the total cost of repeated repair cycles, loss of availability, risk accumulation and maintenance frequency.

A high-performance composite system can be justified where it is expected to reduce the frequency or severity of future interventions, subject to project-specific assessment and validation. The case is strongest when severe exposure, heavy operational duty and high downtime consequences overlap.

The lifecycle question is not whether UHPC is the lowest-cost material per unit volume. It is whether a targeted Steelike UHPC intervention can reduce the total lifecycle burden of an asset when compared with repeated conventional repair campaigns.

| Cost category | Conventional repair-cycle exposure | UHPC assessment lens |
| --- | --- | --- |
| **Initial works** | *Often lower initial material cost; may require deeper demolition or repeat mobilisation.* | *Higher material performance targeted to zones where the consequences justify it.* |
| **Downtime** | *Potentially repeated closures and throughput restrictions.* | *Evaluate shorter intervention windows and longer service intervals.* |
| **Durability** | *Repair may remain vulnerable to chloride ingress and abrasion.* | *Assess low-ingress, low-absorption and abrasion-resistance behaviour.* |
| **Risk** | *Recurring defects can become operational and reputational risks.* | *Evaluate asset availability, criticality and resilience value.* |
| **Lifecycle value** | *Cost may compound across repeated cycles.* | *Compare total intervention frequency, closure cost and service-life extension.* |


## 7. Priority Application Areas

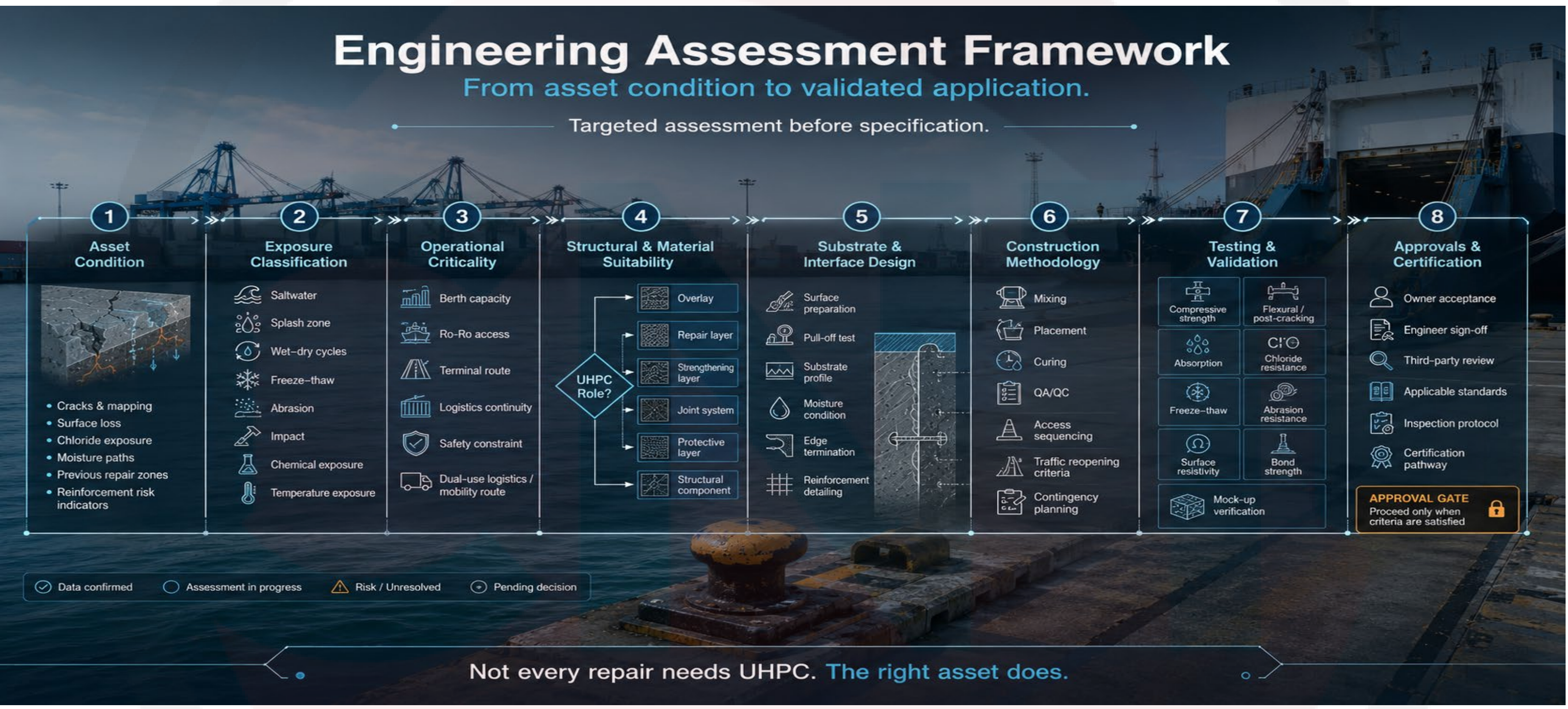
The strongest relevance for Steelike UHPC is expected in assets where aggressive exposure, heavy-duty conditions, and high downtime consequences coexist. The following application areas should be considered for targeted technical assessment rather than generic adoption.

| Asset type | Assessment focus |
| --- | --- |
| **Quay and berth rehabilitation** | *Edge beams, local deck repairs, exposed zones and chloride-affected surfaces where durability and return-to-service matter.* |
| **Ro-Ro ramps and heavy-load transfer zones** | *High wheel loads, impact, abrasion and concentrated operational demand with limited closure windows.* |
| **Terminal slabs and loading areas** | *Surface degradation, abrasion, impact and repair-cycle frequency affecting throughput.* |

| | |
|---|---|
| **Coastal bridges and access routes** | *Chloride exposure, freeze-thaw action and strategic access to ports, energy sites and logistics nodes.* |
| **Breakwaters and exposed marine assets** | *Aggressive wet-dry exposure, wave action, abrasion and difficult access for repeated repair.* |
| **Energy and utility infrastructure near ports** | *Assets supporting fuel, grid, offshore wind, LNG, industrial and emergency supply continuity.* |
| **Dual-use and military logistics infrastructure** | *Routes, ramps and staging areas where availability contributes to readiness; defence performance claims require project-specific validation.* |

## 8. Engineering Assessment Framework

The next step is not generic adoption. The next step is a targeted technical assessment. CNT Plus recommends that every potential Steelike UHPC  marine or coastal application be evaluated through the following framework.




1. ***Asset condition:*** Map deterioration, cracking, chloride exposure, moisture paths, reinforcement condition, surface loss and previous repair history.
2. ***Exposure classification:*** Define saltwater, splash-zone, wet-dry, freeze-thaw, abrasion, impact, temperature and chemical exposure conditions.
3. ***Operational criticality:*** Quantify downtime consequence, berth capacity effect, logistics disruption, route importance and safety constraints.
4. ***Structural and material suitability:*** Determine whether UHPC  is acting as an overlay, repair, strengthening layer, joint system, protective layer or structural component.
5. ***Substrate and interface design:*** Specify surface preparation, bond requirements, moisture condition, geometry, reinforcement detailing and edge termination.
6. ***Construction methodology:*** Plan mixing, placement, curing, QA/QC, access, sequencing, traffic reopening criteria and contingency measures.
7. ***Testing and validation:*** Define project-specific acceptance criteria, laboratory tests, mock-ups, pull-off/bond testing, compressive/flexural performance and durability checks.
8. ***Approvals and certification:*** Identify applicable EN, ASTM, owner standards, structural review, third-party testing, certification needs and inspection protocols.

## 9. Validation, Limits and Controlled Specification


A targeted UHPC application is credible only when supported by project-specific validation. Steelike UHPC should not be presented as a universal replacement material or as a generic durability upgrade. Its use must be justified by asset condition, exposure severity, structural role, operational consequence, constructability and the acceptance criteria defined for the specific project.

The engineering assessment framework identifies where UHPC may be technically relevant. Validation defines whether the proposed application can be specified, executed and accepted with confidence.

General UHPC literature is useful for understanding the material category, but it does not replace CNT Plus / Steelike-specific data, project-specific testing, independent review or owner approval. Any claim made in a tender, technical note, design submission or public-sector dialogue should be traceable to documented evidence.

### Validation before specification

Before Steelike UHPC is proposed for a marine, coastal or dual-use critical infrastructure application, the validation path should define:

- the intended structural or protective role of the UHPC layer or component;
- the existing substrate condition and interface requirements;
- the exposure class and durability drivers;
- the required mechanical and durability performance;
- the construction method, curing regime and QA/QC process;
- the reopening, loading or operational acceptance criteria;
- the inspection, monitoring and maintenance assumptions;
- the approval route required by the owner, engineer or public authority.

This is especially important where the asset carries high operational consequence, such as quay edges, Ro-Ro ramps, terminal slabs, coastal access routes, energy infrastructure, emergency logistics routes or dual-use mobility corridors.

### Recommended validation package

A credible project validation package should include, as applicable:

- current CNT Plus / Steelike product data and safety documentation;
- compressive strength, flexural and post-cracking behaviour data relevant to the proposed application;
- absorption, chloride resistance, freeze-thaw, scaling, abrasion and surface resistivity data where exposure requires it;
- substrate bond and pull-off testing for overlays, repairs and rehabilitation layers;
- substrate preparation requirements, surface profile definition and moisture-condition limits;
- site-specific trial placement or mock-up to confirm workability, finishing, curing and QA/QC;
- interface detailing, edge termination and reinforcement interaction where structurally relevant;
- owner and engineer acceptance criteria for reopening, loading, inspection and long-term performance;
- third-party testing, independent engineering review or certification where project consequence or owner requirements justify it.

### Limits of claim

***Technical discipline is essential.*** No unsupported claim should be made that Steelike UHPC is blast-proof, ballistic-certified, STANAG-certified, fire-rated, permanently protective, maintenance-free or approved for a specific defence or structural standard unless a current CNT Plus / Steelike-specific certification document confirms that claim.

Defence-adjacent, force-protection, critical infrastructure hardening and military mobility applications can be considered potential use cases, but only subject to project-specific testing, engineering validation, acceptance criteria and certification requirements.

The correct position is not that UHPC solves every infrastructure problem. The correct position is that UHPC may create measurable value when the engineering case is clear, the exposure demand is severe, the downtime consequences are significant, and the application can be validated.

### Controlled specification principle

For marine and coastal infrastructure, UHPC should move into specification only when four conditions are satisfied:

1. The asset condition and exposure justify a high-performance intervention;
2. The structural or protective role is clearly defined;
3. The substrate, interface, methodology and QA/QC route are technically controlled;
4. The required testing, review and approval pathway is documented.

This approach protects the credibility of the material, the engineer, the owner and the project. It also prevents overclaiming, misapplication and unrealistic performance expectations.

The objective is controlled specification: validated application, defined limits and evidence-based approval.

## 10. Conclusion and Call to Technical Dialogue

Ports, quays, coastal terminals and marine logistics assets are no longer only transport infrastructure. They are critical nodes in national resilience, strategic supply chains, energy security and military mobility.

Their long-term availability depends not only on structural capacity, but also on durability under aggressive exposure: chlorides, salt water, wet-dry cycles, abrasion, impact, freeze-thaw action and heavy operational loading.

For high-exposure and high-consequence marine assets, repair strategies should therefore be evaluated based on lifecycle value, operational availability and resilience, not only initial repair cost.

UHPC composite systems are not a universal solution. Their strongest relevance appears where severe exposure, heavy operational duty, repeated repair cycles and high downtime consequences overlap.

Where properly designed, validated and applied, Steelike UHPC may support selected applications such as quay rehabilitation, Ro-Ro ramp strengthening, terminal slab protection, coastal bridge repair, exposed marine asset hardening and dual-use logistics infrastructure upgrades.

***The next step is not generic adoption.***

***The next step is a targeted technical assessment.***

CNT Plus, powered by STEELIKE, welcomes technical discussions with port operators, infrastructure owners, engineering consultants, contractors, and public-sector stakeholders assessing UHPC composite systems for marine, coastal, and dual-use critical infrastructure.

Focus areas should include asset condition, chloride exposure, repair frequency, operational downtime, load requirements, deployment feasibility, pilot validation and lifecycle value.

The objective is clear: to identify where Steelike UHPC can create measurable infrastructure value by improving durability, reducing the need for repeated interventions and supporting operational continuity.

## Appendix A. Documented CNT Plus / Steelike Data Used

The following data points are included only where supported by CNT Plus / Steelike documentation available to CNT Plus. They should be verified against the latest issue of product documentation and project-specific test reports before publication, tender submission or specification.

| Data point | Documented value/scope | Source basis | Use in this white paper |
|---|---|---|---|
| **Compressive strength** | *Steelike certificate package reports 28-day average of 23,637 psi (~163 MPa) and 42-day average of 25,505 psi (~176 MPa) in the extracted lab table; CNT Plus-tested samples indicate an average compressive strength of 157.5 MPa, with tested values up to 168 MPa.* | *Steelike technical lab certificates; CNT Plus/BARG test reports.* | *Supports high-performance material positioning without transferring claims from other UHPC systems.* |
| **Water absorption** | *CNT Plus-tested samples indicate water absorption of approximately 1.31%.* | *CNT Plus/BARG report.* | *Supports durability and exposure narrative for marine environments.* |
| **Rapid chloride permeability** | *Steelike certificate package includes* ***ASTM C1202*** *results with an average of 111 coulombs at 28 days and 49 coulombs at 56 days in extracted text.* | *Steelike technical lab certificates.* | *Supports chloride-resistance discussion; project specifications should use current certificates.* |
| **Durability-related test scope** | *The documentation package includes freeze-thaw, scaling resistance, abrasion resistance, bond/pull-off, pull-out, and surface resistivity test categories.* | *Steelike technical lab certificates.* | *Supports the need to assess durability, interface and lifecycle behaviour.* |
| **Regulatory / defence claims** | *No CNT Plus / Steelike-specific STANAG, ballistic, blast or fire classification claim is made in this document.* | *Positioning discipline.* | *Prevents unsupported or overextended claims.* |

## Appendix B. Selected Technical References


- Steelike UHPC / UHPC 2% Steel Fibre, technical lab certificate package provided to CNT Plus.
- CNT Plus / BARG M.B. Gdańsk test reports: compressive strength and absorption results for CNT Plus samples.
- Federal Highway Administration, Design and Construction of Field-Cast UHPC Connections, FHWA-HRT-14-084.
- Federal Highway Administration, Structural Design with Ultra-High Performance Concrete, FHWA-HRT-23-077, October 2023.
- New Mexico State University / Tran-SET, Bridge Deck Overlays Using Ultra-High Performance Concrete, Final Report, October 2018.
- German Committee for Structural Concrete / UHPFRC 2017 paper, The German Guideline for Ultra-High Performance Concrete.
- Source draft supplied by CNT Plus: White Paper UHPC by CNT Plus, marine infrastructure narrative and conclusion.


**Longer life. Fewer interventions. Less downtime.**

---

### Contact


***CNT Plus*** Steelike UHPC systems for resilient infrastructure | www.cnt.gda.pl

***CNT Plus* sp. z o.o.** | ul. Leśna 7, 83-010 Straszyn, Poland

**Przemyslaw Kerczuk** | CEO | przemyslaw.kerczuk@cnt.gda.pl | +48 533 325 241

**Maciej "Magic" Winnicki** | Business Development Director, EMEA | maciej.winnicki@cnt.gda.pl | +44 (0) 730 868 7251