


MARAD
U.S. MARITIME ADMINISTRATION

USDOT MARAD - Office of Ports & Waterways

Maritime Infrastructure – Changing the Mindset

MRMCA Annual Conference

March 12, 2019

1200 New Jersey Ave., SE | Washington | DC 20590
www.dot.gov


The 2017 Hurricane Season: Recommendations for a Resilient Path Forward for the Marine Transportation System

Report Drafted by the U.S. Committee on the Marine Transportation System
Marine Transportation System Resilience Integrated Action Team (RIAT)

NOAA/NASA

December 2018

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The Marine Transportation System (MTS) plays a critical role in United States (U.S.) commerce and security, facilitating the movement of over two billion tons of goods annually. This critical function is often at risk…

The 2017 Hurricane Season: Recommendations for a Resilient Path Forward for the Marine Transportation System, December 2018

Run-to-Failure Management of Waterfront Structures

- More than 300 U.S. ports serve as Gateways to world markets for U.S. products and as intermodal hubs for exports and domestic distribution
- Maritime initiatives have received approximately 10 -12% of past DOT discretionary grant programs.

Our StrongPorts team works to assist ports through:

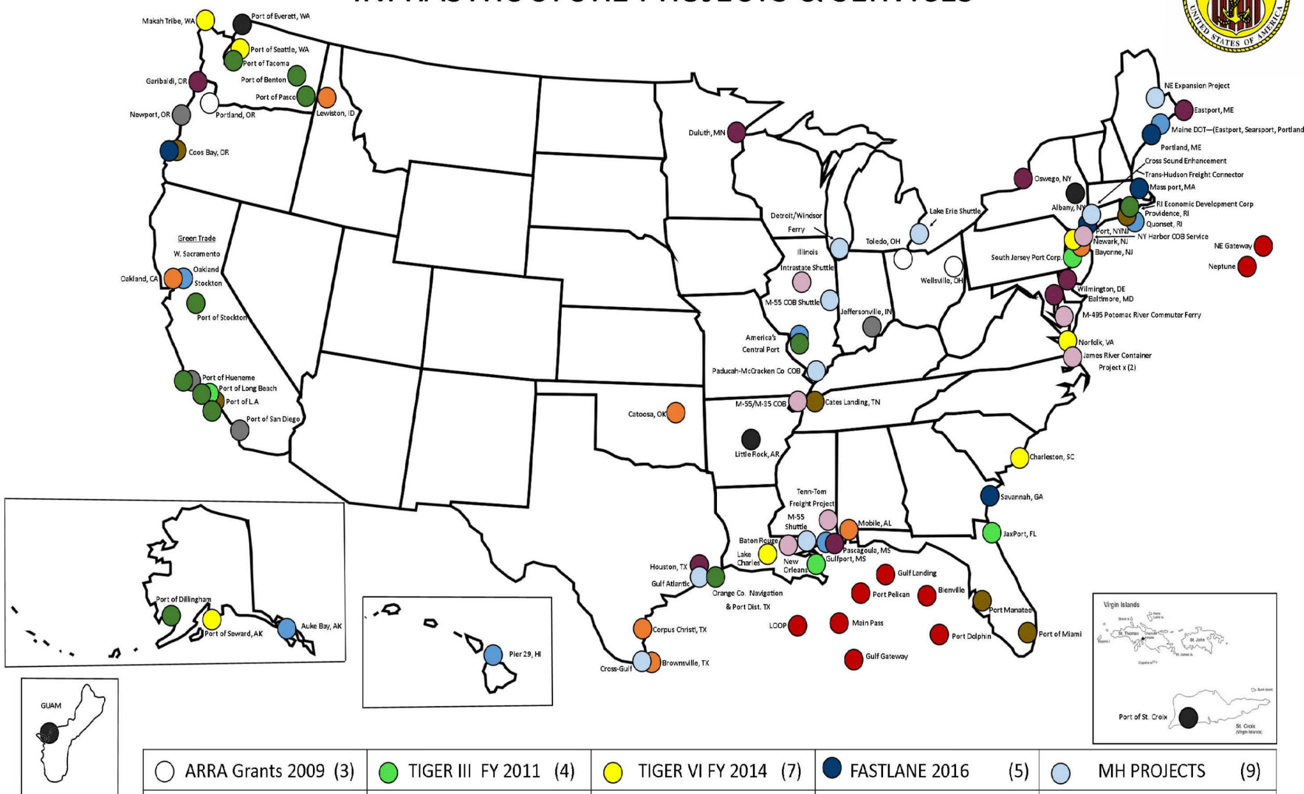
- Providing Port and Intermodal Planning Assistance
- Accessing Funding and Financing Options for Port Modernization and Expansion
- Expanding domestic movement of freight by waterborne transportation
- Administering Grants and Loans for Projects
  - These services are offered to Tribal governments, Regional and Local public entities and Tribal governments, Regional and Local public entities and other such organizations."

StrongPorts™
Office of Ports & Waterways

MARAD

PORTS & WATERWAYS

INFRASTRUCTURE PROJECTS & SERVICES



ARRA Grants 2009 (3)	TIGER III FY 2011 (4)	TIGER VI FY 2014 (7)	FASTLANE 2016 (5)	MH PROJECTS (9)
TIGER I FY 2009 (7)	TIGER IV FY 2012 (7)	TIGER VII FY 2015 (4)	DEEP WATER PORTS (8)	MH GRANTS (8)
TIGER II FY 2010 (6)	TIGER V FY 2013 (8)	TIGER VIII FY 2016 (5)	PORT CONVEYANCE (11)	

As of February 2017

Guidance Document

"Targeted transportation investments are needed to preserve mobility of freight movements. Investment in maintaining, repairing, and rehabilitation infrastructure has not kept pace with growing transportation needs. Ports and waterways face growing maintenance and modernization needs. The failure to modernize our infrastructure compromises the safety, capacity and efficiency of the U.S. transportation network."

Infrastructure - Strategic Objective 1: Project Delivery, Planning, Environment, Funding, and Finance

Facilitate expanded infrastructure development by leveraging all sources of funding

Strategy: Target federal investments toward transportation projects that address high priority infrastructure and safety needs

Infrastructure - Strategic Objective 2: Lifecycle and Preventative Maintenance

Keep the Nation's transportation infrastructure secure and in a state of good repair by maintaining and upgrading existing systems in rural and urban communities.

DOT has increasingly emphasized a risk-based strategy of infrastructure asset management… DOT will increase its effectiveness in ensuring that infrastructure is resilient enough to withstand extreme weather and security events which could otherwise disrupt the transportation network…

Strategy:

Rebuild: Restore transportation infrastructure and assets to a state of good repair through asset management planning and innovative maintenance strategies.

Risk Management: Provide research, technical assistance, and targeted funding to ensure that transportation infrastructure is planned, constructed, and maintained using the best operational and risk management practices.

Infrastructure - Strategic Objective 3: System Operations and Performance

Enhance reliable and efficient movement of people and goods by promoting effective management and ensuring leadership in security data and in sharing information across the transportation system.

Strategy:

System Reliability: Improve the reliability and efficiency of freight movement by assess(ing) overall system reliability and implement strategies that target the sources of unreliable freight movement.

Infrastructure - Strategic Objective 4: Economic Competitiveness and Workforce

Promote transportation policies and investments that bring lasting economic benefits to the Nation by ensuring multimodal infrastructure connectivity to foster the efficient movement of people and goods at home and abroad; increasing foreign market access

Strategy:

Freight: Make targeted investments to increase freight mobility and reliability in support of economic competitiveness

Others Taking Action
ASCE Grand Challenge
www.asce.org/grandchallenge

- Significantly enhance the performance and value of infrastructure projects over their life cycles by 2025
    - (work towards the shared goal of ***reducing infrastructure life cycle costs by 50% by 2025***)

- Foster the optimization of infrastructure investments for society.

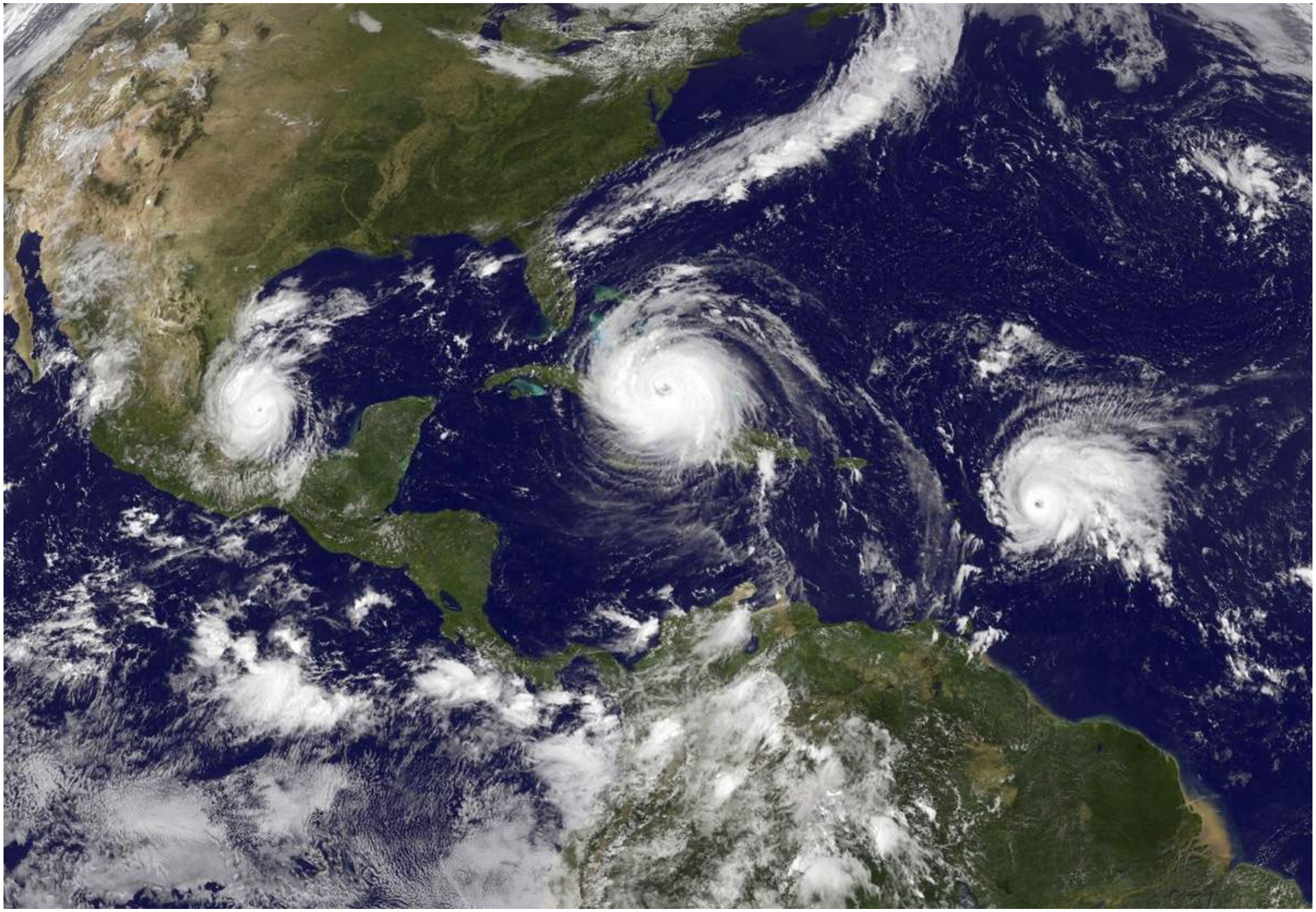
- To reach this goal, the profession must influence major policy changes and infrastructure funding levels, while challenging civil engineers to focus on innovation, **rethink life cycle costs**, and drive transformational change—from planning to design to delivery

ASCE Grand Challenge (con'd)
www.asce.org/grandchallenge

- Challenge Assumptions and Be Open to Change
- Create/Embrace New Possibilities and Solutions
- Improve Practices, Processes, Solutions

Creating Comprehensive Focus to Improve Infrastructure Delivery

- **Performance Based Standards**
- **Innovation**
- **Life Cycle Cost Analysis**
- **Enhanced Resilience**



NOAA Satellite Imagery

Hurricane Michael at Landfall 10 10 2018

NOAA Satellite Imagery

Range of Waterfront Asset Management Practices

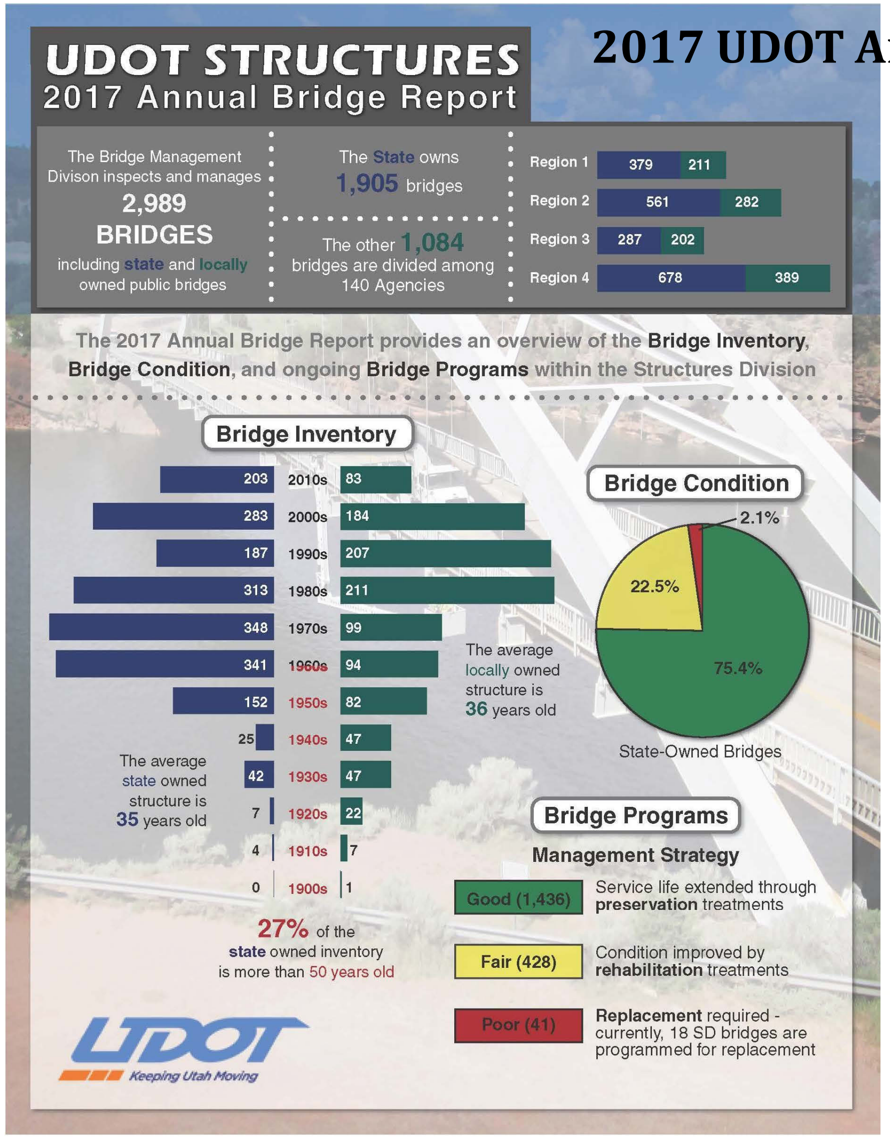
Best practices for waterfront structures Management utilize:

- ❑ Long-term maintenance master planning
- ❑ Risk-based asset management
- ❑ Life-cycle analysis
- ❑ GIS WFAM interface

Proposed StrongPorts™ Waterfront Asset Management Tool

State of Repair of Maritime Assets

2017 UDOT Annual Bridge Report



More Programmatic Questions

- Do public and private port funding and current federal grant and loan programs address the deficiencies in the most critical components of our nation's maritime infrastructure?
- What is the magnitude of the need?
- What is an appropriate management strategy for the derelict in-water structures inventory?
- What is the 10 year prognosis for the MTS under current waterfront structures asset management and spending levels?
- What is the level of risk to the nation's economy and strategic readiness that is associated with current waterfront asset management?

Port Asset Management Defined

- The strategic and systematic practice of procuring, operating, inspecting, maintaining, rehabilitating, and replacing port capital assets to manage their performance, risks, and costs over their life cycles to provide safe, cost-effective, and reliable connections at ports (the hubs where people and cargoes are transferred between ocean going vessels, barges, trucks, trains, other vehicles and pipelines).

Why Waterfront Assets Management?

- Waterfront Asset Management typically represents the largest maintenance budget demand across all port assets.
- Aged waterfront infrastructure poses very high risk to property, business operations and human safety.
- Anecdotal evidence suggests that run-to-failure waterfront asset management may be common.

Benefits

- Increase system reliability.
- Increase asset service levels at decreased cost.
- Decrease lifecycle costs.
- Identify and manage risk especially identify current risks and how they evolve over time.
- Deliver highest value from assets and resources.
- Make risk-informed decisions.
- Generate analytics capable of facilitating trade-offs between maintenance and capital projects.
- Enable strategic lifecycle management of risk and revenue requirements for the entire asset base.
- Generate asset investment plans that explain why a portfolio of investments is the most appropriate course of action.
- Increase the visibility of long-term spending requirements.
- Enhance ability to communicate and defend decisions.

Proposed Phase 1 Waterfront Asset Management Tool
Full Build-Out Module Components

- The tool allows individual ports to establish a maintenance priority for implementing repairs by berth/facility through the development of a factor series for each berth in the inventory.

- Reports and charts are generated that depict time histories of risk and condition at various maintenance funding levels across the entire asset base.

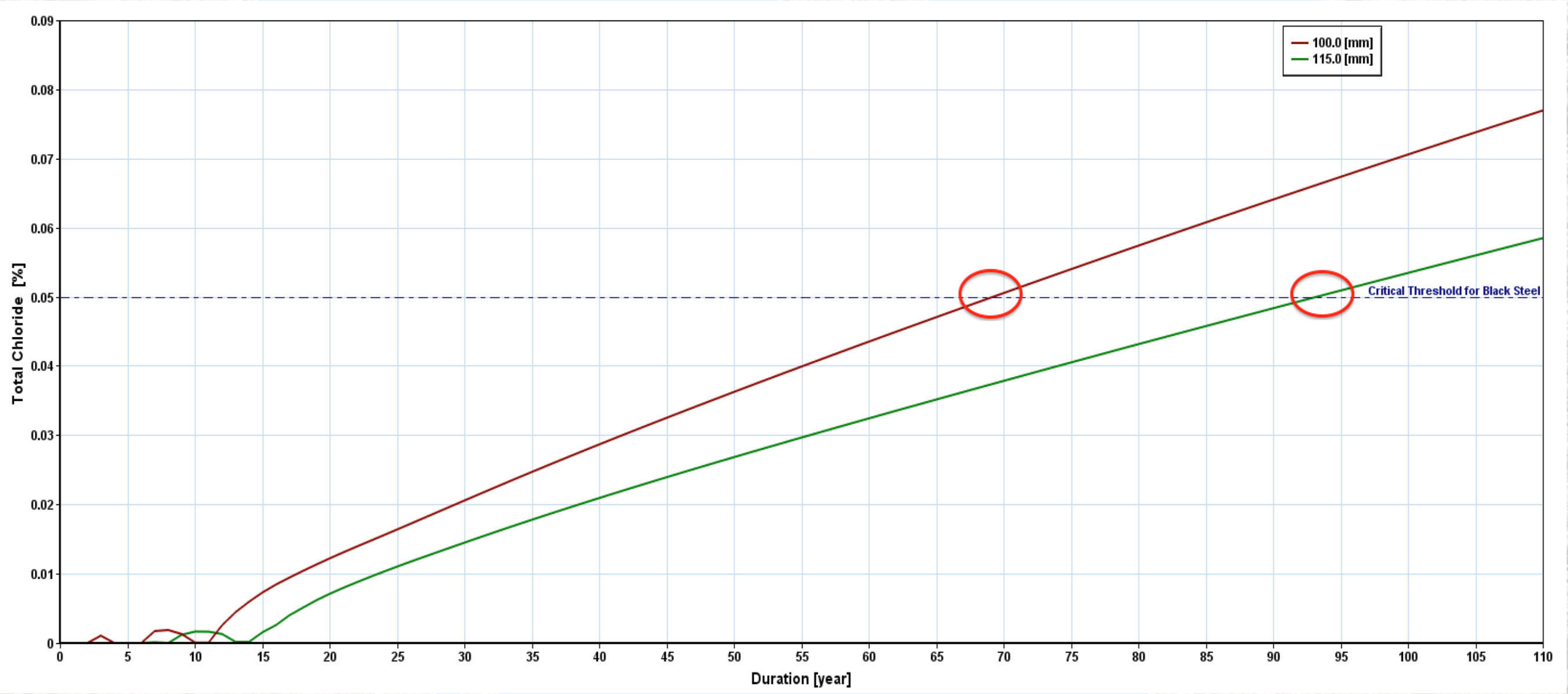
What can design engineers and inspectors do today to mitigate the vulnerabilities of our Marine Transportation System?

Maritime Structures
Pile Foundations for In-Water and Near-Shore Structures

Marine Concrete Pile Mix Design

PROPERTY	[6]Waterside Structures	Concrete Slab on Grade	[7]Utility Structures	[8]Miscellaneous Structures	Prestressed Concrete Piles	Precast Concrete Deck Panels	[11]Precast Concrete Utility Structures
28-Day Compressive Strength, ASTM C 39 (psi)	5,000	5,000	5,000	5,000	7,000	6,000	5,000
28-Day Flexural Strength, ASTM C 78 (psi)	--	700	--	--	--	--	--
Nominal Max Size Aggregate[5]	1"	2"	1-1/2"	1-1/2"	1"	1"	1"
Unmitigated Aggregate Reactivity	Innocuous				Innocuous	Innocuous	
Cement Type	II, IS(MS)	II, IS(MS)	II, III or IS(MS)	II, III or IS(MS)	II, IS(MS)	II, IS(MS)	II, III or IS(MS)
ASTM C1202 Rapid Chloride Ion Testing	0.08%				0.06%	0.06%	
MacroFibers			Type III only	Type III only			Type III only
Slag Replacement, %	25%	25%	25%-50%	25%-50%	25%	25%	25%-50%
Water-Cement Ratio (by weight)	0.40	0.45	0.45	0.50	0.40	0.40	0.40
Design Slump (inch)	[2] 4	[3] 2-3	[2] 4	[2] 2-5	[4] 4	[2] 4	[2] 4
Air Entrainment, % (ASTM C 231)	6	5.5	6	6	6	6	6
Calcium Nitrite Corrosion Inhibitor	YES	NO	NO	NO	YES	YES	NO
[9] Water Reducing Admixture Required	YES	YES	YES	NO	YES	YES	YES
[10]Anti-Washout Admixture	YES	NO	NO	NO	NO	NO	NO

Ion Transfer Modelling for Concrete



Marine Concrete Pile Mix Design Specification

All Cement

For category S1 exposure, an ASTM C 595, Type IS(MS) blended cement except as modified herein:

1. The blended cement shall consist of a mixture of ASTM C 150 Type II cement and ground iron blast-furnace slag. Alternatively, the blended cement may be batched at the ready mix plant if batching certifications required for NRMCA are submitted and approved. Type I, Type III, and Type V cements shall not be accepted, except as indicated in the mix design table. Type III cements may be approved for use in prestressed applications within the stipulated curing temperature limitations.
2. Ground Iron Blast-Furnace Slag: ASTM C 989, Grade 120. Testing shall be performed no more than six months prior to submittal date. Grade 100 slag may be approved under at the Engineer's discretion.
3. The ground iron blast-furnace slag shall comprise 25% - 50% by weight of total cementitious material, as specified for each application in the mix design table.
4. The tricalcium aluminate content of the blended cement shall be less than 8% by weight.

For mass concrete and steam cured precast items; the following shall be met in addition to the requirements above:

1. The maximum percent of sulfur reported as sulfate (SO3) in the blended cement shall be less than 3.0%.
2. The alkali content of the blended cement shall be less than 0.7%
3. The molar ratio of sulfate to tricalcium aluminate in the blended cement shall be less than 0.3.

Aggregates

1. Aggregates shall not contain any substance that may be deleteriously reactive with the alkalies in the cement in an amount sufficient to cause excessive expansion of the concrete.
2. For all aggregate sources, submit ASTM C1260 (or 12 month C1293, as stipulated below) test results dated within the last 6 months. Aggregates shall show expansions less than 0.10% at 16 days when tested in accordance with ASTM C 1260. Aggregate suppliers certified by and listed in the SHA's Aggregate Bulletin are preapproved and require only submittal of SHA OMT test results, current ASTM C1260 mortar bar (or C1293 prism) test results, and certification of the stipulated gradation for each mix design. Aggregates demonstrating expansions in excess of this limit shall not be accepted, regardless of inclusion in the SHA Aggregate Bulletin, unless 12 month C1293 expansions yield an innocuous result. These C1293 prisms shall not include pozzolans or slag in the mix and results shall be dated within the last 6 months. At the Engineer's discretion, consideration may be given for aggregates demonstrating non-innocuous C1260 results if successfully mitigated for aggregate reactivity in accordance with C1260 or C1567 in non-structural or non-marine applications only and as stipulated herein.

Admixtures - Corrosion Inhibiting:

1. Concentration of corrosion inhibitor shall be sufficient to produce a content not less than 5.1 pounds per cubic yard in the hardened concrete.

Steam Curing Temperature Limitations & Monitoring Specification Provisions

Immediately after each pile has been cast and finished, it shall be placed in a curing chamber, curing box, or under a tight enclosure which will protect the pile from wind and drafts. Such chambers and enclosures shall be sized to allow full circulation of steam around exposed surfaces of the pile.

Instrumentation: Install exterior recording thermometers and interior temperature probes with enclosures and power source along with wiring. All thermometers and probes shall record continuously and automatically. Each pile shall be instrumented with either one exterior thermometer or one interior probe. Exterior thermometers and interiors probes shall be installed in an alternating sequence. Parallel casting beds shall have the instrumentation placed in a staggered and alternating pattern along the piles. The thermometer and the probe shall be installed close to the middle of the pile, not closer than 5 feet and not farther than 10 feet from the orifice where the steam is introduced. The exterior thermometer shall be located at the side where the steam is introduced. The interior probe shall be located more than 8-inches and less than 10-inches from the surface of the piles. Under no circumstances are the interior probes permitted to touch the jet tube. Do not commence concrete placement until temperature recording devices have been checked to the satisfaction of the Engineer. A uniform curing temperature shall be maintained throughout the entire length of the piles. Submit prints of the automatic readout daily.

Commencing not earlier than three (3) hours and not later than five (5) hours after completion of concrete placement, the piles shall be subjected to the continuous action of steam. Care shall be exercised to see that heat is introduced gradually to avoid thermal shock to the concrete. During the heating, the temperature rise shall not exceed 25 to 35 degrees Fahrenheit per hour. The interior temperature of the piles shall be held at a target temperature of 140 degrees F with an upward tolerance of 10 degrees F. A single pile reaching an interior temperature of more than 150 degrees F or less may be accepted at the option of the Engineer. A run of several piles with an interior exceeding 150 degrees F will be rejected.

Cooling shall follow the steaming cycle. Care shall be exercised to protect the piles from rapid drops in temperature, mechanical injury and other conditions likely to cause damage or loss of strength. During the cooling, the temperature drop shall not exceed 35 degrees F per hour until a temperature of 20 degrees F above ambient air temperature is reached. The cool down procedures shall be as follows:

Steam shall be turned off following the steam cycle.

The sides of the tarps shall be folded to the top of the form.

Transfer breaks shall be performed to confirm that the required 5,250 psi has been reached.

The tarps shall be completely removed, the top doors will be opened, and the strands will be released.

After steam curing, moist curing shall be applied using until a total steam and moist curing time of seven (7) days is achieved.

Mitigating Vulnerabilities of Marine Concrete Piles

Service Life Issue	Solutions	Advantage	Disadvantage
Chemical reactions (ASR)	Non reactive siliceous aggregates	Reduce ASR	Hard to obtain in many areas
	Use of SCM	Reduce permeability, reduce ASR, limit alkalis from outside	Quality fly ash or slag missing in many areas
	Low w/cm	Reduce infiltration of solutions, limits alkalis from outside	Can produce high strength concrete that is brittle
	Chemical admixtures	Improved properties	Cost, incompatibility, side effects
	Lithium based admixtures	Inhibit ASR	Cost
	Limestone sweetening (blending with limestone)	Limit expansion	Reduced skid resistance
Chemical reactions (ACR)	Non reactive carbonate aggregates	Reduce ACR	Hard to obtain in some areas
	Reduce infiltration of solutions, limits alkalis from outside	Can produce high strength concrete that is brittle	Cracking
	Blend aggregate	Limit expansion	Hard to obtain in some areas
	Limit aggregate size to smallest practical	Limit expansion	Rich mixes with high paste content
Sulfate attack	Low C3A contents	Reduce sulfate attack	N/A
	Use of SCM	Reduce permeability, reduce sulfate attack, limit sulfates from outside	Quality fly ash or slag missing in many areas
	Low w/cm	Reduce infiltration of solutions, limits sulfates from outside	Can produce high strength concrete that is brittle

SHRB2 Renewal Project R19A, Design Guide for Service Life

Durability Technologies

Ion Transfer Modelling for Concrete

STADIUM Results for MPA Mix Designs

Element	Salinity (‰)	STADIUM® Analysis Graph ID	Reinforcement	Corrosion Inhibitor (gal/CY)	Cover (inches)	Time to Initiation + 10 years propagation (years)	Service Life (years)
Pile – Severe Exposure	30	A	Black	0	3.0	7 +10	17
	30	A	Black	0	3.25	9+10	19
	30	A	Black	0	3.5	10 + 10	20
	30	A	Black	3.5	3.0	65 + 10	75
Pile – Severe Exposure	18	B	Black	0	3.0	11 + 10	21
	18	B	Black	0	3.25	13+10	23
	18	B	Black	0	3.5	15+10	25
	18	B	Black	2.5	3.0	72+10	>75
Deck – Severe Exposure	30	C	Black	0	3.0	7+10	17
	30	C	Black	0	3.25	9+10	19
	30	C	Black	0	3.5	11+10	20
	30	C	Black	3.0	3.25	66+10	>75
	30	C2	Black	3.5	3.0	>75	>75
Deck – Severe Exposure	18	D	Black	0	3.0	12+10	22
	18	D	Black	0	3.5	14+10	24
	18	D	Black	0	4.0	17+10	27
	18	D	Black	2.0	3.5	70+10	>75
	18	D2	Black	2.5	3.0	>75	>75
Deck - Moderate Exposure	20	E	Black	0	3.0	21+10	31
	20	E	Black	0	3.25	24+10	34
	20	E	Black	0	3.5	29+10	39
	20	E	Black	2.0	3.0	29+10	>75
Deck - Moderate Exposure	12	F	Black	0	3.0	37+10	47
	12	F	Black	0	3.25	45+10	55
	12	F	Black	0	3.5	55+10	65
	12	F	Black	2.0	3.0	>75	>75

Concrete Pile Driving Stresses and Damage

A new pile driving system, modifications to existing system, or new pile installation procedures shall be proposed by the Contractor if the pile installation stresses exceed the following maximum values:

- Compression Stresses: 0.85(f'c) - fpe
- Tension Stresses: 3 times the square root of f'c + fpe

Are reductions in allowable driving stresses appropriate for prestressed concrete piles in marine environments?

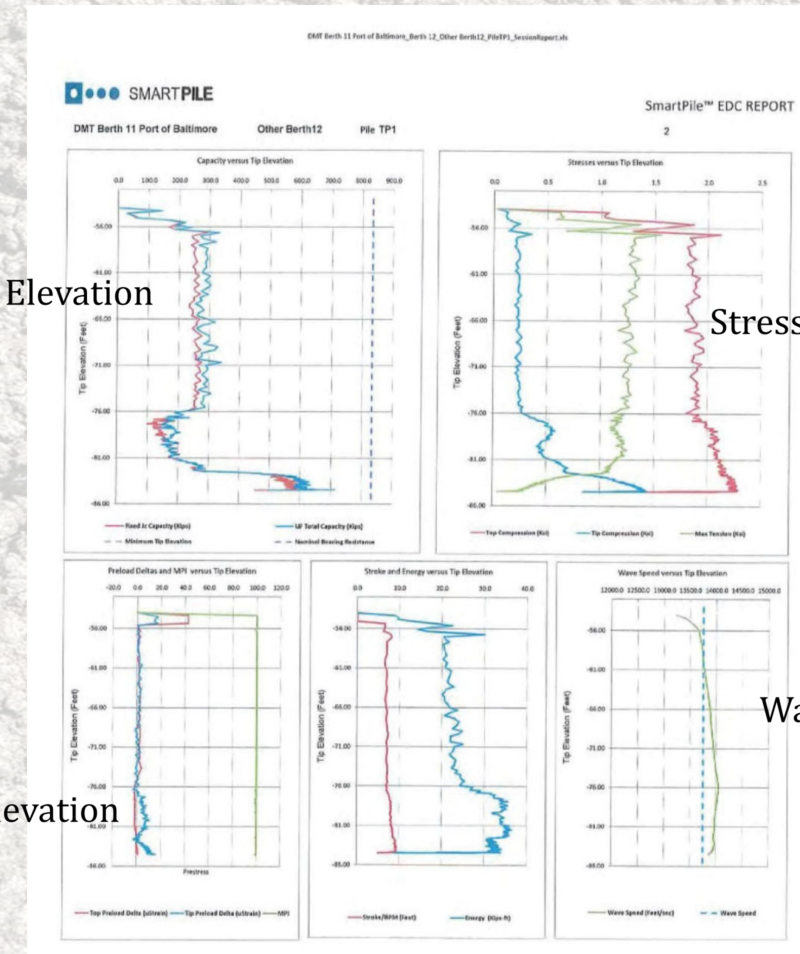
Concrete Pile Driving Damage

What is Embedded Data Collection (EDC)?

- Electronics/sensors embedded in the pile core at both pile ends
- Wireless data transmission from the pile
- Local workstation to collect sensor data as driving progresses
- Analytical and reporting software
- Improves quality by preventing damaging and unnecessary overdriving of piles

Courtesy of SmartStructures™

EDC Driving Data for Concrete Piles



Capacity vs Tip Elevation

Stresses vs. Tip Elevation

Wave Speed vs. Tip Elevation

Preload Delta vs Tip Elevation

Concrete Pile Driving Damage

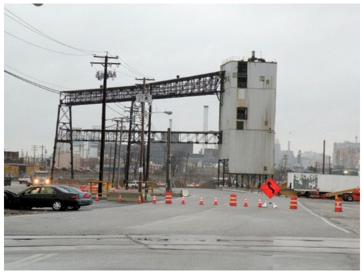
Re-evaluation of the method to determine pile damage using the Beta Method

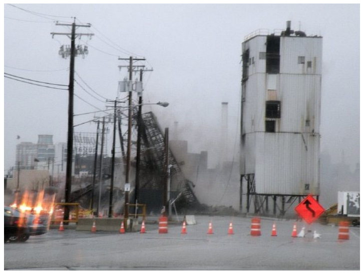
Verbeek, G.E.H.
VMS, USA
Goble, G.
Goble Pile Test, USA

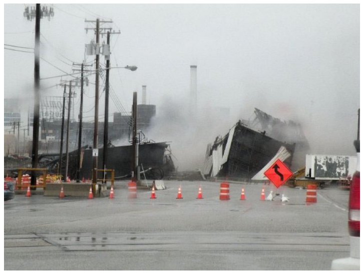
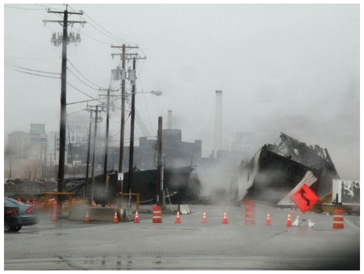
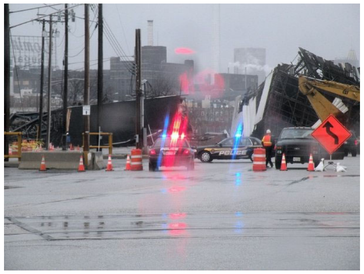
The theoretical review of the method showed clearly that the Beta Method cannot be a reliable indicator of pile toe damage… …the Beta method should not be used to protect against pile toe damage."

Verbeek, G.E.H. / Goble, G.

Run-to-Failure Waterfront Asset Management

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