Fiberglass Composite Bridges

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Engineered Wood
Advanced Fibers
Advanced Thermosets
Hybrid Composite structures

Summary

Fiberglass Composite Bridges as structural prefab elements offers tremendous potential to meet owners critical needs at bidders price, for rehab or new construction. At approx. 1% bridge deck inventory, wood bridges in Canada and the United States have lost market share primarily to concrete which is not due to a lack of wood, but rather technical issues regarding environmental, durability and capacity which can be resolved using hybrid means/methods to save time and money.

Keywords: fiberglass composite bridges at bidder's price

1. Introduction

1.1 Problem

Engineering firms hired by bridge owners assign the design engineer to produce three design concepts and associated costs which more than often does not include wood because service loads with timber low modulus of elasticity radially results in higher fabrication costs of due to more superstructure elements such as girders, diaphragms compared to concrete decks. Timbers increased depth of section compared to concrete results in disqualification during 100 year flood, hydrology affects.

1.2 Solution

Concrete is poor in tension and engineers compensate with internal reinforcement. Wood benefits from external reinforcement to solve the problem of durability and capacity. Since 2000 the Canadian Highway Bridge Design Code Section 16 has allowed consideration of fiberglass composite. 70% of the bridge inventory is short and medium span bridges. The following case study is an example of our rigid span structure in fiberglass composite compared to concrete.

1.3 Implementation

Concrete rigid span structures are vetted in design contracts because in the opinion of engineering consultants it has many attractive features such as prefabricated and benefits in conformance to the CHBDC CL625 ON Truck with a design service life of 75+ years. Rigid Span structures are used by engineers concerned about the environmental assessment fit, hydrology and 100 year flood obligations. The Rigid Span structure by design is well suited to mitigate flooding/damming compared to slab on girder designs where the potential for flooding debris can lodge up into/ between the girders compared to a flat bottom design with Rigid Span structures which often deflects the material through the length and width reducing the risk of the bridge from acting as a dam. To further understand the compelling argument of fiberglass composite in comparison to precast concrete, refer to Figure 1 & Figure 2.

1.4 Figures

Figure 1

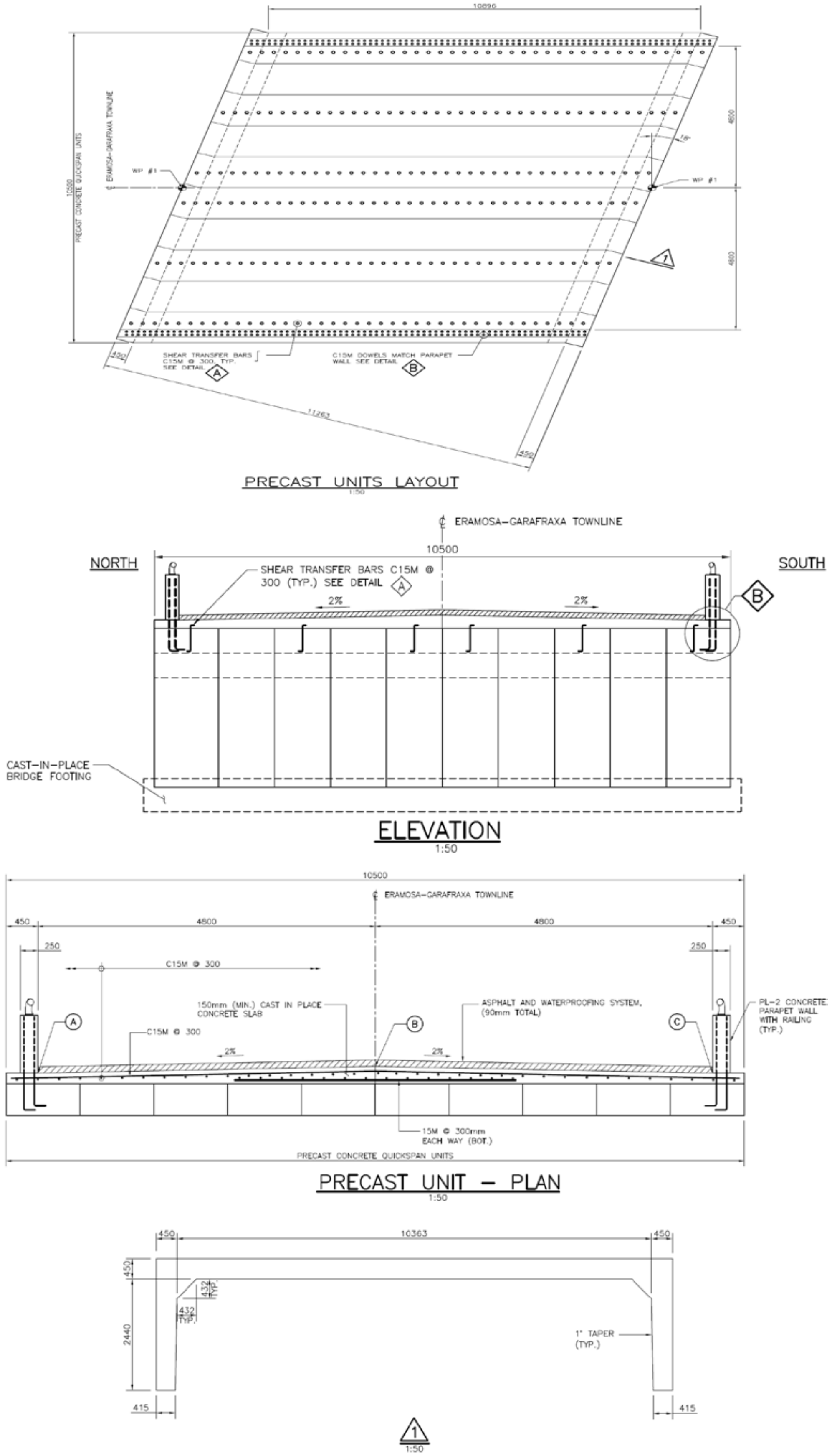

Figure 2

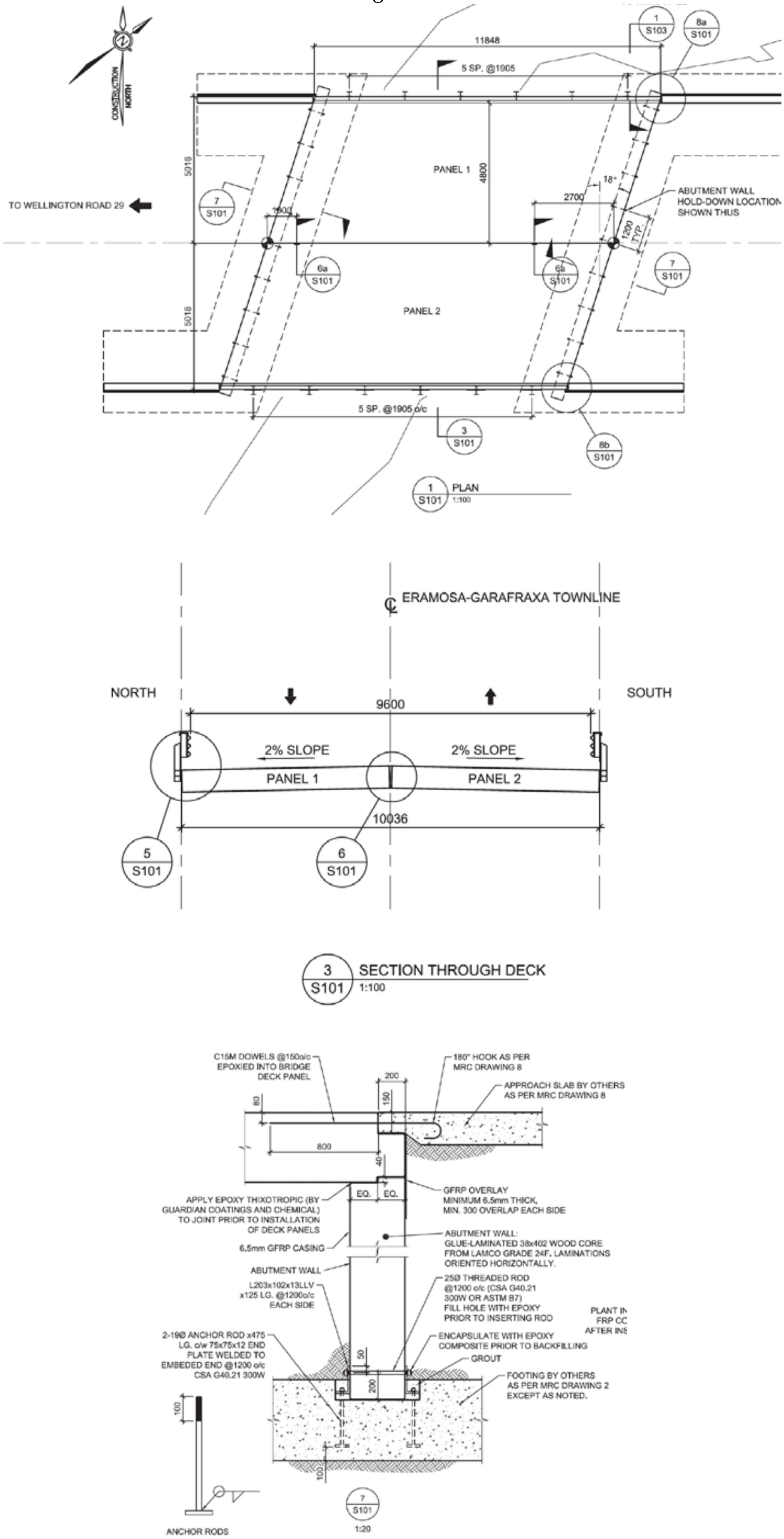
11848
5 SP. @1905
PANEL 1
4800
5018
TO WELLINGTON ROAD 29
2700
18°
ABUTMENT WALL HOLD-DOWN LOCATION SHOWN THUS
1200 TYP.
PANEL 2
5 SP. @1905 o/c
PLAN
1:100
ERAMOSA-GARAFRAXA TOWNLINE
NORTH
SOUTH
9600
2% SLOPE
PANEL 1
2% SLOPE
PANEL 2
10036
SECTION THROUGH DECK
1:100
C15M DOWELS @150o/c EPOXIED INTO BRIDGE DECK PANEL
180° HOOK AS PER MRC DRAWING 8
APPROACH SLAB BY OTHERS AS PER MRC DRAWING 8
GFRP OVERLAY MINIMUM 6.5mm THICK, MIN. 300 OVERLAP EACH SIDE
APPLY EPOXY THIXOTROPIC (BY GUARDIAN COATINGS AND CHEMICAL) TO JOINT PRIOR TO INSTALLATION OF DECK PANELS
6.5mm GFRP CASING
ABUTMENT WALL: GLUE-LAMINATED 38x402 WOOD CORE FROM LAMCO GRADE 24F. LAMINATIONS ORIENTED HORIZONTALLY.
ABUTMENT WALL
L203x102x13LLV x125 LG. @1200o/c EACH SIDE
25Ø THREADED ROD @1200 o/c (CSA G40.21 300W OR ASTM B7) FILL HOLE WITH EPOXY PRIOR TO INSERTING ROD
2-19Ø ANCHOR ROD x475 LG. c/w 75x75x12 END PLATE WELDED TO EMBEDED END @1200 o/c CSA G40.21 300W
ENCAPSULATE WITH EPOXY COMPOSITE PRIOR TO BACKFILLING
GROUT
FOOTING BY OTHERS AS PER MRC DRAWING 2 EXCEPT AS NOTED.
ANCHOR RODS
1:20

Figure 1 shows a precast concrete design with 10 rigid span structures at 450mm deep plus the added work scope item of dowels, rebar with a 150mm cast in place concrete deck.

Figure 2 has a fiberglass composite design with 4 prefabricated elements being two abutment walls and two slab spans with a depth of section of 508mm.

The bridge owner chose the fiberglass composite design proposal for the following reasons

- Bidders price cost in place 20% less than concrete
- 92mm less depth of section
- Depth of section ideally suited for hydrology
- Depth of section conforms to 100 year flood
- Conformance to CHBDC CL625 ON Truck
- Durability at 100+ years
- Product immune to water ingress and de-icing materials

The disadvantage overcome in the design was the PL3 Jersey type barrier specified in the concrete design as to our knowledge there exists no proven crash test method for PL3 to a timber deck design. We gratefully acknowledge the USDA , Forest Products Lab, U.S. DOT FHA for the "Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks" which was submitted an approved for use by Designer Cory Zurell Ph.D P.Eng Blackwell Bowick Engineering in Waterloo Ontario. In our opinion, PL3 remains a major disadvantage as AADT volumes demand the use of PL3 thus disqualifying PL1 or PL2 designs. It would highly advantageous for a PL3 design using timber.

1.5 Manufacturing to Site

Our manufacturing allows us to press timber up to 1.2m deep x 5.5m wide x 15m long with an extension frame to a length of 30m.

The fiberglass composite slab spans have a manufactured SPF wood core, vertically laminated 495mm deep x 5.018m wide x 11.848m long with a 18 degree skew to be cut after pressing.

Example of vertically laminated wood deck

The fiberglass composite slab manufactured as a monolithic slab to span from abutment to abutment. Each panels weighs 19,660 kg or approx. one fifth the weight of concrete.

Fiberglass Composite Bridge Slab

Fiberglass composite bridge slab on edge

Robust material can be picked up from CL Span

And rotated using slings.

Picture also shows skew.

Fiberglass composite bridge slabs

Both panels can be prefitted at shop

Prior to shipping

Payment Certifier can inspect

Reduces risk on site

Promotes confidence and credibility

Fiberglass composite abutment

Two abutments

Dimensions:

400mm thick

2.46m high with a 2% cross slope from CL

12m long

Weight 5498 kg

Panel One Fiberglass Composite Bridge Slab

Using a 400 ton crane

Panel one is lifted in place in thirty minutes

Each abutment bearing has adhesive applied

Set in place requires four rigging persons

Fiberglass composite abutments, Panel One & Two

Installation using four rigging persons

After panel one set in place

Rig panel two and apply adhesive to panel one longitudinal joint and abutments in prep for panel two lift and set in place.

Fiberglass Composite Rigid Span installed

Installation complete

Longitudinal joint with adhesive

Abutments joints with adhesive

Exotherm set adhesive in 160 minutes permanent

No mechanical connections required

Anchor rods used for footings and wing walls

Project completed

PL2 Railing

Asphalt on approaches and bridge

Completed on time and budget

1.6 Niche Market

Truss structures, bascule, swing bridges benefit greatly from our lightweight high strength ratios as we are able to remove all steel stringers and span from floor beam to floor beam with a typical dead load savings up to 40% compared to open steel grating, steel orthotropic decks, 80% less than concrete and were desired build in a 2% cross fall from CL. In the US there are approx. 7,800 of these structures with 5.3 million square meters of bridge deck to be replaced with a construction value of 8 Billion dollars.

1.7 Conclusion

The wood industry in North America has done a superb job of cutting big sticks into little sticks but has lost market share in the bridge industry at approx. 1% in the US but it would be very beneficial for all wood manufacturers to support value added wood programs, such as Wood Works in North America, at the expense of the concrete industries market share as bridge owners are looking for alternative design solutions in tandem with compelling evidence of value added engineering at bidder's price that saves them time and money.

Fiberglass composite structural elements are readily available off the shelf, shovel ready and offer tremendous potential to meet the critical needs of rehab or new construction because hybrid design, using engineered wood, advanced composite materials in tandem with a proprietary process to produce merchant quality robust, durable products with high strength, low weight ratios lend themselves well to prefabricated, modular parts in width and length, with a cost in place less than concrete, as constructability on site is accelerated and completed in days versus months with the value added features of immune to water ingress, salt and de-icing materials with a service life 2 to 3 times greater than concrete and provide redundant load paths that satisfy in service stiffness and exceed section strength requirements as ultimate loads provide for safety factors in excess of five when compared to in service conditions.

1.8 References

[1] Canadian Highway Bridge Design Code

[2] FHWA

[3] AASHTO

[4] USDA Forest Service, Forest Products Laboratory

1.9 Acknowledgements

- County of Wellington Gord Ough P.Eng Mark Eby P.Eng
- Centre Wellington Township Council
- McCormick Rankin Bob Stofko P.Eng
- Blackwell Bowick Engineering David Bowick P.Eng Cory Zurell PhD P.Eng