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Bridges Я Us

New Brunswick Department of Transportation

York County Medium Span Bridge

Introduction

A new subdivision is planned to be built in New Maryland, New Brunswick. This new subdivision requires a bridge to cross the Route 101 which is 76 kilometres of provincially owned highway that runs from Downtown Fredericton to Welsford. Bridges R Us have been contracted to design a new embankment bridge to cross Route 101. The bridge requires a design for the underpass & overpass roadways, roadway embankment, steel arch culvert, retaining wall, and foundation.

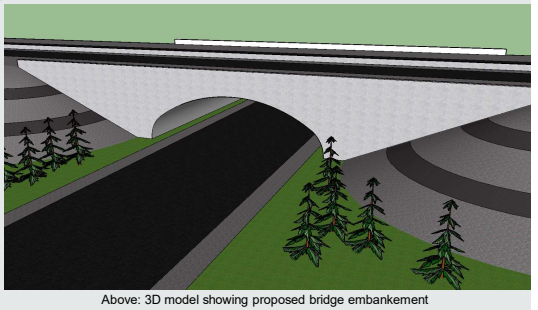
Location

Design Process

- Roadway
  - Choose lanes for traffic loads
  - Design roadway thickness
- Embankment
  - Choose materials
  - Design slope (check stability, reduce ROW)
  - Analyze deformations
    - Compare traffic vs. no traffic
    - Compare TDA vs. no TDA
- Steel Structure
  - High profile arch: Provide high rise
  - Low profile arch: Provide low rise (selection)which matches our need
  - Ellipse: Provide long span
- Retaining Wall
  - Least concrete use; (Design with minimum volume)
  - Minimum excavation need; (Design with minimum depth)
  - Provide enough strength to carry wind load and soil pressure
- Foundation
  - Least material use;
  - Provide enough strength while not disturbing roadway construction

Details of Design

Above: 3D model of proposed bridge showing lanes for underpass and overpass roadway

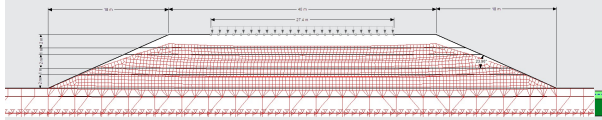


Above: 3D model showing proposed bridge embankement

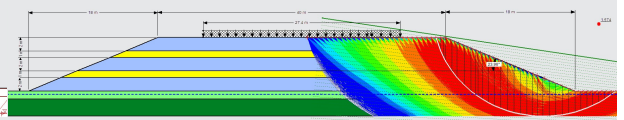
Color	Name	Model	Young's Modulus (E) (kPa)	Unit Weight (kN/m³)	Poisson's Ratio
	Bedrock	Linear Elastic (Total)	1,000,000	24	0.2
	Class A Backfill	Linear Elastic (Total)	100,000	22	0.3
	Native Soil (Loose Gravelly Sand)	Linear Elastic (Total)	25,000	17.5	0.3
	Native Soil (Saturated) (Loose Gravelly Sand)	Linear Elastic (Total)	50,000	18.5	0.3
	TDA	Linear Elastic (Total)	3,000	7	0.3

Color	Name	Category	Kind	Parameters
	Fixed-X	Stress/Strain	Force/Displacement	X-Displacement: 0 m
	Fixed-XY	Stress/Strain	Force/Displacement	X-Displacement: 0 m Y-Displacement: 0 m
	Traffic Load	Stress/Strain	X-Y Stress	X-Stress: 0 kPa Y-Stress: -10 kPa

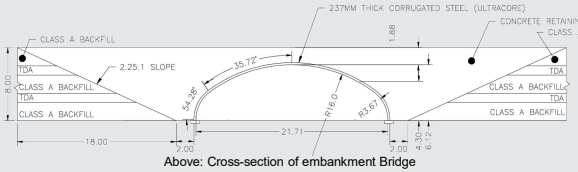
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Bedrock	Bedrock (Impenetrable)					1
	Class A Backfill	Mohr-Coulomb	22	0	38	0	1
	Native Soil (Loose Gravelly Sand)	Mohr-Coulomb	17.5	0	28	0	1
	Native Soil (Saturated) (Loose Gravelly Sand)	Mohr-Coulomb	18.5	0	29	0	1
	TDA	Mohr-Coulomb	7	15	24	0	1



Above: Geostudio SIGMA/W results for roadway embankment (deformations are exaggerated 30 times)

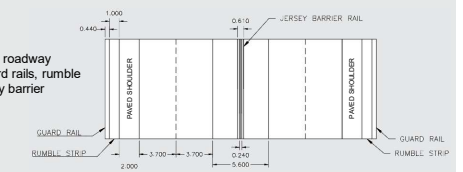


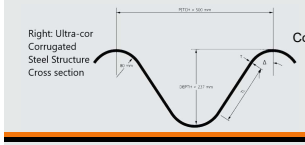
Above: Geostudio SLOPE/W results for roadway embankment. Stability was checked to ensure factor of safety was above 1.5. Materials used were Class A Backfill and Tire Derived Aggregate (TDA).



Above: Cross-section of embankment Bridge

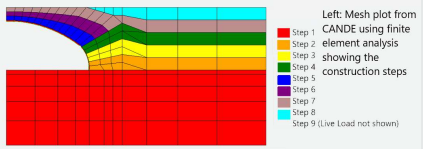
Right: Overpass roadway design with guard rails, rumble strips, and jersey barrier





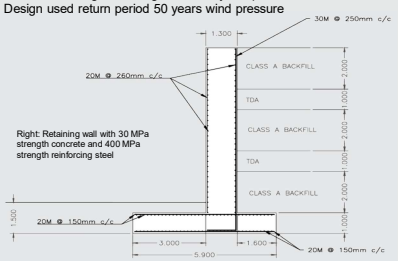
Right: Ultra-cor Corrugated Steel Structure Cross section

Corrugated steel structure selection:
- Deep corrugated ultra-cor for high strength
- Low rise arch profile for long span low rise

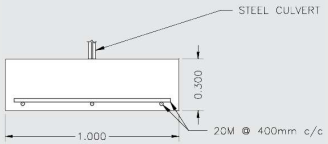


Left: Mesh plot from CANDE using finite element analysis showing the construction steps

Below: Retaining wall designed to carry soil pressure and horizontal wind load:
Design used return period 50 years wind pressure

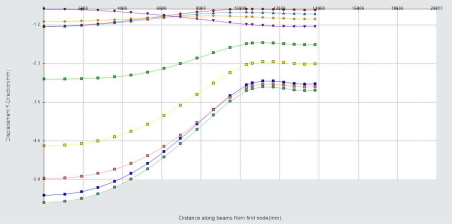


Right: Retaining wall with 30 MPa strength concrete and 400 MPa strength reinforcing steel



Above: Steel culvert foundation

Below: Displacement from CANDE of each steps.
Maximum deflection: 6.67mm



Conclusion

Ultimately, due to the required specifications and adequacy to current environmental and traffic conditions, the following design was selected.

As part of the roadway design, a 4 lane divided overpass as well as a 4 lane undivided underpass were constructed according to Nova Scotia standards.

The roadway embankment was engineered such that it would preserve structural integrity satisfying deformation and geotechnical standards. This incorporates a 2.25:1 slope leading to a height of 8m.

Furthermore, designing the foundation was a critical section of our project due to the structural complexity that is linked to it. Considering the nature of applied loading at the given location, it was seen most appropriate to design a 1x20m strip footing to support such loading patterns.

Following the foundations, retaining walls are essential to reinforce geotechnical safety to the existing soil and allow for the construction of the underpass. This includes the use a 20 m wide retaining wall integrated with an ultracor corrugated steel in order to resist the resultant thrust.

Finally a Class D cost estimate of the project design approximates a total cost of 7.2 million dollars.

Recommendations

After presenting all specifications and findings, the proposed design could have been further enhanced given additional bore hole tests.

Finally, conducting site visits would have enhanced our understanding of the potential complications that may arise therefore making us more equip come up with improved alternatives.

References

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