City of Dublin
OHIO, USA

DUBLIN SCIOTO RIVER PEDESTRIAN BRIDGE

ASCE LUNCHEON

SEPTEMBER 22, 2016

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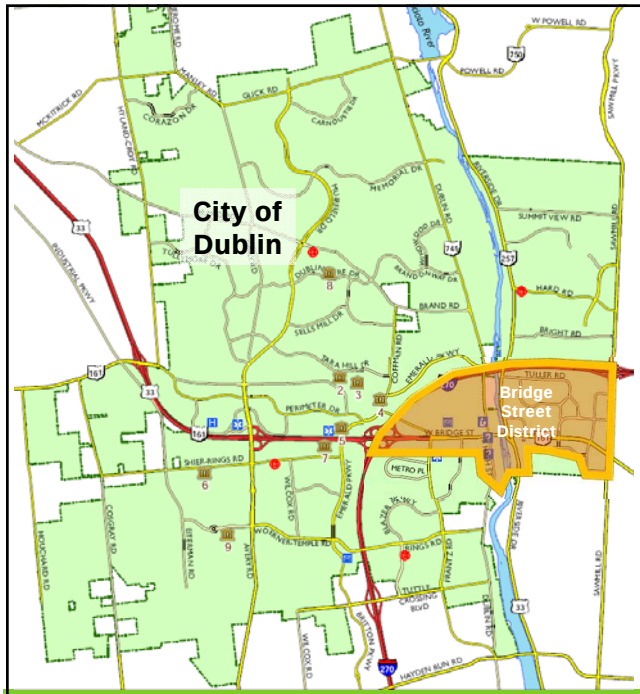

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Greenville, SC - 2008

THE VISION PLAN - 2010

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Bridge Street District Area Plan
Dublin Community Plan | 2013 Update

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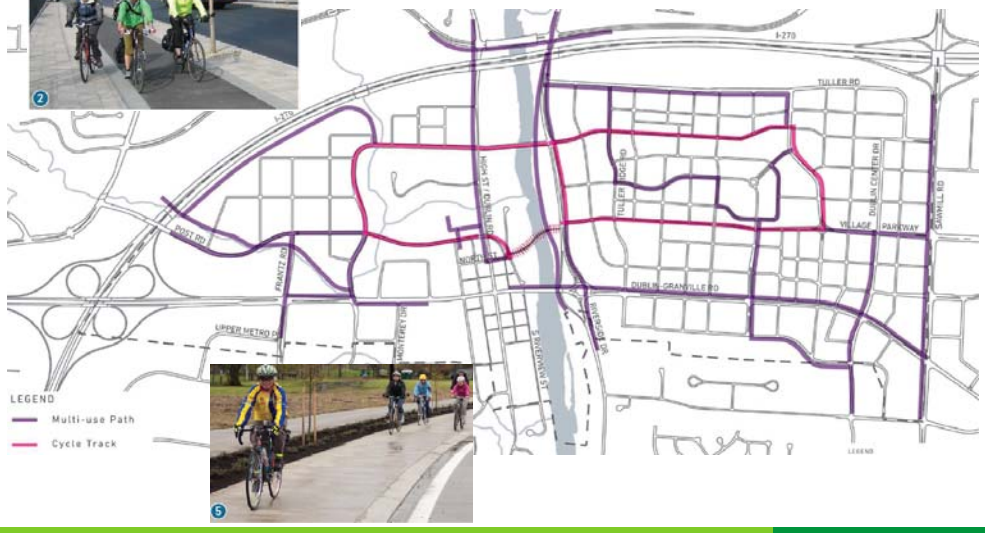
Bridge Street District Bicycle Network



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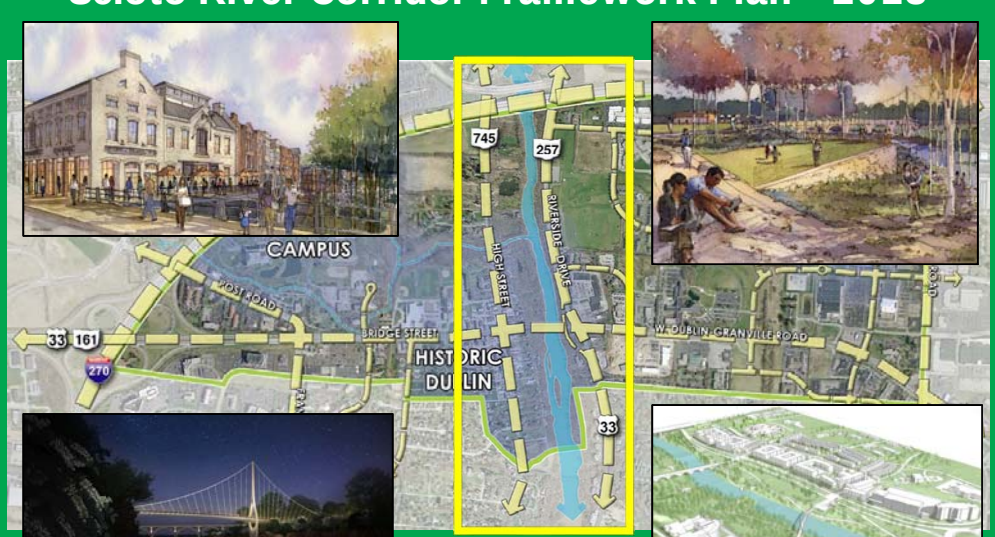
Scioto River Corridor Framework Plan - 2013



Scioto River Corridor Public Improvements Approved Fall 2013

Riverside/161 Roundabout

Riverside Drive Relocation

Pedestrian Bridge

Riverfront Park

John Shields Parkway

Dale Drive/Tuller Ridge Connector

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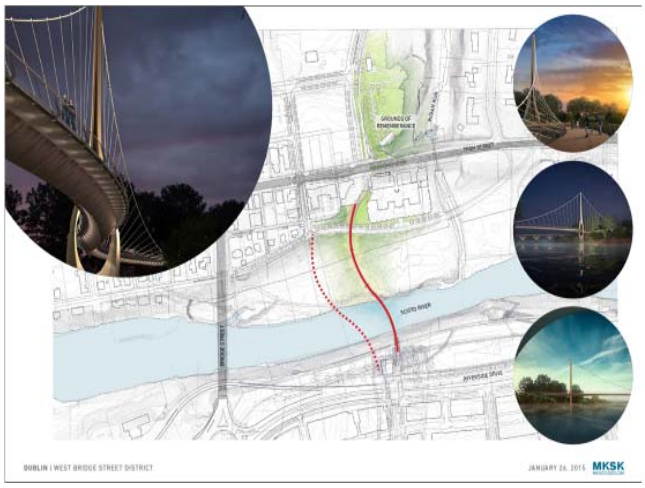
Ped Bridge Planning and Design Issues – 2014/2015

- Continued Concept validation and refinement
- Value Engineering
- West Side Landing location at North Street had challenges
- Planning for roadway infrastructure, new River Park, library, pedestrian bridge landing plaza, Bridge Park West
- The preferred west side landing location that emerged is the proposed Rock Cress Parkway



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BRIDGE PARK

Project Snapshot - EAST

- **Office:** 373,000 SF
- **Retail:** 120,000 SF
- **Food & Beverage:** 115,000 SF
- **Grocery:** 76,000 SF
- **Apartments:** 720
- **For-Sale Condos:** 70 units ($350K – $450K)
- **Conference Center:** 500 person
- **Hotel:** 150 Key
- **Timeline:** First delivery Fall 2016

Project Snapshot - WEST

- **Office:** 15,000 SF
- **Retail /Food & Beverage:** 15,000 SF
- **For-Sale Condos:** 41 ($300,000 – $1,700,000)
- **Timeline:** Fall 2016

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Design Kick-Off – Fall 2015

T·Y·LIN INTERNATIONAL

EMH&T Engineers, Surveyors, Planners, Scientists

endres studio ARCHITECTURE ENGINEERING

S&ME

MKSK

LIGHTING DESIGN ALLIANCE

RWDI CONSULTING ENGINEERS & SCIENTISTS

Resource International Rii

AmeriCost.

GENESIS STRUCTURES

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Riverside Park – Adopted by City Council May 2016

RIVERSIDE PARK MASTER PLAN

1| Pedestrian Bridge East Plaza
2| Pedestrian Bridge West Plaza
3| Pedestrian Bridge
4| The Green
5| Pathways & Trails
6| Indian Run Falls Trail
7| River Access & Overlooks
8| John Shields Parkway Plaza

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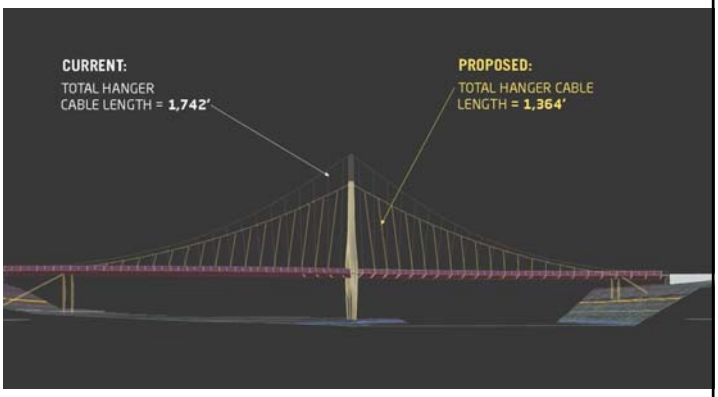
Scioto River Park

June 2016 City Council Workshop – 30% Design Update

- Status of the project based on 30% design documents
- Demonstrate how the detailed design efforts are continuing to be guided by the previously established vision, concept, and budget parameters for this iconic public improvement
- Bridge lighting design concepts

➢ Council directed staff to reevaluate the tower height



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2 weeks later – Follow-up

- Primary tower height can be increased to an above-deck height of 110 feet
- Suspended span length remains unchanged at 500 feet
- Enhanced experience for pedestrians on and near the bridge, as well as when viewed from a distance

- Cost Implication
  - Estimated additional $500,000
- Schedule Implications
  - Estimated additional 3 months design and review time
  - Estimated additional 2 months construction time

EVERYTHING GROWS HERE.

Budget and Schedule Moving Forward

- Construction Budget
  - At 30% design – construction estimate $19,600,000
  - Increase tower height to 110 feet, Intermediate lighting level, additional contingency.
  - ***Total Estimated Construction Cost $22,750,000***

- Schedule
  - 60% design submission – September 2016
  - 90% design submission – December 2016
  - 100% bid documents – February 2017
  - Environmental Permitting – March 2017
  - ***Bid – March 2017 (permit dependent)***
  - ***2 construction seasons***

EVERYTHING GROWS HERE.

PROGRESS

EVERYTHING GROWS HERE.

T.Y. LIN INTERNATIONAL CABLE SUPPORTED PROJECTS

- Harbor Drive Pedestrian Bridge, San Diego, CA
- Lusail Pedestrian Bridge, Doha, Qatar
- San Francisco-Oakland Bay Bridge, San Francisco, CA
- Panama Canal 2nd Crossing, Panama City, Panama
- Port Mann Bridge, Vancouver, BC, Canada
- Hoover Dam Bypass Bridge, Colorado River, AZ/NV
- Lowry Avenue Bridge over Mississippi River, Minneapolis, MN

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HARBOR DRIVE PEDESTRIAN BRIDGE, SAN DIEGO

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LUSAIL PEDESTRIAN BRIDGE, DOHA, QATAR

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PARTNERS – SUB-CONSULTANT PARTICIPATION

Team Member	Location	Level of Effort	Role	Work Assignments
MKSK Studios (MKSK)	Columbus, OH	2.8%	Advisor & Transportation Plan	• Strategic advisor • Transportation and planning • Landing design
EMH&T	Columbus, OH	11.9%	Civil Engineering	• Environmental engineering and remediation • Water permitting preparation • Land surveying • Electrical engineering
S&ME	Columbus, OH	1.3%	Geotechnical Engineering	• Review existing geotechnical reports • Lead geotechnical investigations
Resource International (Rii)	Columbus, OH	4.8%	Bridge Design & Geotechnical Engineering	• Bridge substructure design • Review existing geotechnical reports • Coordinate structural design reports based on geotechnical investigation
AmeriCost Infrastructure Estimators, Inc. (AC)	Novato, CA	2.0%	Cost Estimating	• Provide cost estimates
RWDI Consulting Engineers (RWDI)	Bromont, Ontario	2.3%	Wind Study & Testing	• Wind analysis and tunnel testing
Endrestudio (ES)	Emeryville, CA	6.3%	Bridge Architecture	• Bridge aesthetics
Lighting Design Alliance (LDA)	Los Angeles, CA	3.6%	Lighting Design	• Aesthetic lighting

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TEAM TOOLS

- COLLABORATIVE SPIRIT
- Early agreement on the bridge layout – permitting process
- Deflection and Vibration studies – comfort and safety
- Geotechnical investigations – foundation economy
- Direct pricing from vendors – realistic cost estimate
- Pier development – aesthetics, cost, material
- Aesthetic lighting – beauty and function
- Wind studies and testing – comfort and safety

THE ENGINEERING ASPECTS AND CODE COMPLIANCE

- Suspension Bridges behavior – soft response
- Peculiarity of Pedestrian Bridges – vibration under the pedestrian and wind loading – British BS5400, Ontario Bridge Design Code, Setra Technical Guide compliance
- Wind studies and testing – confirming the code compliance through model testing in the wind tunnel
- Pedestrian load – analytical studies of the bridge without and with damping when vibration overpasses the code comfort limits

LAYOUT OF THE BRIDGE BETWEEN PROPOSED LANDINGS

EVERYTHING GROWS HERE.

VALUE ENGINEERING RECOMMENDATIONS

Feature	Preliminary Design or VE Recommendation	60% Design
Bridge length/max. span	632-ft / 250-ft	760-ft / 250-ft
Pylon height above deck	83-ft	110-ft
Main cable size/length	4 inches / 564-ft	5 inches / 564-ft
Girder depth	3-ft	4-ft
Piers	2 short steel	4 concrete (2 short + 2 tall)
Foundations	Drilled shafts	Spread footings/Drilled Shafts
Tune Mass dampers	Yes	Yes

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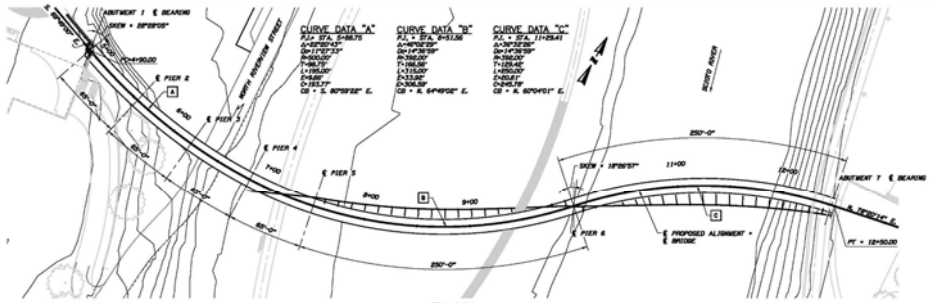
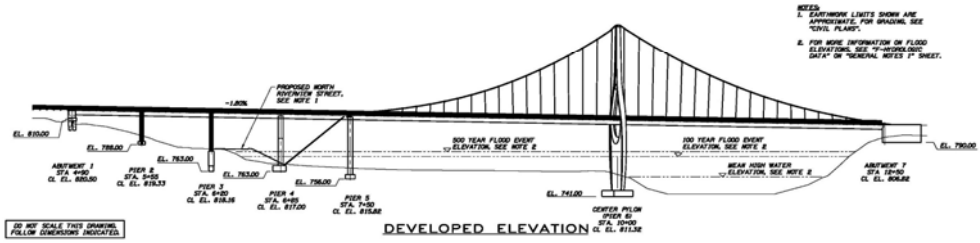
THE BRIDGE LAYOUT AS PRESENTED IN THE 30% DESIGN





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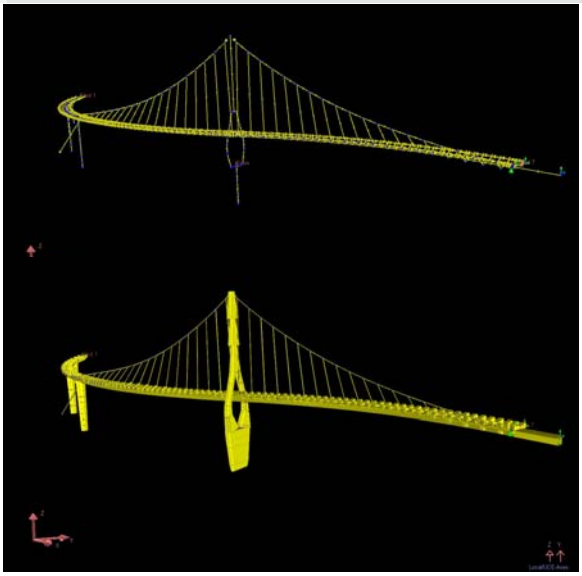
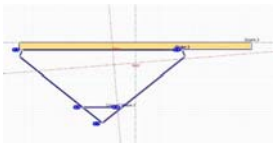
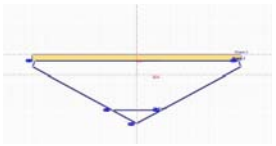
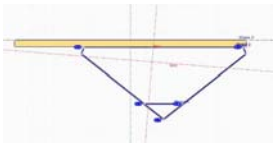
ANALYSIS MODEL AND SECTIONS









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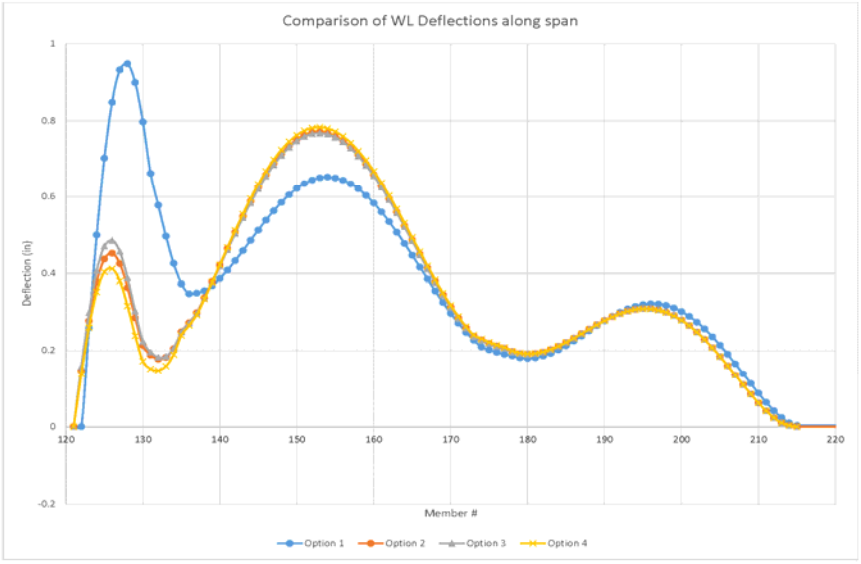
HORIZONTAL DEFLECTION STUDIES



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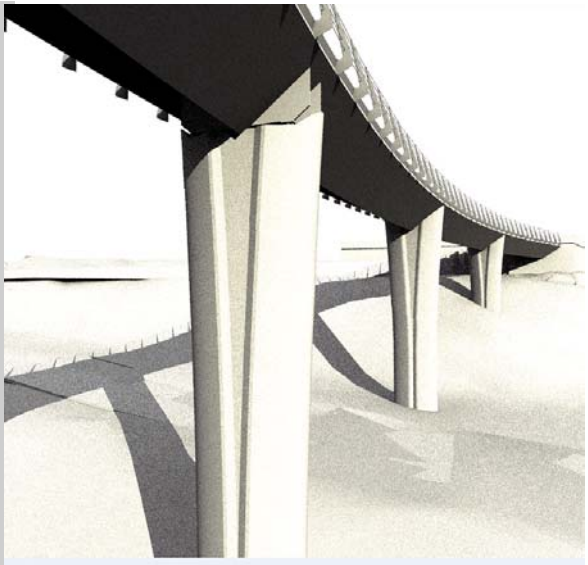
STUDIES FOR PIERS IN STEEL/CONCRETE



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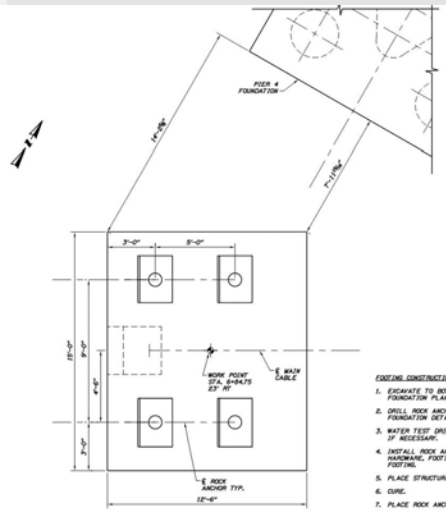
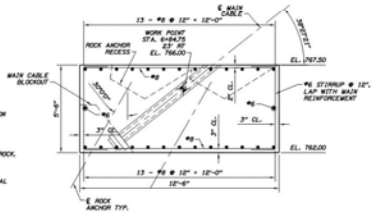
EVOLUTION OF MAIN CABLE ANCHORAGE @ PIER 4





FOOTING CONSTRUCTION SEQUENCE:

1. EXCAVATE TO BOTTOM OF FOOTING ELEVATION AS SHOWN ON FOUNDATION PLAN.
2. DRILL ROCK ANCHOR HOLES PER DETAILS ON "PIER 4 FOUNDATION DETAILS 3".
3. WATER TEST DRILLED HOLES AND CONSOLIDATION GROUT ROCK, IF NECESSARY.
4. INSTALL ROCK ANCHOR AND POST-TENSIONING DUCTS AND HARDWARE, FOOTING REINFORCEMENT, AND FORM STRUCTURAL FOOTING.
5. PLACE STRUCTURAL FOOTING.
6. CURE.
7. PLACE ROCK ANCHORS, GROUT BONDED LENGTHS, AND LET CURE.
8. STRESS AND TEST ROCK ANCHORS PER THE ROCK ANCHOR DETAILS ON "PIER 4 FOUNDATION DETAILS 3".
9. PLACE SECOND STAGE ROCK ANCHOR GROUT.

NOTE: CONTRACTOR SHALL ADJUST SPACING OF REINFORCEMENT SHOWN AS NECESSARY TO CONSTRUCT MAIN CABLE AND ROCK ANCHORS.

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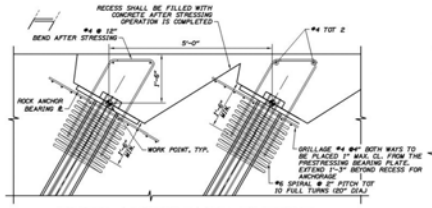
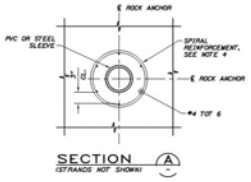
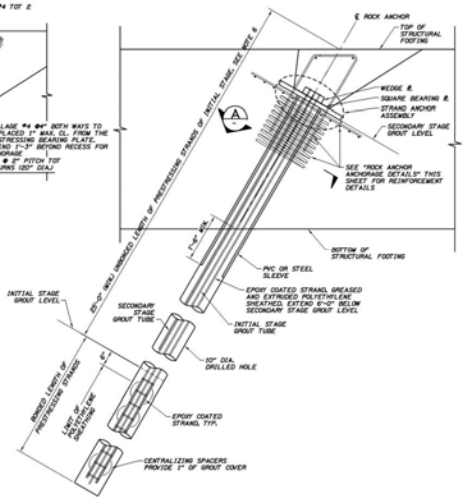
ROCK ANCHOR FOR MAIN CABLE







PRESTRESSING NOTES:

PRESTRESSING STRANDS – ASTM DESIGNATION: 882
T = ROCK ANCHOR DESIGN FORCE = 950 kips
A_g (MIN) = MINIMUM CROSS SECTION AREA OF PRESTRESSING STEEL (in^2)
A_g (MIN) = $\frac{1.35\ T}{0.75\ f_{pu}}$
f_{pu} = GUARANTEED MINIMUM ULTIMATE TENSILE STRESS OF PRESTRESSING STRAND = 270 KSI
ANCHOR SET = ¾"
BONDED LENGTH SHALL BE DETERMINED BY THE CONTRACTOR
STRUCTURAL ABUTMENT CONCRETE:
f'c = 5000 psi @ 28 DAYS
f'c = 4000 psi @ STRESSING

NOTES:

1. PROVIDE BLOCKOUTS IN STRUCTURAL FOOTING FOR ROCK ANCHORS.
2. LOCK-OFF FORCE FOR ROCK ANCHOR = 100% OF T
3. PRESTRESSING SYSTEM SHOWN IS DESCRIPTIVE ONLY. IT IS INTENDED TO DESCRIBE THE MINIMUM LEVEL OF CORROSION PROTECTION IN THE BONDED AND UNBONDED PORTIONS OF THE ANCHOR THE ENGINEER WILL APPROVE THE ACTUAL SYSTEM BASED ON ITS ABILITY TO PROVIDE THE SAME LEVEL OR EXCEED THE LEVEL OF PROTECTION SHOWN ON THIS SHEET.
4. CONTRACTOR SHALL PROVIDE ADEQUATE BURSTING REINFORCEMENT ACCORDING TO THE SYSTEM USED. BURSTING REINFORCEMENT SHOWN SHALL BE THE MINIMUM USED.
5. ANGLE ROCK ANCHOR AS INDICATED ON "PIER 4 FOUNDATION DETAILS 2" SHEET.
6. SECONDARY STAGE GROUT SHALL NOT BE PLACED UNTIL ALL OF THE ROCK ANCHORS HAVE BEEN ACCEPTED BY THE ENGINEER.
7. THE ROCK ANCHORS SHALL BE STRESSED AND TESTED IN THE FOLLOWING SEQUENCE: A1, A2, A3, A4.

DO NOT SCALE THIS DRAWING. FOLLOW DIMENSIONS INDICATED.

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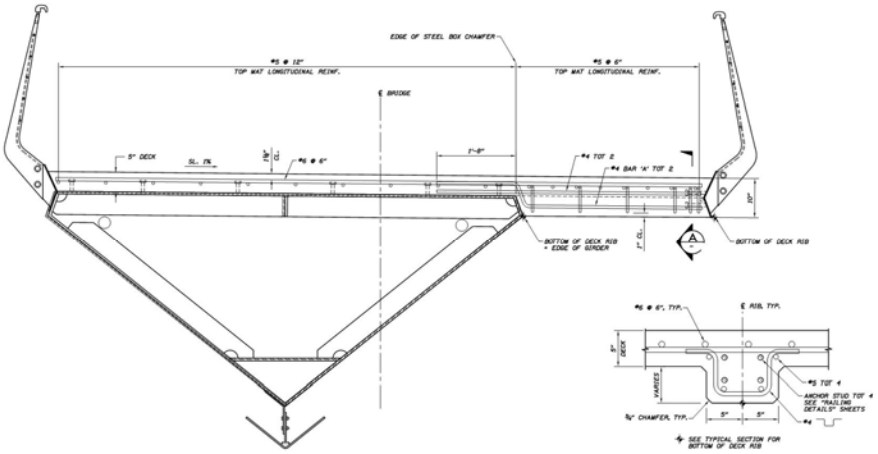
DECK REINFORCING



TYPICAL SECTION – DECK REINFORCING

SECTION (A) DECK RIB SECTION

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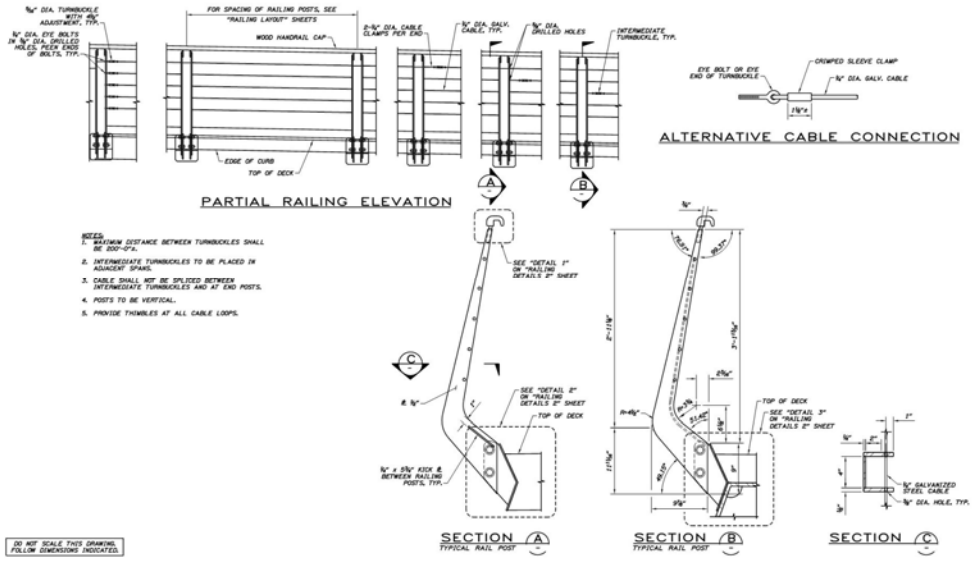
BRIDGE RAILING



PARTIAL RAILING ELEVATION

ALTERNATIVE CABLE CONNECTION

SECTION (A) TYPICAL RAIL POST

SECTION (B) TYPICAL RAIL POST

SECTION (C)

DO NOT SCALE THIS DRAWING, FOLLOW DIMENSIONS INDICATED.

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IS THE BRIDGE SAFE?

Vibration can damage or even destroy the bridge:

- By a wind load
- By pedestrians

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SECTIONAL MODEL TESTING IN THE WIND TUNNEL

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WIND INDUCED VIBRATION DISCOVERED IN TESTS

- Vortex shedding induced oscillation – vertical deflection more than 2.5" at a full scale wind of 12-15mph, an equivalent of *10% of g* acceleration, in access of the ASCE-7 comfort criteria of *5% of g* - this requires mitigation measure
- Galloping instability and flutter would occur at a mean wind speed well in access of the 10,000 year return period – flutter and galloping are not of a concern for this type of the cross section.

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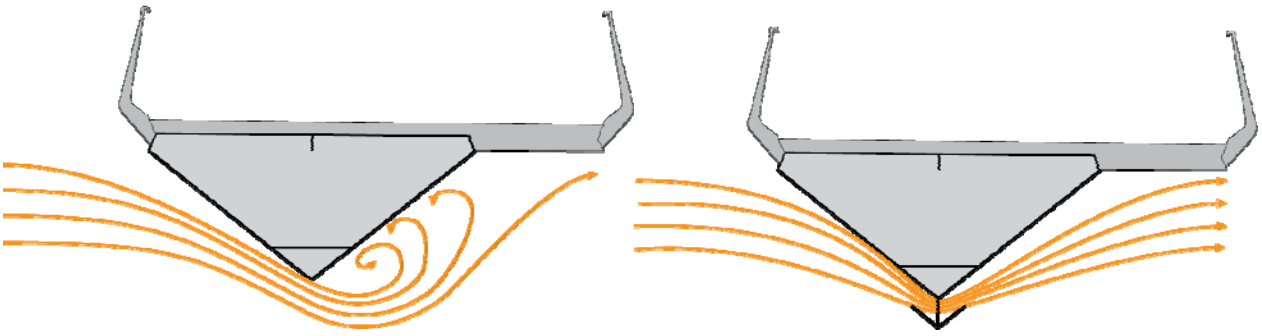
PROPOSED MITIGATION – CONTINUOUS GUIDE VANES



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PEDESTRIAN VIBRATION ANALYSIS

British Design Code, BD 37/01 requires checking the lateral response of footbridges with lateral frequencies below 1.5 Hz.

Bridge response without Tuned Mass Damper system:

Table 1: Critical Numbers of Pedestrians, no TMD			
Mode	Frequency, Hz	Number of Pedestrians	Pedestrian Density /m²
2	0.885	306	0.31
10	2.078	619	0.63
23	4.687	943	0.95
17	3.492	118	1.20
27	5.54	1306	1.32

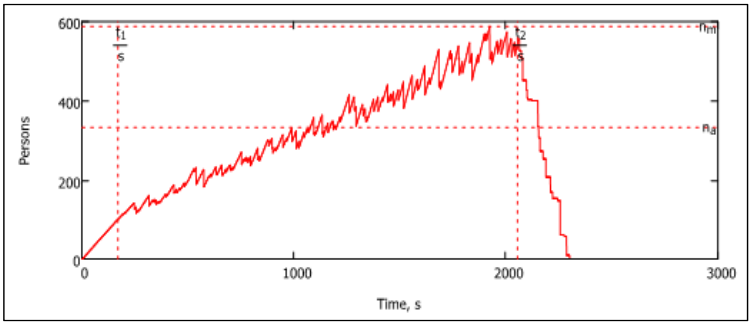

Figure 1. Loading the bridge with pedestrians (600 max)

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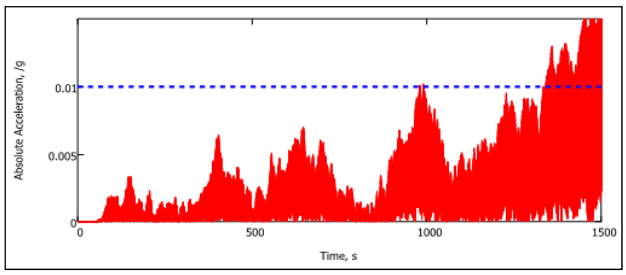
PEDESTRIAN INDUCED VIBRATION ANALYSIS

Bridge response without Tuned Mass Damper system:



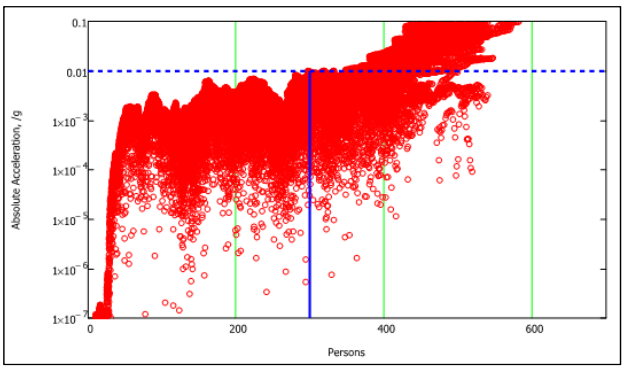


Figure 3. Normalized, Absolute Acceleration vs. Number of Pedestrians (Mode 2), no TMD

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PEDESTRIAN VIBRATION MITIGATED BY TMD

Bridge response with the addition of Tuned Mass Damper system:

Table 2: Critical Numbers of Pedestrians, TMD			
Mode	Frequency, Hz	Number of Pedestrians	Pedestrian Density /m²
2	0.885	4946	5 >0.8
10	2.078	10012	10
23	4.687	15249	15
17	3.492	19158	19
27	5.54	21107	21

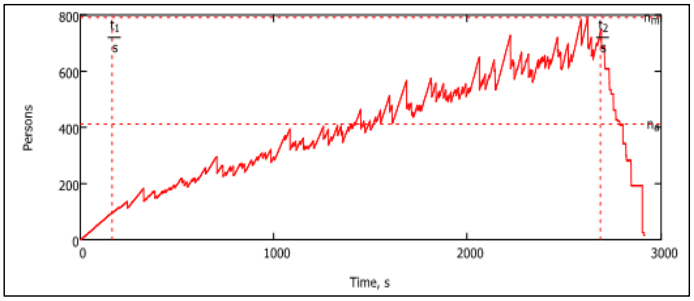

Figure 4. Loading the bridge with pedestrians (800 max corresponds with loading criteria of 0.8 person per sq. meter)

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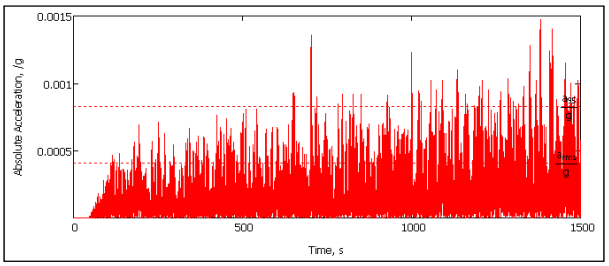
PEDESTRIAN VIBRATION MITIGATED BY TMD

Bridge response with the addition of Tuned Mass Damper system:



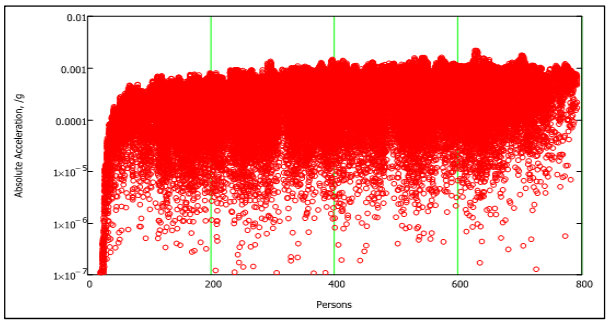


Figure 6. Normalized, Absolute Acceleration vs. Number of Pedestrians (Mode 2), TMD

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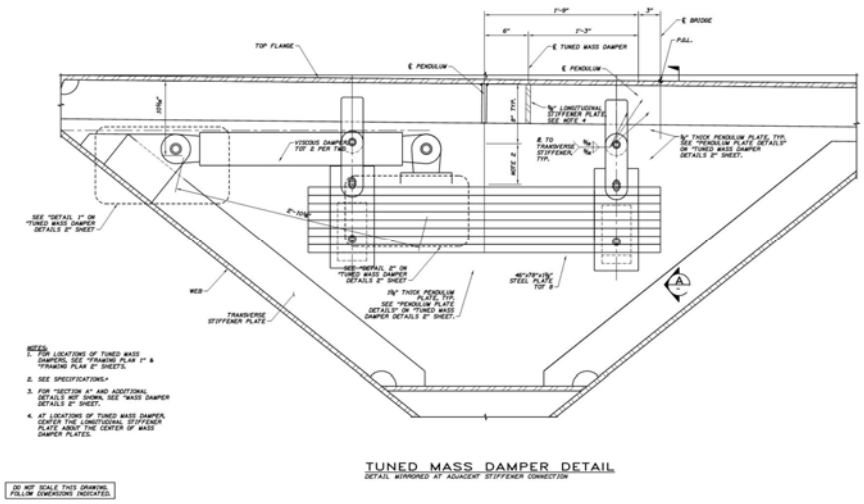
TUNED MASS DAMPER



TUNED MASS DAMPER DETAIL

Mitigation measure for pedestrian induced horizontal vibration

EVERYTHING GROWS HERE.

BRIDGE WALKER

Inspection Vehicle allowing easy access to any area of superstructure

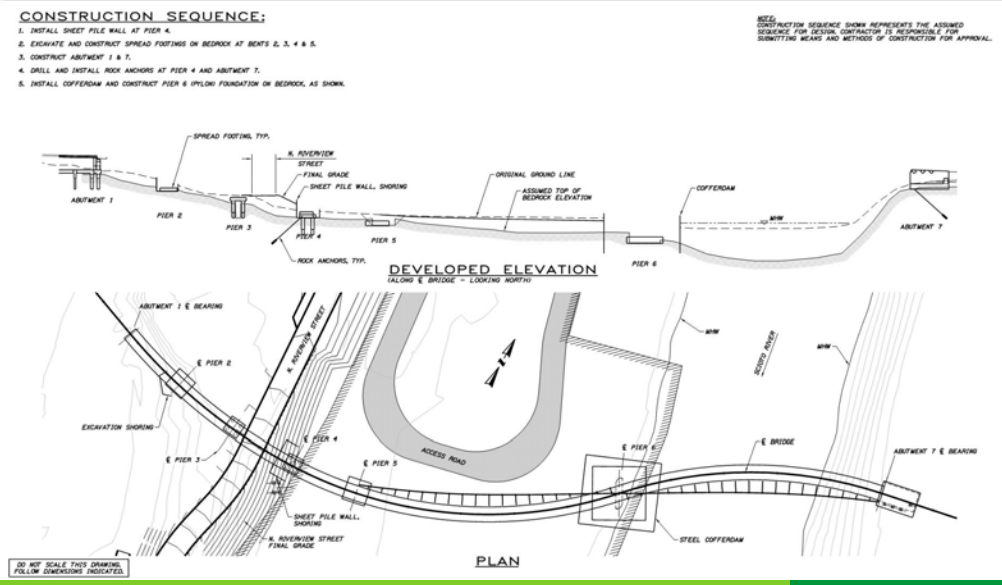
EVERYTHING GROWS HERE.

BRIDGE STREET DISTRICT IS TRANSFORMING

Construction is already underway!

EVERYTHING GROWS HERE.

ERECTION SEQUENCE 1



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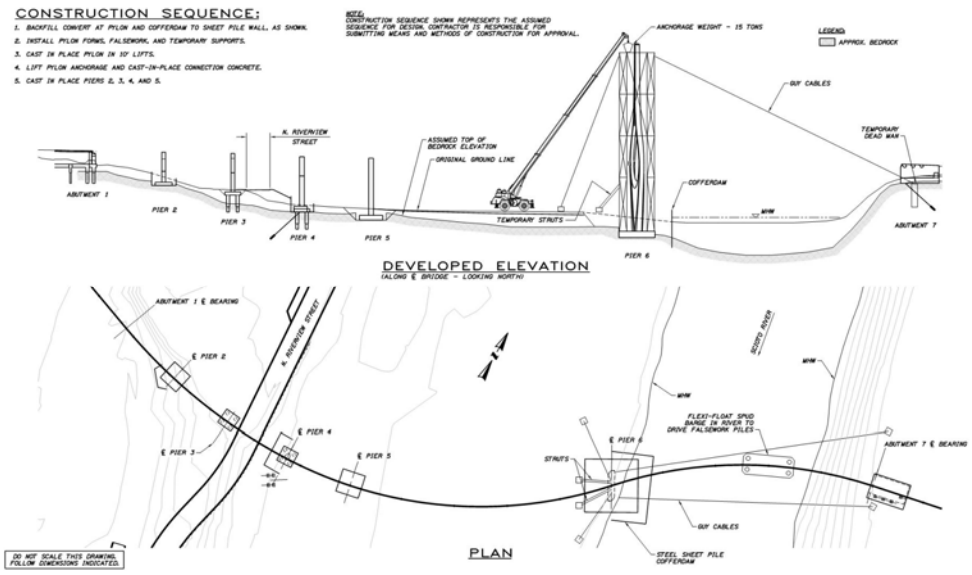

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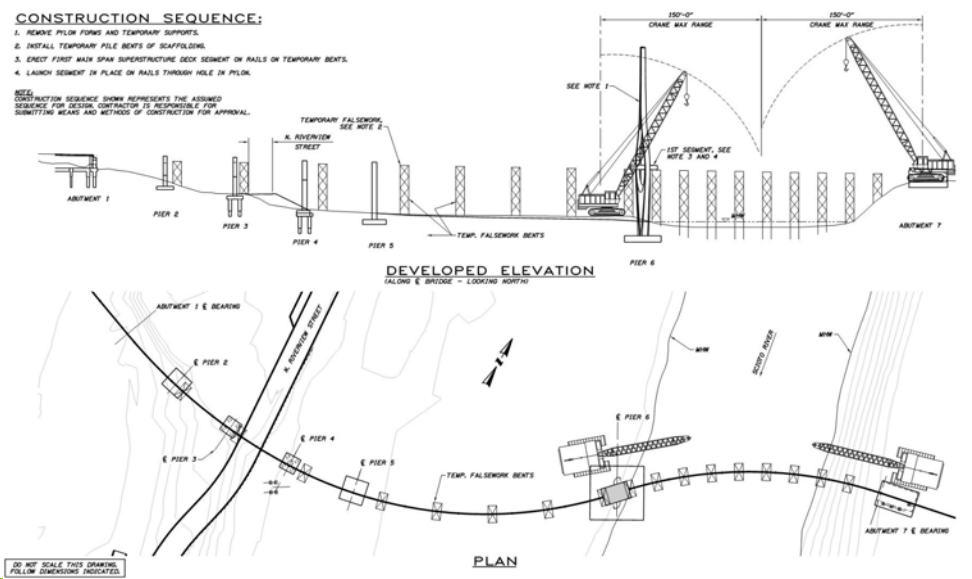
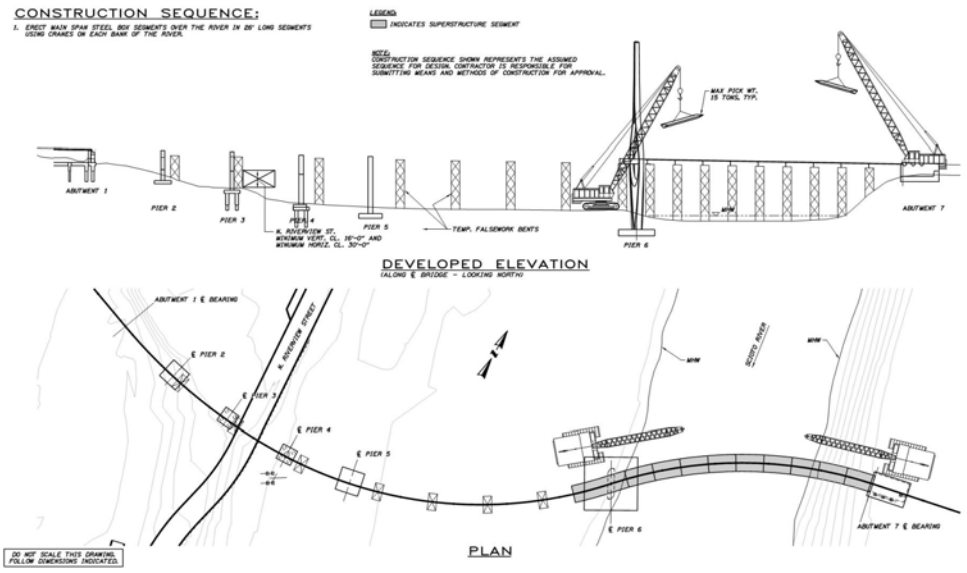


EVERYTHING GROWS HERE.

City of Dublin OHIO, USA

ERECTION SEQUENCE 4



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City of Dublin OHIO, USA

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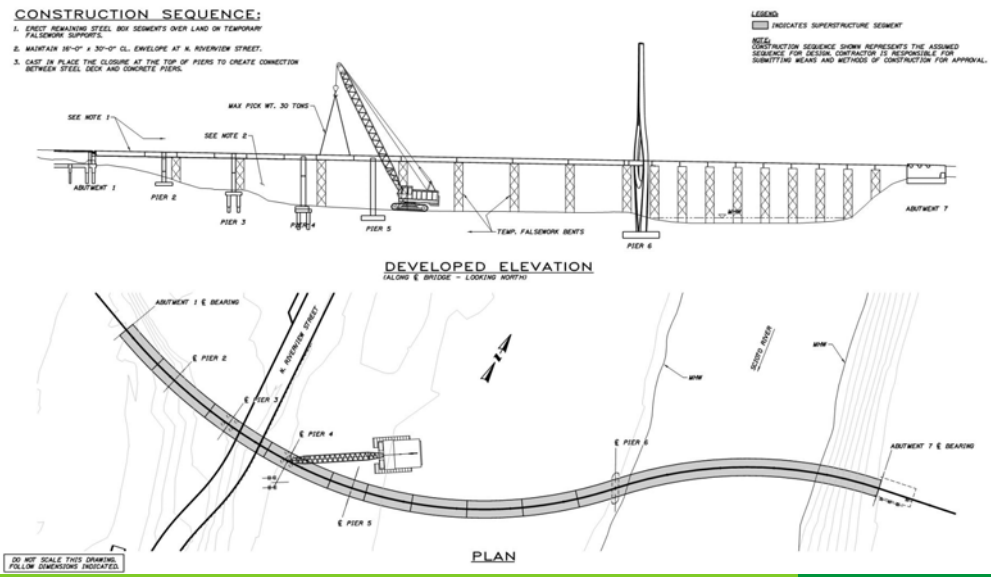

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City of Dublin OHIO, USA

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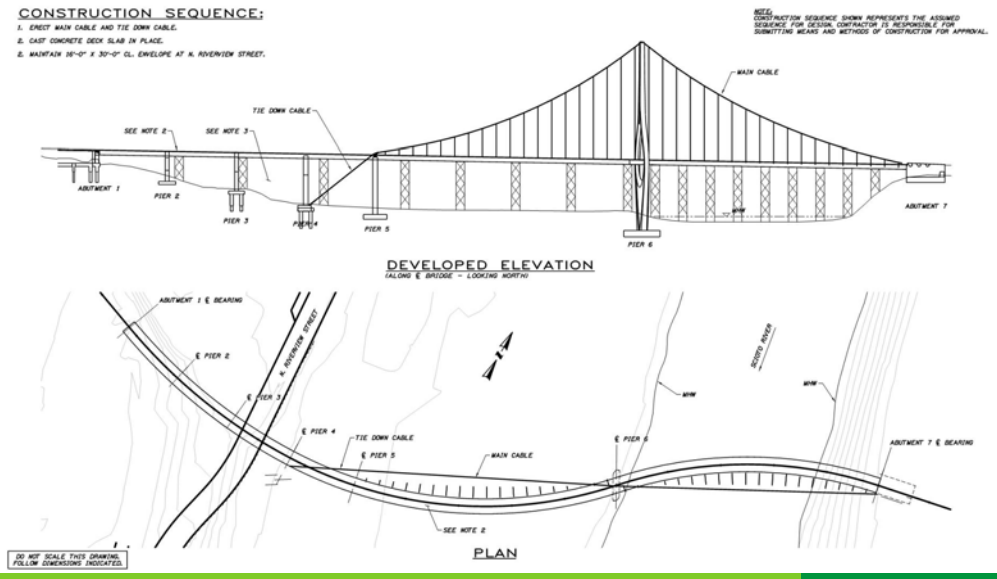

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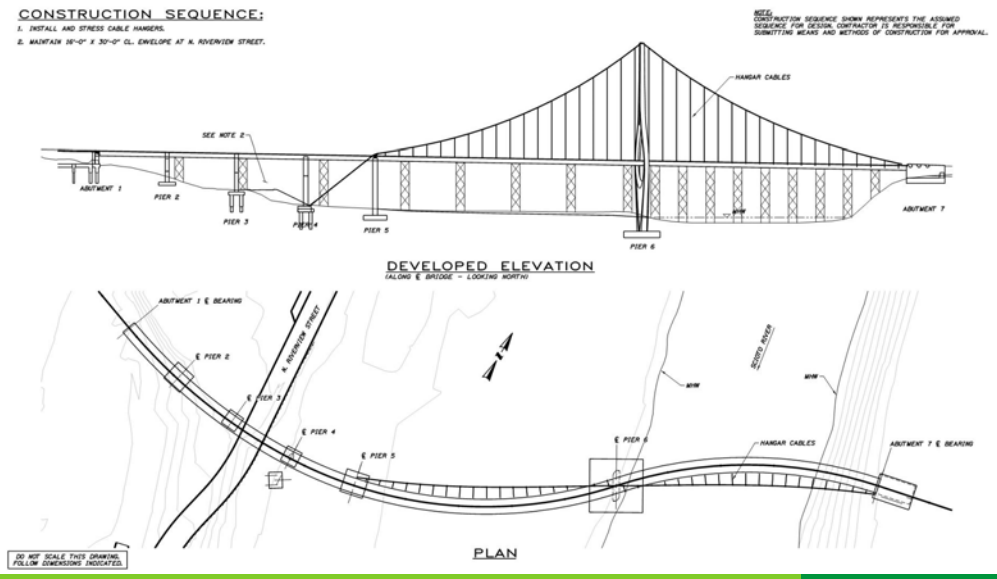

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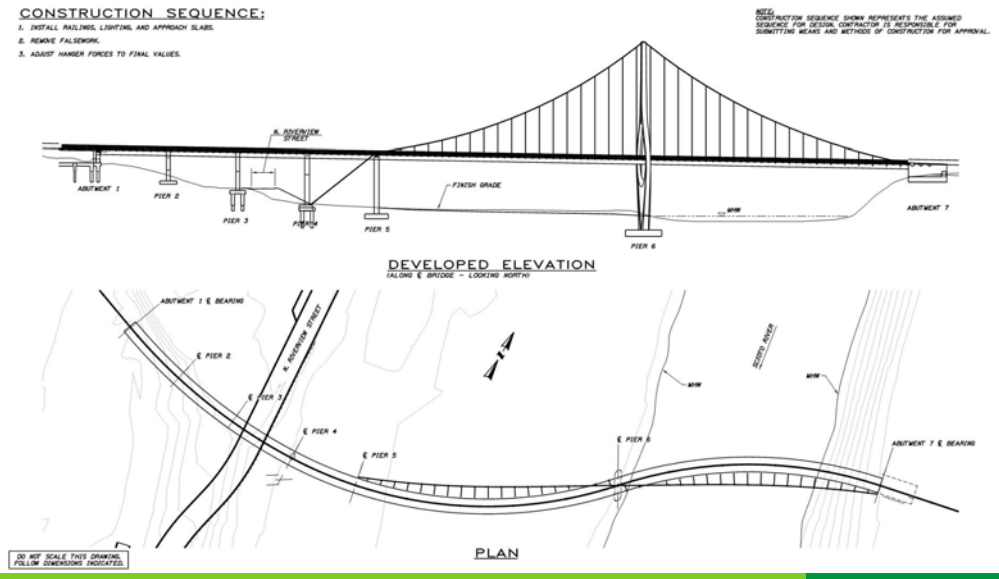
City of Dublin
OHIO, USA

ERECTION SEQUENCE 8



EVERYTHING GROWS HERE.

WEST LANDING AERIAL VIEW

EVERYTHING GROWS HERE.

WEST LANDING TOWARDS THE BRIDGE

EVERYTHING GROWS HERE.

WEST LANDING FROM THE BRIDGE

EVERYTHING GROWS HERE.

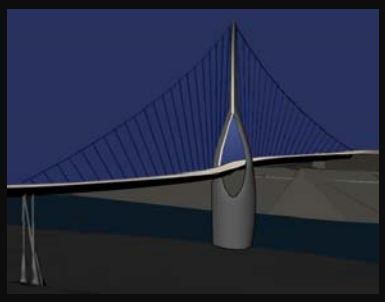
H-1 WALL

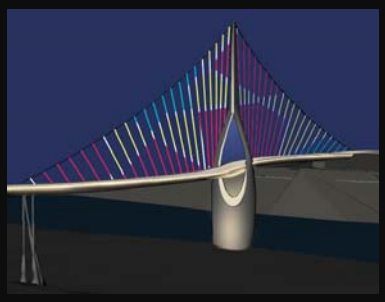
EVERYTHING GROWS HERE.

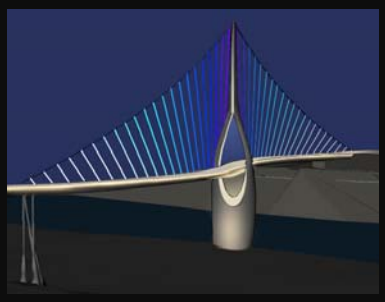
City of Dublin
OHIO, USA

BRIDGE TO WEST LANDING TRANSITION WALL H-1

EVERYTHING GROWS HERE.



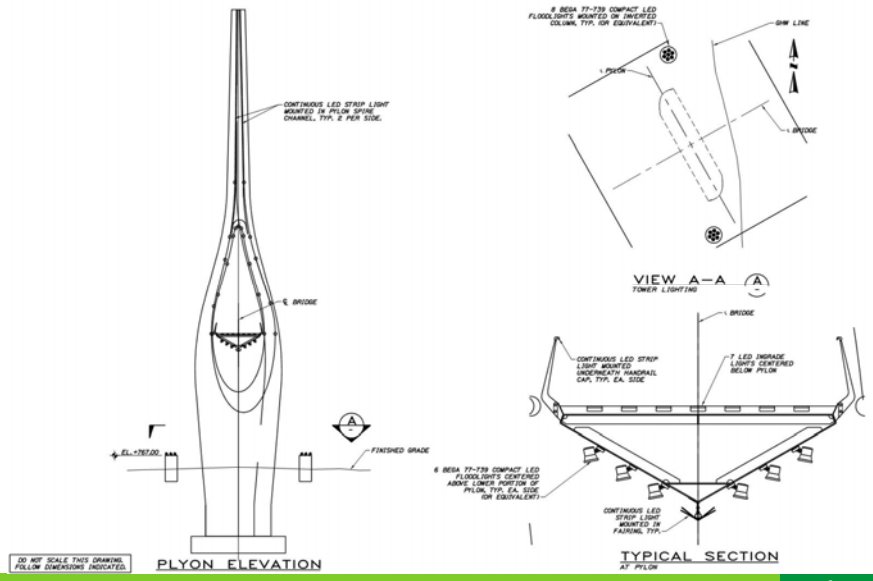




Primary plus Secondary Color

Primary + Secondary White

PYLON LIGHTING DETAILS



EVERYTHING GROWS HERE.

AESTHETIC LIGHTING IN WINTER

EVERYTHING GROWS HERE.

BRIDGE IN THE AUTUMN

EVERYTHING GROWS HERE.

BRIDGE WALK THROUGH

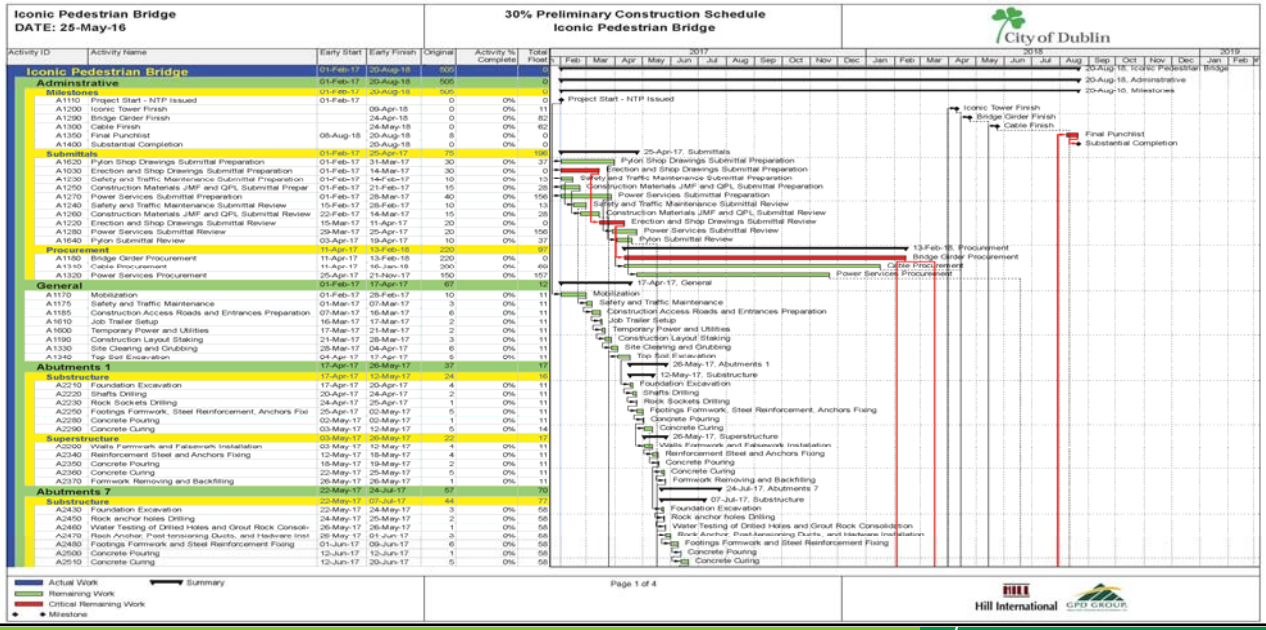
EVERYTHING GROWS HERE.

City of Dublin
OHIO, USA

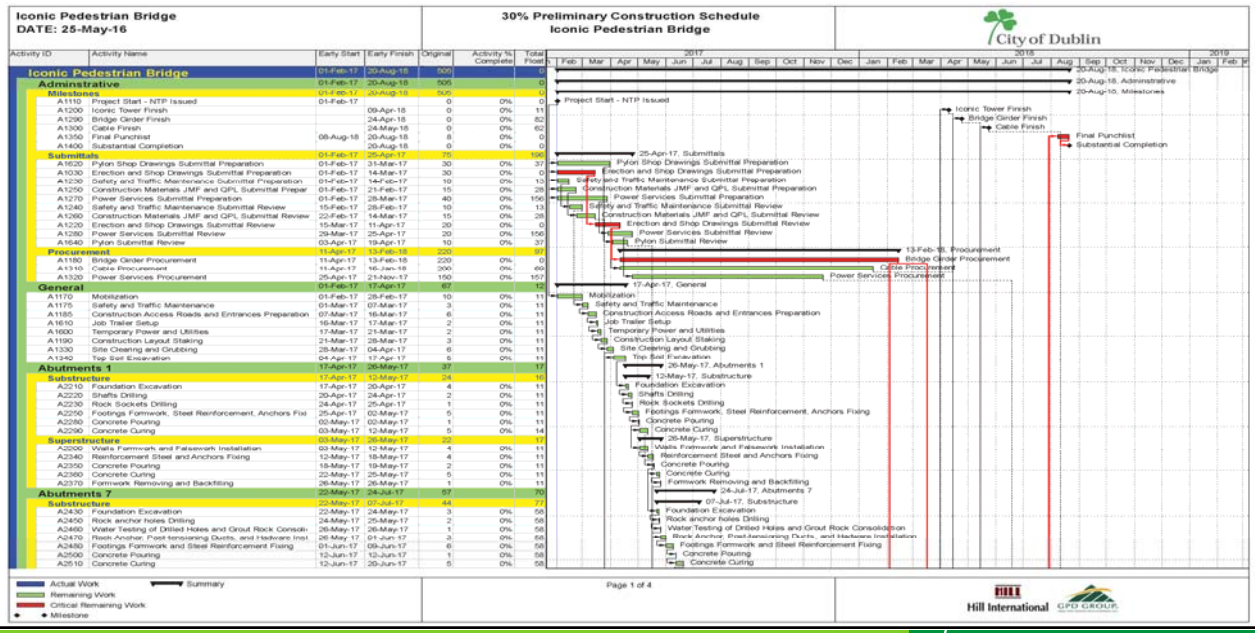
PROJECT DESIGN SCHEDULE

WBS	Task Name	Duration	Start	Finish
1	Kick-off Meeting	0 days	Mon 1/11/16	Mon 1/11/16
2	**Preliminary Engineering Phase**	**85 days**	**Mon 1/11/16**	**Fri 5/6/16**
2.1	Develop Preliminary Alternatives	53 days	Mon 1/11/16	Wed 3/23/16
2.3	AER Design	35 days	Mon 1/11/16	Fri 2/26/16
2.4	Prepare Cost Estimates	10 days	Mon 2/29/16	Fri 3/11/16
2.6	Coordination Point	20 days	Mon 2/29/16	Fri 3/25/16
2.5	Submit Draft 30% Plans	0 days	Fri 4/22/16	Fri 4/22/16
2.6	30% Estimate	10 days	Mon 4/25/16	Fri 5/6/16
2.7	TVLI Independent Review	10 days	Mon 4/25/16	Fri 5/6/16
2.7	Stage 1 Design (60%)	66 days	Mon 2/8/16	Fri 5/6/16
2.7	Preliminary Engineering Submittal (30% Design)	0 days	Fri 5/6/16	Fri 5/6/16
4	City Staff QA Review	10 days	Mon 5/9/16	Fri 5/20/16
3	**Environmental Engineering Phase**	**195 days**	**Mon 3/7/16**	**Fri 12/2/16**
3.1	Environmental Field Studies and Refined Impacts	40 days	Mon 5/9/16	Fri 7/1/16
3.2	Stage 1 Value Engineering	10 days	Mon 5/9/16	Fri 5/20/16
3.3	Stage 2 (60% Design)	135 days	Mon 3/7/16	Fri 9/9/16
3.3A	Detailed Design Submittal (60% Design) - Draft	0 days	Fri 9/9/16	Fri 9/9/16
3.3B	Detailed Design Submittal (60% Design) - Final	0 days	Fri 9/23/16	Fri 9/23/16
3.4	Right of Way Plans	1 day	Mon 9/12/16	Mon 9/12/16
3.5	Project Environmental Document	80 days	Mon 9/12/16	Fri 12/2/16
3.6	Environmental Commitments and Plan Notes	60 days	Mon 9/12/16	Fri 12/2/16
3.7	Final Mitigation Plans Coordination	60 days	Mon 9/12/16	Fri 12/2/16
3.8	Prepare Cost Estimates and Revise Milestone	10 days	Mon 9/12/16	Fri 9/23/16
3.9	Management and Oversight	50 days	Mon 9/12/16	Fri 11/18/16
4	**Final Engineering and R/W Phase**	**55 days**	**Mon 9/12/16**	**Fri 12/30/16**
4.1	Right of Way Acquisition	1 day	Mon 9/12/16	Mon 9/12/16
4.2	Stage 3 Detailed Design Plans	50 days	Mon 9/12/16	Fri 11/18/16
4.2A	Detailed Design Submittal (90% Design) - Draft	0 days	Fri 11/18/16	Fri 11/18/16
4.2B	Detailed Design Submittal (90% Design) - Final	0 days	Fri 12/9/16	Fri 12/9/16
4.3	Prepare Cost Estimates and Revise Milestone	5 days	Mon 11/21/16	Fri 11/25/16
4.4	Final Plan Package	40 days	Mon 11/21/16	Fri 12/30/16
4.4	Construction Documents Submittal (100% Design)	0 days	Fri 12/30/16	Fri 12/30/16
4.5	Oversight and Management	35 days	Mon 12/5/16	Fri 1/20/17

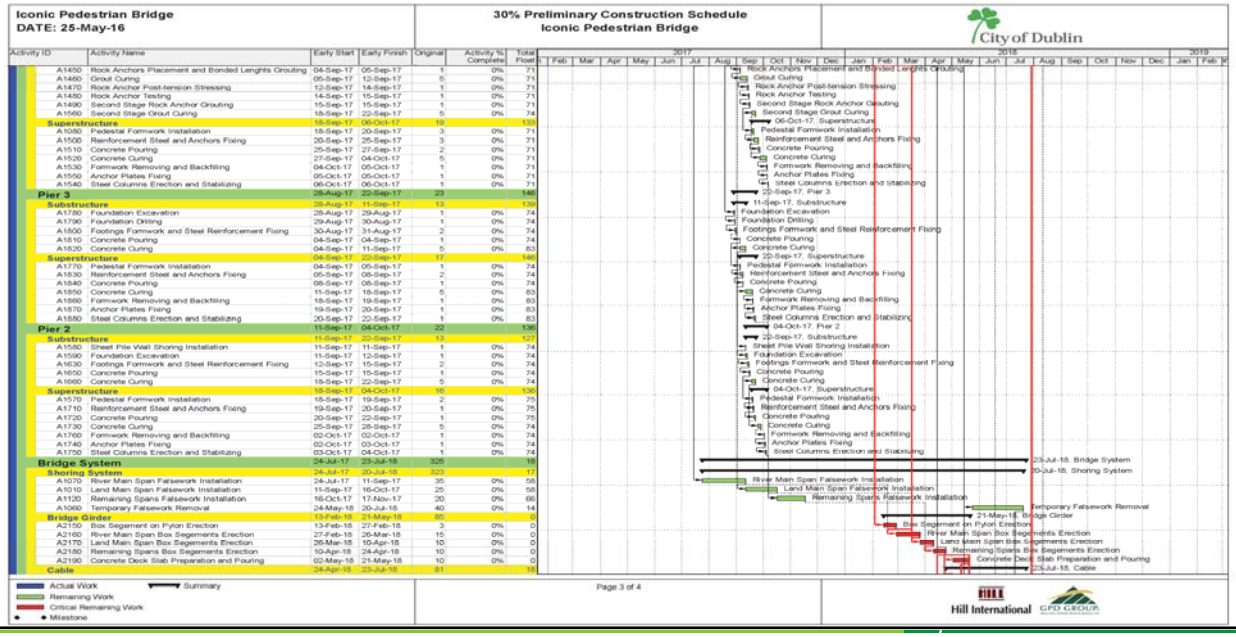
PROJECT CONSTRUCTION SCHEDULE 1



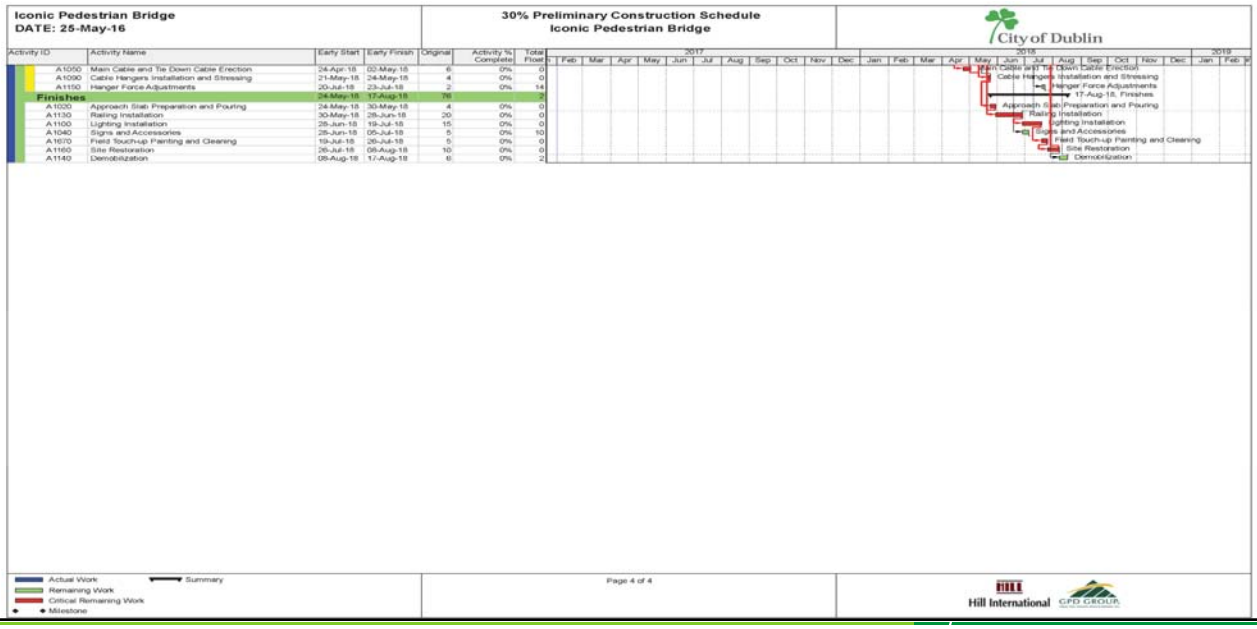
PROJECT CONSTRUCTION SCHEDULE II



PROJECT CONSTRUCTION SCHEDULE III



PROJECT CONSTRUCTION SCHEDULE IV



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QUESTIONS?

EVERYTHING GROWS HERE.