Design and Construction of the 100 metre Span UHPC Batu 6 Segmental Box Girder Bridge

Prepared By: Adj. Assoc. Prof Ir. Dr VOO Yen Lei

10th March 2016

DURA®
like concrete • like steel

SCIENTIA
MANU ET MENTE
UNSW

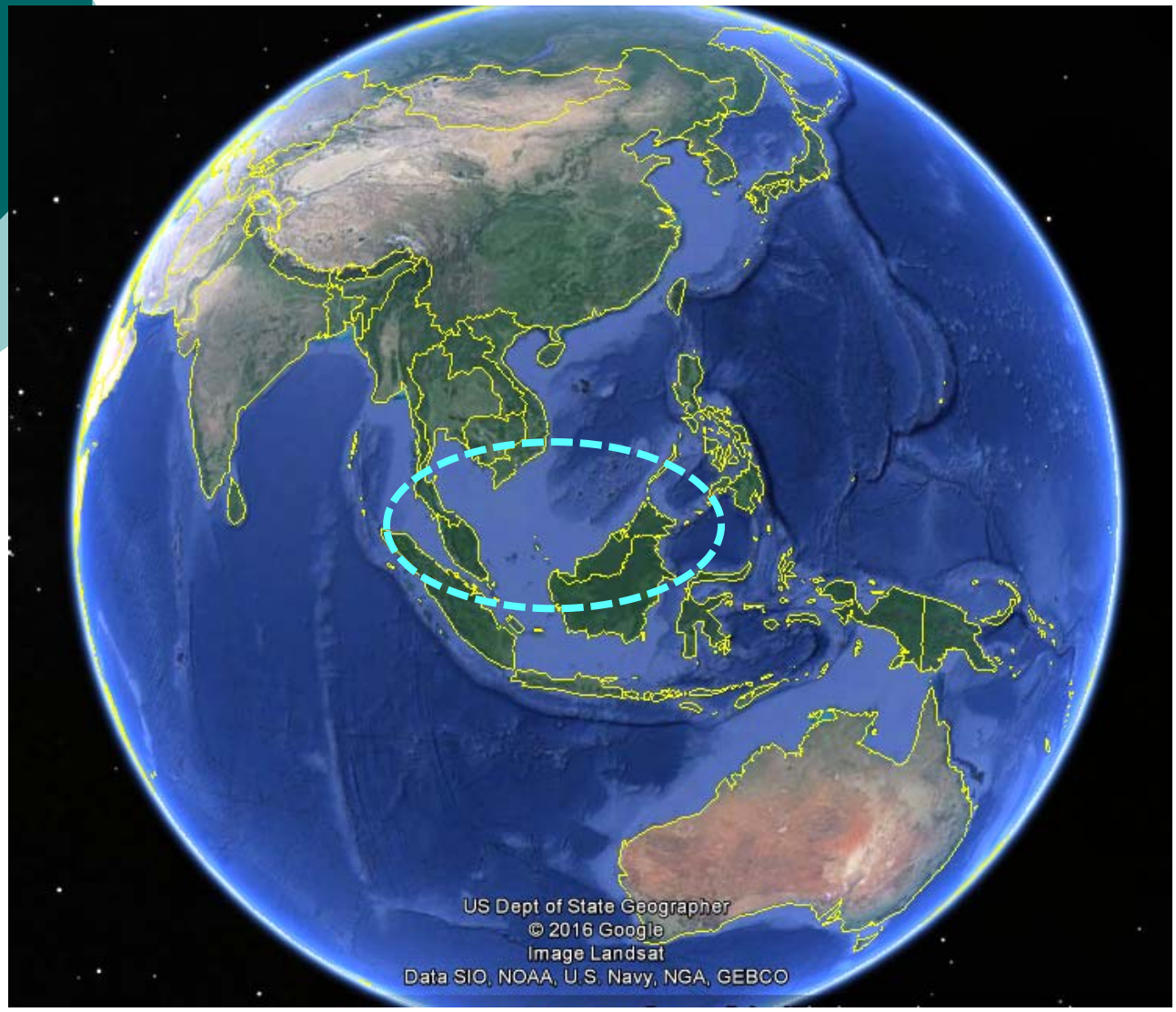
Bio-data

i. Founder / CEO / Executive Director of Dura Technology
ii. PhD in Civil Engineering – University New South Wales, Sydney, Australia, 2004
iii. 15 over years experience in the development of UHPC Technology (bridge engineering)
iv. Adjunct Associate Professor of University of New South Wales (Australia)
v. More than 70 publications (including a Book)
vi. 2 times Malaysia Book of Records holders
vii. Prestigious Entrepreneurs Award Winner 2015
viii. Prestigious Company Award Winner 2015
ix. Member of FIB Task Group 6.5

UHPC Bridges in Malaysia

(OVERVIEW)

Where is Malaysia??



A small and young country, with population and GDP of 9.6% and 4.6% respectively of USA.

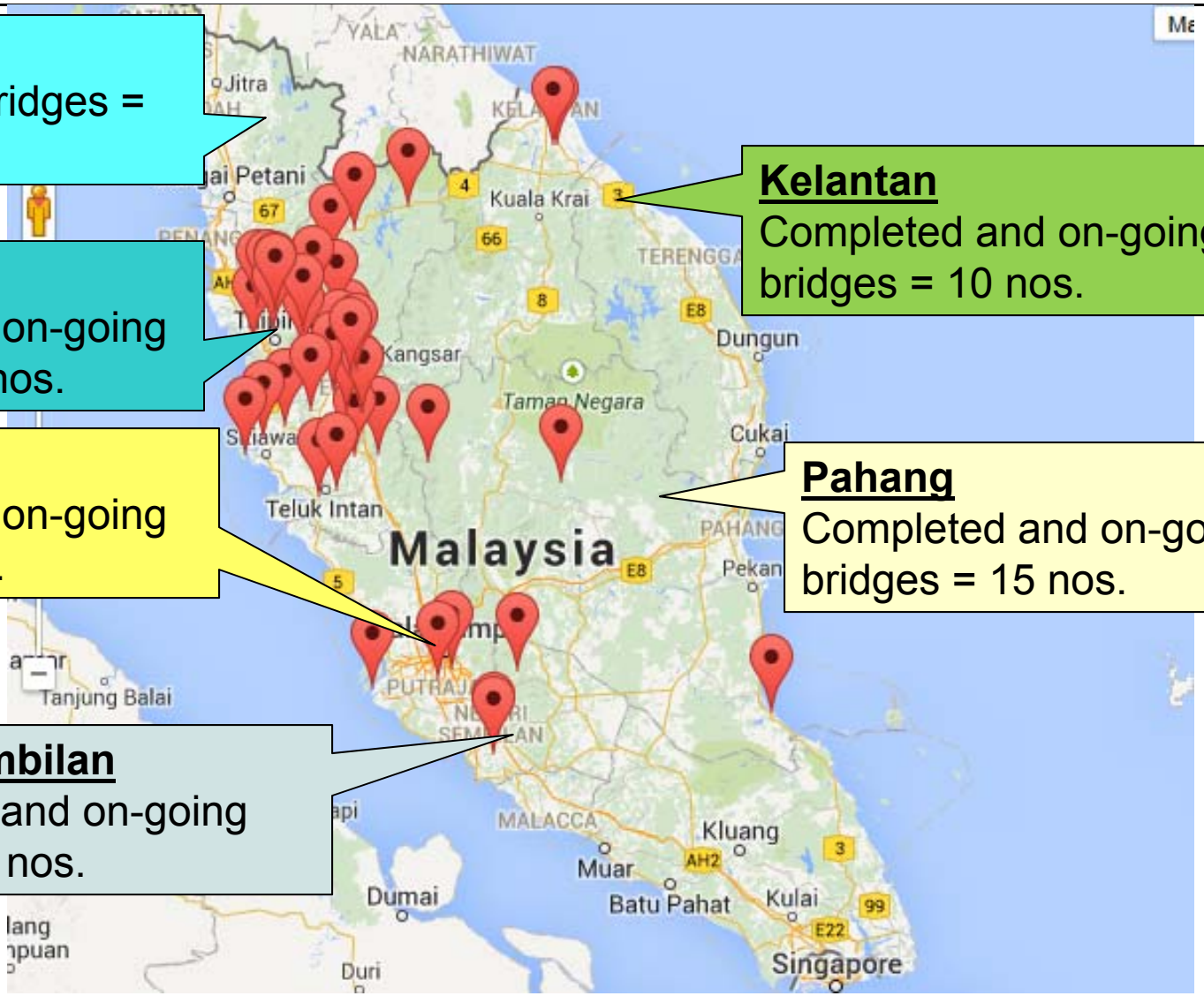
Where is DURA Bridges Have Been Used in Malaysia?

Kedah
On-going bridges = 13 nos.

Perak
Completed and on-going bridges = > 51 nos.

Selangor
Completed and on-going bridges = 4 nos.

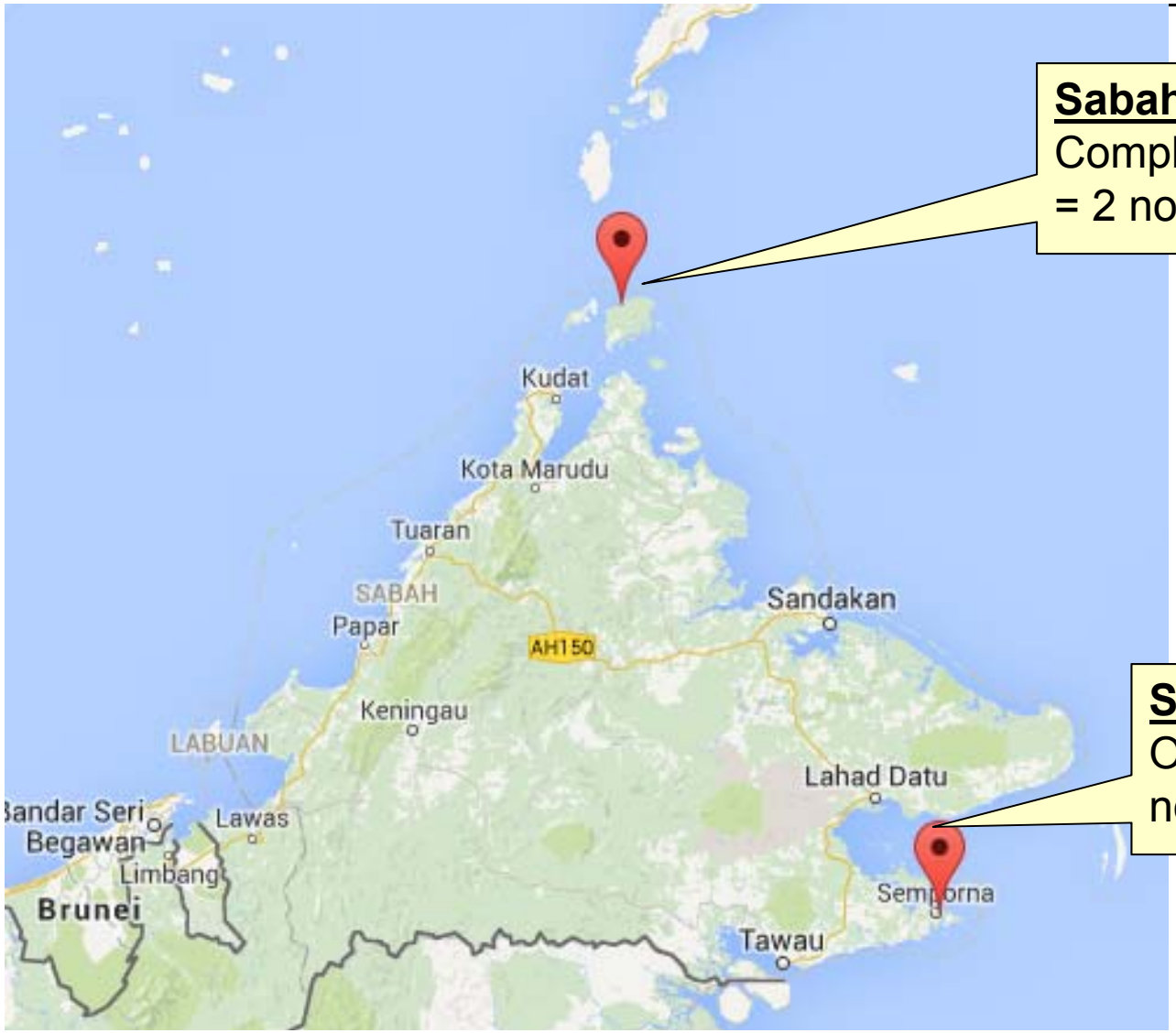
Negeri Sembilan
Completed and on-going bridges = 4 nos.



Kelantan
Completed and on-going bridges = 10 nos.

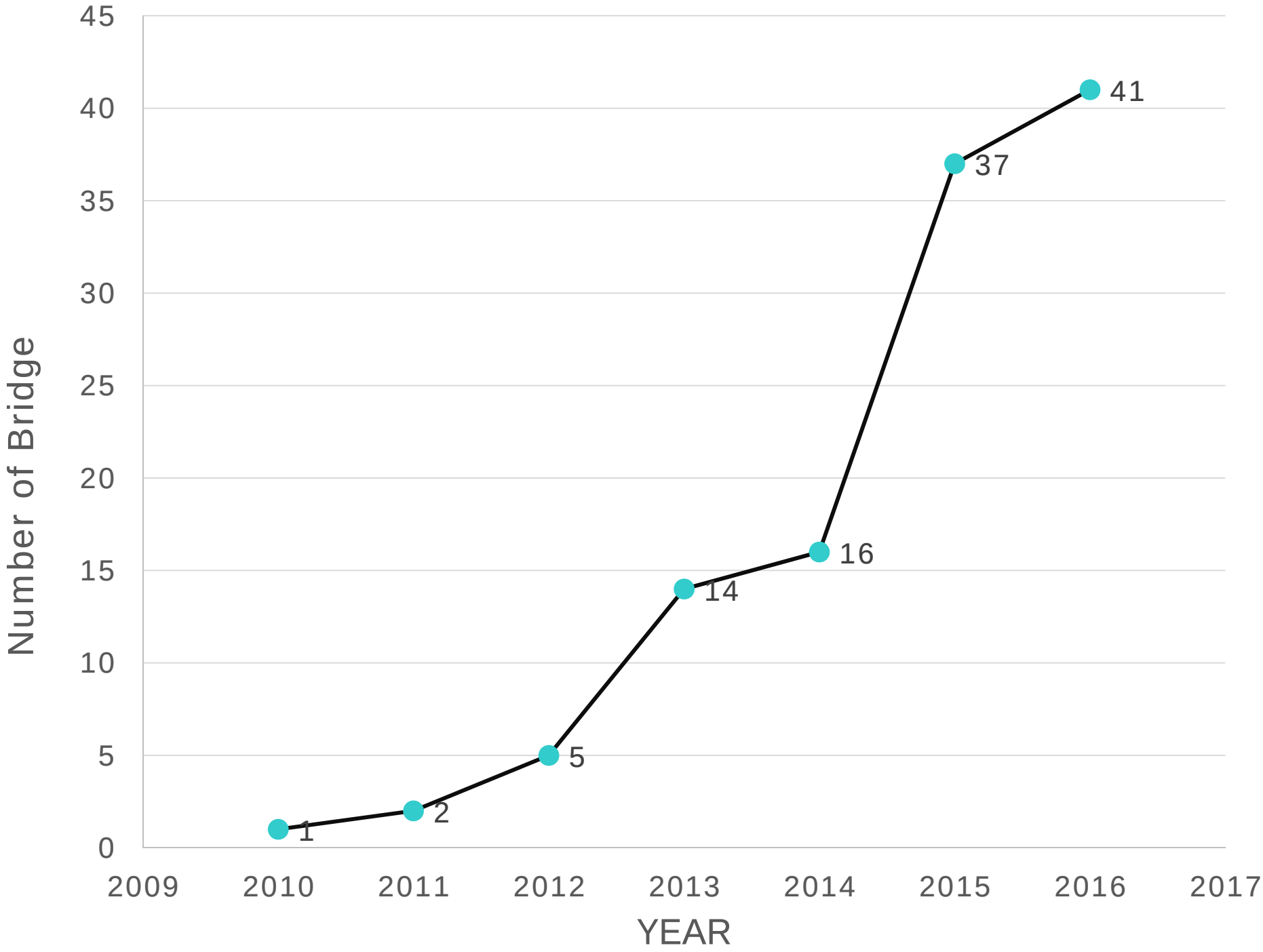
Pahang
Completed and on-going bridges = 15 nos.

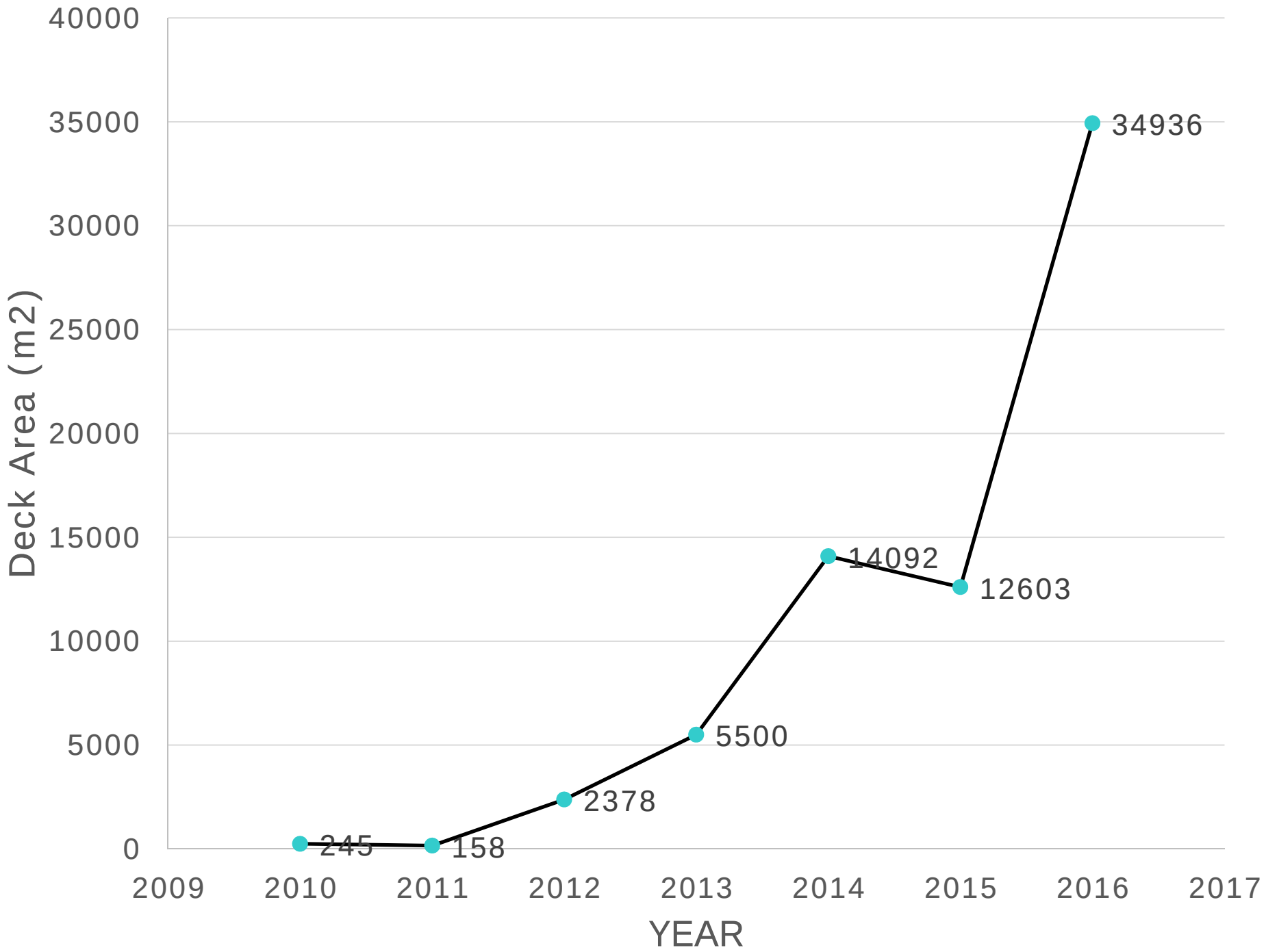
Where is UHPC Bridges Have Been Used in Malaysia?



Sabah
Completed bridges = 2 nos.

Sabah
On-going jetty = 1 nos.


45
40
35
30
25
20
15
10
5
0
Number of Bridge
1
2
5
14
16
37
41
2009
2010
2011
2012
2013
2014
2015
2016
2017
YEAR


40000
35000
30000
25000
20000
15000
10000
5000
0
Deck Area (m2)
2009
2010
2011
2012
2013
2014
2015
2016
2017
YEAR
245
158
2378
5500
14092
12603
34936

Kampung Linsum Bridge (50m) (Negeri Sembilan, 2010)

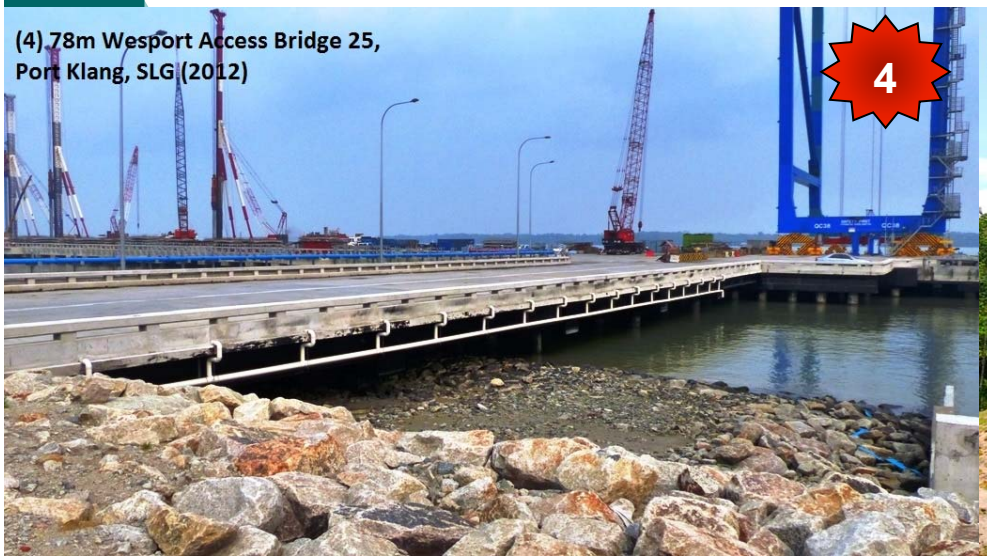
1

(Year 2011)


2. 25m Sungai Itik Bridge, Gopeng, PRK
2


(3) 18m Ulu Kampar Bridge,
Gopeng, PRK (2012)
3
DURA

Year 2012


(4) 78m Wesport Access Bridge 25,
Port Klang, SLG (2012)
4


(6) 12m Kg. Beng Bridge,
Lenggong, PRK (2012)
6


5
(5) 32m Ulu Kinta Bridge,
Ipoh, PRK (2012)


7
(7) 30m Ulu Chemor Bridge, Chemor, PRK (2012

40m Sk. Taayah Footbridge (2012)

8

(Year 2013)


9
(9) 50m Titi Bridge, Jelebu, NSDK (2013)


10
(10) 20m Sungai Guntung Bridge, Jalan Lahat, Ipoh, PRK (2013)

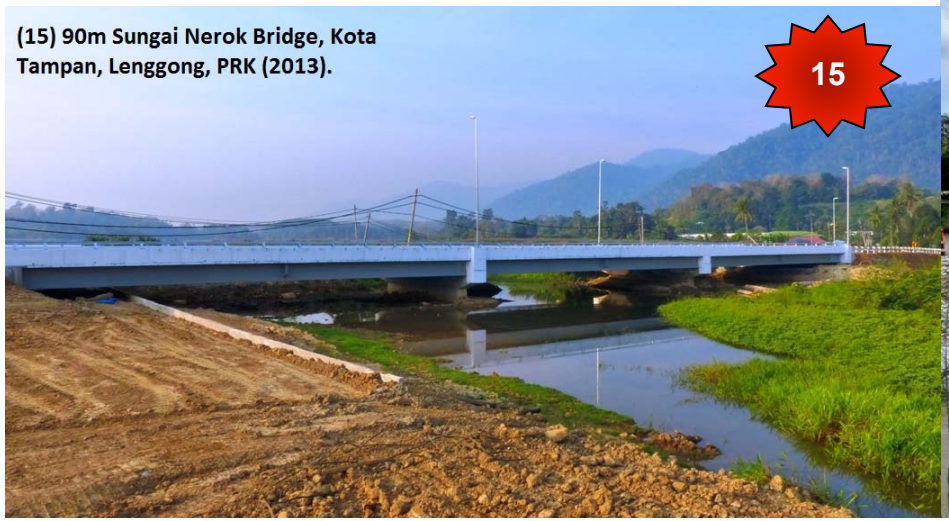

(11) 42m Kampung Bermin Bridge, Tapah, PRK (2013)
11


12
(12) 30m Kampung Malau Bridge, Lawin, PRK (2013).

(Year 2013)

(13) 52m Rantau-Siliau Bridge, Rantau, NSDK (2013).

(14) 110m Kuala Sepetang Footbridge,PRK (2013).



(15) 90m Sungai Nerok Bridge, Kota Tampan, Lenggong, PRK (2013).

(16) 12m Kampung Banjar Bridge, Manjung, PRk (2013)

(Year 2013)


17
(17) 12m Desa Murni Bridge,
Kuala Rompin, PHG (2013).


18
(18) 30m Kampung Chuar Bridge,
K. Kangsar, PRK (2013).


19
(19) 32m Mardi Bridge,
Kuala Kangsar, PRK (2014)


20

(Year 2013)


(21) 50m Sungai Kurau Bridge 1, PRK (2013)
21


(22) Sungai Kurau Bridge 2, PRK (2013)
22

(Year 2014)

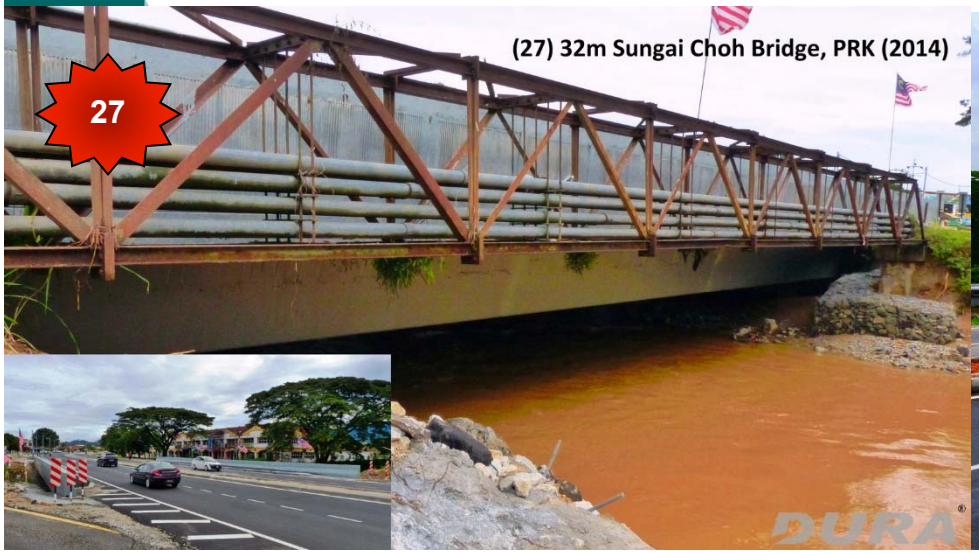

(23) Tapak Rapit Bridge, PRK (2014)
23


24
(24) MINES Shopping Centre Bridge, SLG (2014)


(25) Wisma LKIM Bridge, SLG (2014)
25


JUAL
AN AYAM
26

(Year 2014)


(27) 32m Sungai Choh Bridge, PRK (2014)
27


(28) Sungai Ranting Bridge, PRK (2014)
28


(29) 50m Sungai Yap Bridge, PHG (2014)
29


30

(Year 2014)


31


32


(33) 58m Kampung Merdeka Bridge, PRK (2015)
33


(34) 200m CFS Bridge, PRK (2014)
34

(Year 2014)


35

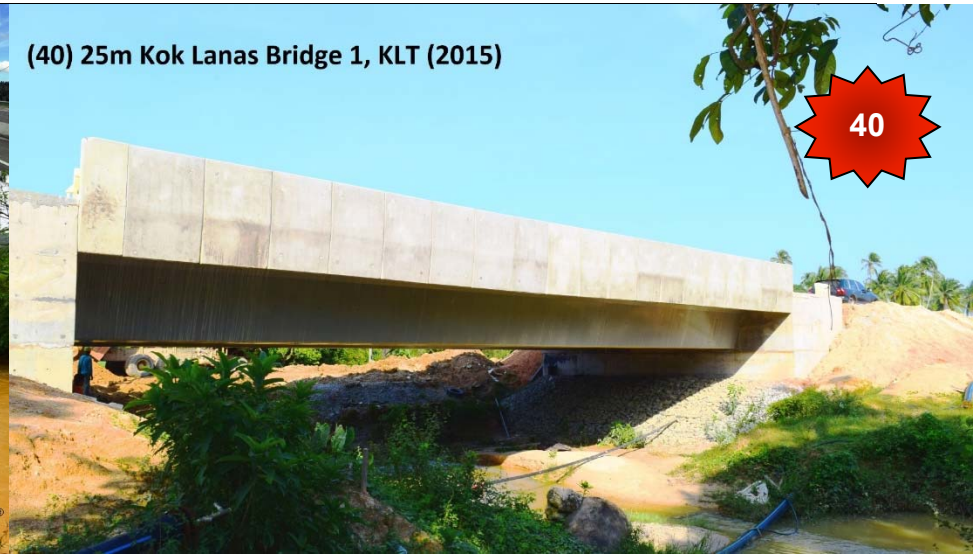

(36) 16m Bukit Berapit Bridge, PRK (2014)
36


(37) 25m Pulau Banggi Bridge 3, SBH (2014)
37


(38) 30m Pulau Banggi Bridge 4, SBH (2014)
38

(Year 2015)


(39) 50m Sungai Ijok Bridge, PRK (2015)
39


(40) 25m Kok Lanas Bridge 1, KLT (2015)
40


(41) 40m Kok Lanas Bridge 2, KLT (2015)
41

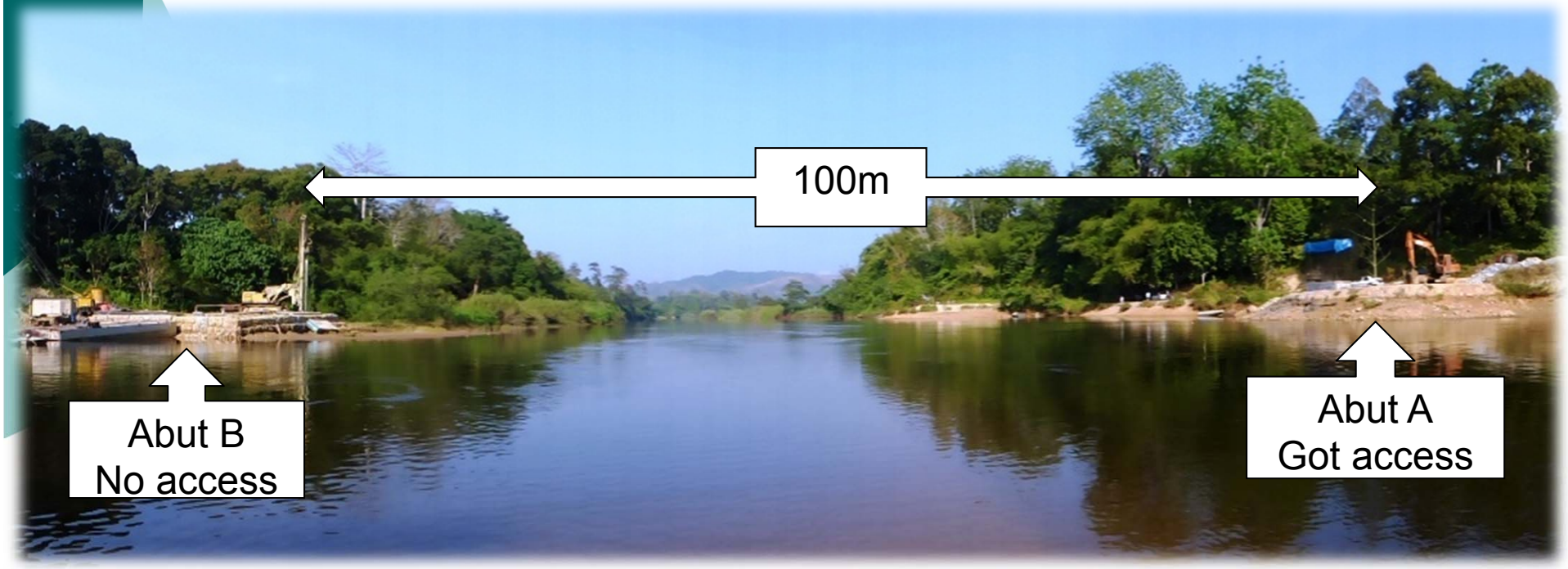

42

(Year 2015)

(Year 2015)

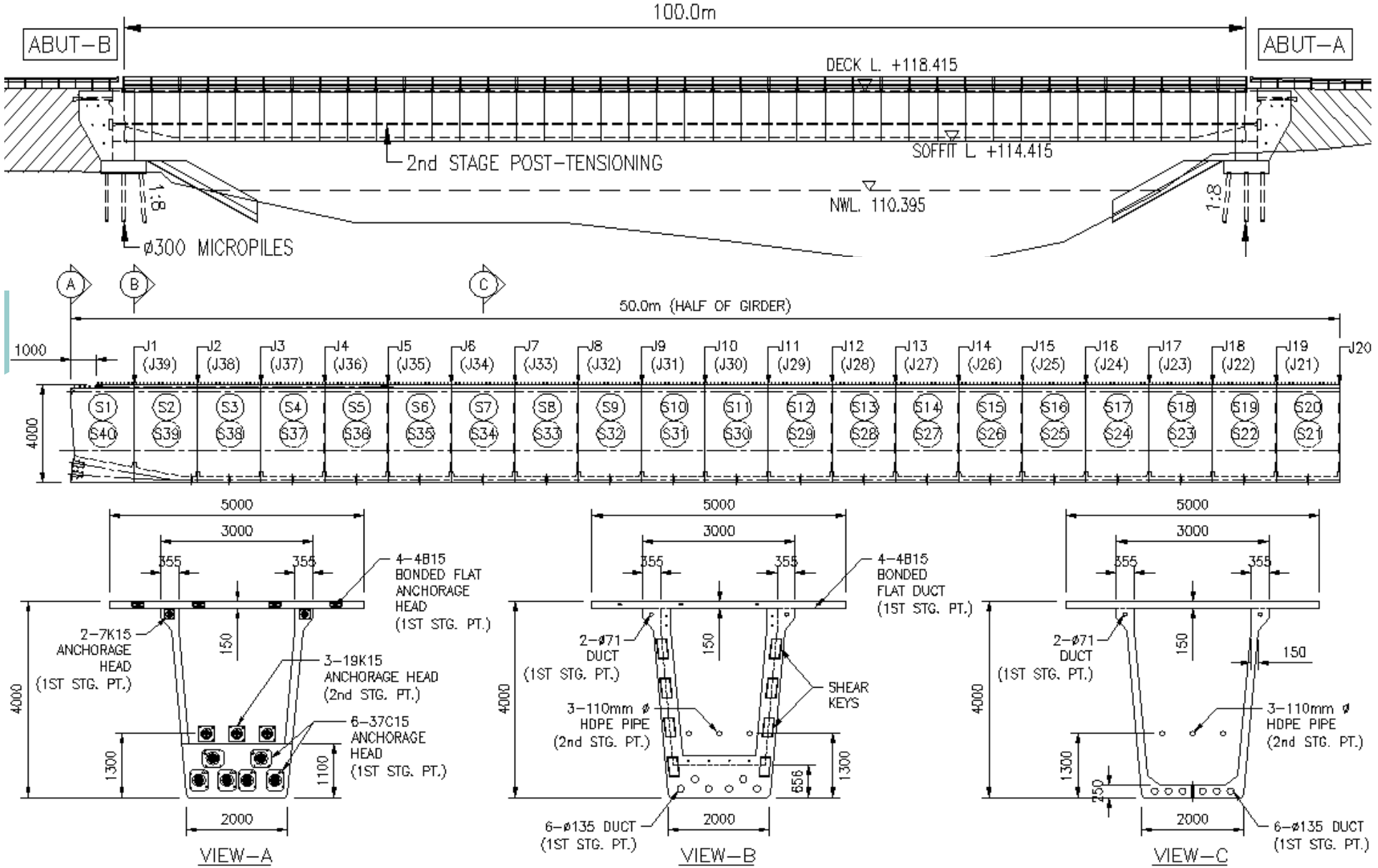
Membina Jalan dan Jambatan di Kawasan Kampung Batu 6, Bandariang, Gerik, Daerah Hulu Perak, Perak D.R. (2014)

100m Single Span Bridge



Bridge Location

Bridge Detail

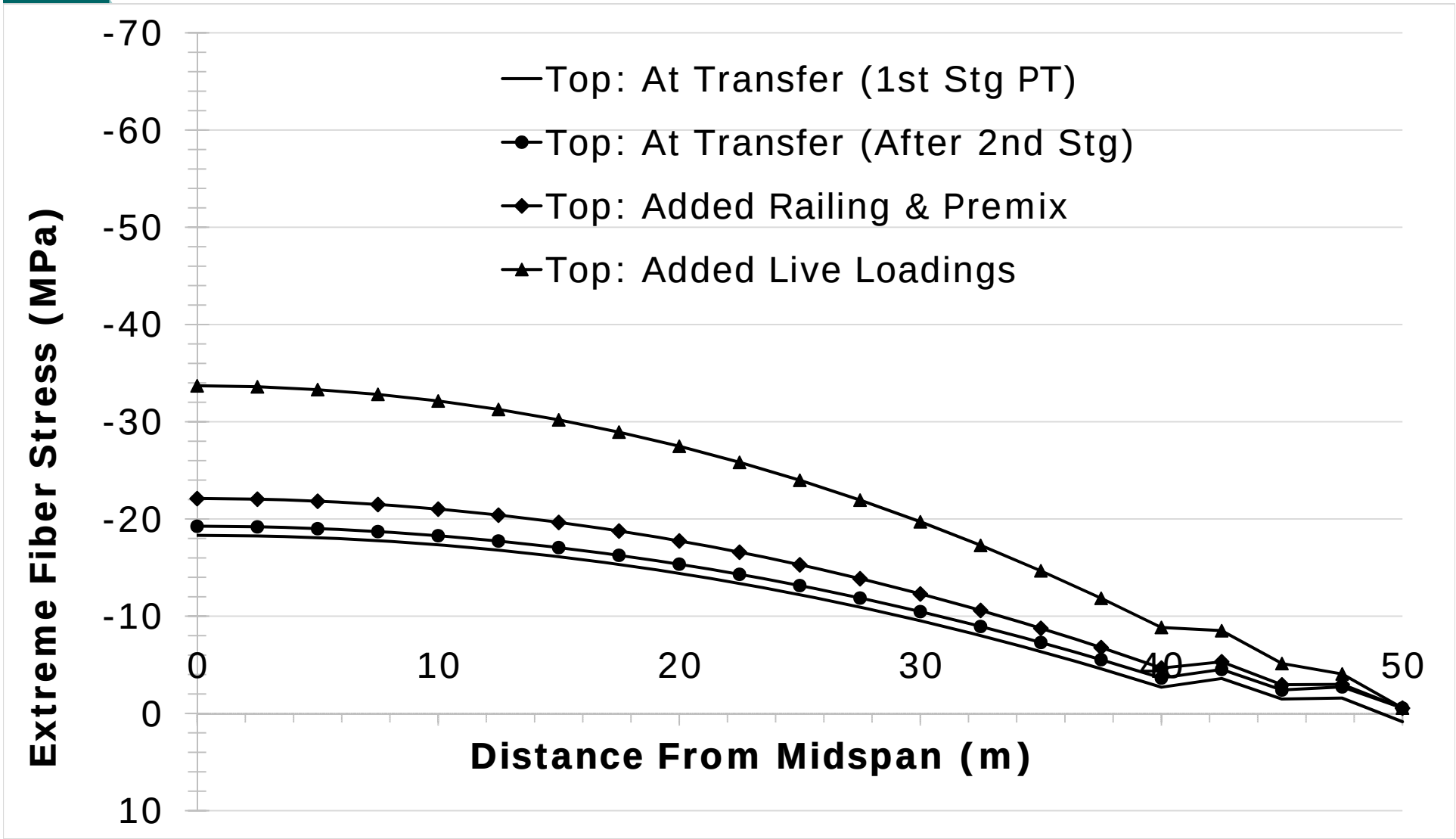


Design Load

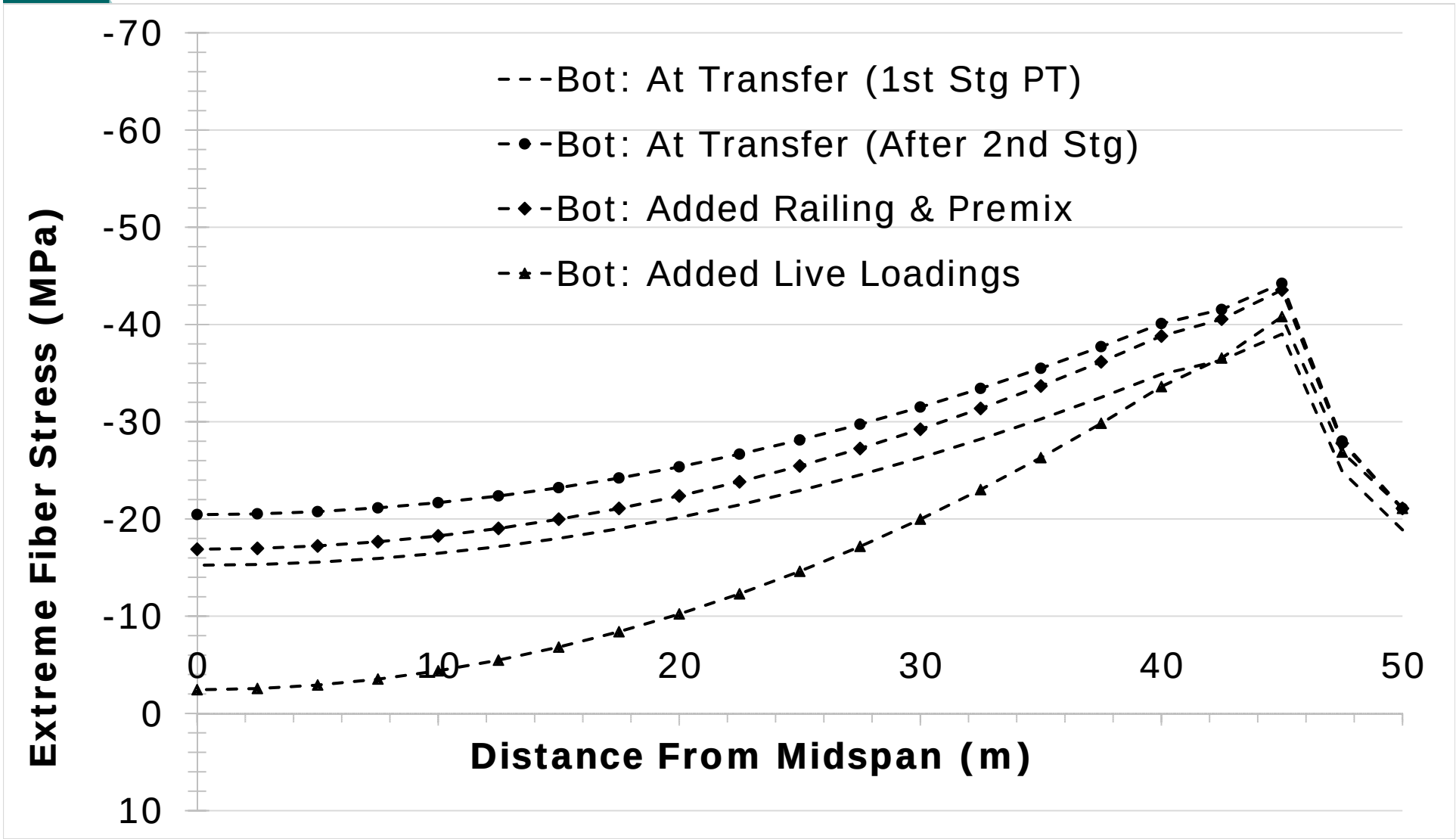
- The traffic loading used was according to the specification of the bridge design code BD37/01 [5].
- At SLS stage, using HA-UDL (25.2kN/m UDL) and KEL (120kN point load) and pedestrian loadings (5kPa x 1m width = 5kN/m).
- At ULS, both of the HA+KEL and 30 units HB loadings (i.e. 4 axles x 300 kN/axle) combined with pedestrian loadings (whichever governed).
- 30unit HB loading: 30t x 4 axles = 120 ton (nominal); 120t x 1.1 = 132 ton (SLS); 120t x 1.3 =156 ton (ULS)

	SLS				ULS	
(1)	(2) Moment (kNm)	(3) Shear Force (kN)	(4) Deflection [3] Theo. (mm)	(5) Deflection Field (mm)	**(6) Moment (kNm)**	**(7) Shear Force (kN)**
SW of box-girder (G_1= 70 kN/m)	87,500	3,500	-49.6 (net) (1st Stg PT) -81.4 (net) (2nd Stg PT)	-50 (net) (1st Stg PT) -78 (net) (2nd Stg PT)	**100,625 (60%)**	**4,025 (60%)**
SW of G.I. railing (G_2 = 3 kN/m)	3,750	150	+ 13.6 (incremental) = -67.8 (net)	+ 36 (incremental)	**4,312.5**	**172.5**
SW of premix (G_3 = 5.175 kN/m)	7,762.5	310.5	+ 28.2 (incremental) = -39.6 (net)	= -42 (net)	**11,320**	**453**
Live load 1 (Q_1 = 25.1 kN/m equivalent HA)	37,672	1,509	+ 136.8 (incremental) = +97.2 (net)	No Data	**47,090 (27.8%)**	**1,886 (27.8%)**
Live load 2 (Q_2 = 300 kN x 4 axles, 30 unit HB)	N/A	N/A	N/A	N/A	**37,128**	**1,425**
Live load 3 (Q_3 = 3.07kN/m pedestrian)	3,837.5	153	+ 14 (incremental) = +111.2 (net)	No Data	**5,756**	**230**
Total	140,522	5,623			**M_{Ed} = 169,104**	**V_{Ed} = 6767**

SLS Stresses (Top Extreme Fiber)



SLS Stresses (Bot Extreme Fiber)



ULS – Flexural Capacity

- M_{Ed}^{+} = 169,103kNm (@ S.S. scenario)
- Using Material Factor:
  - UHPC = 1.3 (JSCE No.9, 2006)
  - Tendon = 1.15 (EC2)
- M_{Rd}^{+} = 215,229kNm >> M_{Ed}^{+} = 169,103kNm (OK!!!)
- Flexure Capacity is adequate!!!!!

ULS – Shear Capacity (None Joint Section) (JSCE No.9, 2006)

- V_{Ed} = 6,764 kN (Av. Web Shear Stress = 5.64 MPa)
- Using Material Factor:
  - UHPC ϕ_c = 1.3 (JSCE No.9, 2006)
  - Tendon ϕ_p = 1.15 (EC2)
- Using Member Reduction Factor
  - ϕ_b = 1.3
- V_{Rd} = 10,107 kN >> V_{Ed} = 6,764 kN (OK!!!)
- Shear Capacity at none joint section is adequate!!!!!

ULS – Shear Capacity (@ Joint Section) (Voo et al., 2015)

- Ref: **Voo, Y.L.**, Foster, S.J., and Voo, C.C., (2015). "Ultrahigh-Performance Concrete Segmental Bridge Technology: Toward Sustainable Bridge Construction." *Journal of Bridge Engineering*, Vol. 20, No.8, August, SPECIAL ISSUE: Design, Analysis, and Construction of Segmental Bridges, B5014001. ASCE.
- V_{Ed} = 6,764 kN
- Using Member Reduction Factor ϕ = 0.7
- $V_{j,Rd}$ = 19,224 kN >> V_{Ed} = 6,764 kN (OK!!!)
- Shear Capacity at joint section is adequate!!!!!

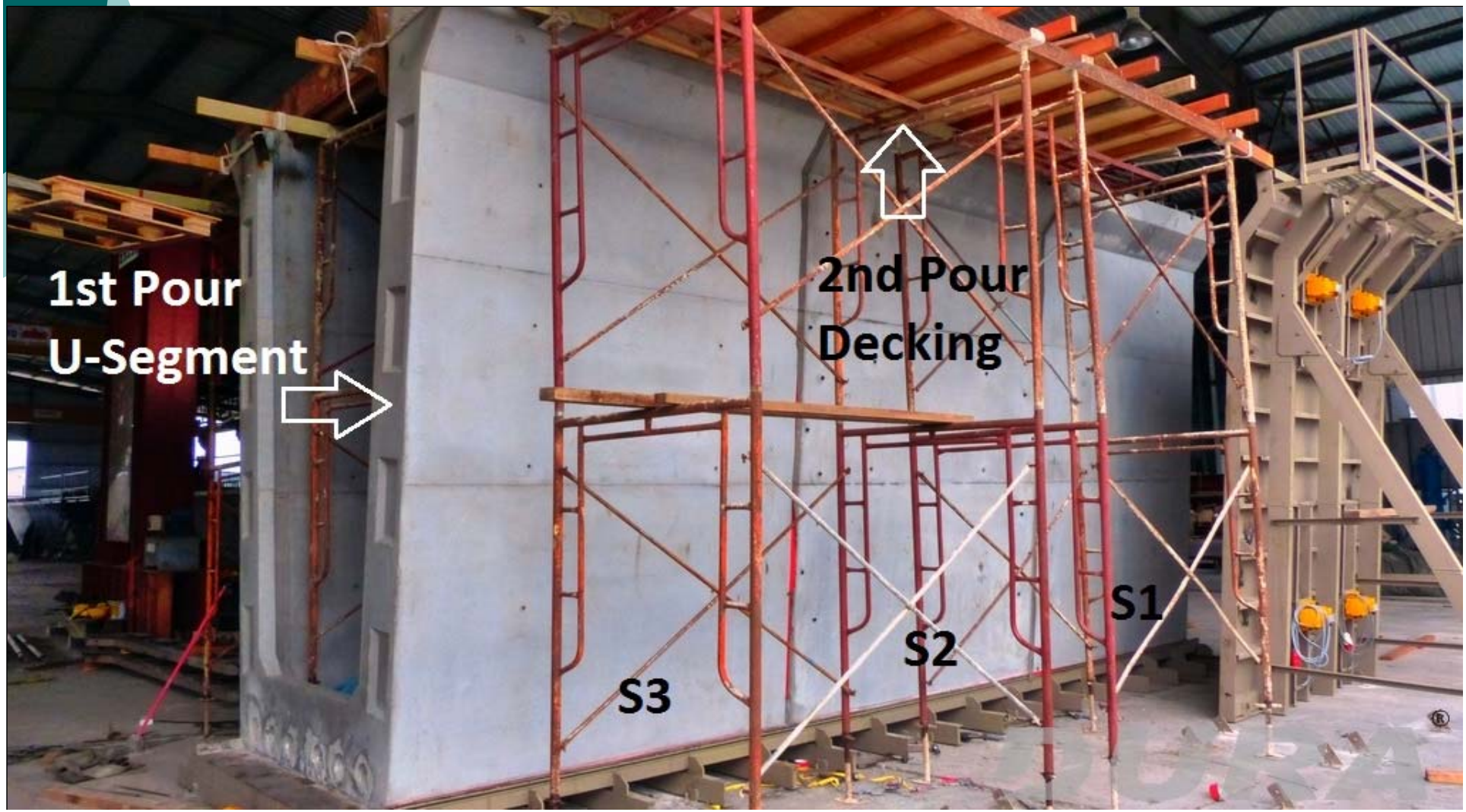
Mechanical Property of DURA

Properties	Unit	Min	Max	Mean	S.D.	Characteristic
1 Day Cube Compressive Strength, $f_{cu,1d}$	MPa	82	95	85 [1]	4.4 [1]	78
28 Days Cube Compressive Strength, $f_{cu,28d}$	MPa	165	185	173 [1]	6.2 [1]	163
Flexural Strength, $f_{cf,28d}$	MPa	26.6	31.2	29.1 [2]	2.8 [2]	24.4
Modulus of Elasticity, E_o	GPa	44.8	46.8	45.6 [3]	N/A	N/A
Poisson's Ratio, ν		0.19	0.21	0.2 [3]	N/A	N/A

There are a total of 80 pours in the manufacturing of one single girder. A total of min. 480 cubes and 240 prisms quality control samples were made and tested destructively to produce the above results.

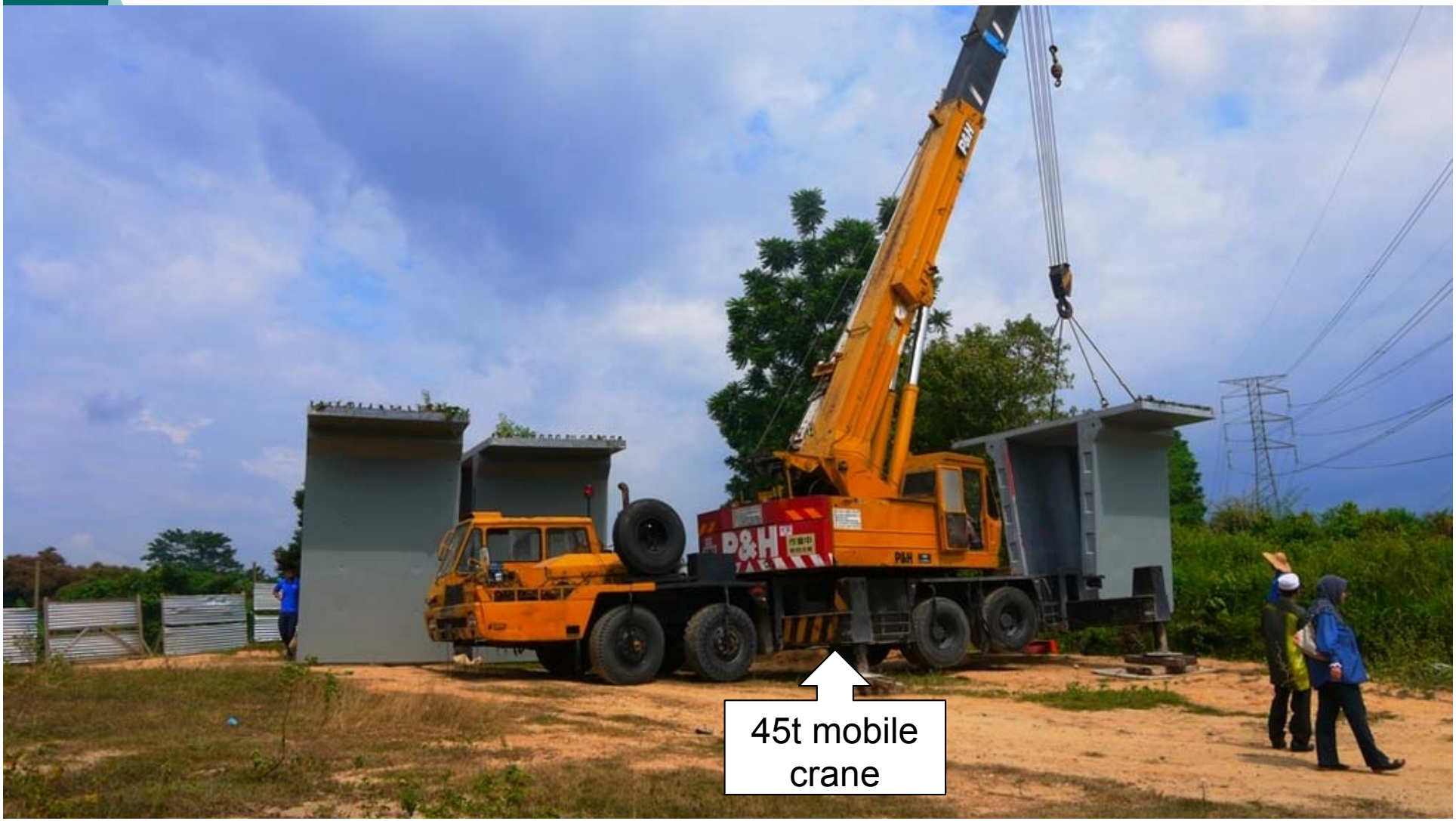
Note: 1. Out of min 240 cube samples; 2. Out of 240 prism samples; 3. Out of 3 cylinder samples

Matched Casting

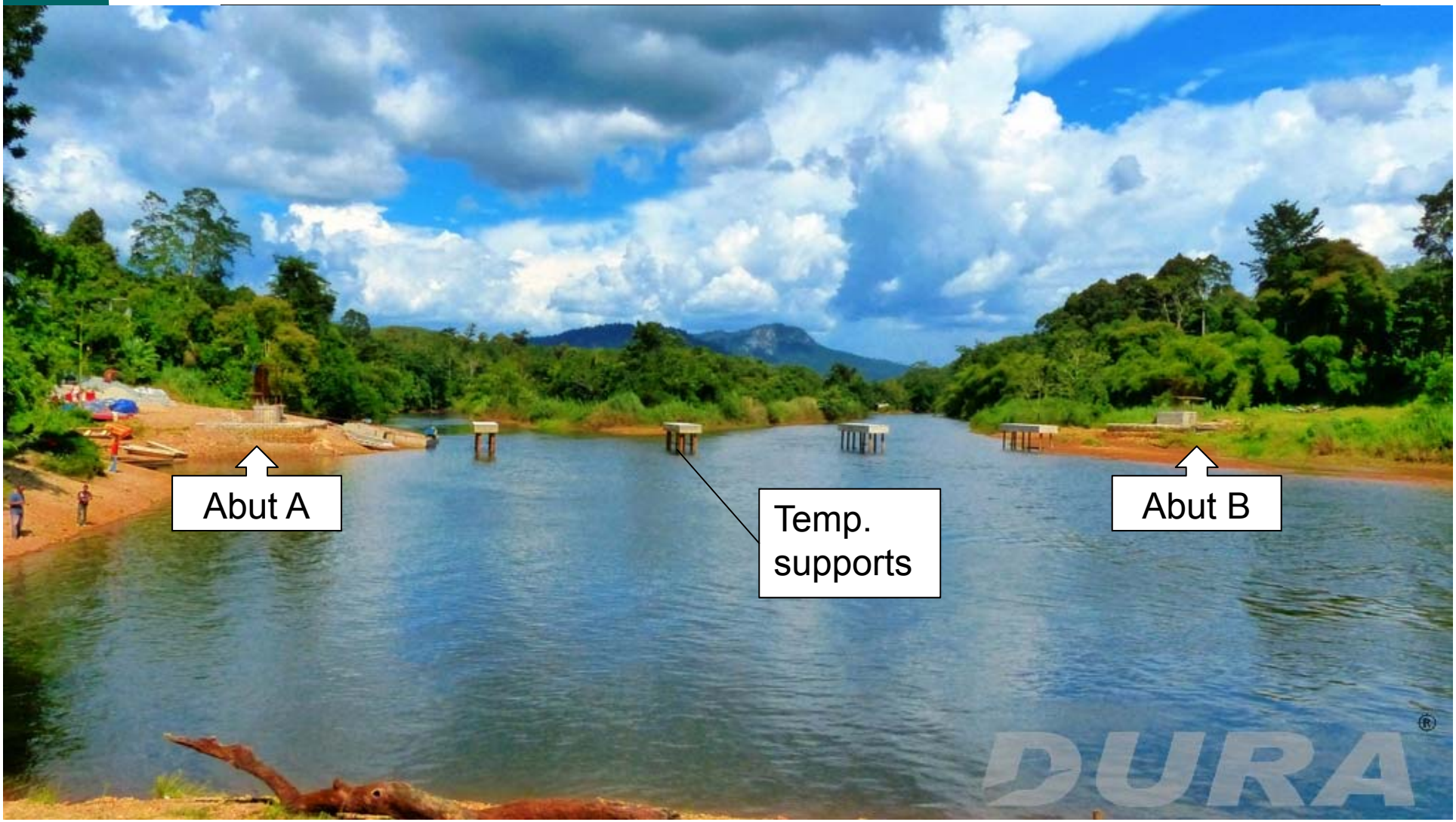


Transportation of Segments

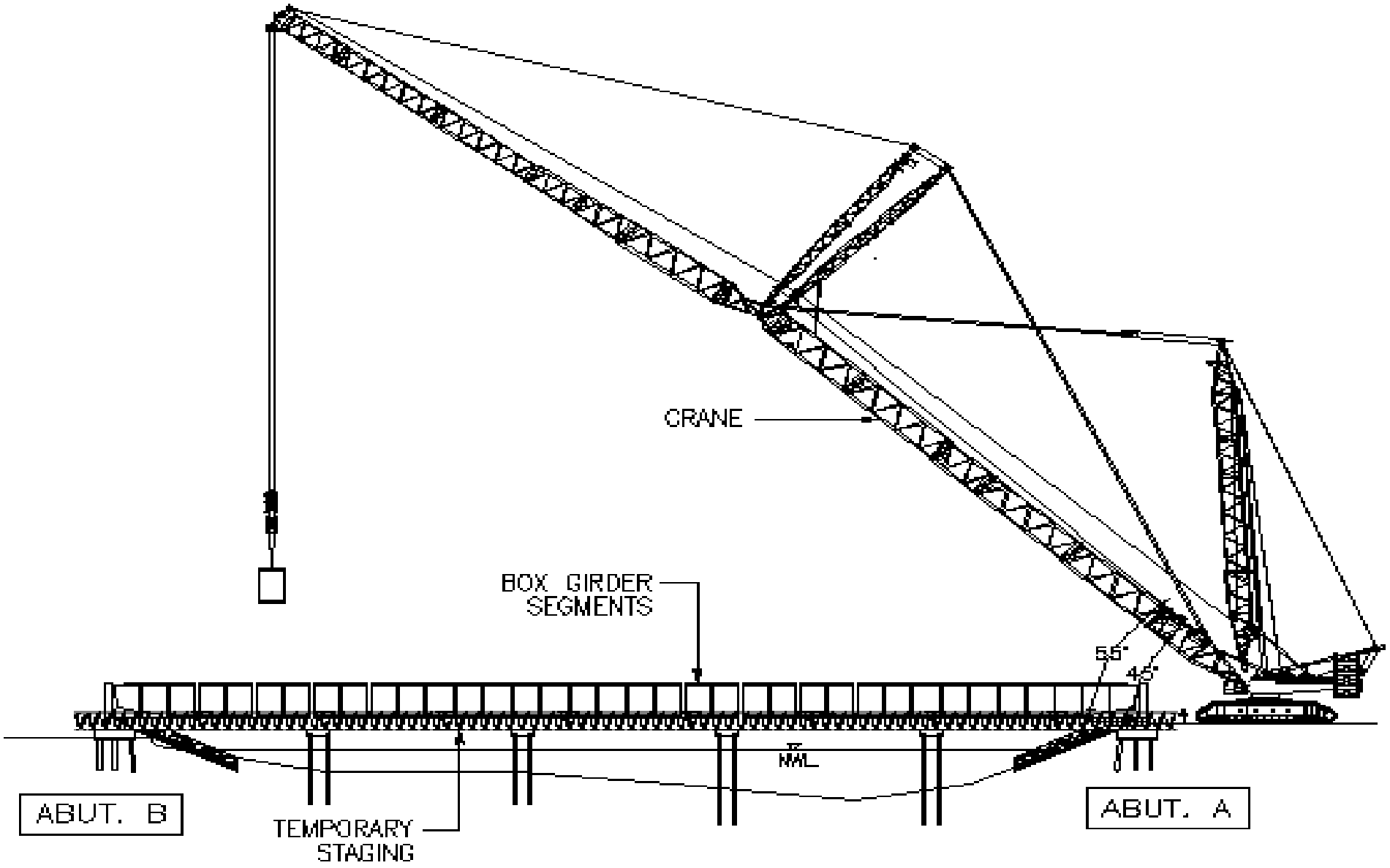
Unload Segments at Site using 45t crane



Temporary Supports



Assembly Method



ELEVATION

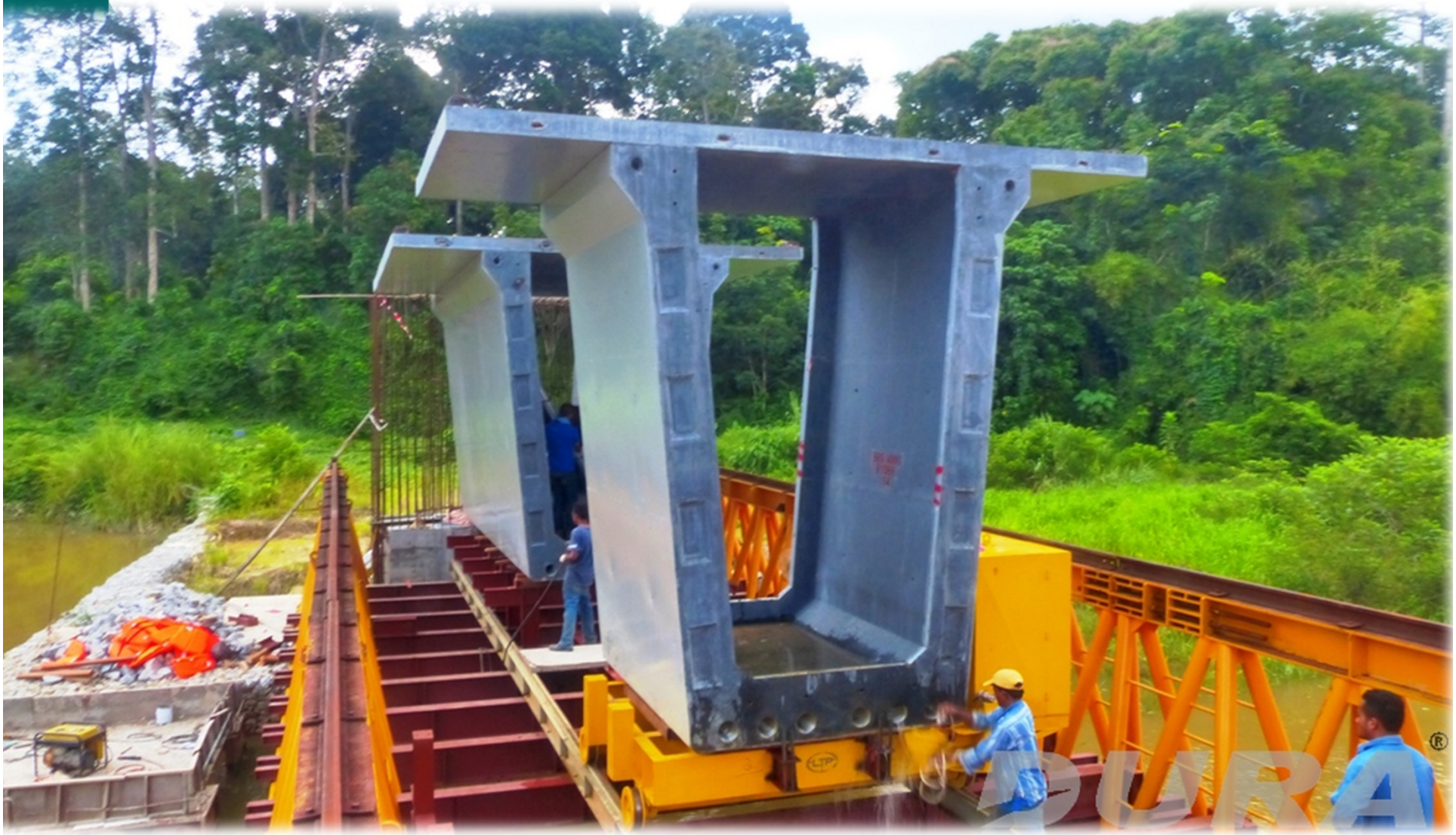
LAUNCHING METHOD

Assembly Temporary Steel Truss

550t crawler crane is used mainly to assembled the last steel frame

Assembly Segment Using Trolley

Assembly of 4th Segment



Inside the Box

Assembling the Last Segment

Fully Assembled in 10 days

Post Tensioning Work

Completed After 1 Year

Completed After 1 Year

Advantageous

- No column in river
- Beam light-weight
- Shorter construction time
- Easier to construct / less environmental disturbance
- More durable
- More economical
- Maintenance free