The International Bridge Conference

Session W-7
International Bridge Engineering Practices

Specifications and Applications of Composite Materials in Bridge Infrastructure in Australia

Michael Kemp

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WAGNERS Composite Fibre Technologies

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Wagners CFT – Building the Future

Manufacturing Structural Composites since 2002

- Head Office Toowoomba, Queensland Australia
- Manufactures and Fabricates over 3 Million pounds of Fibre Composite Material per annum
- Australia's only Pultruder
- Publicly Listed on Australian Stock Exchange – ASX:WGN

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Wagners - Corporate

- Supply of Construction Materials
  - Cement
  - Concrete
  - Quarry Materials
  - Precast
  - Transport

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Gross Mass – 300,000 Pounds
Payload – 185,000 Pounds
18 axles total


TATA
MOTORS
49ERS
98

WCFT Product

SQUARE HOLLOW SECTIONS – WCFT Grade GV35-S

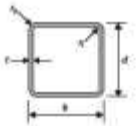
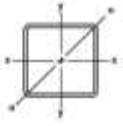


Table 2.1

DIMENSIONS & SECTION PROPERTIES

SQUARE HOLLOW SECTIONS
WCFT Grade GV35-S
Fibre Reinforced Polymer (FRP)



DIMENSIONS										SECTION PROPERTIES								
Designation					Outside Corner Radius	Inside Corner Radius	Mass	External Surface Area	Gross Section Area	About x- and y-axis			About u-axis			Torsion Constant	Torsion Modulus
Depth d		Width b		Thick. t	r_o	r_i			A_g	I_x	Z_x	r_x	I_u	Z_u	r_u	J	C
mm		mm		mm	mm	mm	kg/m	m²/m	mm²	10⁶mm⁴	10³mm³	mm	10⁶mm⁴	10³mm³	mm	10⁶mm⁴	10³mm³
WCFT 125	x	125	x	6.4	10.0	4.75	5.89	0.489	2970	6.89	110	48.2	6.90	81.9	15.0	10.0	66.2
WCFT 100	x	100	x	5.2	10.0	4.75	3.75	0.389	1965	2.80	56.1	38.4	2.81	42.3	11.9	4.55	36.4

RECTANGULAR HOLLOW SECTIONS – WCFT Grade GV35-S

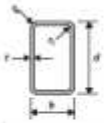
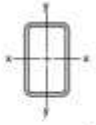


Table 2.2

DIMENSIONS & SECTION PROPERTIES

RECTANGULAR HOLLOW SECTIONS
WCFT Grade GV35-S
Fibre Reinforced Polymer (FRP)



DIMENSIONS										SECTION PROPERTIES								
Designation					Outside Corner Radius	Inside Corner Radius	Mass	External Surface Area	Gross Section Area	About y-axis			About x-axis			Torsion Constant	Torsion Modulus
Depth d		Width b		Thick. t	r_o	r_i			A_g	I_y	Z_y	r_y	I_x	Z_x	r_x	J	C
mm		mm		mm	mm	mm	kg/m	m²/m	mm²	10⁶mm⁴	10³mm³	mm	10⁶mm⁴	10³mm³	mm	10⁶mm⁴	10³mm³
WCFT 100	x	75	x	5.0	10.0	4.75	3.12	0.333	1594	2.14	42.8	36.8	1.57	36.5	28.4	2.76	59.2

BONDED RECTANGULAR BEAMS – WCFT Grade GV35-S

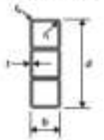
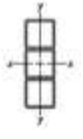


Table 4.1

DIMENSIONS & SECTION PROPERTIES

BONDED RECTANGULAR BEAMS
WCFT Grade GV35-S
Fibre Reinforced Polymer (FRP)



DIMENSIONS										SECTION PROPERTIES								
Designation					Outside Corner Radius	Inside Corner Radius	Mass	External Surface Area	Gross Section Area	About x-axis			About y-axis			Torsion Constant
Depth d		Width b		Thick. t	r_o	r_i			A_g	I_x	Z_x	r_x	I_y	Z_y	r_y	J
mm		mm		mm	mm	mm	kg/m	m²/m	mm²	10⁶mm⁴	10³mm³	mm	10⁶mm⁴	10³mm³	mm	10⁶mm⁴
WCFT 625	x	125	x	6.40	10.0	4.75	29.3	1.37	14848	406	1300	165	34.4	551	48.2	34.6
WCFT 500	x	125	x	6.40	10.0	4.75	23.4	1.20	11879	260	1038	148	27.5	441	48.2	45.7
WCFT 375	x	125	x	6.40	10.0	4.75	17.4	1.05	8909	113	605	113	20.7	330	48.2	32.0
WCFT 250	x	125	x	6.40	10.0	4.75	11.7	0.756	5939	57.0	296	78.9	13.8	220	48.2	21.8
WCFT 500	x	100	x	5.20	10.0	4.75	18.8	1.27	9527	209	838	147	14.0	280	38.4	32.8
WCFT 400	x	100	x	5.20	10.0	4.75	15.0	1.05	7621	106.3	532	118	11.2	224	38.4	38.2
WCFT 300	x	100	x	5.20	10.0	4.75	11.3	0.828	5716	48.5	310	90.2	8.41	168	38.4	15.7
WCFT 200	x	100	x	5.20	10.0	4.75	7.51	0.606	3811	15.1	151	63.0	5.61	112	38.4	8.11

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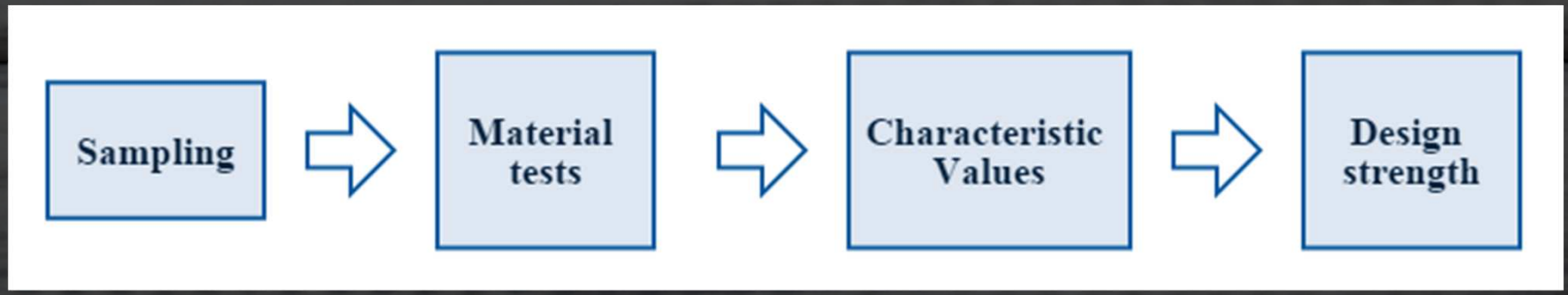
Derivation of Characteristic Material Properties

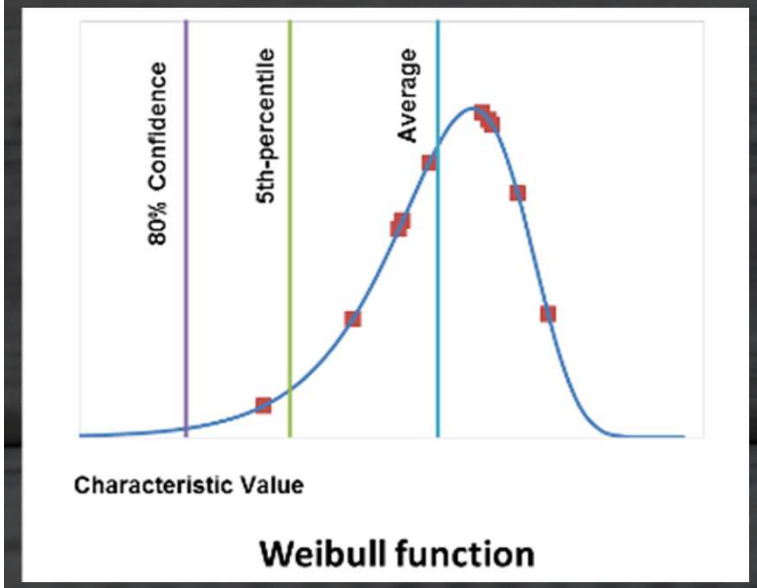


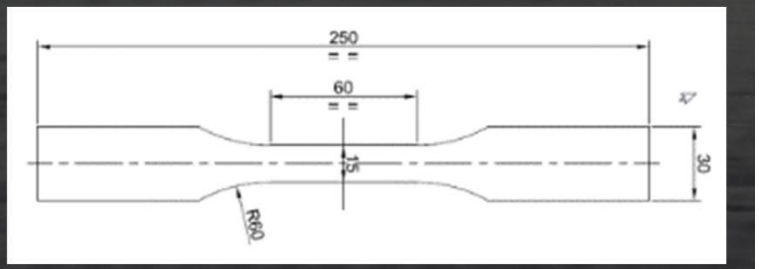
ASCE (2010) *Pre-Standard for Load and Resistance Factor Design (LRFD) of Pultruded Fiber Reinforced Polymer (FRP) Structures (Final)*, American Society of Civil Engineers

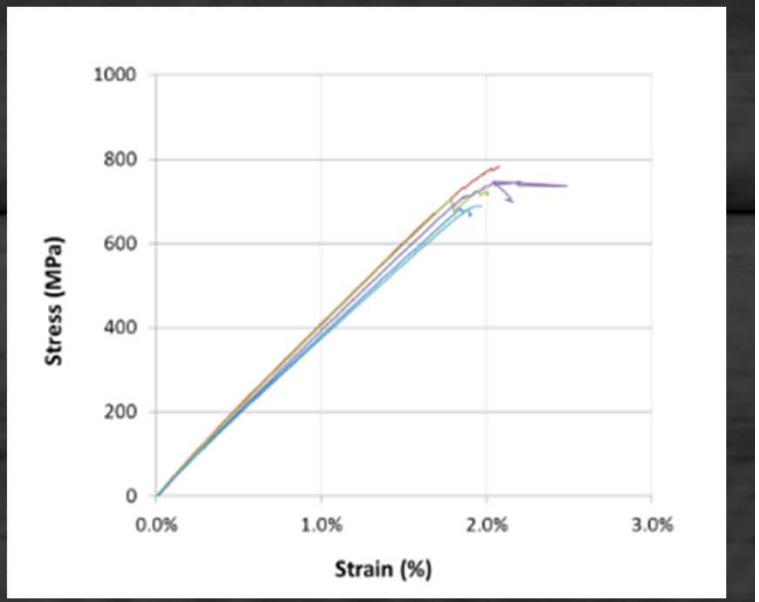
Characteristic Values

ASTM D7290

- Statistically determined values
- Considering two parameters – Shape and Scale
- Representing 80 % lower confidence bound on a 5th percentile of specific population







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Timber Bridges

Bridge repairs form a significant part of asset management for many councils across Australia, with an estimated 40,000 timber bridges in Australia. Recent surveys suggest most timber frames are nearing the end of their structural lives and are in desperate need of repairs to meet current safety standards. But with many councils restricted by limited budgets, many bridge asset owners are unable to fund comprehensive bridge maintenance programs.

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- $1.5 billion worth of timber bridges under local council management
- $0.98 billion of those, or around 65% were determined as being in a poor, to very poor state.

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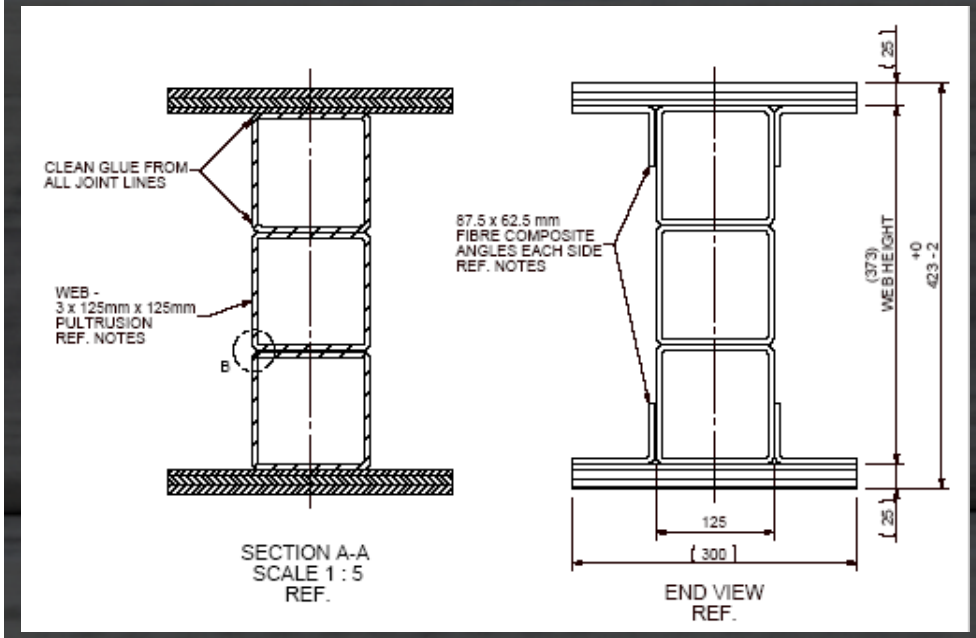
Beam Development

Bridging the Gap!



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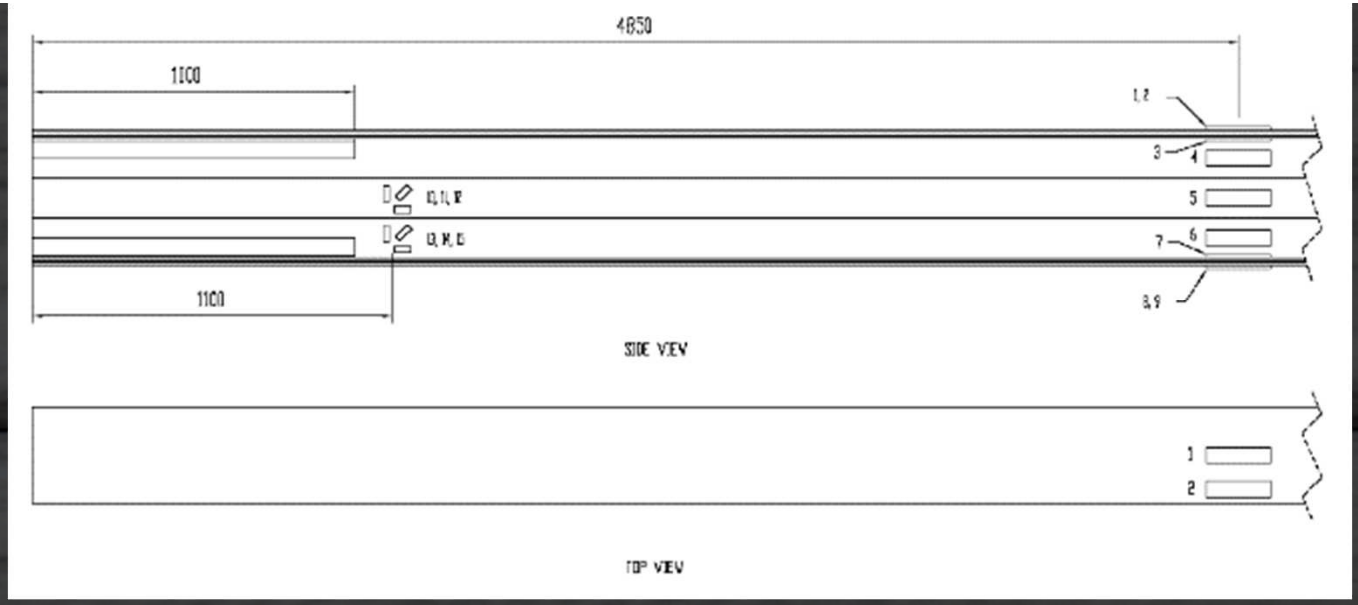
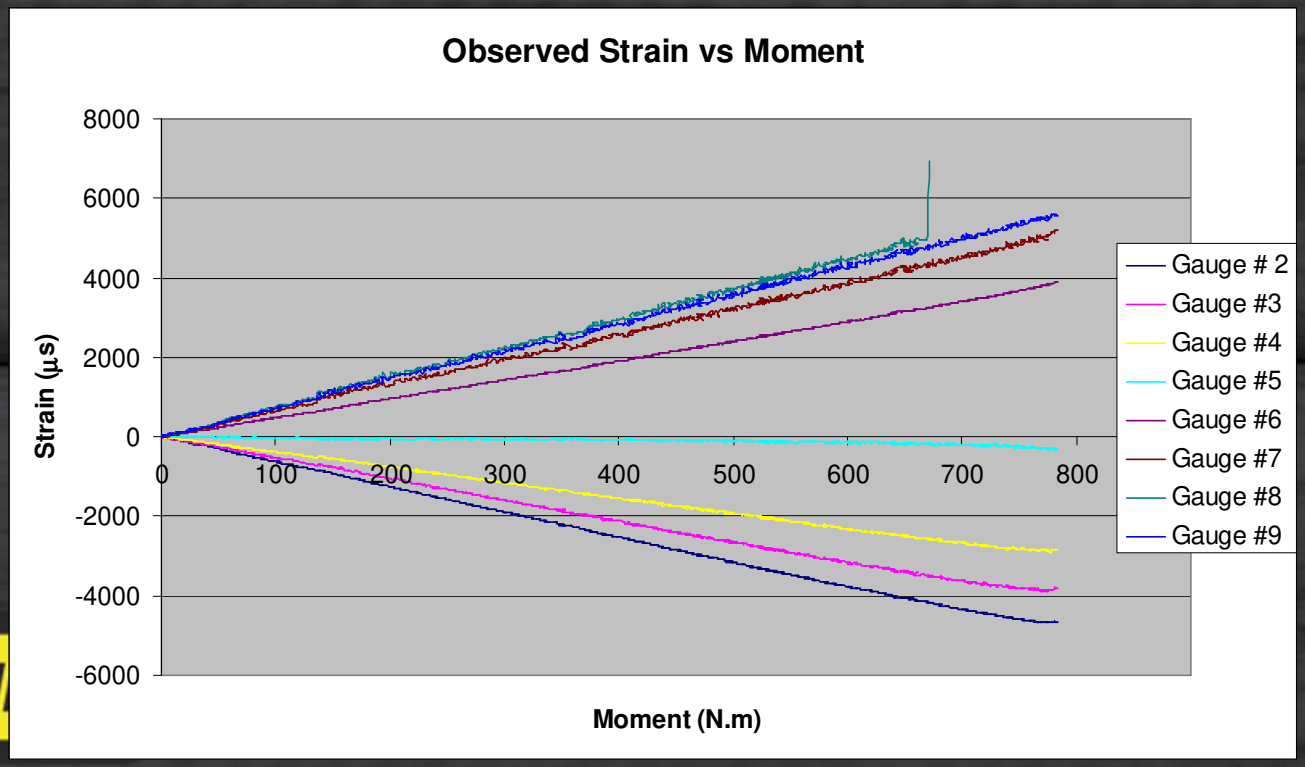

4850
1100
1100
SIDE VIEW
TOP VIEW


Observed Strain vs Moment
Strain (µs)
8000
6000
4000
2000
0
-2000
-4000
-6000
0
100
200
300
400
500
600
700
800
Moment (N.m)
Gauge # 2
Gauge #3
Gauge #4
Gauge #5
Gauge #6
Gauge #7
Gauge #8
Gauge #9

Fatigue Testing

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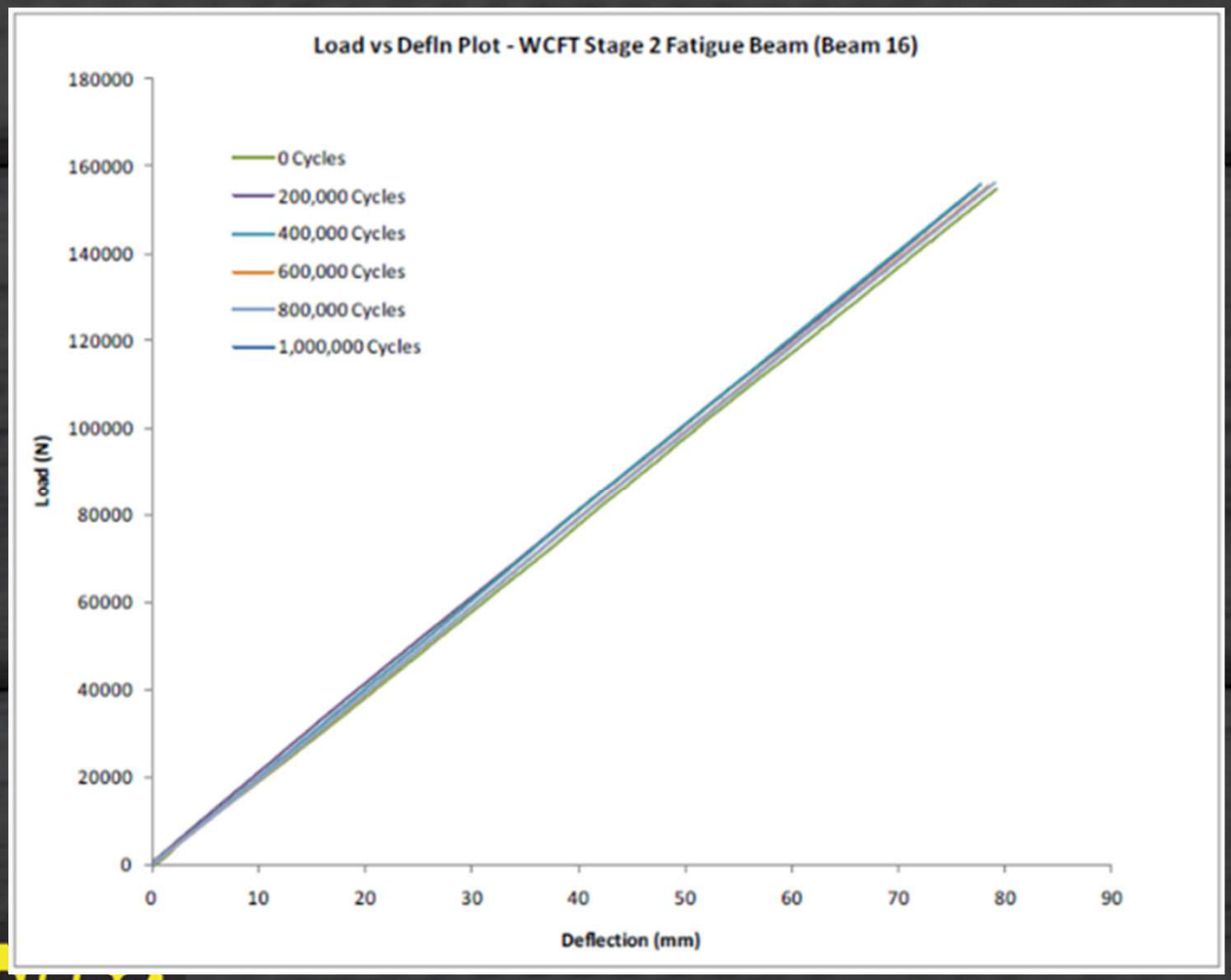
Fatigue Testing



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Requirements Met!

Beam Property	Requirement	Tolerance	Wagners Beam	Requirement Met?
Max width	350 mm	+0	300mm	Yes
Max depth	425 mm	+0	424mm	Yes
Mmax at failure	660 kNm	-0	780kN	Yes
EI of girder	29.6×10^{12} Nmm^2	+/- 10%	27.4×10^{12} N.mm^2	Yes
Working live load capacity	109 kNm	NA	NA	NA
Shear Capacity	350 kN	-0	435 kN	Yes
Max Deflection (at ultimate = 350kN)	170 mm	+/- 10%	172.4mm	Yes

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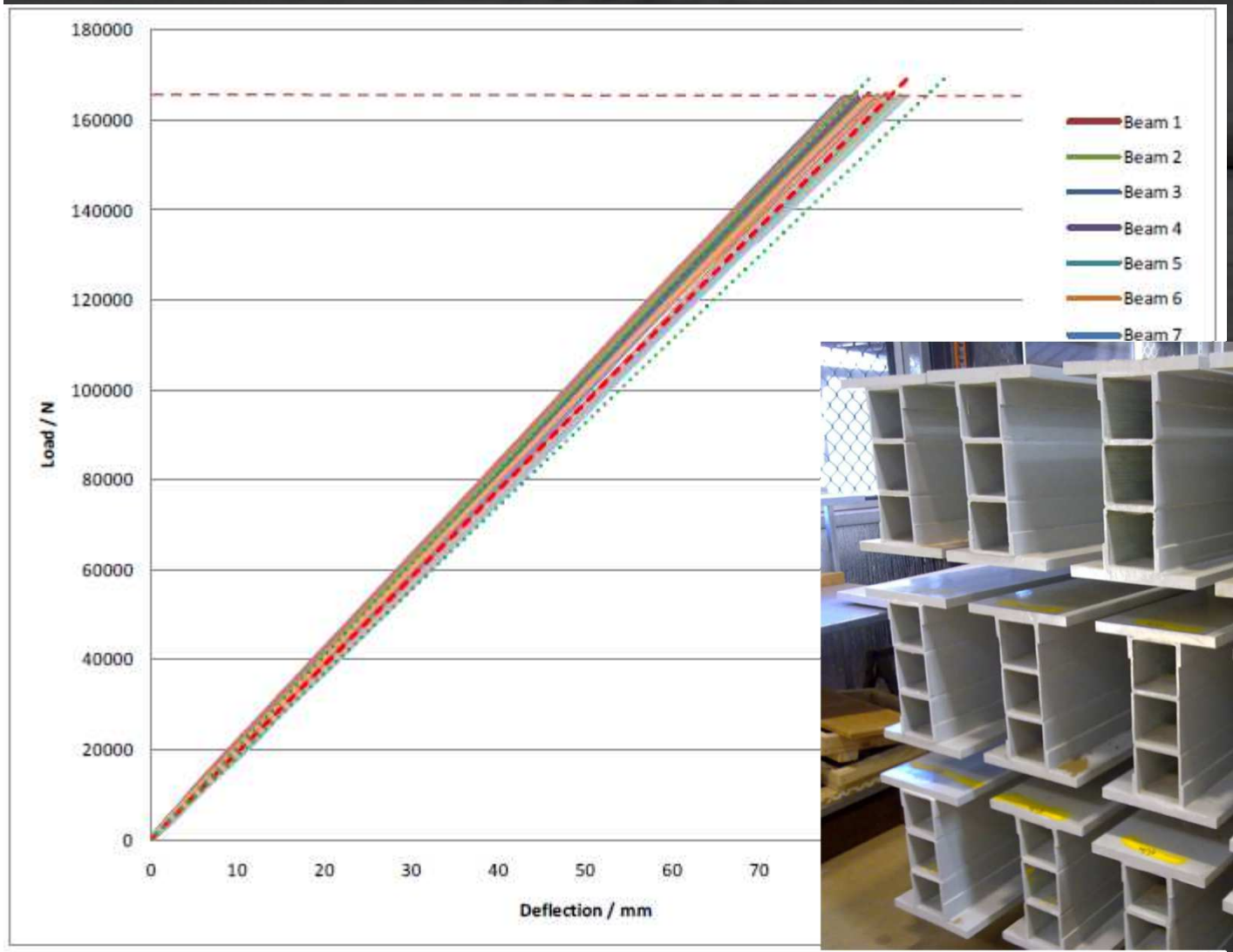
One is not enough



Trial Installations

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Pile Strengthening

Bridge Widening

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- Supply of 80 Beams
- Rigourous testing regime
- Not just product properties but Installation methods
- http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Standard-drawings-roads/Bridges-Marine-and-structures#Bridgesandotherstructures
- Click on standard drawing #'s SD2285 and SD2286

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Queensland Main Roads Specifications

Manufacture Spec
MRTS 59

Installation Spec
MRTS 60

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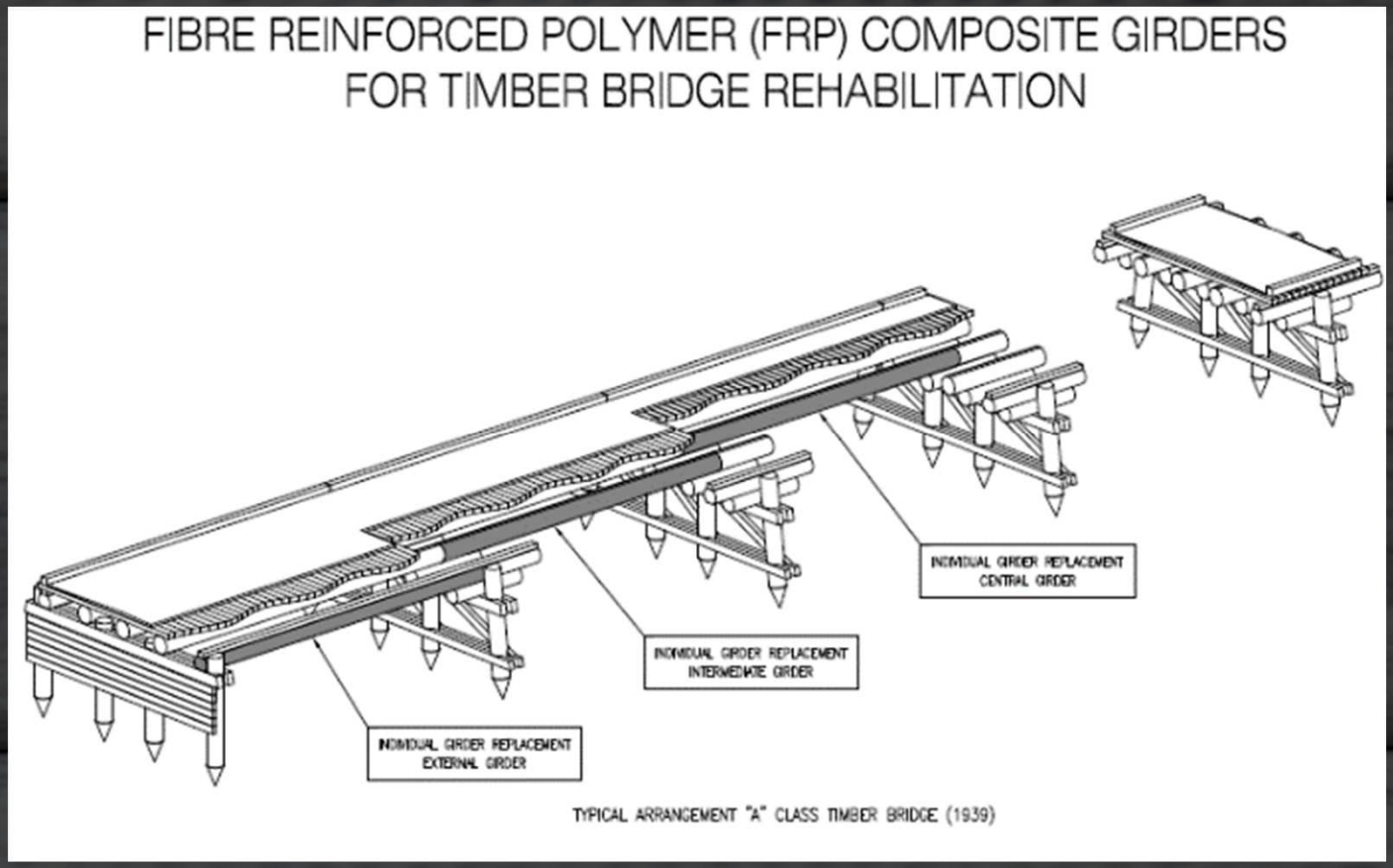
Queensland Main Roads Std Drawings



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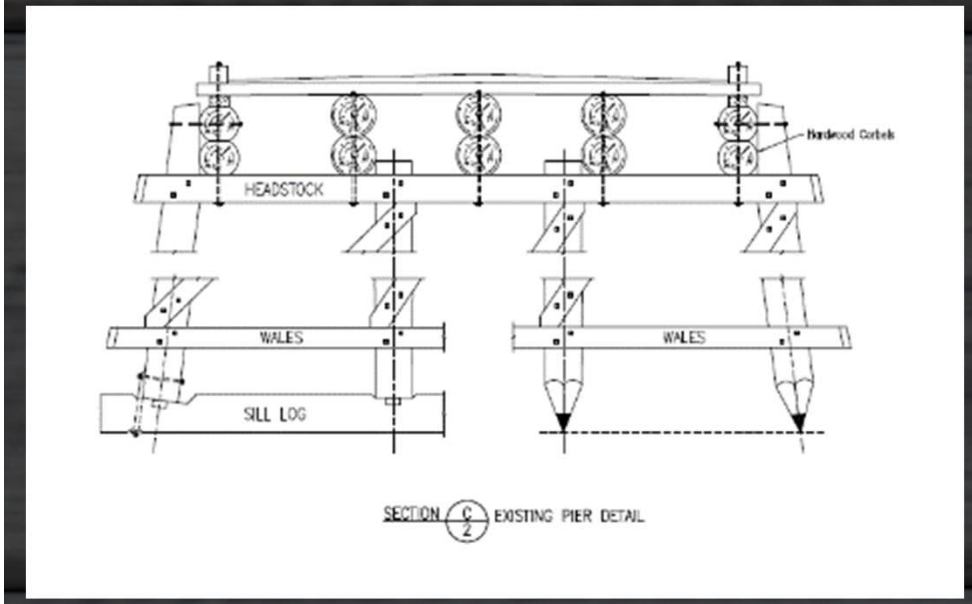
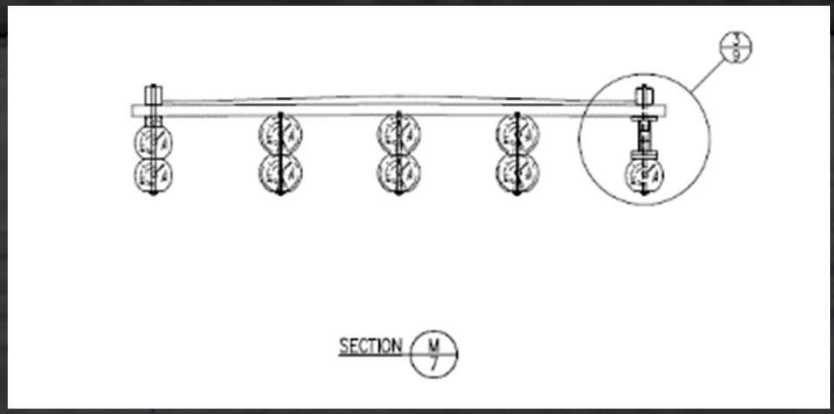
Queensland Main Roads Std Drawings





- New FRP I Beam

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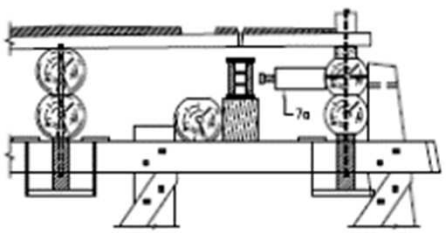
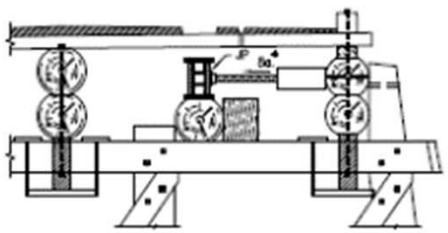
7 – PREPARATION JACKING NEW GIRDER



7a. Install Jack.

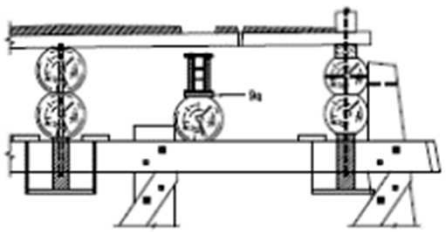
STEP 8 – JACKING NEW GIRDER IN PLACE



8a. Jack new girder (FRPC) into position under bridge with temporary jacking plate (JP)

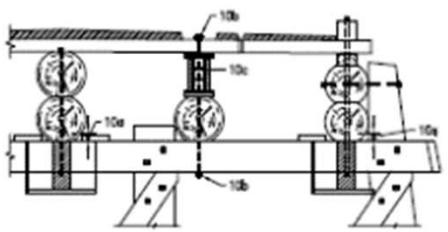
* Jacking procedure and details to be approved by an RPEQ

9 – INSTALL BOTTOM PACKER



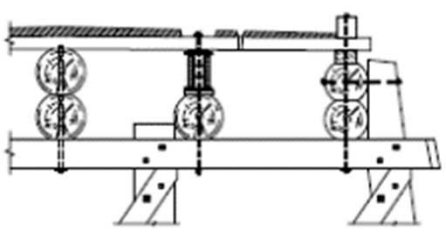
9a. Install new bottom packer and shims if required.

STEP 10 – LOWER THE DECK, REPAIR DWS



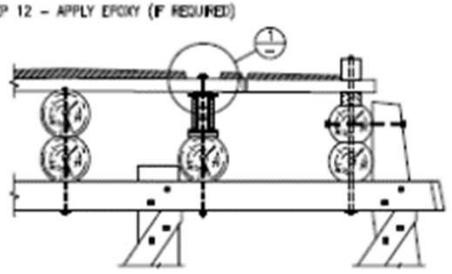
10a. Lower jacks.
10b. Drill new holes on Deck Flat Bar (DF) and install DF on top of deck aligned with new girder (FRPC) centreline.
10c. Drill new bolt holes and install bolts with saddle washer (SW).

11 – REMOVE JACKS



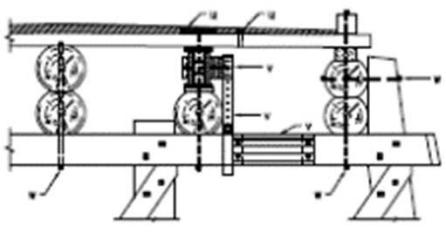
11a. Remove jacks.

STEP 12 – APPLY EPOXY (IF REQUIRED)

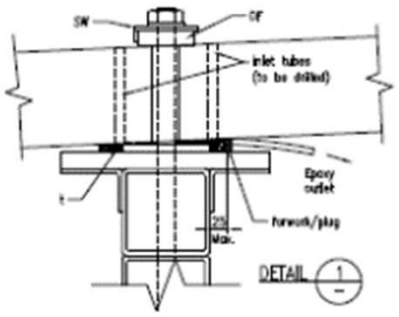


12a. Apply epoxy when required.
12b. Inspect contact between girder and deck. If significant gap exists, install formwork, inlet and outlet tubes and pour epoxy.

13 – INSTALL STEEL BRACKETS



13a. Repair DWS as necessary.
13b. To install RBA, temporarily clamp each component in position. Adjust accordingly to ensure RBU, RBM and RBL are in correct alignment.
13c. Tighten all bolts through outside Web/Girders/Corbel/Headstock.



Department of Transport and Main Roads

FRP COMPOSITE GIRDERS
FOR TIMBER BRIDGE REHABILITATION

WCFT–S1, S2 & S3
INSTALLATION PROCEDURE
SHEET 3 of 3

A3
Not to Scale

Standard Drawing No
2286
Date 7/15

A

Implementation and Development

- Baio Bridge
- Rehabillitation of piles and replacement of headstocks / corbels / girders and decking
- Increased load capacity
  - T44 Vehicle Load – Grillage in various positions
  - 5kPa Pedestrian Load
  - 400kN Braking Force
  - Water – 1m above deck / 4 ms^{-1}

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Engineering Design Procedure

- Investigation of Timber Structure
- Definition of desired level of service
- Analysis to determine level of upgrade required
- Options Presented

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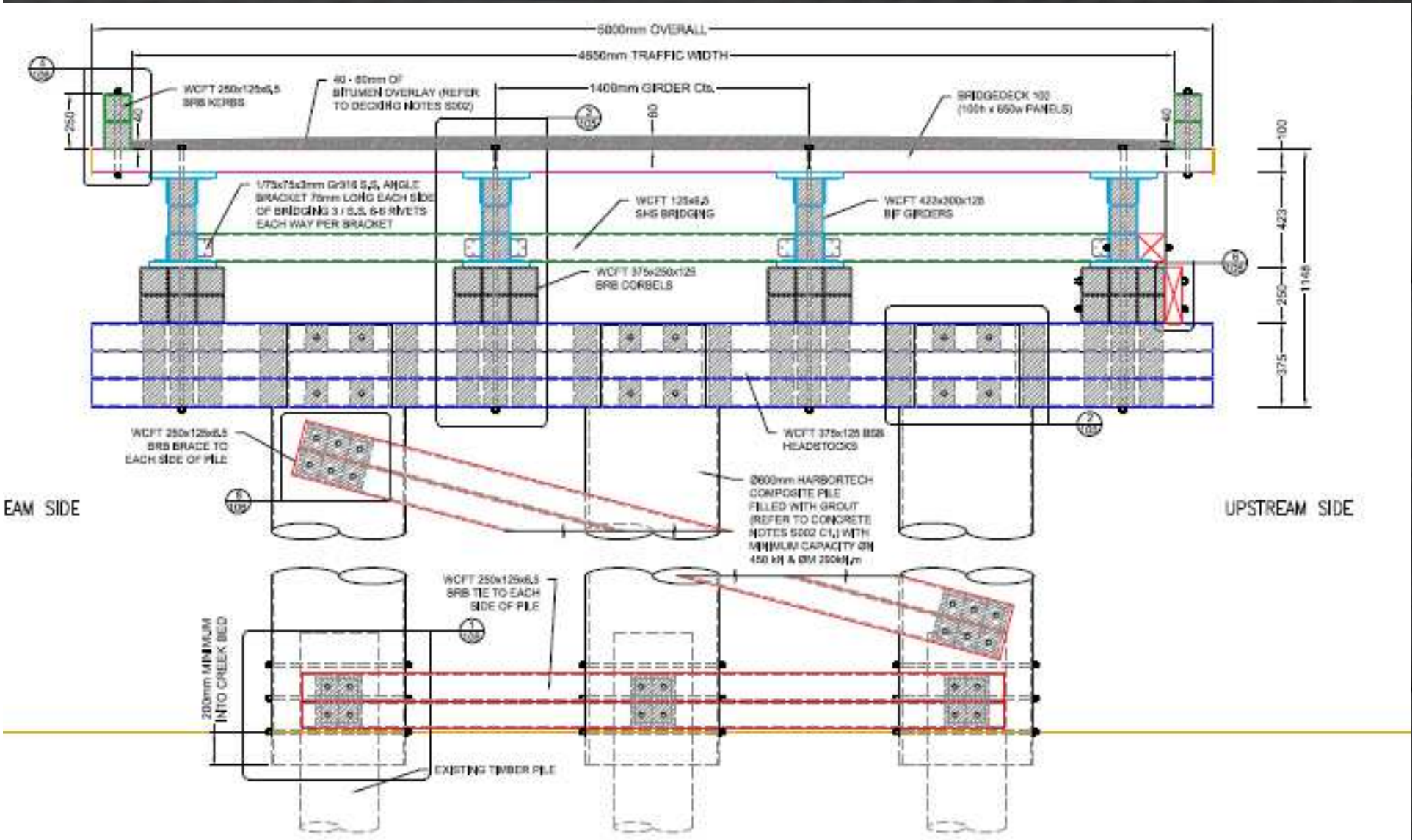

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06/11/2050 06:40 AM


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Pinkenba Wharf

Jetty – 260 ft x 20 ft
Wharf – 825ft x 50ft

Loading

- Superstructure
  - FRP U-Girder Deck
  - Class 25 Wharf – 3.6psi deck UDL (25kPa) + 112,000 lb point load on 3ft square point load from Crane (General Purpose wharf)
  - Construction Load – Liebherr 1280 tracked crane
  - Concrete Top (Earth Friendly Concrete)
  - FRP Rebar in Concrete
  - No Corrosion in Deck
- Substructure – Cathodically Protected

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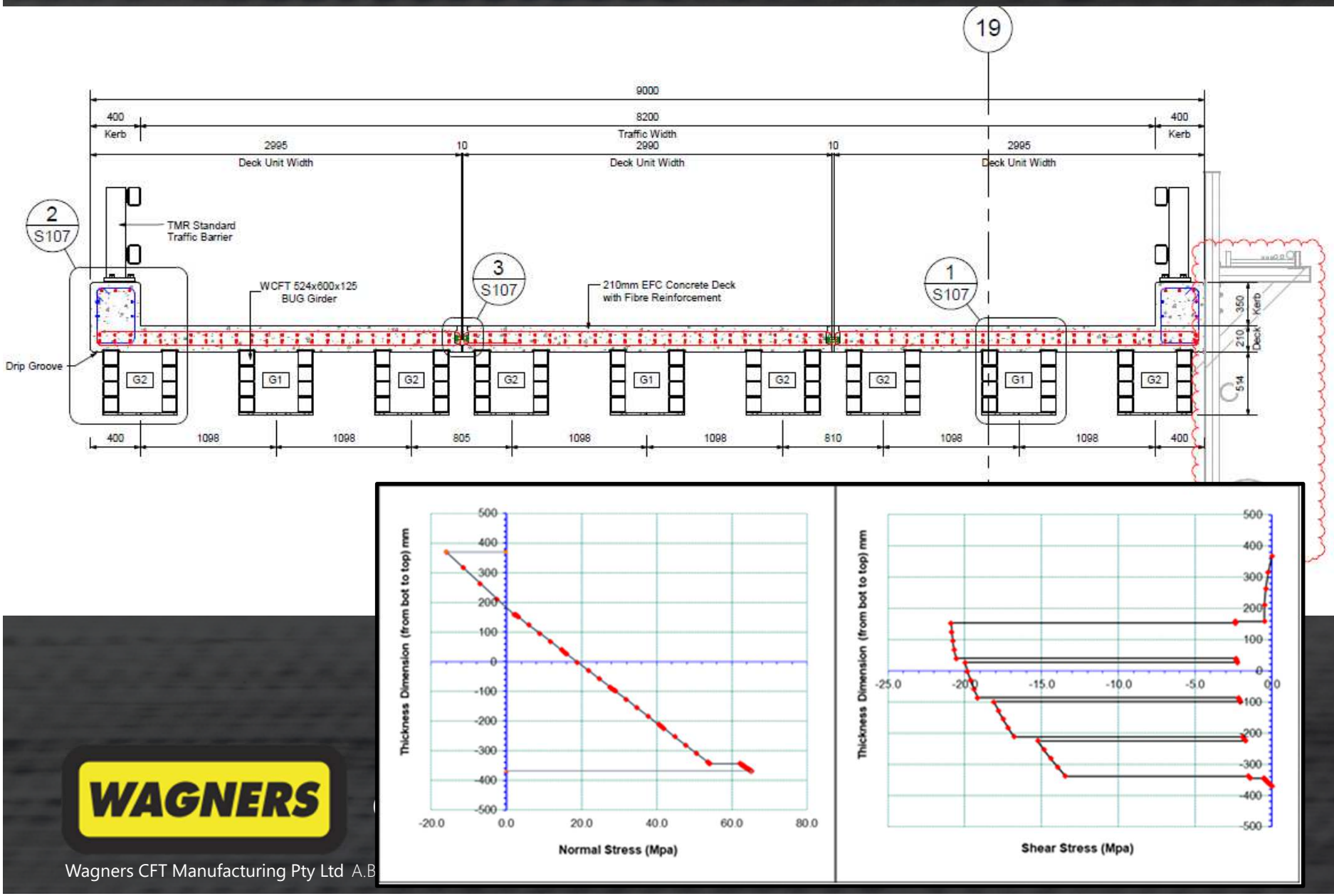
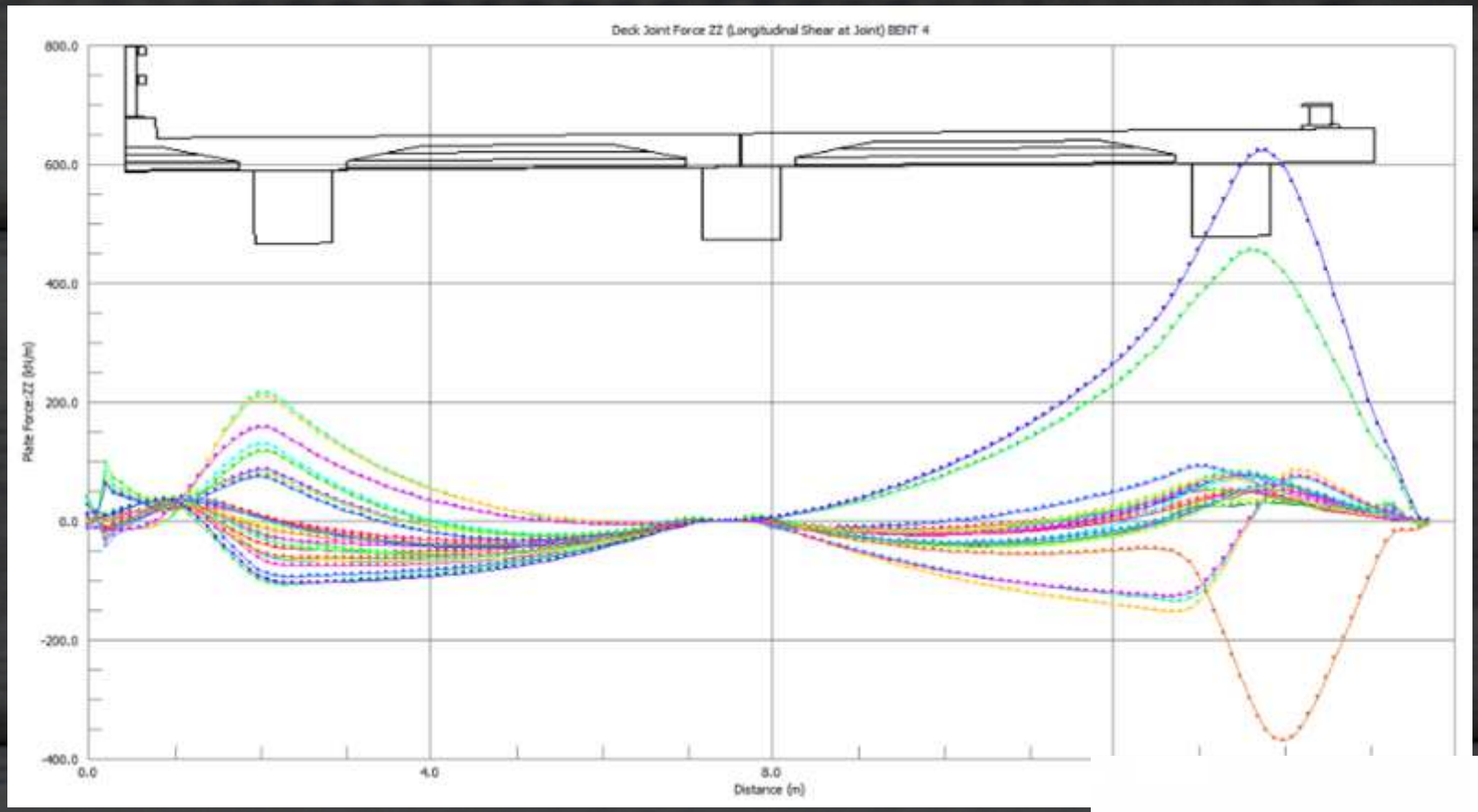
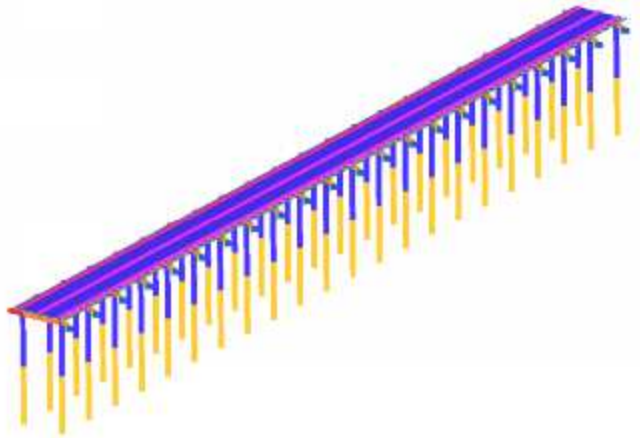
Proposed Section



FE Model





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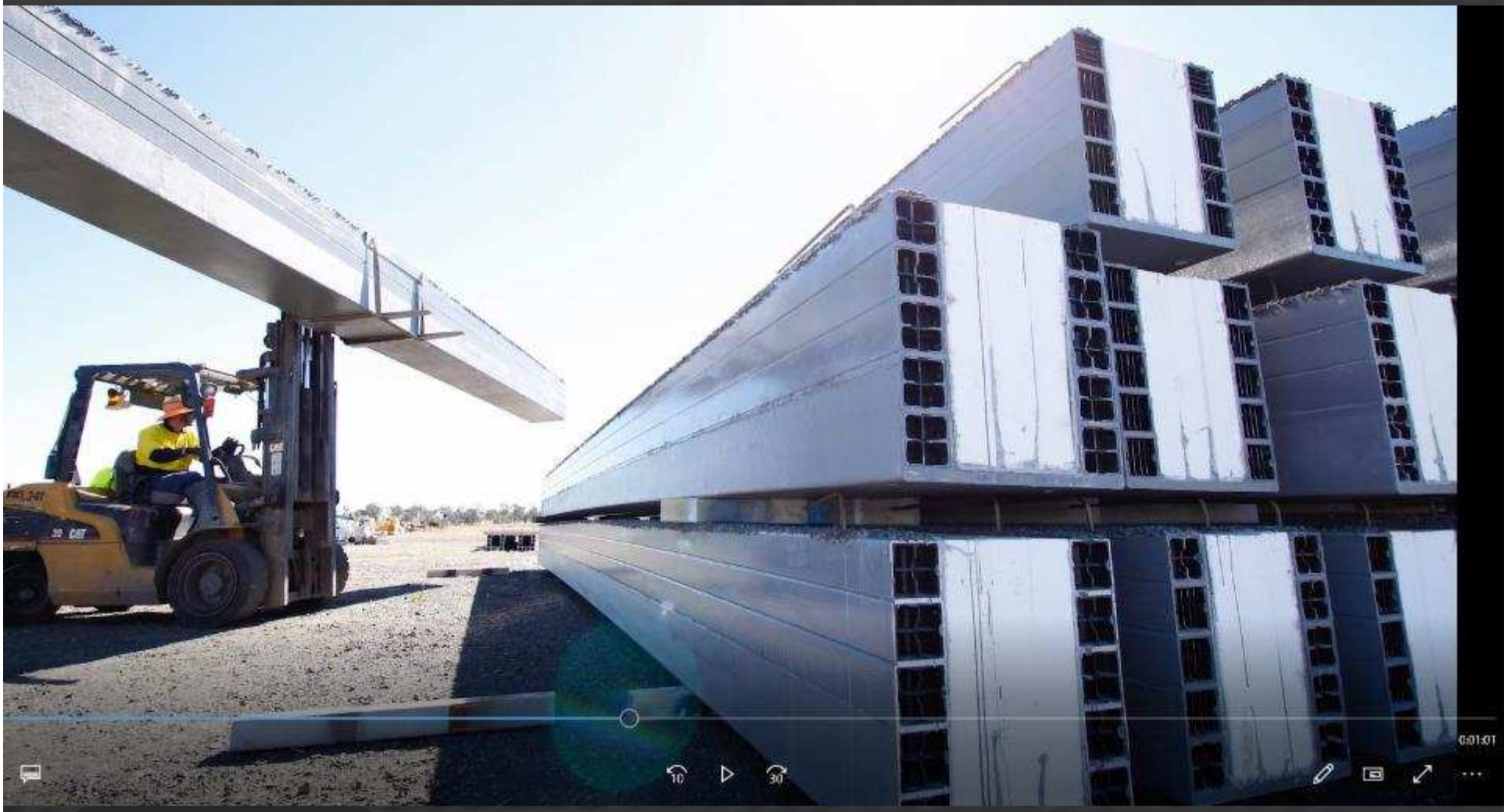

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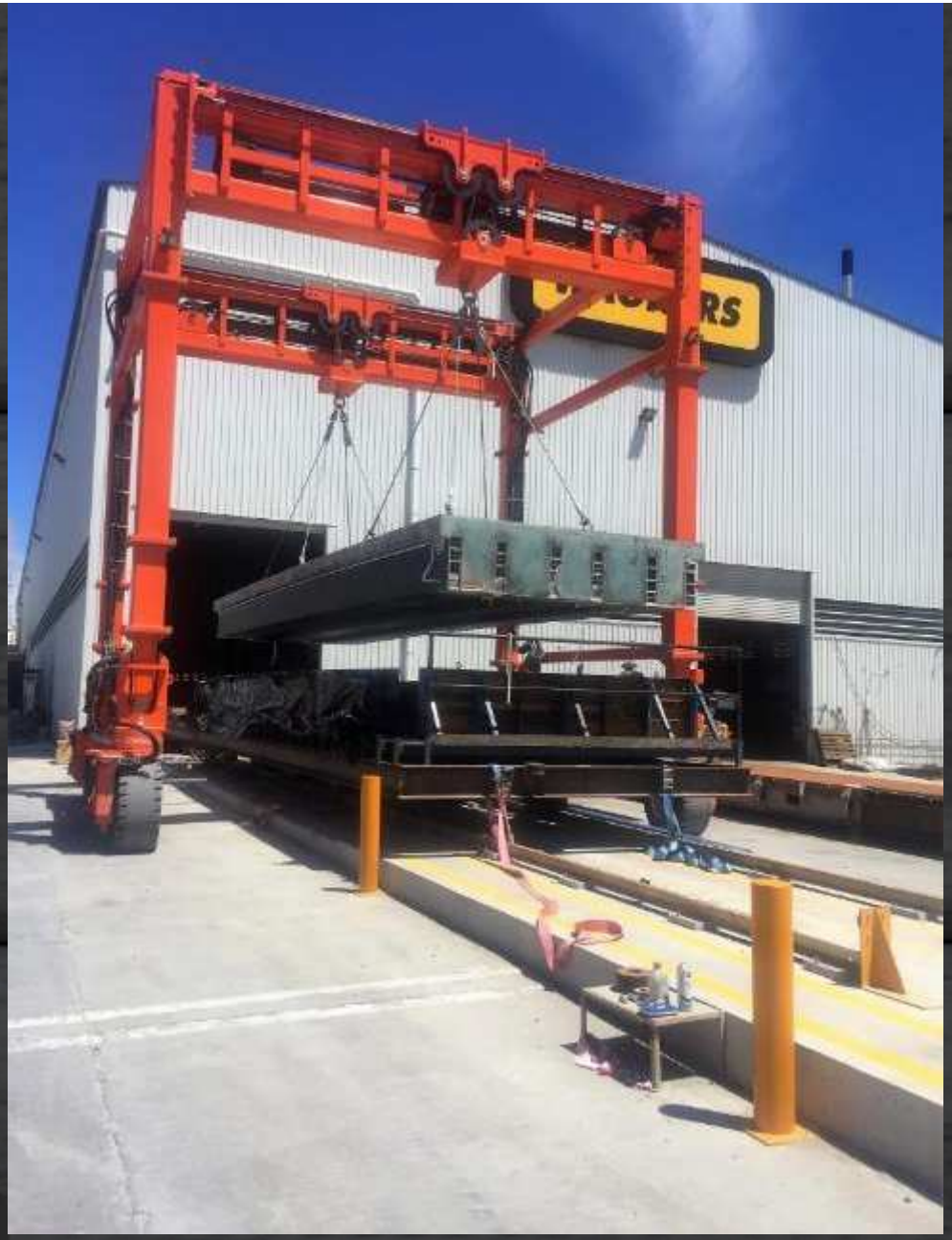

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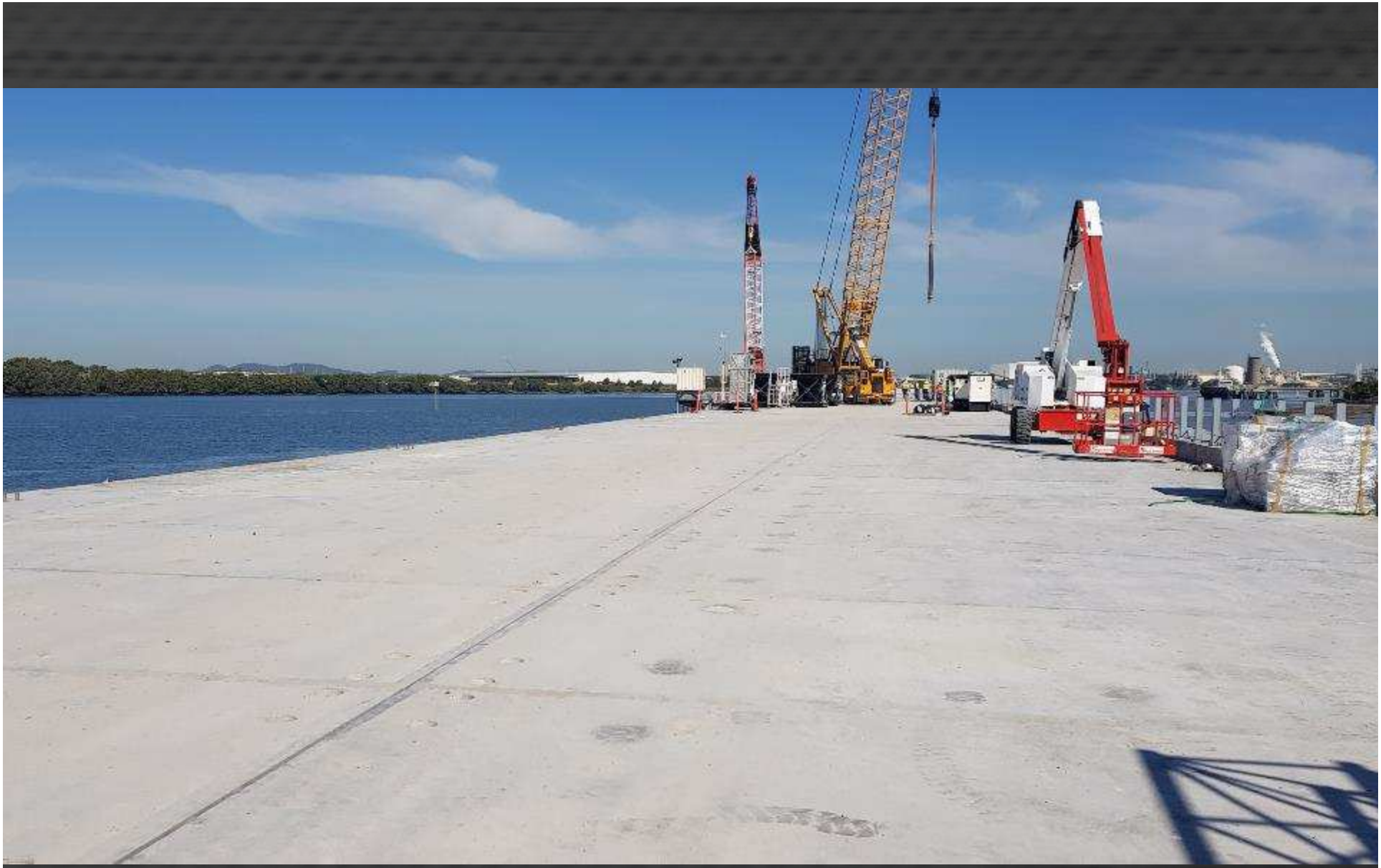

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