Italian Dam Engineering Abroad
Aggiornamento 2021

Case histories:
Il Canale di Panama

Nicola Valiante

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Case histories:
Il Canale di Panama

Nicola Valiante
HEAD OF DESIGN SERVICES

11 Ottobre 2021

Panama Canal

“Puente del Mundo, Corazón del Universo”

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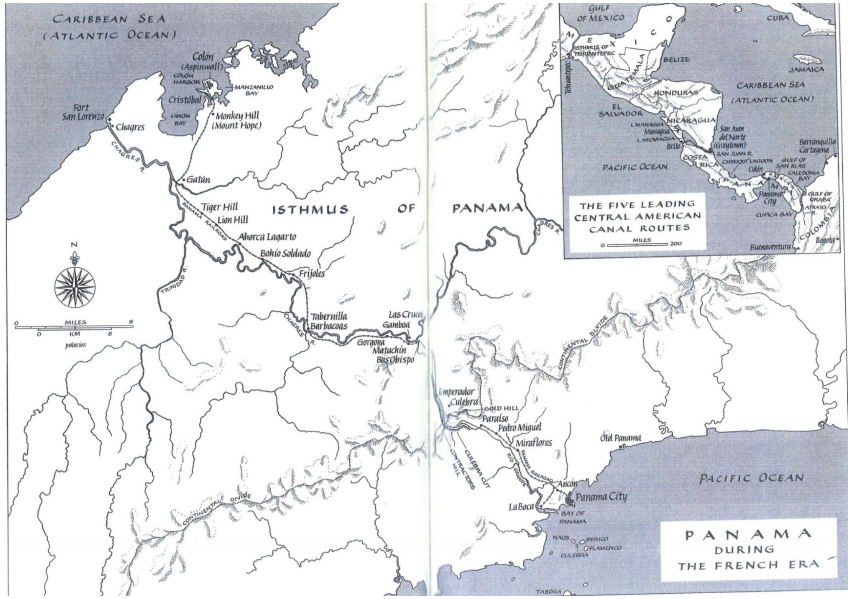
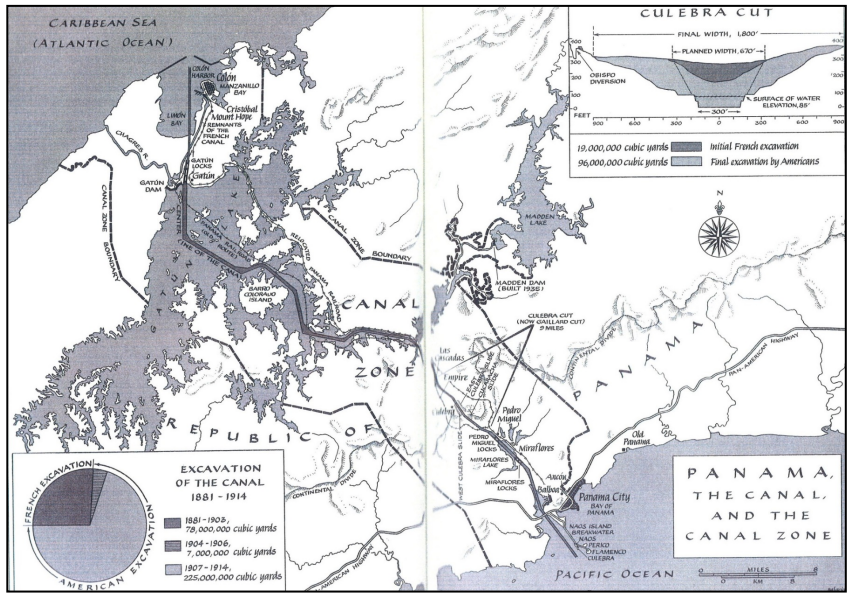
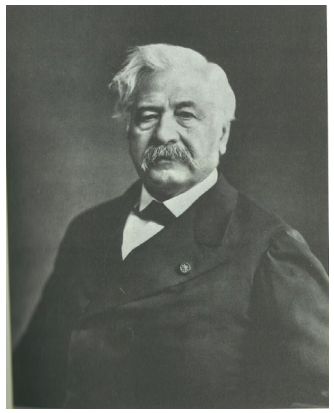
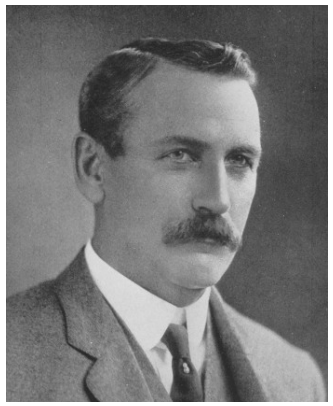
Panama Canal - Hystory







Ferdinand de Lesseps



John Stevens
1905-1907
Chief Engineer

- **1850** US began construction of the **Panama Railroad** to cross the Isthmus.
- **1876** French exploration of the Panama Isthmus for an Interoceanic Canal.
- **1879 International Interoceanic Canal Congress**: Sea level Canal. (**Adolphe Godin de Lépinay** proposed a «Lock and Lake» Canal).
- **1881-1894 French Period**
- **1881** Establishment of the **French Panama Canal Company** (*Compagnie Universelle du Canal Interocéanique de Panama).*
- **1887** Plan **level canal abandoned.**
- **1889 Bankruptcy** of the French Panama Canal Company.
- **1894** Establishment of the **New Panama Canal Company.**
- **1898 Technical committee** identified a **Canal with Locks**.
- **1903 Hay - Bunau-Varilla Treaty**, granting rights to the United States to build and indefinitely administer the **Panama Canal Zone.**
- **1904-1914 US Period**
- **1905** US Engineering panel recommended a **Sea level Canal.**
- **1906 J. Stevens** convinced Pres. Roosevelt to adopt the solution of a **Canal with locks**.
- **1914** Inauguration of the **Panama Canal.**

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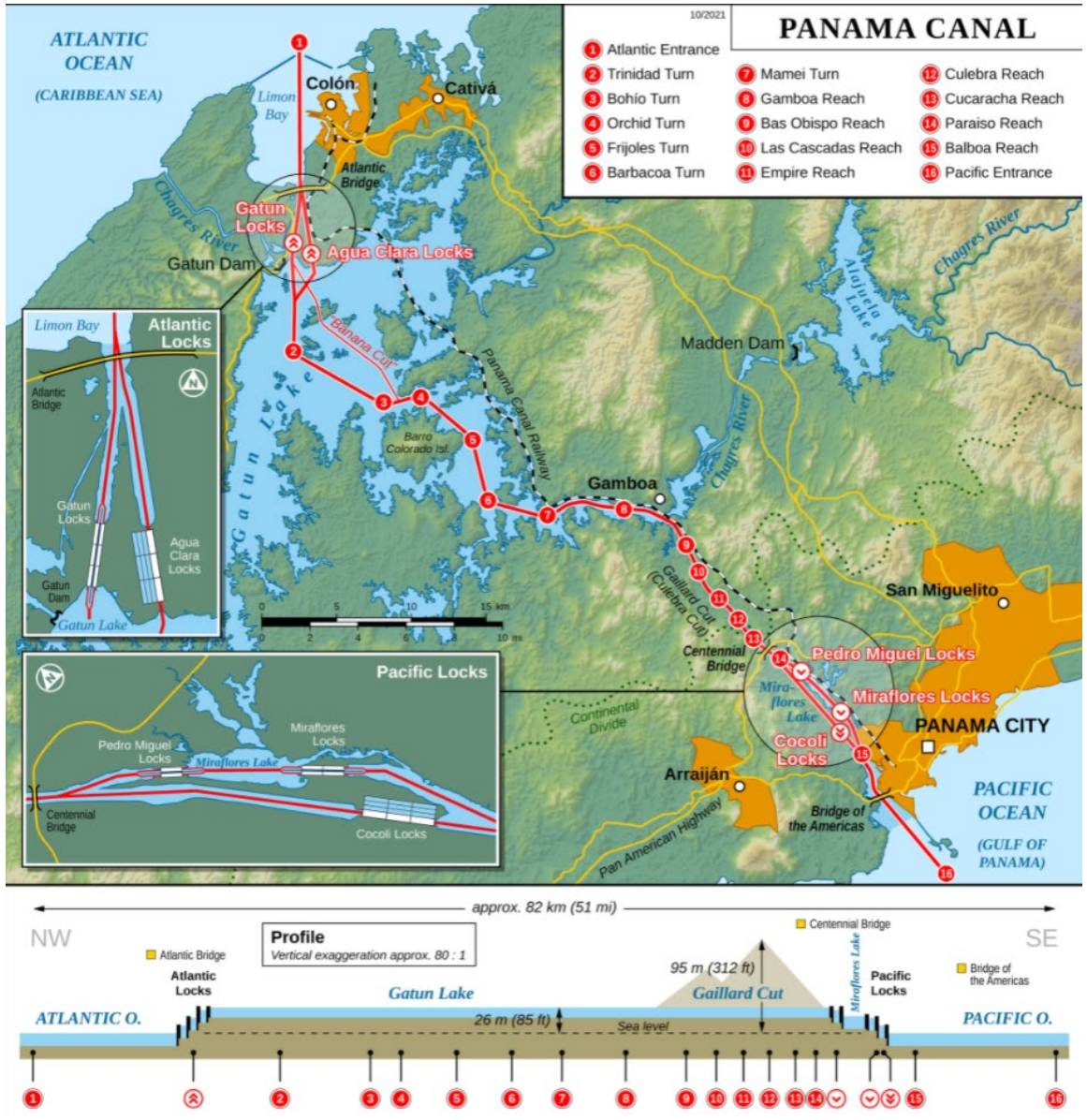
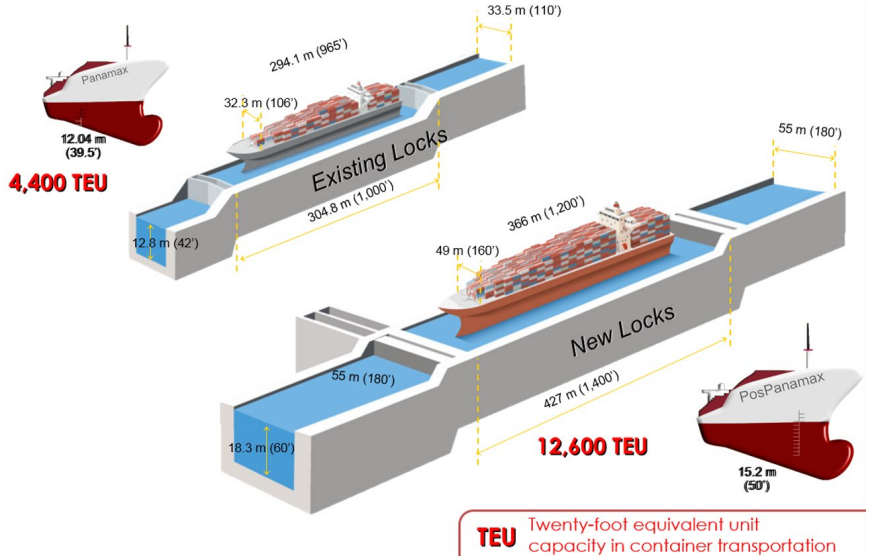
Panama Canal – Route and Third Set of Locks





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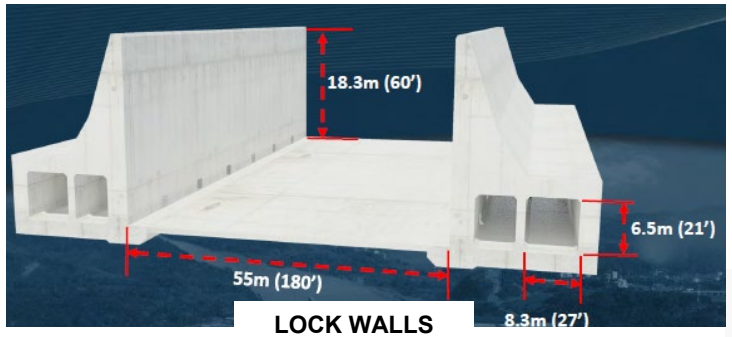
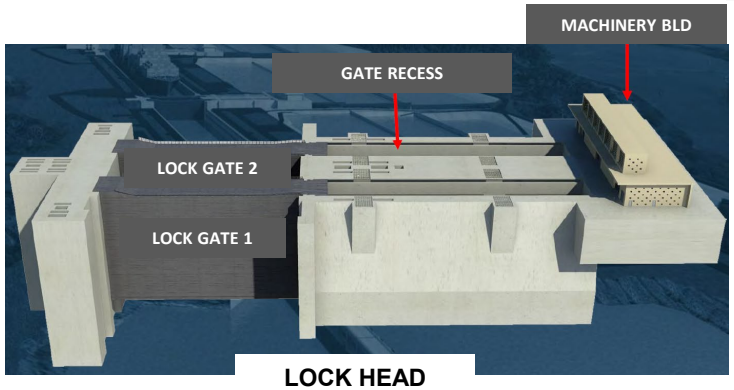
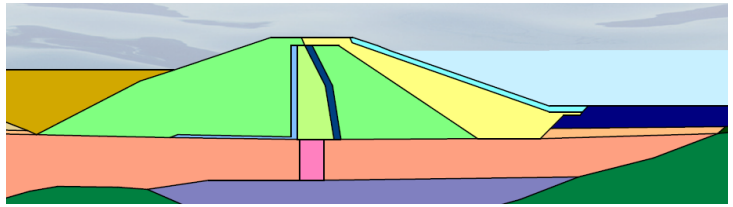
Third Set of Lock – Pacific Locks

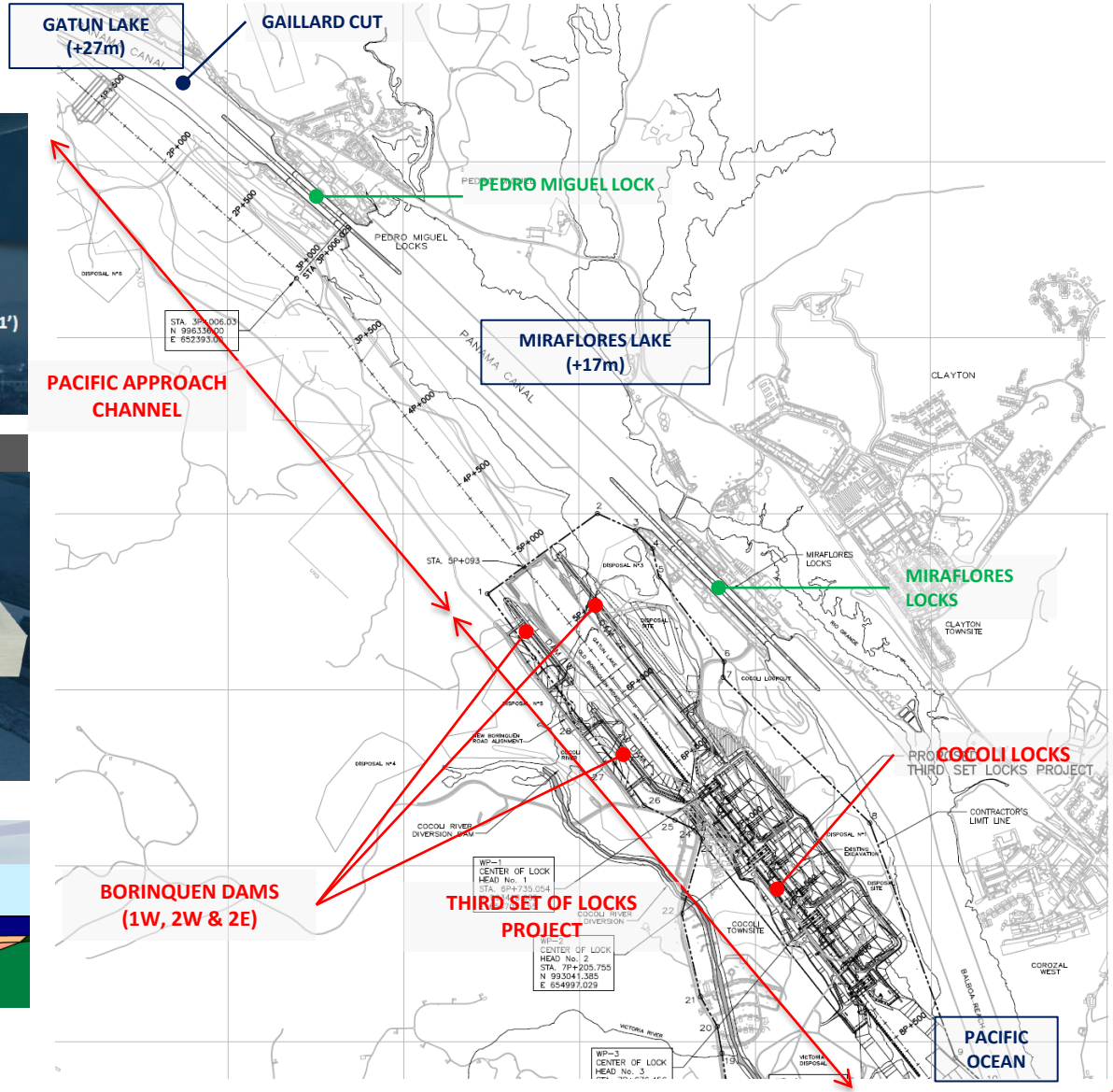


LOCK WALLS



LOCK HEAD





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Third Set of Lock – Initial Surveys

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Third Set of Lock – Clearing & Grubbing

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Third Set of Lock – Wildlife Rescue

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Third Set of Lock – Industrial Installations

Third Set of Lock – Industrial Installations

PLANTS (PACIFIC LOCKS)

CRUSHING PLANT	3.300 t/h
CONCRETE PLANT	540 m3/h
COOLING SYSTEM	17.400.000 Kcal/h
✓ AIR COOLING PLANT (SAND)	
✓ WATER COOLING PLANT (AGGREGATES)	
✓ ICE MAKING PLANT	
INDUSTRIAL WATER	4.500 m3/h
POWER PLANT	14 MW
DIESEL TANKS	>400 m3

UTILITIES (electricity, seewage, potable & industrial water, compressed air, lighting, fiber optic, etc.)

Third Set of Lock – Crushing & Batching Plants

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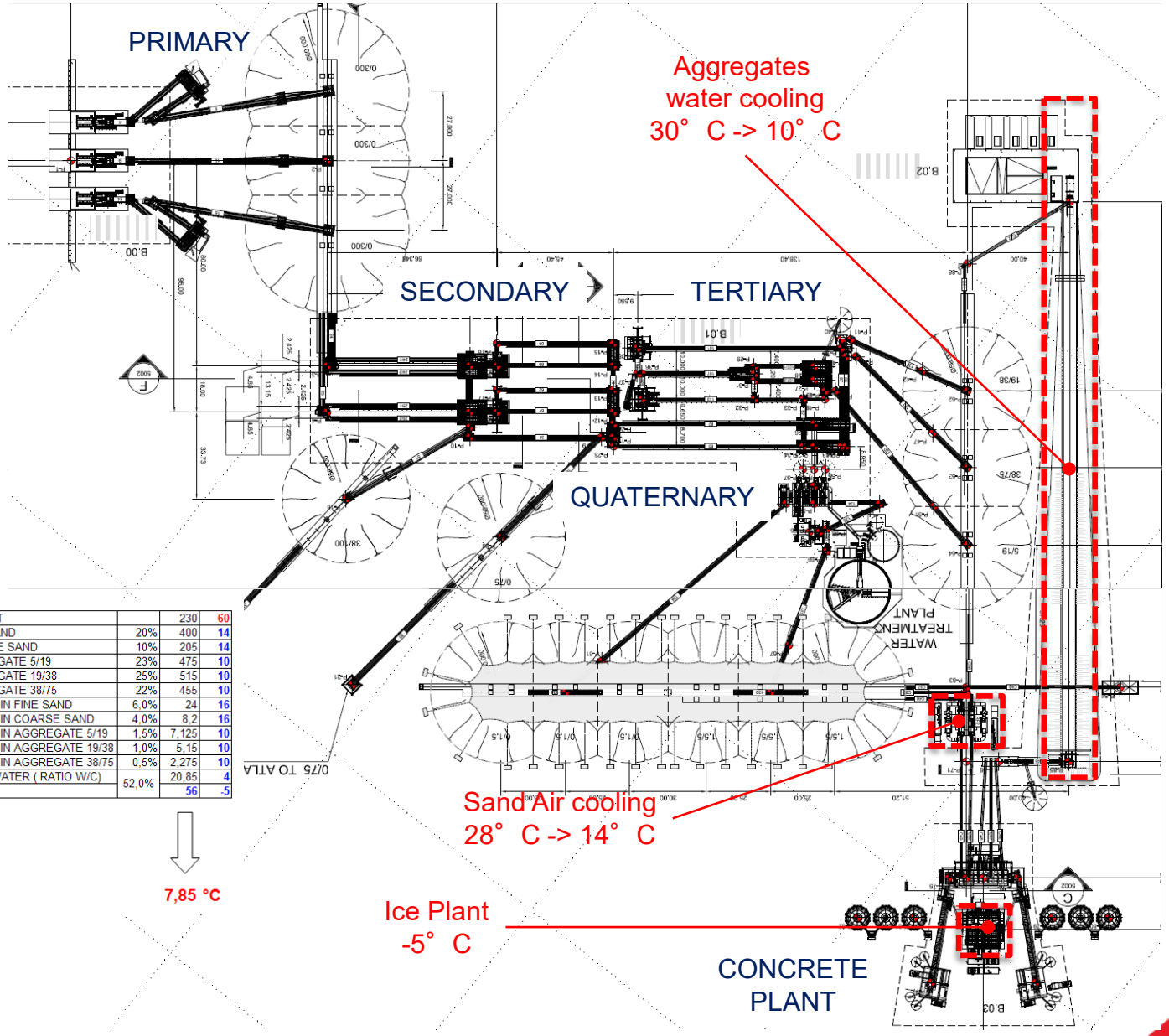
Third Set of Lock – Crushing & Batching Plants



Thermal Balance

CEMENT		230	60
FINE SAND	20%	400	28
COARSE SAND	10%	205	28
AGGREGATE 5/19	23%	475	30
AGGREGATE 19/38	25%	515	30
AGGREGATE 38/75	22%	455	30
WATER IN FINE SAND	6,0%	24	28
WATER IN COARSE SAND	4,0%	8,2	28
WATER IN AGGREGATE 5/19	1,5%	7,125	30
WATER IN AGGREGATE 19/38	1,0%	5,15	30
WATER IN AGGREGATE 38/75	0,5%	2,275	30
FREE WATER (RATIO W/C)	52,0%	72,85	29

33 °C

CEMENT		230	60
FINE SAND	20%	400	14
COARSE SAND	10%	205	14
AGGREGATE 5/19	23%	475	10
AGGREGATE 19/38	25%	515	10
AGGREGATE 38/75	22%	455	10
WATER IN FINE SAND	6,0%	24	16
WATER IN COARSE SAND	4,0%	8,2	16
WATER IN AGGREGATE 5/19	1,5%	7,125	10
WATER IN AGGREGATE 19/38	1,0%	5,15	10
WATER IN AGGREGATE 38/75	0,5%	2,275	10
FREE WATER (RATIO W/C)	52,0%	20,85	4
ICE		56	-5

7,85 °C

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Third Set of Lock – Transport aggregates from Pac to Atl

Earthworks (Pacific Locks

EXCAVATION WORKS

EXCAVATORS

- Face Showel (Bucket: 16 m3)
- Backhoe (Bucket: 9; 7; 4 m3)

DUMPERS

- Rigid (60, 90 tons)
- Articulated (40 tons)

DOZER & WHEEL LOADER

COMPACTOR & GRADER

TRUCK DRILL

SERVICES

Earthworks (Pacific Locks)

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Earthworks (Pacific Locks)

ROCK BLASTING (21M m3)

- PRE-BLAST SURVEYS
- BLASTING SCHEDULE
  - ✓ ALLOWED 7:00 AM TO 6:00 PM ON WEEKDAYS
  - ✓ ACP AUTHORIZATION ON SATURDAY AND SUNDAY
- PPV LIMITS FOR EXISTING FACILITIES
- MONITOR VIBRATIONS AND AIR BLAST (500m)
- SAFE AREA RADIUS (500m)
- BLASTING NOTIFICATION TO PUBLIC
- TESTS BLAST
- BLASTING PLAN
- 1° BLASTING 17 JUN 2010

Earthworks (Pacific Locks)

Earthworks (Pacific Locks)

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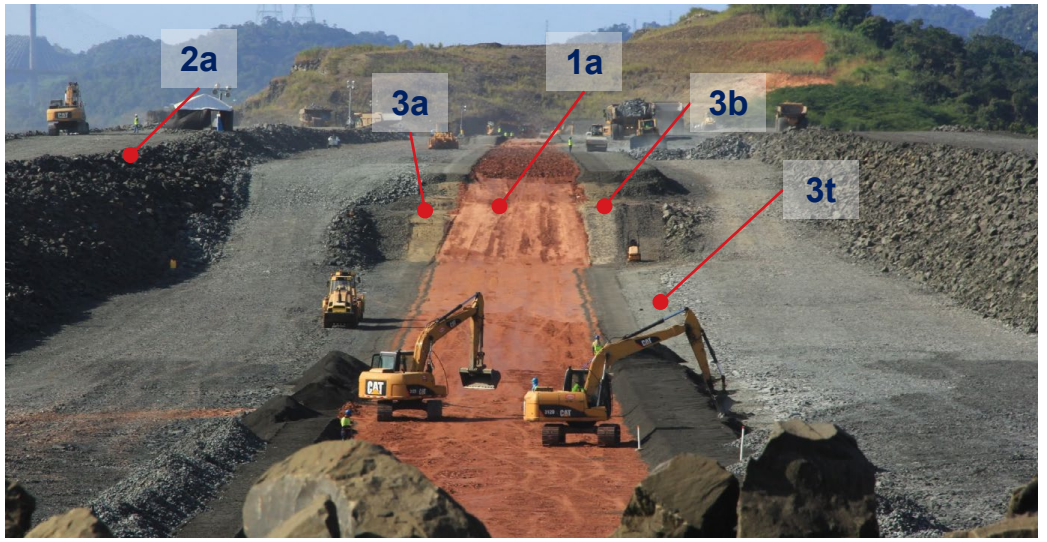
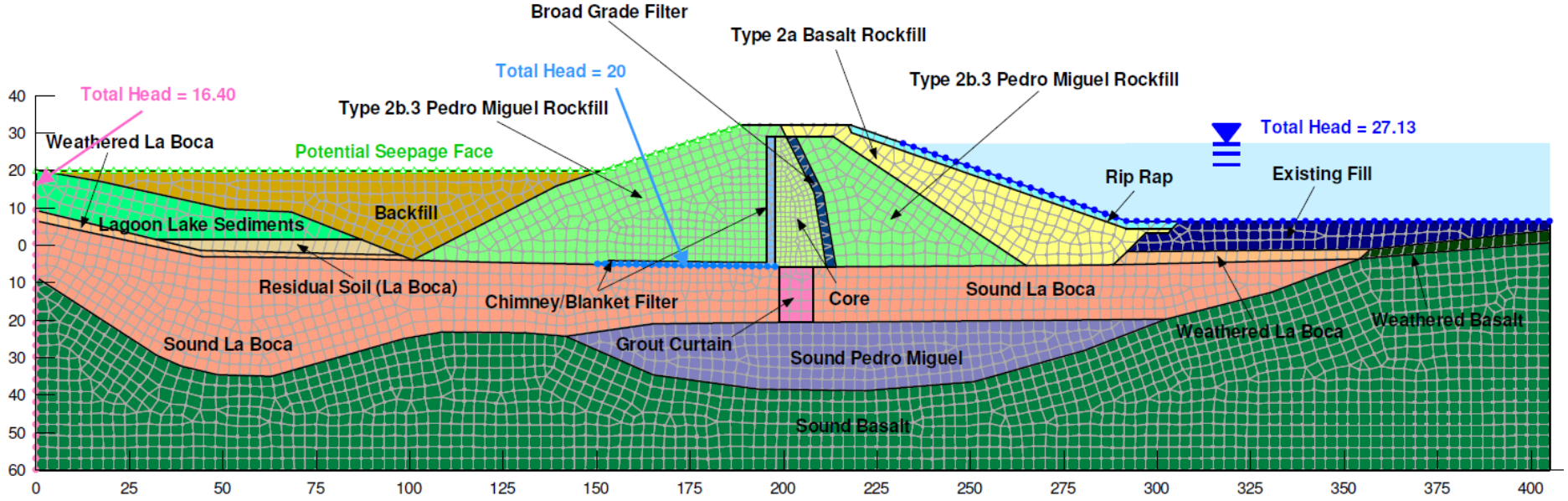
Earthworks (Pacific Locks)

BORINQUEN DAMS

- EXCAVATION
- FOUNDATION TREATMENT
- GROUT CURTAIN
- FILL EMBANKMENT
- INSTRUMENTATION



1a IMPERVIOUS EARTHFILL (CORE)
2a BASALT ROCKFILL
2b.3 PEDRO MIGUEL ROCKFILL
3a BROAD GRADED FILTER/TRANSITION
3b FINE GRADED FILTER
3t TRANSITION
4 RIPRAP



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Earthworks (Pacific Locks)

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Concrete works

QUANTITIES

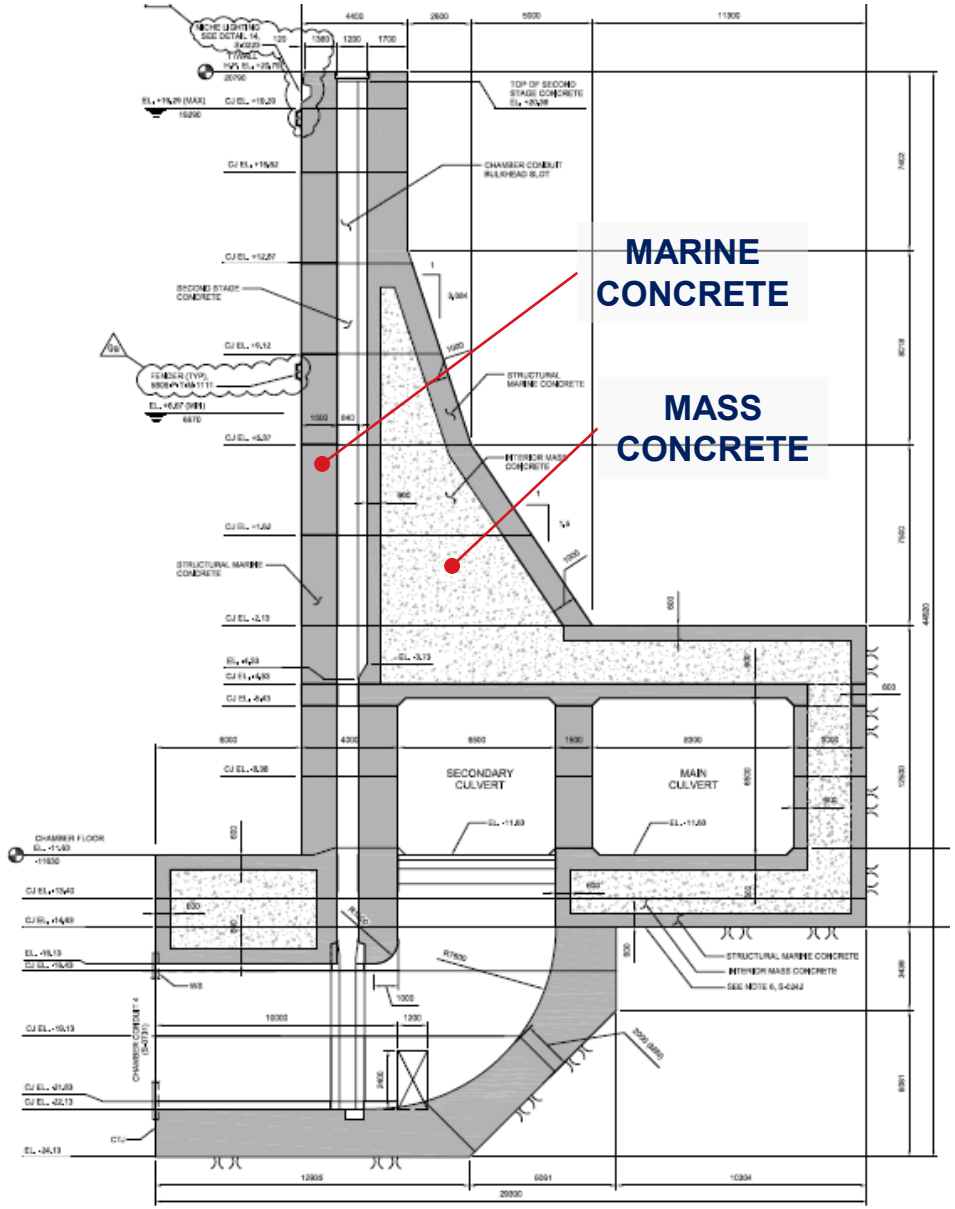
- PACIFIC
  - ✓ CONCRETE — 2,6M m3 (1,2 Keops Pyramid)
  - ✓ STEEL REINFORCEMENT — 102.000 ton (10 Eiffel Towers)
- ATLANTIC
  - ✓ CONCRETE — 2,3M m3 (1 Keops Pyramid)
  - ✓ STEEL REINFORCEMENT — 90.000 ton (9 Eiffel Towers)

Concrete works

Concrete Type & Classes

- MARINE & MASS CONCRETE
- 14 CONCRETE CLASSES
  - ✓ CLASS I – STRUCTURAL MARINE CONCRETE (37,5 mm)
  - ✓ CLASS II – INTERIOR MASS CONCRETE (75 mm)
  - ✓ CLASS III – STRUCTURAL CONCRETE (37,5 mm)
  - ✓ CLASS IX - HIGH STRENGTH MARINE CONCRETE (37,5 mm)

Classification	Specified Compressive Strength,
Class I – Structural Marine Concrete	35 MPa @ 90 days
Class IA – Structural Marine Concrete	35 MPa @ 90 days
Class II – Interior Mass Concrete	28 MPa @ 90 days
Class IIA – Interior Mass Concrete	28 MPa @ 90 days
Class III – Structural Concrete	28 MPa @ 28 days
Class IV – Lean Concrete	15 MPa @ 90 days
Class V – Tremie Concrete	28 MPa @ 28 days
Class VI – Miscellaneous Concrete	21 MPa @ 28 days
Class VII – Pervious Concrete	12 MPa @ 28 days
Class VIII – Structural Precast Concrete	40 MPa @ 28 days
Class IX – High Strength Marine Concrete	55 MPa @ 90 days
Class IXA – High Strength Marine Concrete	55 MPa @ 90 days
Class X – High Strength Marine Concrete around Culvert Ports	42 MPa @ 90 days
Class XA – High Strength Marine Concrete around Culvert Ports	42 MPa @ 90 days



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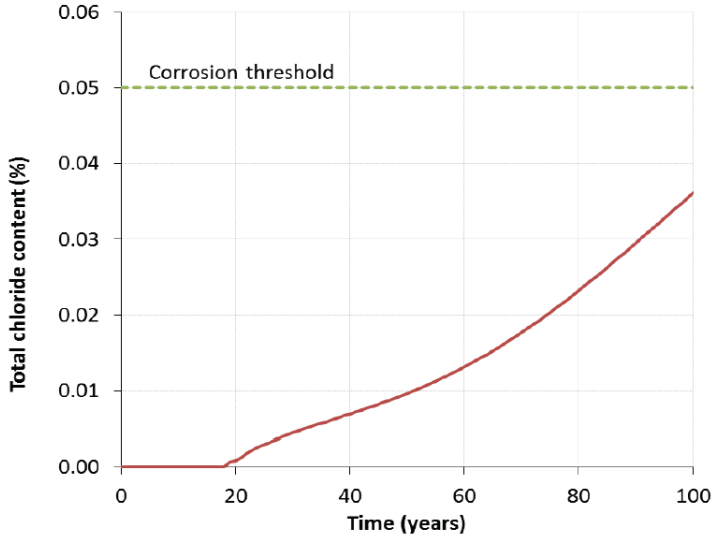
Concrete works

Concrete Mixes

- EXSPOSURE CONDITIONS
  - ✓ ATLANTIC OCEAN
  - ✓ GATUN LAKE
  - ✓ PACIFIC OCEAN

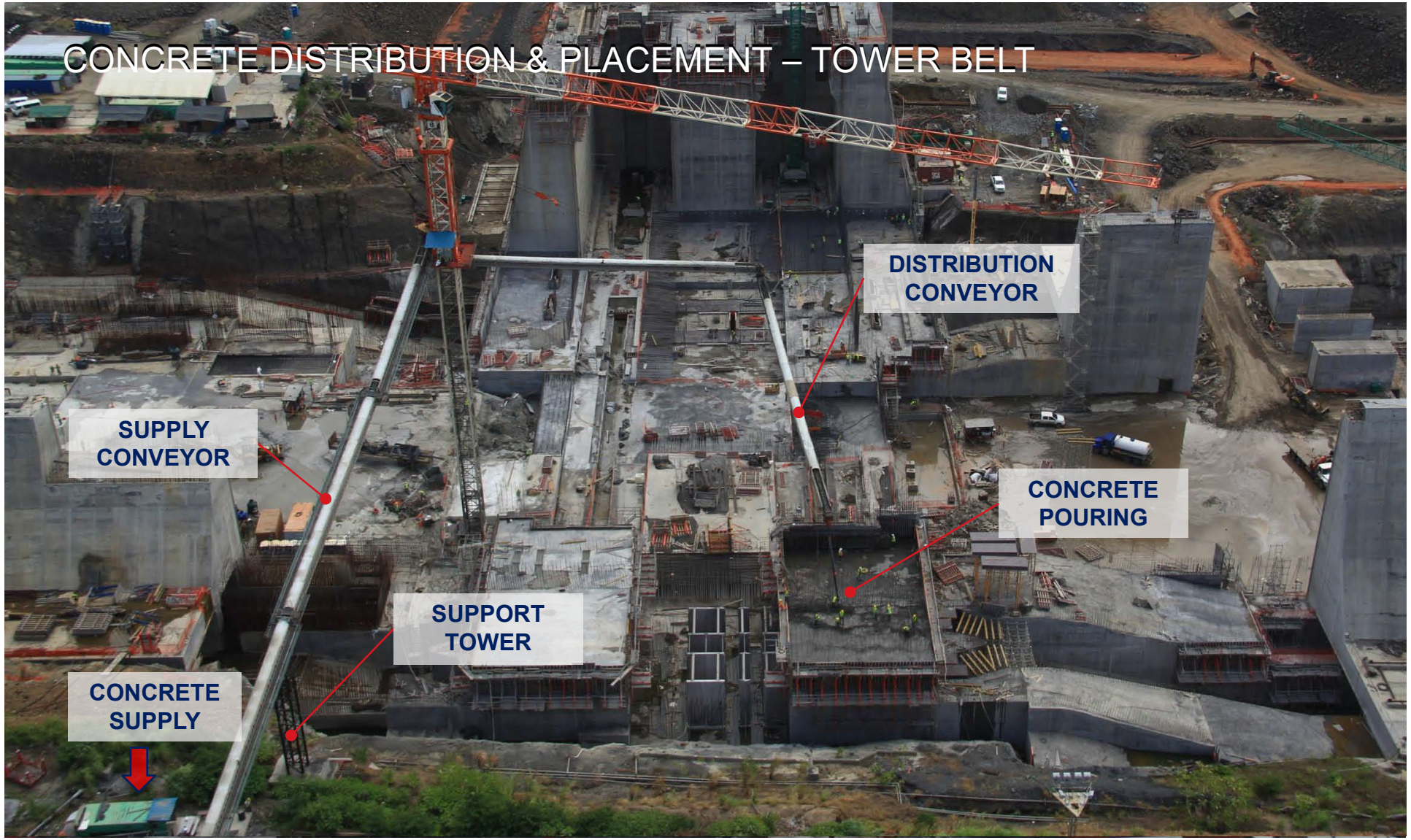
- MIX DESIGN
  - ✓ AGGREGATES FROM EXCAV./QUARRIES
  - ✓ CEMENT TYPE II (LOW ALKALI)
  - ✓ NATURAL POZZOLAN
  - ✓ SILICA FUME
  - ✓ >50 RECIPES

- DURABILITY (100 yrs)
  - ✓ SERVICE LIFE PREDICTION (CHLORIDE INGRESS)
  - ✓ CONCRETE COVER (100mm; 125mm; 150mm)



Locks	Location	Salinity (ppt)
Pacific	Approach structures	34
	Wing walls + Lock head 4	30
	Lower chamber + Lock head 3	19.2
	Middle chamber + Lock head 2	4.6
	Upper chamber + Lock head 1	0.6
Atlantic	Upper chamber + Lock head 1	0.6
	Middle chamber + Lock head 2	3.8
	Lower chamber + Lock head 3	16.2
	Wing walls + Lock head 4	27.6
	Approach structures	32

Concrete works



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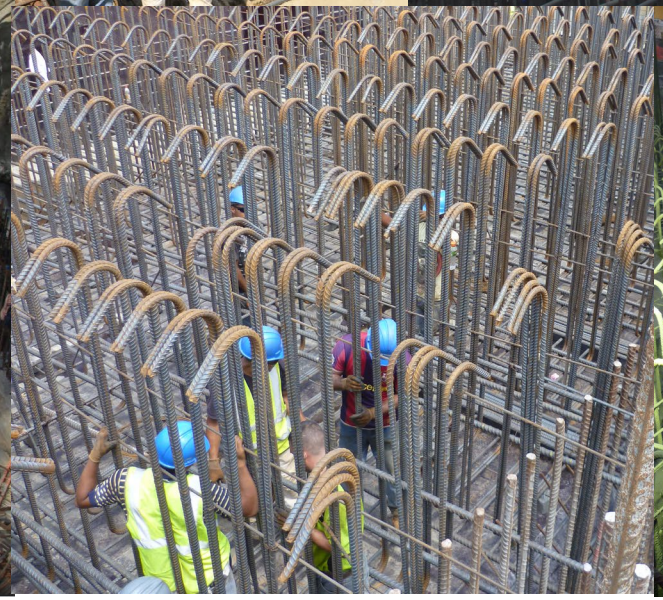
Concrete works

Concrete works

Steel Reinforcement



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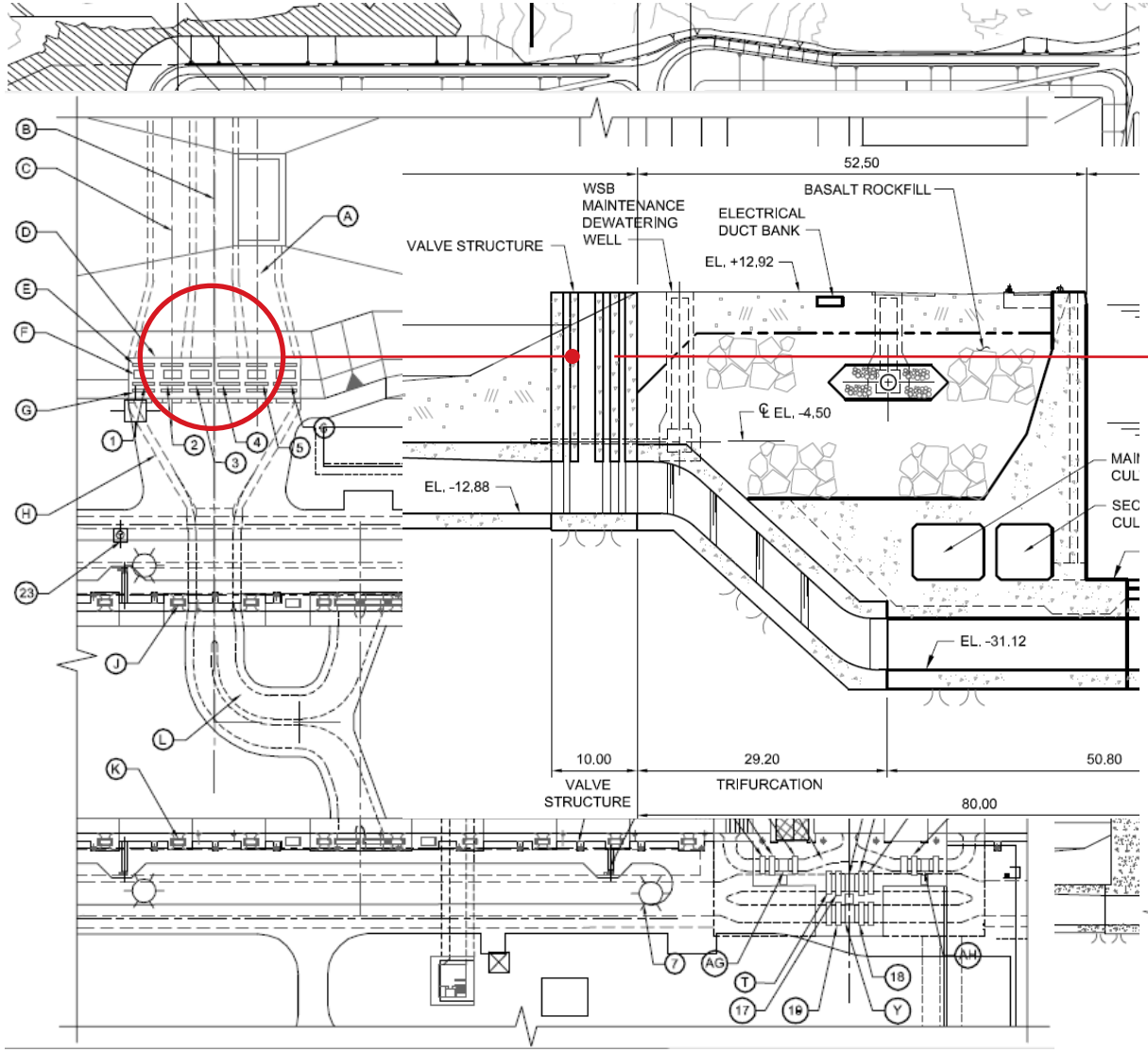
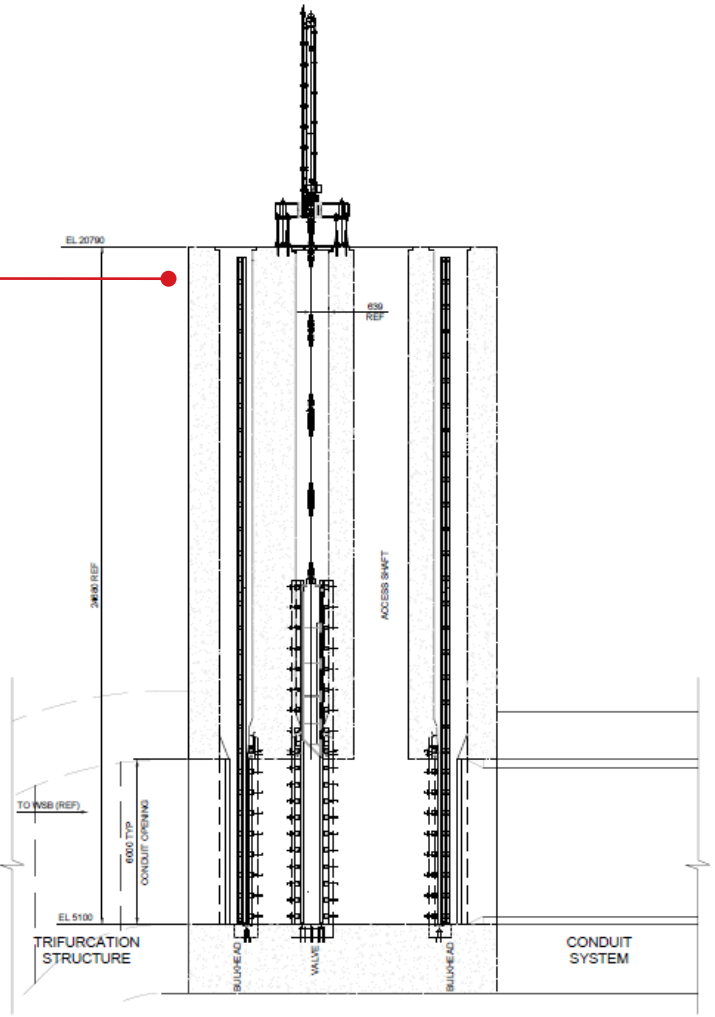
Lock gates & valves

VALVES AND BULKHEADS



CONDUITS VALVE (5m x 6m; 25ton)



Lock gates & valves

VALVES (PACIFIC)

- ✓ No. 76
- ✓ CONDUITS (5m x 6m; v=4m/s)
- ✓ CULVERTS (4,15m x 6,5m; v=8m/s)
- ✓ EQUALIZATION (3m x 4m)

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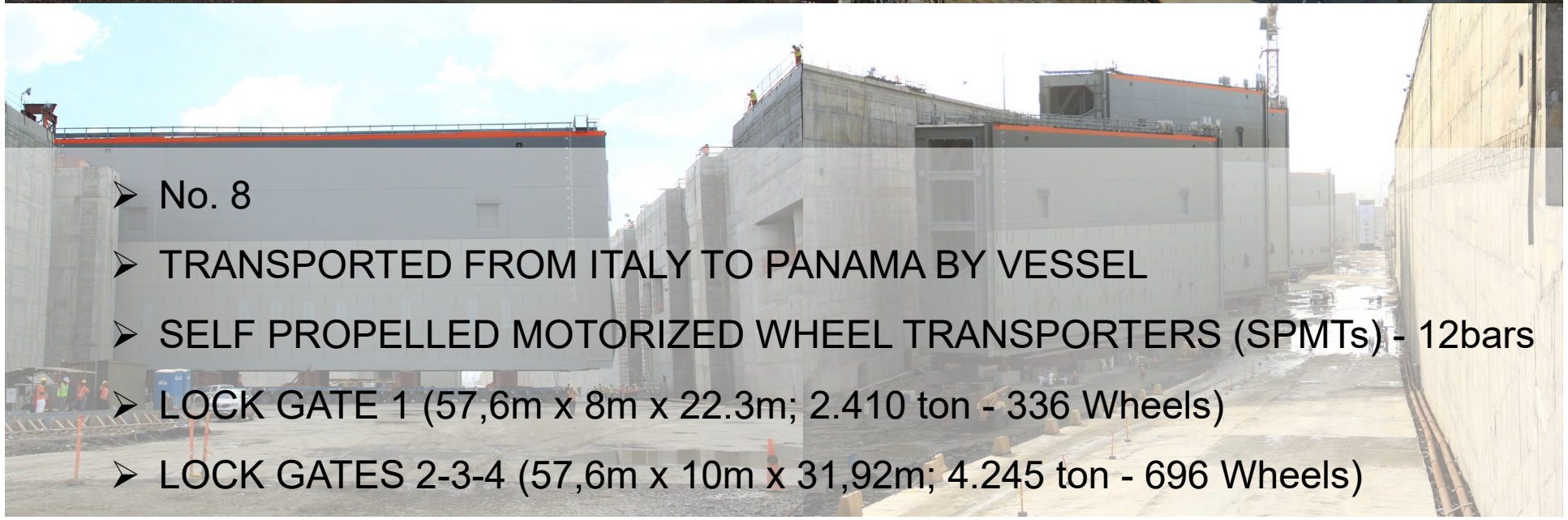
Lock gates & valves



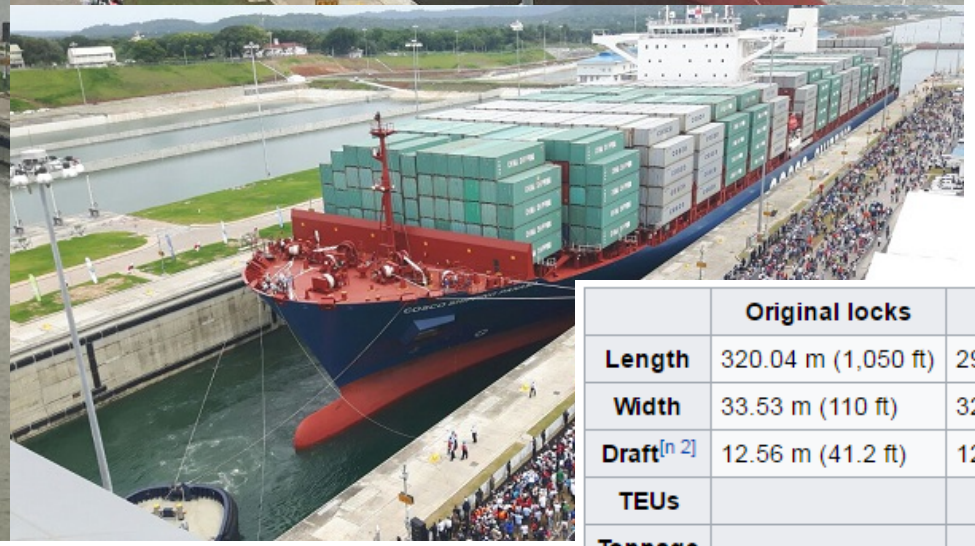
- No. 8
- TRANSPORTED FROM ITALY TO PANAMA BY VESSEL
- SELF PROPELLED MOTORIZED WHEEL TRANSPORTERS (SPMTs) - 12bars
- LOCK GATE 1 (57,6m x 8m x 22.3m; 2.410 ton - 336 Wheels)
- LOCK GATES 2-3-4 (57,6m x 10m x 31,92m; 4.245 ton - 696 Wheels)

Lock gates & valves

TESTING AND COMMISSIONING

- LOCKAGE TIME MAX (SINGLE LOCKAGE)
  - ✓ 154 min. with WSBs (9,4 ships/day => 16,4 in Relay Lockage)
  - ✓ 133 min. without WSBs (10,8 ships/day => 19,5 in Relay Lockage)
- PRE-COMMISSIONING TESTS (COMPONENTS FUNCTIONAL TEST)
- COMMISSIONING TESTS (SYSTEM FUNCTIONAL TEST)
- PERFORMANCE TESTING (FUNCTIONAL COMPLETION: 31 MAY 2016)
- TRIAL OPERATION (UP/DOWN LOCKAGE)
- FIRST TRANSIT POST PANAMAX VESSEL: 26 JUNE 2016

Inauguration of the New Panama Canal



26 JUNE 2016

TRANSIT OF NEOPANAMAX

COSCO SHIPPING PANAMA

(10,000 TEUs - TOLL RATE

$829.468)

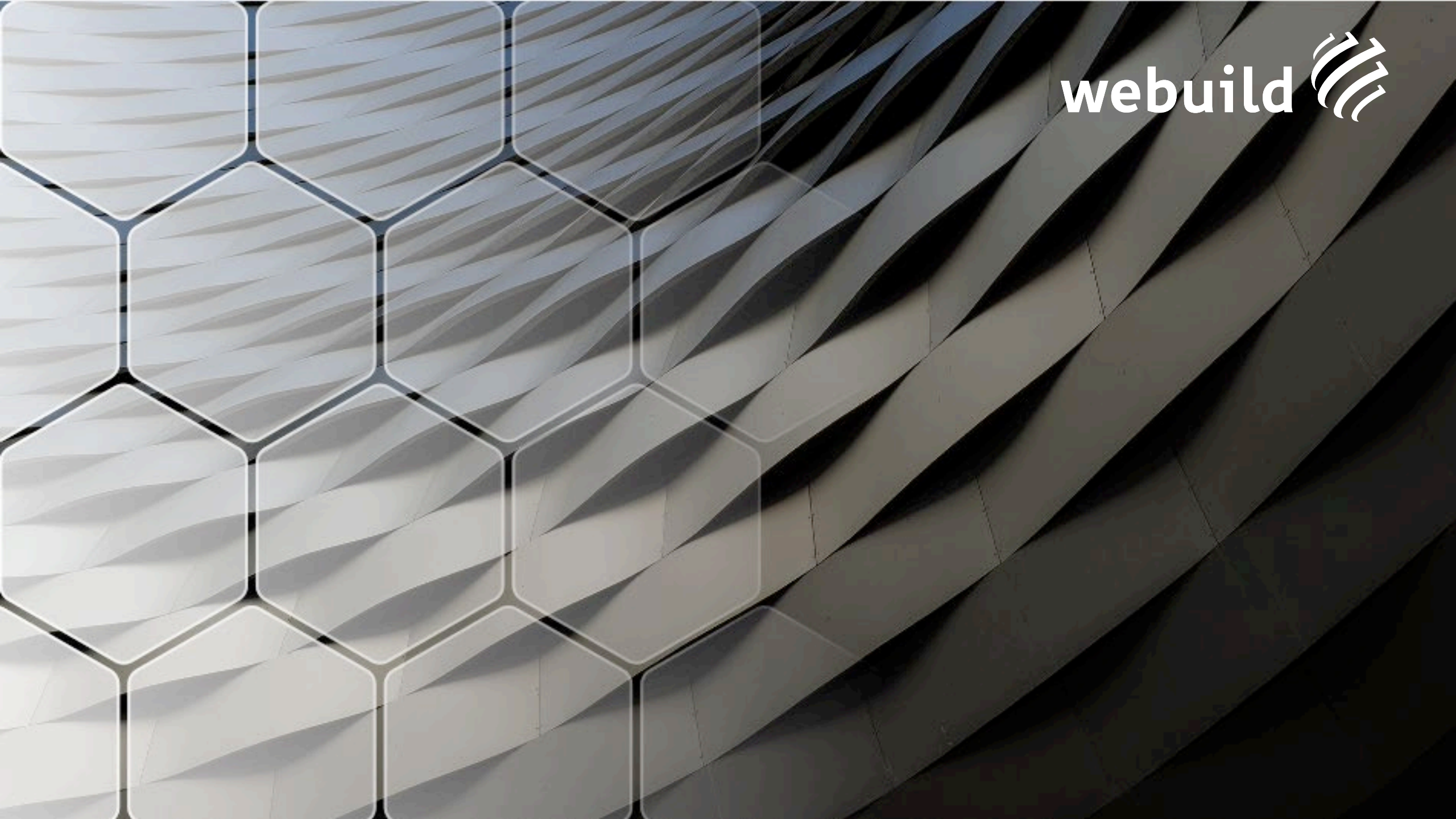
	Original locks	Panamax	Third locks[n 1]	Neo- Panamax[n 1]
Length	320.04 m (1,050 ft)	294.13 m (965 ft)	427 m (1,400 ft)	366 m (1,200 ft)
Width	33.53 m (110 ft)	32.31 m (106 ft)	55 m (180 ft)	49 m (161 ft)
Draft[n 2]	12.56 m (41.2 ft)	12.04 m (39.5 ft)	18.3 m (60 ft)	15.2 m (50 ft)
TEUs		**5,000**		**13,000**
Tonnage		**52,500 DWT**		**120,000 DWT**

Conclusions

Construire, c'est collaborer avec la terre: c'est mettre une marque humaine sur un paysage qui en sera modifié à jamais […].

Costruire, significa collaborare con la terra, imprimere il segno dell'uomo su un paesaggio che ne resterà modificato per sempre […].

M. Yourcenar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