MIDAS UK Expert Engineer Webinar Series

Case study of Integral Bridge structure -Forder Valley Viaduct Bridge

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CONTENTS

Section 1 - Who We Are

AECOM

American multinational engineering firm provides design, consulting, construction and management services to a wide range of clients.

Presenter

Please search for “Mahesh Sankaran” in LinkedIn to get my professional introduction

1.1 AECOM Credentials

FAST FACTS

- Approximately ***$20.2 billion*** of revenue during fiscal year 2018
- Ranked ***#1*** in Transportation and General Building in *Engineering News – Record's* 2018 "Top 500 Design Firms"
- Named one of Fortune magazine's "World's Most Admired Companies" for the fifth consecutive year

CORE VALUES

- ***Safeguard, Collaborate, Inspire, Anticipate, Deliver and Dream***

COMMITMENT

- ***Safety, Corporate Responsibility and Sustainability***

1.2 AECOM Projects

ICONIC PROJECTS

One World Trade Center
Tallest building in the Western Hemisphere standing 1,776 feet high. Its sheer size, geographic constraints and operational necessities make it one of the most complex projects ever built.

Taizhou Bridge
First ever, three-tower suspension bridge connecting four main cities in China.

Crossrail London
Largest construction project in Europe, stretching more than 62 miles from Maidenhead and Heathrow Airport in the west of London with Shenfield and Abbey Wood in the east.

Rio 2016 Olympic and Paralympic Games
AECOM won an international competition to design the Games' master plan, which included three stages: games, transition and legacy.

Hyperloop Technologies
Imagine traveling at airline speeds for the price of a bus ticket. AECOM is the only infrastructure company in the world to have planned, designed and constructed Hyperloop projects.

Los Angeles International Airport
AECOM is managing the comprehensive LAX implementation plan for modernizing the airport.

Source: AECOM Intranet

1.3 AECOM Bridge Projects

ICONIC PROJECTS

THE PEACE BRIDGE
NORTHERN IRELAND

RION-ANTIRION BRIDGE
GREECE

TAIWAN HIGH SPEED
RAIL, TAIWAN

PONT-Y-WERIN
FOOTBRIDGE CARDIFF

KAP SHUI MUN BRIDGE
HONGKONG

IZMIT BAY BRIDGE
TURKEY

Source: AECOM Intranet

Section 2 – Integral bridges – An overview

2.1 What is an integral bridge?

2.2 Why integral construction?

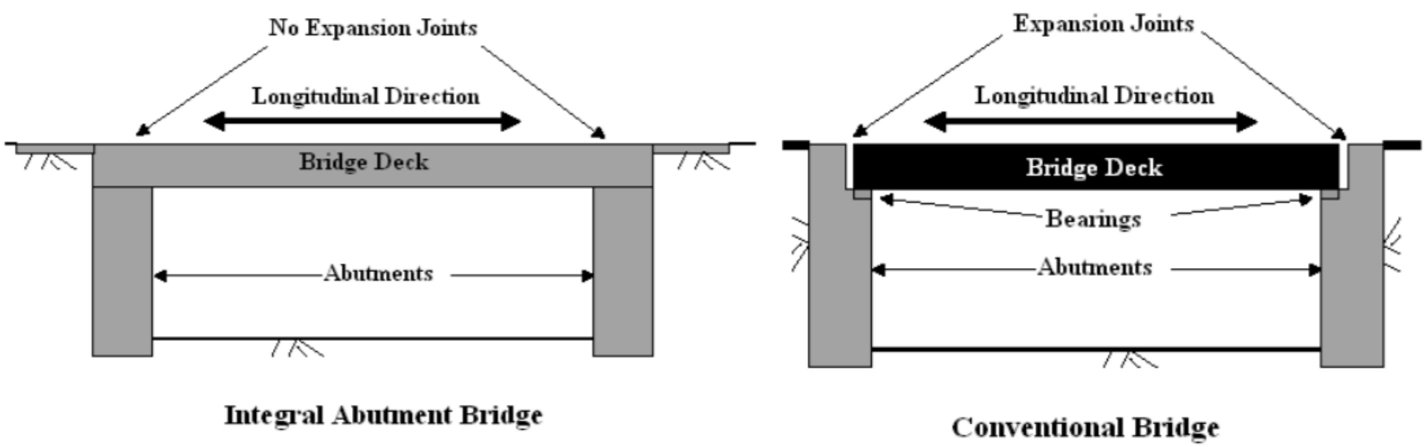
2.3 Integral bridge types of construction

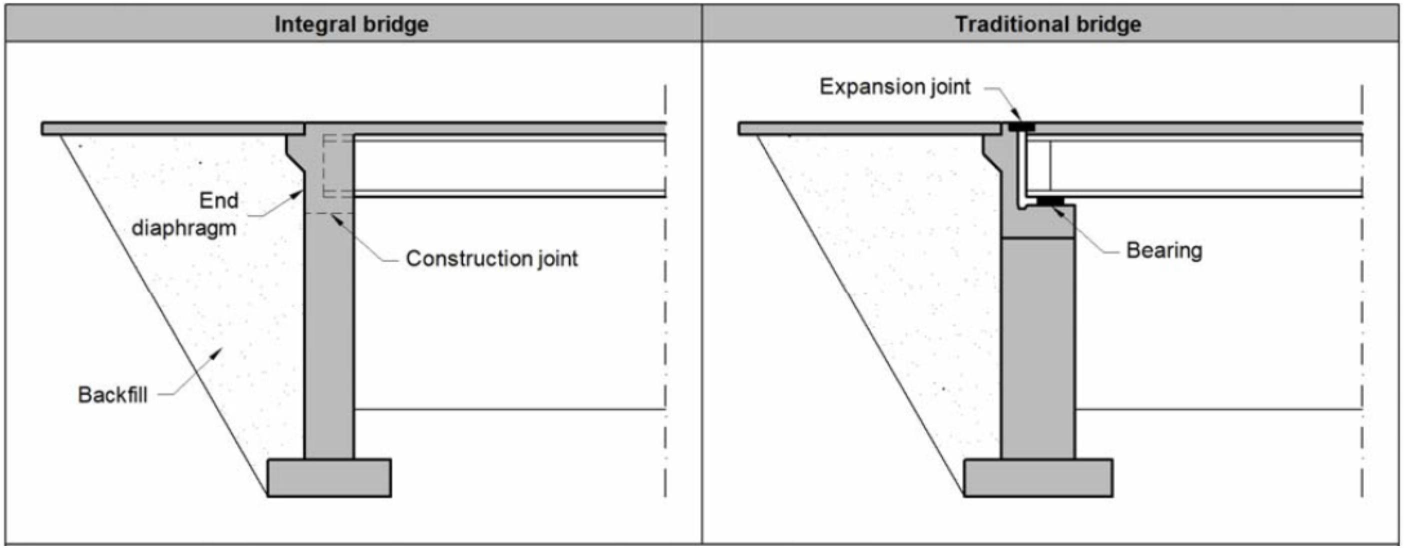
2.4 Earth Pressure distribution

2.1 What is an Integral bridge?

- An integral bridge contains no expansion joints to accommodate enlargement due to temperature variations
- Spans monolithically from abutment to abutment
- Movement due to thermal expansion and contraction or braking loads is accommodated by the abutments and piers(if present).

Structural arrangement of integral bridge and traditional bridge





Structural arrangement of integral and jointed deck bridge

2.2 Why integral construction?

- Continuous structures have proved to be more durable than simply supported decks, primarily because deck joints have allowed salty water to leak through to piers and abutments

- Serious inspection construction and maintenance problems associated with in-span discontinuities. Therefore not provided unless agreed by Overseeing Organisation.

- BD 57/01 recommends the bridge structures to be designed as continuous over intermediate supports

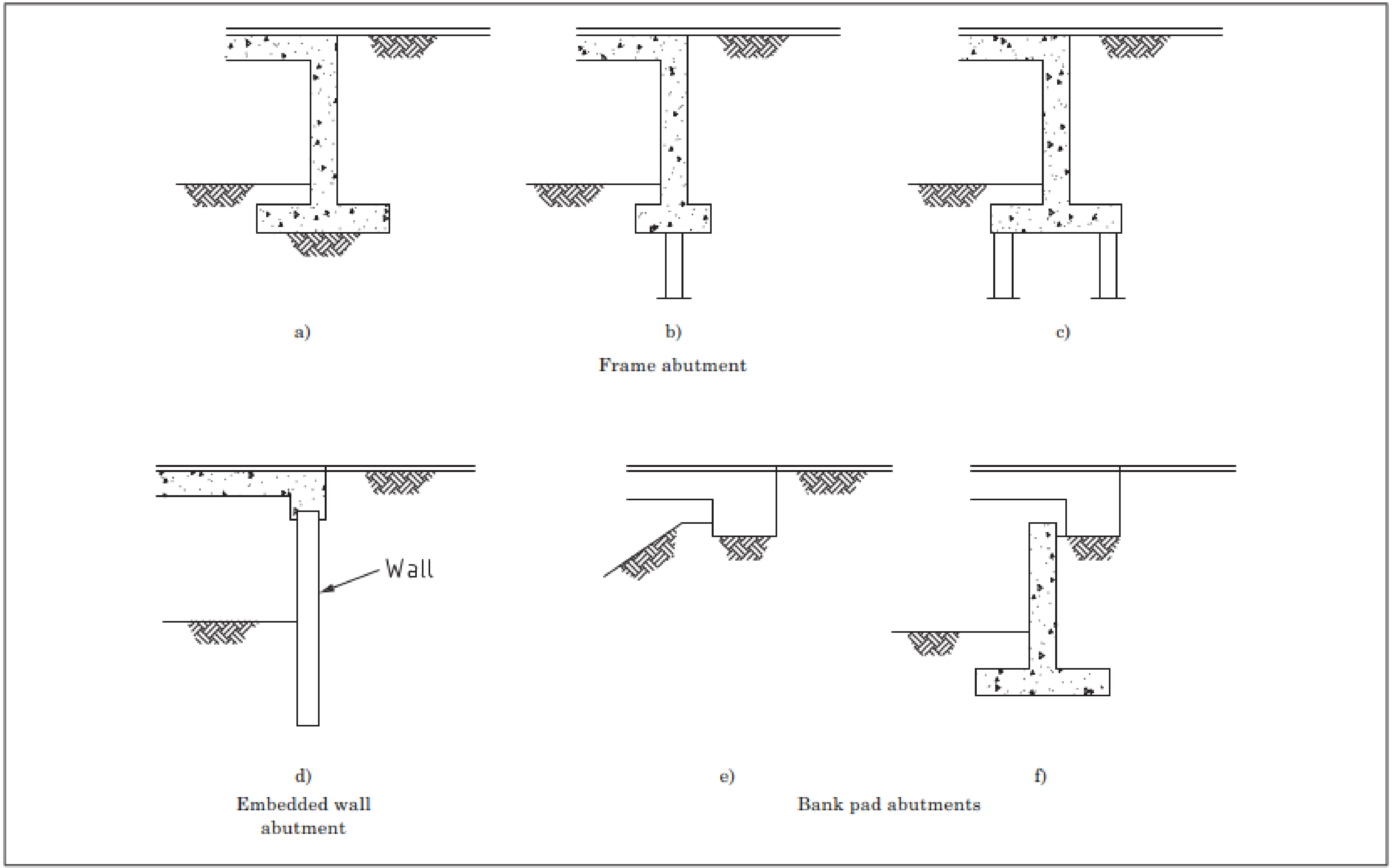
- BD57/01 also recommends bridges with lengths not exceeding 60m and skews not exceeding 30 degrees shall be designed as integral bridges, with abutments connected directly to the bridge deck without movement joints for expansion or contraction of the deck.

De-icing salts and its effects

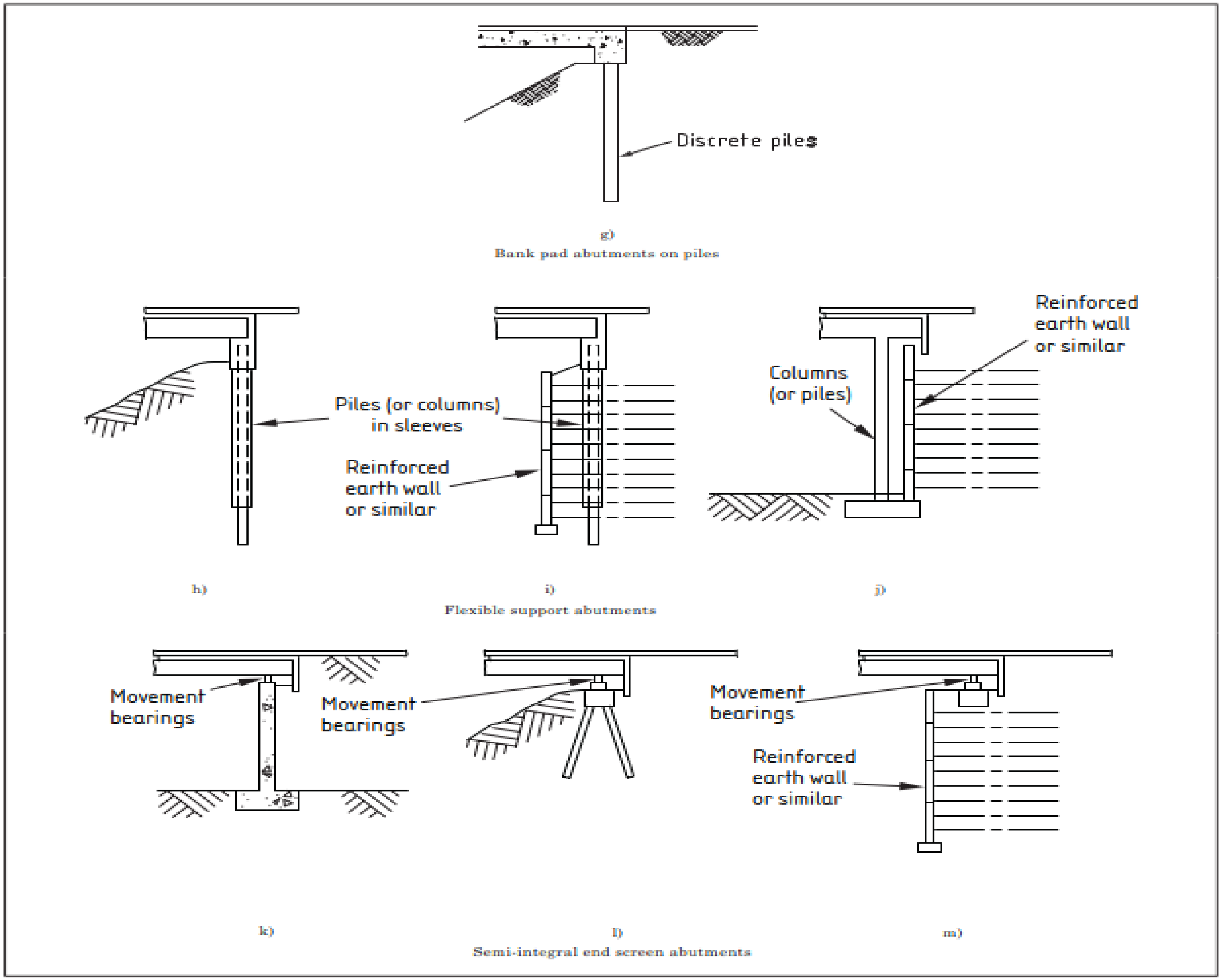
Source: Google Images

Overpass collapse in Montreal, Canada

2.3 Types of Integral bridge construction



Types of Integral bridge construction



2.4 Earth Pressure distribution and live load surcharge models

Topics

A. **Strain ratcheting (K* and Soil springs)**

B. **Earth pressure distribution for a conventional abutment wall**

C. **Earth pressure distribution for integral abutment walls**

- **Option 1 - Full height frame abutment wall**
- **Option 2 – Flexible support abutments (End screen wall)**

D. **Earth pressure distribution for wing walls**

E. **Live load surcharge model for abutment walls**

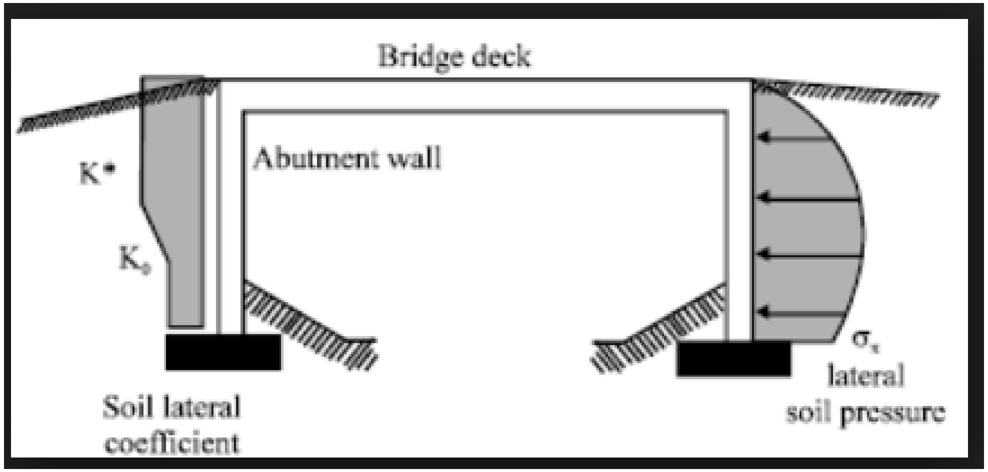
F. **Live load surcharge comparison between BS5400 and PD6694**

G. **Live load surcharge model for wing walls**

Eurocode 7 doesn't explicitly mention about earth pressure distribution and live load surcharge model for integral structures and hence reference is made to PD 6694:1-2011.

Strain Ratcheting – Soil Structure Interaction at abutments

- Integral bridges are subjected to many thermal cycles, repeated backward and forward movement of the abutment due to thermal expansion and contraction.
- Generates pressure when the bridge is expanding which are significantly higher than those that would occur with a single thermal cycle, for e.g. simply supported decks.
- After many cycles, this pressure tends to a maximum value with a pressure coefficient of K*.
- K* is dependent on the total movement of the end of the deck from its maximum contraction position to its maximum expansion position.



A1) Soil Springs

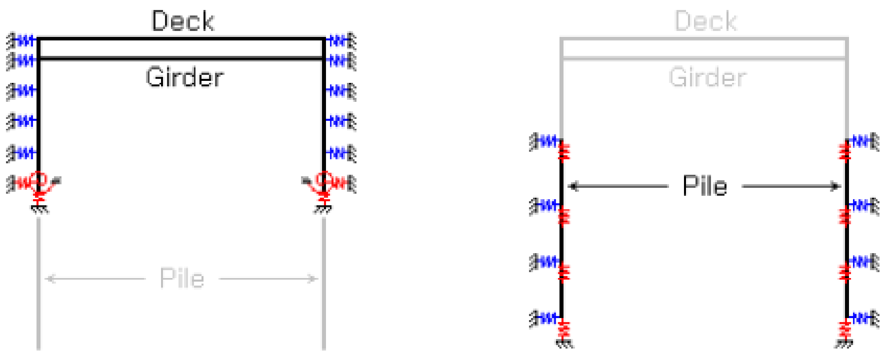
- An alternative to applying the earth pressure loads is to assign appropriate spring supports to the abutment and/or piles to represent the soil properties.

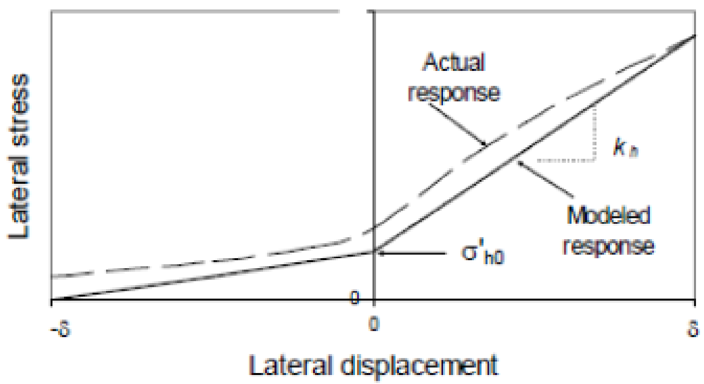
- A number of studies have looked into ways to calculate equivalent spring stiffness based on soil parameters.

- A method for calculation of the spring stiffness for abutments and piles published by Barry Lehane (1999, 2000, 2006) has gained significant popularity due to satisfactory performance in the prediction of the soil-structure interaction.

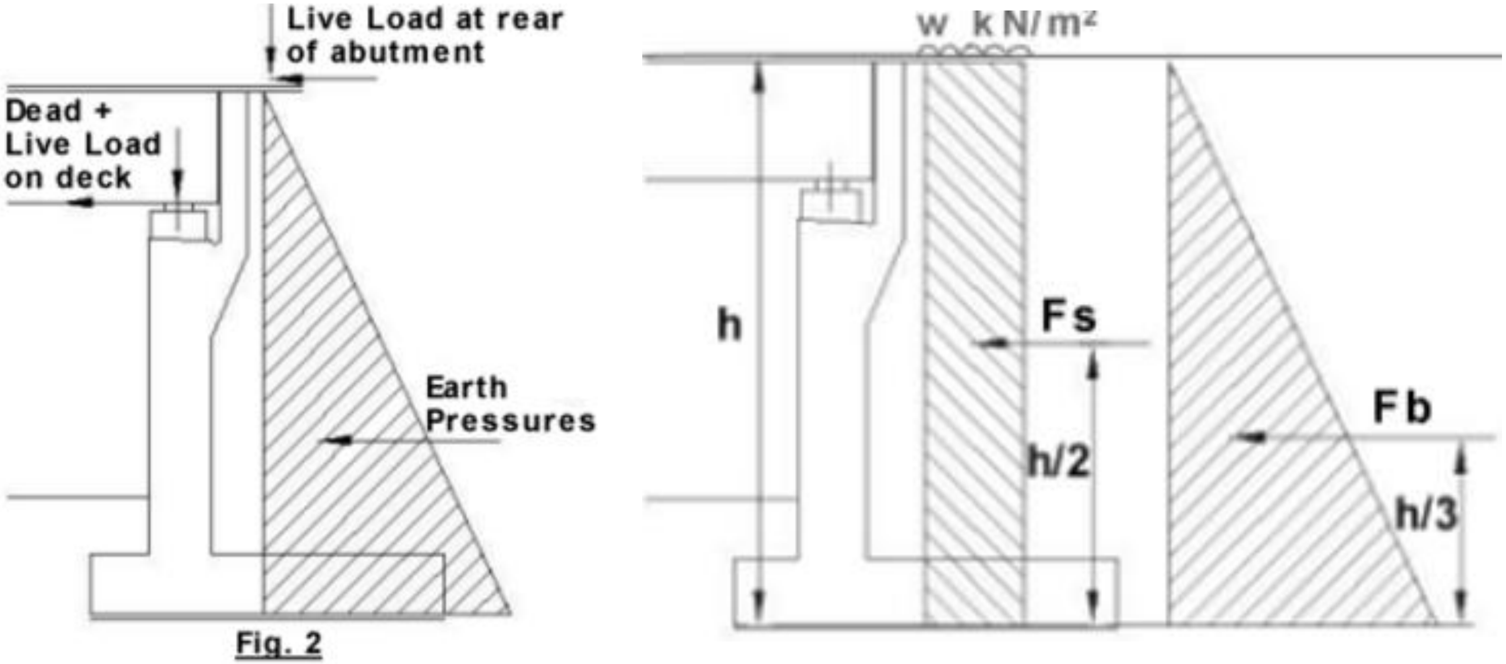
- The procedure considers the nonlinear behaviour of soils and accounts for long term ratcheting effects.

- In MIDAS Civil this method has been adopted for automated definition of soil springs for abutments and piles.



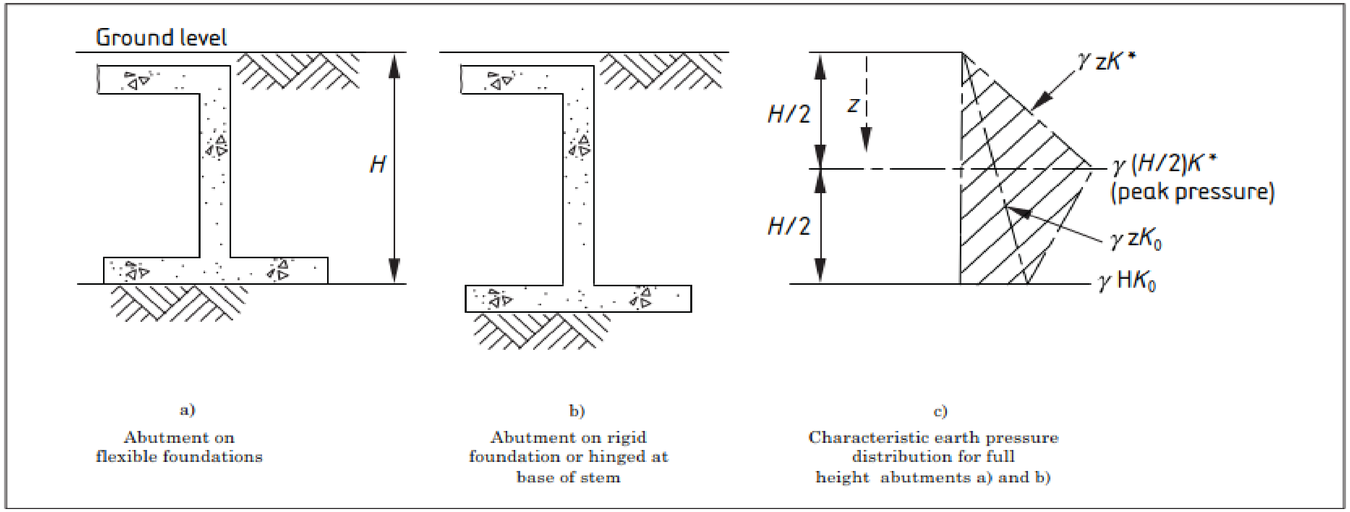


B) Earth pressure distribution for a conventional abutment wall



Active Earth Pressure and Live load Surcharge diagram for deck jointed abutment wall

C) Option 1- Earth pressure distribution for integral frame abutment wall



Reference:- Figure 5:- PD 6694-1:2011

Earth Pressure distributions for abutments which accommodate thermal expansion by rotation/or flexure

EP coefficient → $K_d^* = K_o + \left(\frac{Cd'_d}{H}\right)^{0,6} K_{p;t}$ Cl9.4.3 PD6694-1:2011

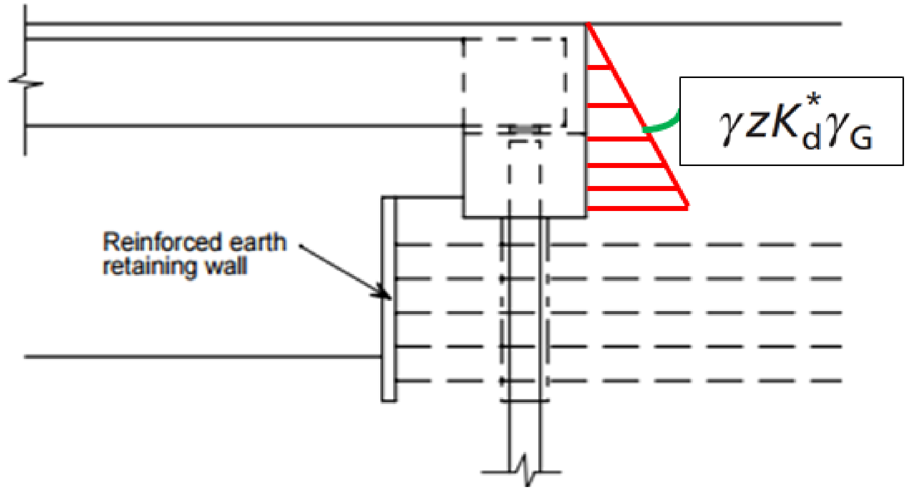
EP application

The pressure distribution on the retained face can be simulated as shown in Figure 5c); namely:

a) a triangular pressure diagram from ground level to *H*/2 based on the pressure coefficient K_d^*;

b) a trapezoidal pressure diagram between *H*/2 to *H* with the pressure coefficient reducing linearly from K_d^* at mid-height to K_o at depth *H*.

C) Option 2 - Earth Pressure distribution for flexible support abutment



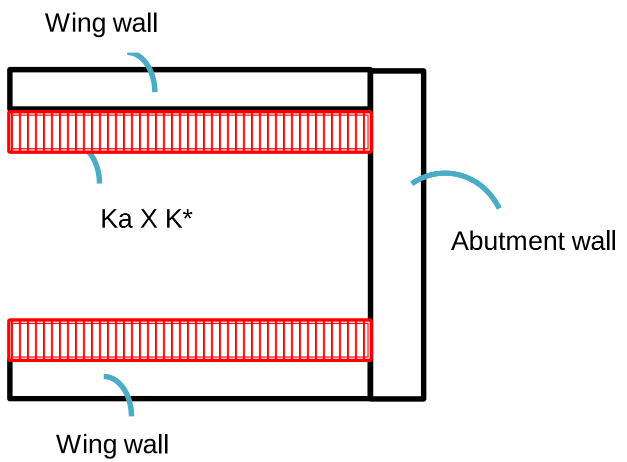
Earth Pressure distribution for End Screen abutment wall

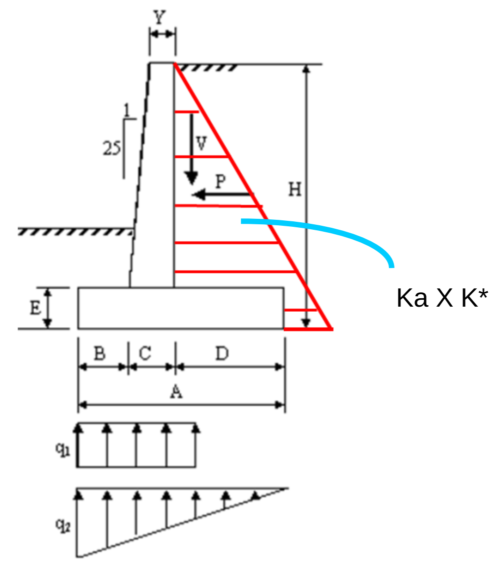
Flexible support abutments

EP coefficient → $K_d^* = K_o + \left(\frac{40 d_d'}{H}\right)^{0,4} K_{p;t}$ Cl9.4.4 PD6694-1:2011

EP application For this type of abutment, the pressure diagram may be assumed to be triangular with the design pressure at depth z equal to $\gamma z K_d^* \gamma_G$.

D) Earth pressure distribution for integral bridge wing walls





Earth Pressure distribution for integral bridge wing walls

EP coefficient

⟶ Wing walls which provide lateral restraint to backfill that is subject to strain ratcheting are themselves subjected to enhanced earth pressures.

⟶ These enhanced earth pressures need to be taken in to the design.

⟶ Pressure coefficient of Ka multiplied by K*, but not less than Ko.

E) Live load surcharge model for abutments

Table 7 **Horizontal surcharge model for highway traffic loading**

	Loading from normal traffic		**SV/100 and SV/196** [A]		**SOV model vehicles**	
	Horizontal line load F at top of structure [B]	Horizontal uniformly distributed load (UDL) σ_h	Horizontal line load F at top of structure [B]	Horizontal UDL σ_h	Horizontal line load F at top of structure [B]	Horizontal UDL σ_h
Case A: Characteristic horizontal surcharge for each effective lane of traffic [C), D]	Two 1 m wide line loads each $330K_dL_f$ (kN)	3 m wide UDL of $20K_dRL_f$ (kN/m^2)	Two 1 m wide line loads each $330K_d$ (kN)	3 m wide UDL of $30K_d$ (kN/m^2)	Two 1 m wide line loads each $330K_d$ (kN)	3 m wide UDL of $45K_d$ (kN/m^2)
Case B: Characteristic horizontal surcharge for a metre width design [E]	$330K_dD_f$ (kN/m) width	$20K_dR$ (kN/m^2)	$330K_d\ D_f$ (kN/m) width	$30K_d$ (kN/m^2)	$330K_dD_f$ (kN/m) width	$45K_d$ (kN/m^2)
Case C: Characteristic horizontal surcharge for segmental structures [F]	$330K_d$ (kN/m) width	$20K_d$R (kN/m^2)	$330K_d$ (kN/m) width	$30K_d$ (kN/m^2)	$330K_d$ (kN/m) width	$45K_d$ (kN/m^2)

where:

K_d is the design value of K_a or K_o (as appropriate) based on Φ'_d;

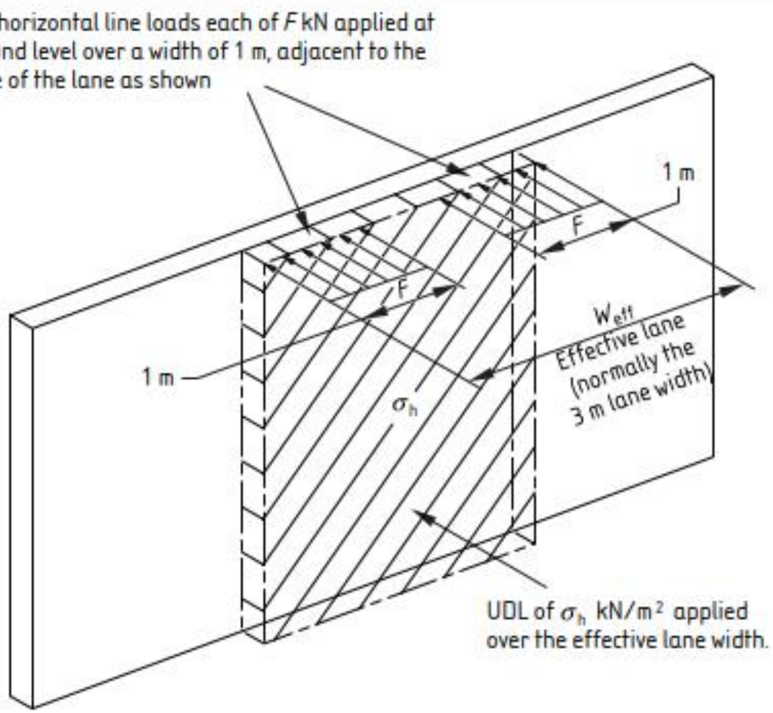
R is $3{,}0/W_{eff}$;

L_f is the lane factor specified in the UK National Annex to BS EN 1991-2:2003, **NA.2.34.2**; and

D_f is the dispersion factor applied to the effect of the horizontal line load in a metre-strip design [E].

E) Application of Live load surcharge model

Figure 2 **Horizontal surcharge model**



*NOTE 1 The figure shows the surcharge model for one lane of effective width W_{eff}. The models for adjacent lanes are similar. For most situations, W_{eff} will be equal to 3,0 m. However, for carriageways between 5,4 m and 6,0 m in width subject solely to normal traffic (see National Annex to BS EN 1991-2:2003, **NA.2.34.3**), the effective lane width, W_{eff}, will be equal to the notional lane width, see BS EN 1991-2:2003, **4.2.3**.*

*NOTE 2 For carriageways subject to SV or SOV (LM3) loading (see National Annex to BS EN 1991-2:2003, **NA.2.16**) which encroaches on the adjacent notional lane, the effective width of that lane available for carrying normal traffic should be taken as the distance from the edge of the LM3 vehicle to the far edge of the notional lane (see UK National Annex to BS EN 1991-2:2003, **NA.2.16.4**), except that if that width is less than 2,5 m, no normal traffic need be applied adjacent to the LM3 vehicle in that lane.*

NOTE 3 The effective width of a lane carrying LM3 loading used in applying the surcharge model is always 3,0 m.

F) Comparison of surcharge between PD6694 and BS 5400

BS 5400-2:2006 → Cl.5.8.2.1says “In absence of more exact calculations the nominal load due to live load surcharge for suitable material properly consolidated may be assumed to be:

a) for HA loading: 10kN/m2

b) for HB Loading:

45 units: 20kN/m2

30 units: 12kN/m2

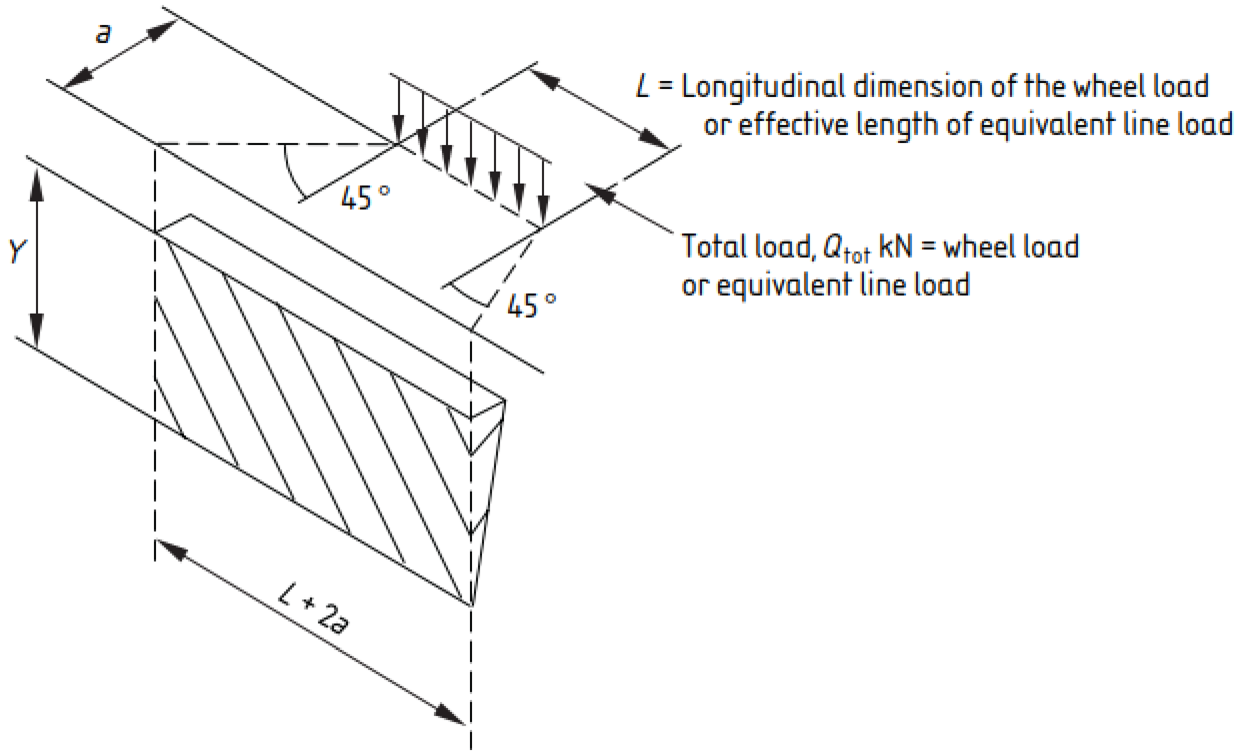
	PD6694		BS 5400
	Line load (kN)	UDL (kN/m^2)	UDL (kN/m^2)
LM1/HA	109	6.6	10
LM3/HB 45 units	109	9.9	20

Comparison of live load surcharge model for abutments between PD6694 and BS 5400

→ assuming K_d as 0.33, R as 1 and L_f as 1

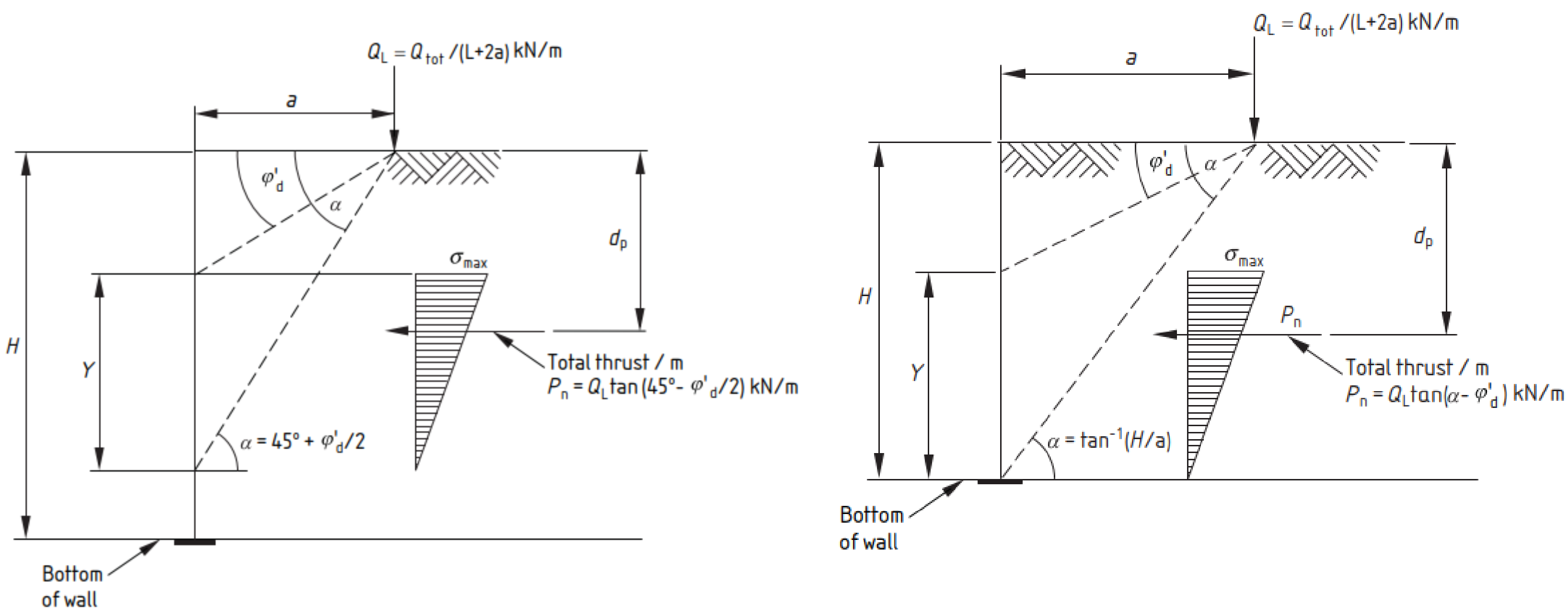
G) Surcharge model for wing walls

Figure 3 **Lateral and vertical dispersion of finite line loads for calculating horizontal surcharge pressure**



a)

G) Surcharge model for wing walls



PD 6694:1:2011, Figure 3 Lateral and Vertical dispersion of finite line loads for calculating horizontal surcharge pressure

Section 3 – Forder Valley Viaduct Bridge A Case Study

i) Case Study Brief

- Forder Valley viaduct bridge
- Project location
- Viaduct options

  a)Choice of structure type and backfill materials

  b)Choice of abutment for integral construction
- Structure details
- 3D visuals

Forder Valley Viaduct bridge

- Design and Build Contract – AECOM detailed design consultants

  Client - Balfour Beatty

- Forder Valley Link Road (FVLR) is a proposed one-kilometre road linking William Prance Road in Derriford to the junction of Forder Valley Road and Novorossiysk Road.

- The new link will reduce delays between the A38 and Derriford by providing an additional route from the east of the city to the north, avoiding the often heavily congested A38 at the Manadon junction and the A386 Tavistock Road.

- It will also improve accessibility for vehicles, buses, cyclists and pedestrians to key destinations such as Derriford Hospital, the University of St. Mark and St. John and the Plymouth Science Park.

- It is estimated that the total project will cost about £38.0m out of which the viaduct is to be constructed at a cost of £8.0m.

Project location – Forder valley road, Plymouth

Source: Google Maps

VIADUCT OPTIONS

a) **Choice of structure type and backfill materials**

b) **Choice of abutment for integral construction**

a) Choice of structure type and backfill material

Integral structure or semi integral → *Integral* – Large thermal movements***(30mm on each end)***, design complexities, not a traditional structure but durable.

→ *Semi-Integral* – Less design complexities at abutments, but maintenance liability (replace bearings and risk of corrosion through deicing salts).

4 Span or 5 Span Analysis carried out for 4 and 5 spans. 4 spans found to be beneficial.

Backfill material → 6N/6P Backfill – traditional backfill material – High density, large earth pressures on the abutment wall.

→ Lightweight Backfill – Low density material hence less earth pressure on the abutment wall. Not very common in practice, need to obtain approval from overseeing organisation for its usage.

→ Geofoam/Expanded Polystyrene blocks (EPS)– minimum or no pressure on abutment walls, very expensive, no maintenance liability, durable and environment friendly. Need to obtain approval from overseeing organisation.

Pile foundation or pad foundation → Pile foundation – Flexible system, accommodate thermal movements and huge horizontal loads, but time consuming, expensive, h&s risks

Pad foundation – Rigid system, generate huge forces on substructure and foundation, need wider base to accommodate large horizontal forces.

EPS/Geofoam backfill to abutments

→*Geofoam and Lightweight backfill material were not used in Forder valley viaduct*

b) Choice of abutment wall

Detailed analysis Option 1

→*Full height abutment wall (Frame abutment) with 6N Backfill*

a) 4 rows X 9 nos. of 1200 dia. Pile for both abutments

b) Pier 3 anticipated to be piled

c) Pier 1&2 pad foundation

Detailed analysis Option 2

→*Sleeved column for abutments (Flexible system)*

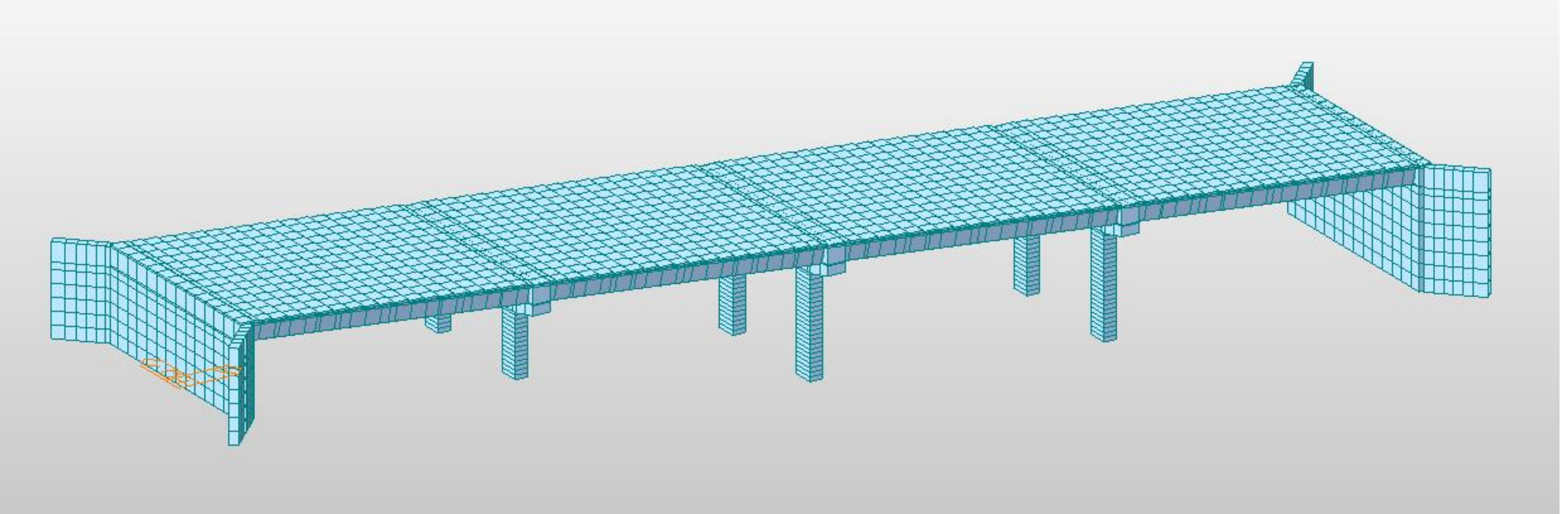
a) No earth pressures on abutment columns as they are sleeved with manhole rings

b) 3 rows X 9 nos. of 900 dia. Pile for both abutments

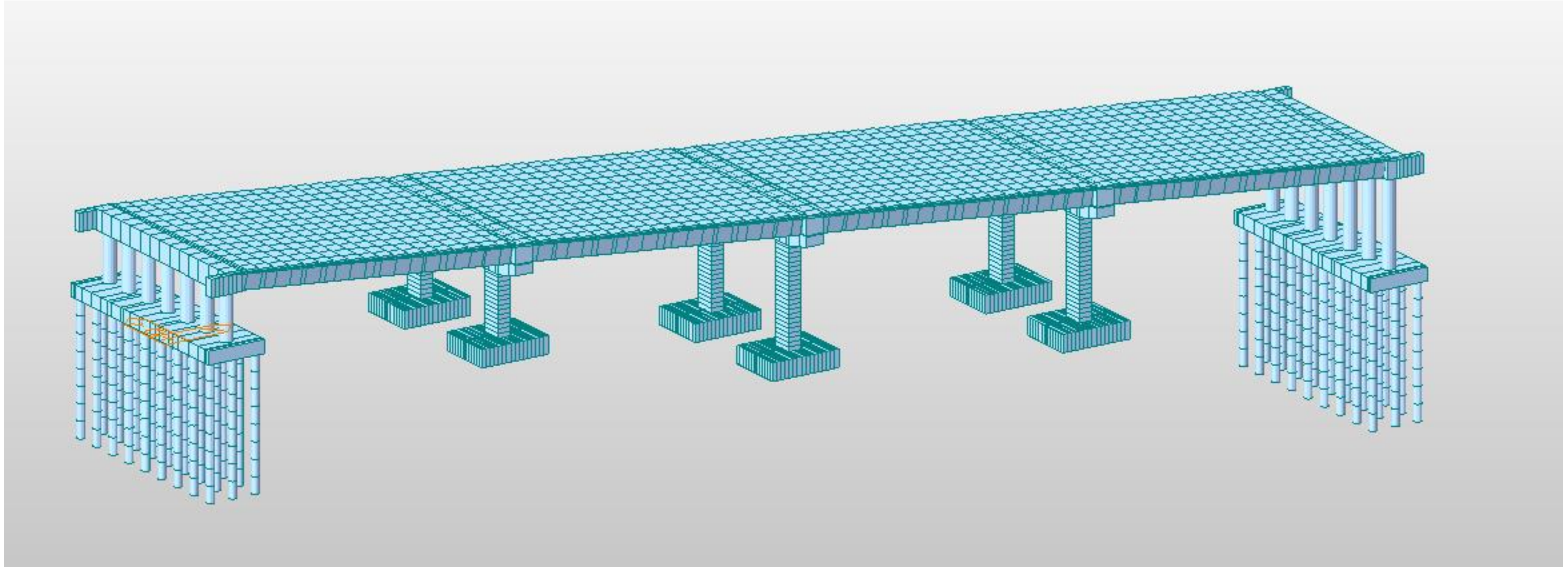
c) All piers to be founded on pad foundation

Design was finalised with Option 2 as it was structurally sound and cost effective solution.

Isometric View of detailed options



Option 1 – Full height abutment frame model

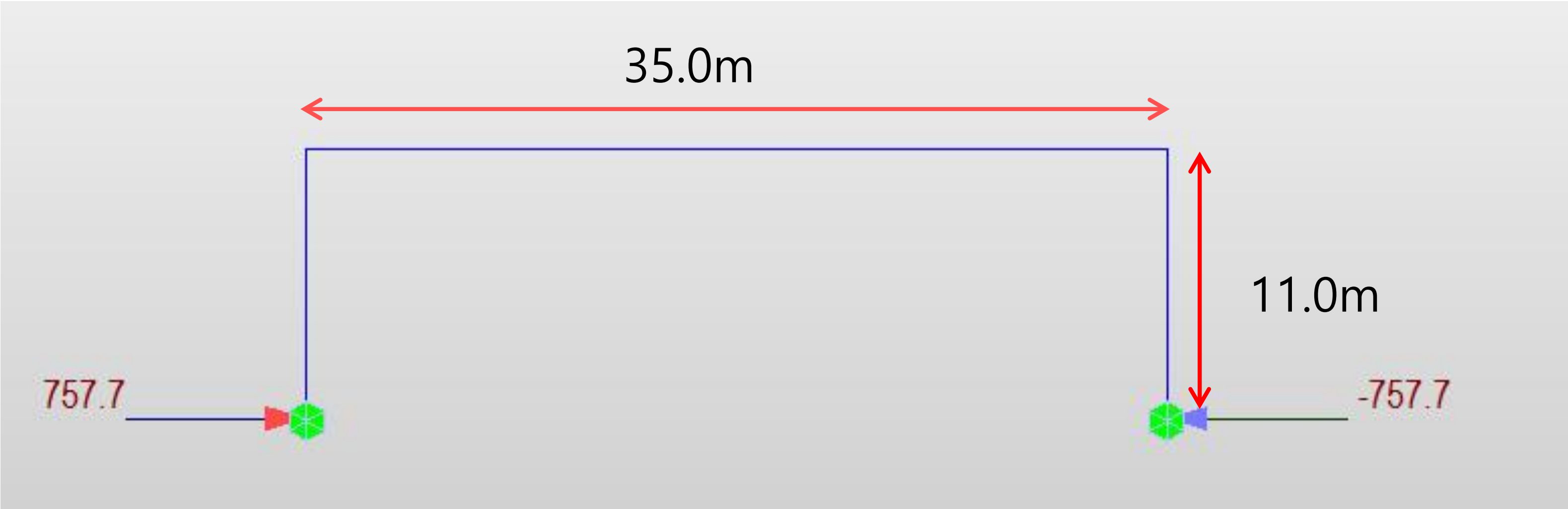


Option 2 –Flexible support structure with end screen abutment walls

MIDAS Analysis for flexible/stiff structural system – An example

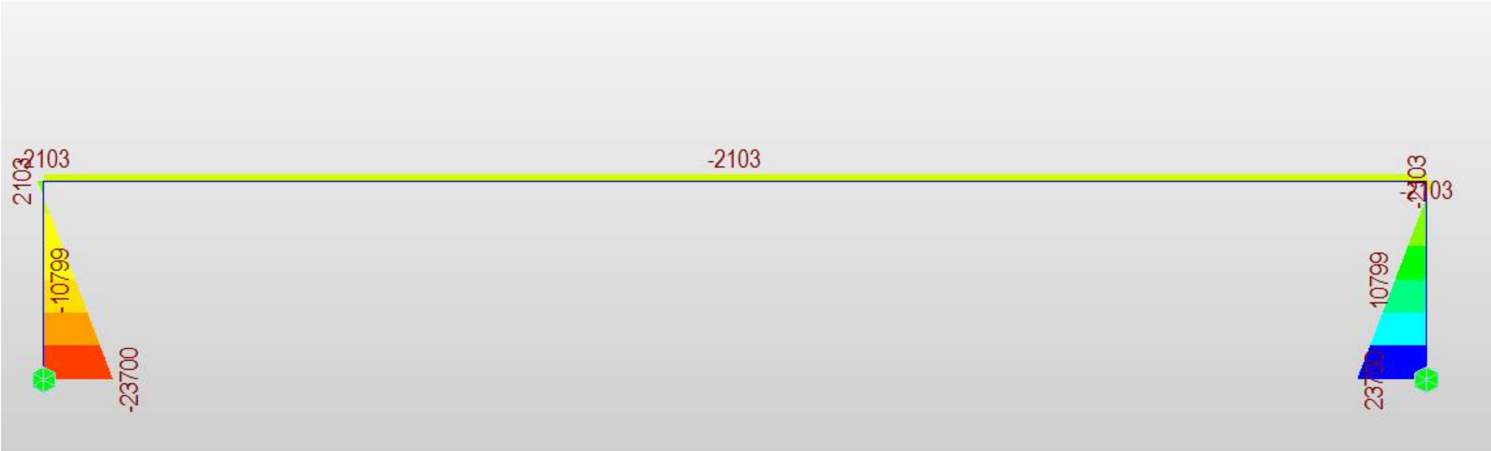
Reaction output for a stiff structural system

EI/L^3



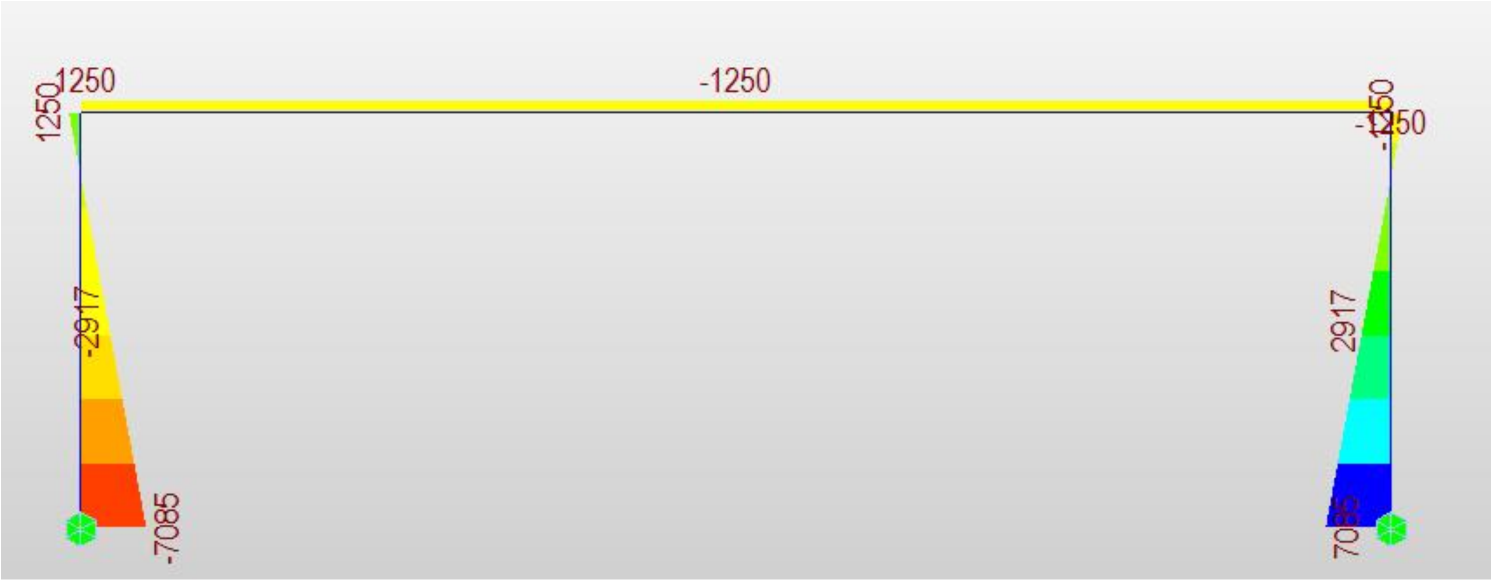
Reaction output for a flexible structural system usually in the form of piles

MIDAS Analysis for flexible/stiff structural system – An example



Bending moment output for a stiff structural system

EI/L^3



Bending moment output for a flexible structural system

Structure details - finalised Option 2

Integral bridge structure

→ 4 span (each 35.0m)

→ Total length 140.0m

→ 25.0m wide deck

→ 3 lanes + Cycleway + Shared footway/cycleway

→ 7 numbers W16 prestressed concrete beams

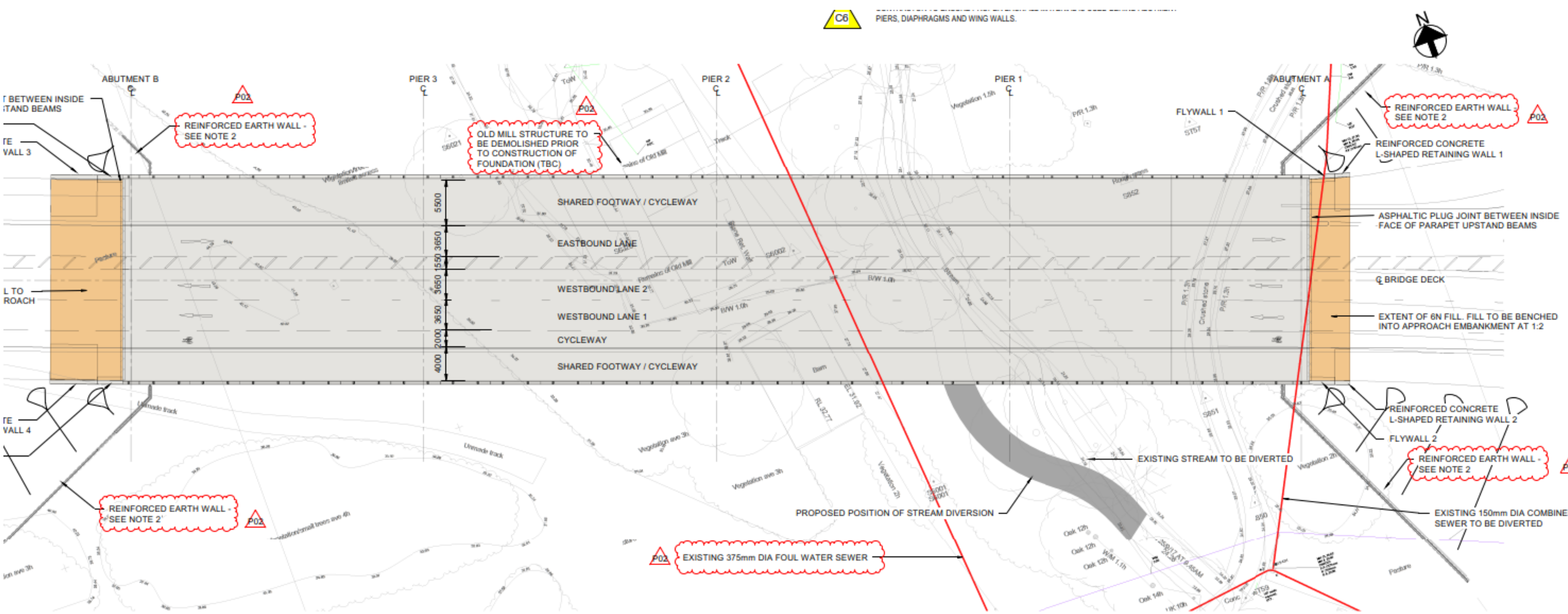
→ 7 numbers abutment circular columns

→ Twin square columns for intermediate supports

→ Piled foundation for abutment columns

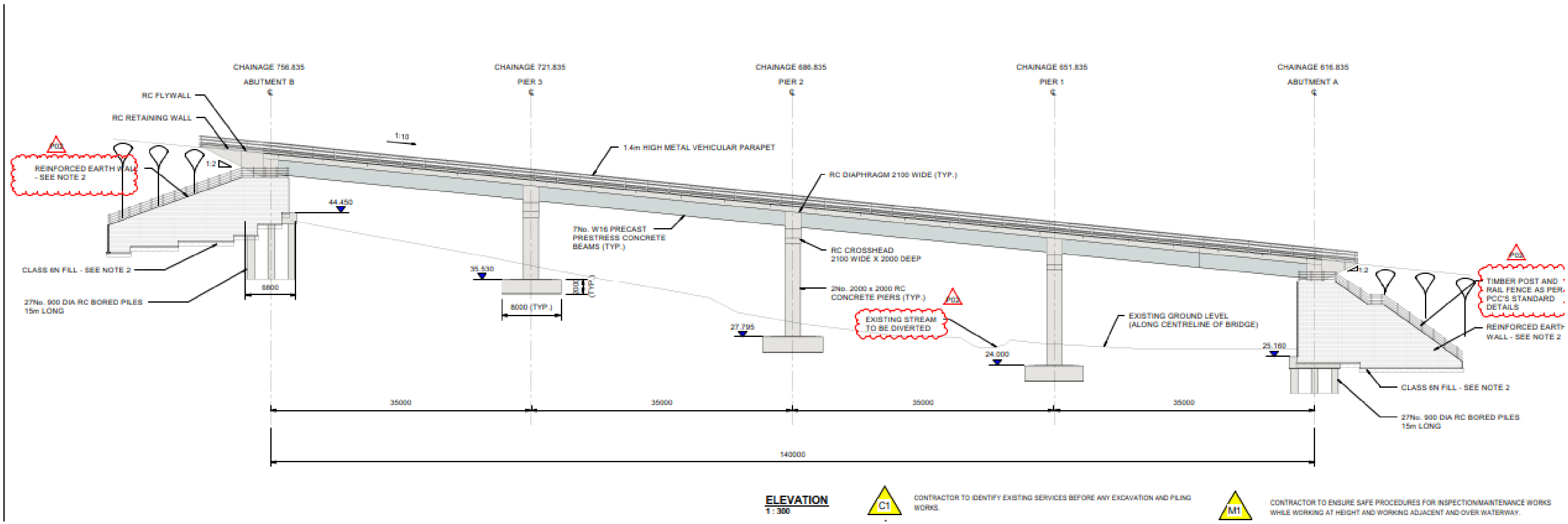
→ Pad foundation for abutment piers

Bridge plan view

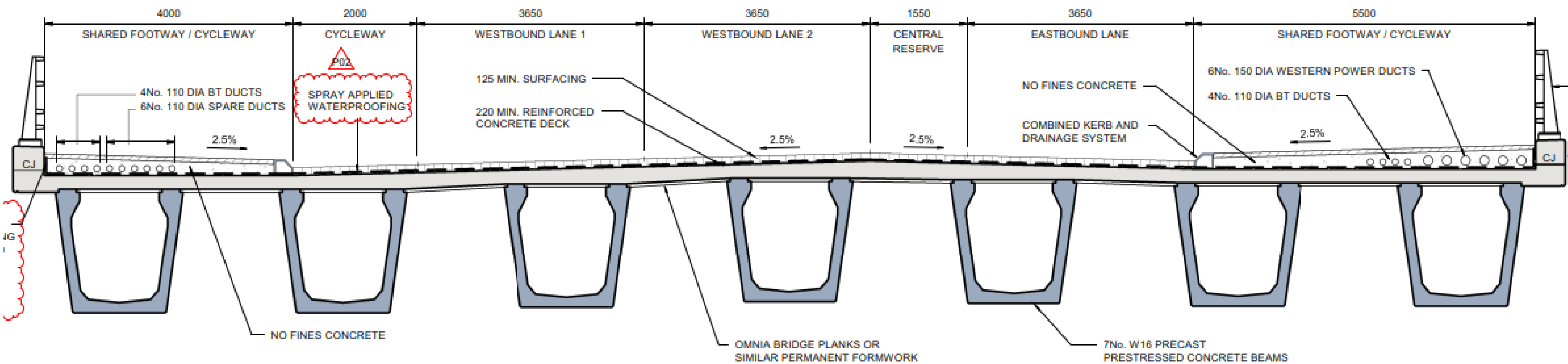


PLAN AT DECK LEVEL
1 : 300

Bridge elevation view

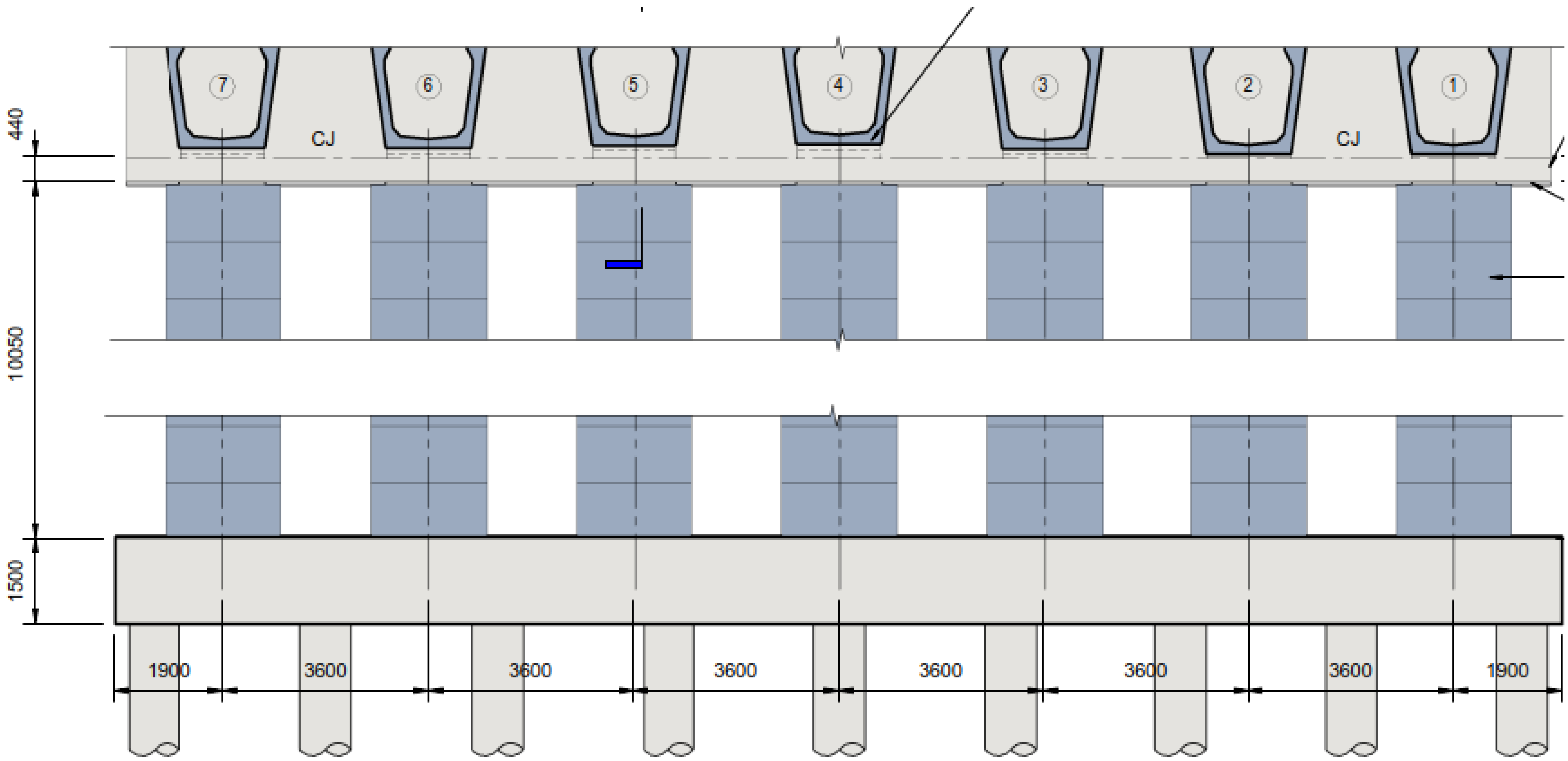


Bridge Cross section view

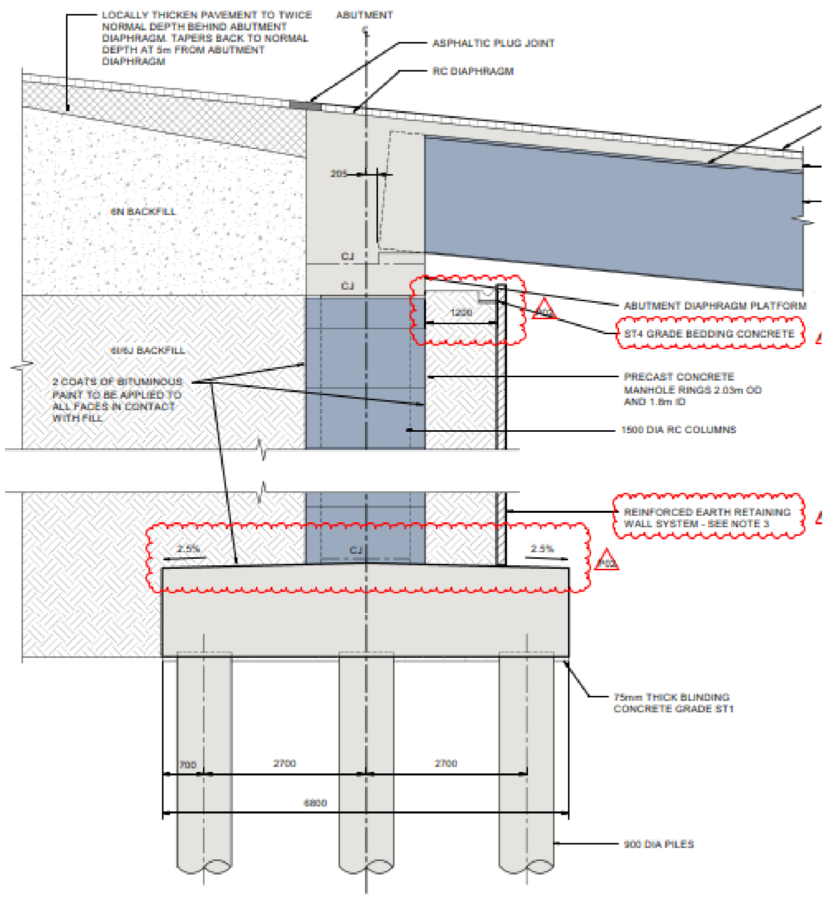


TYPICAL DECK SECTION
1 : 50

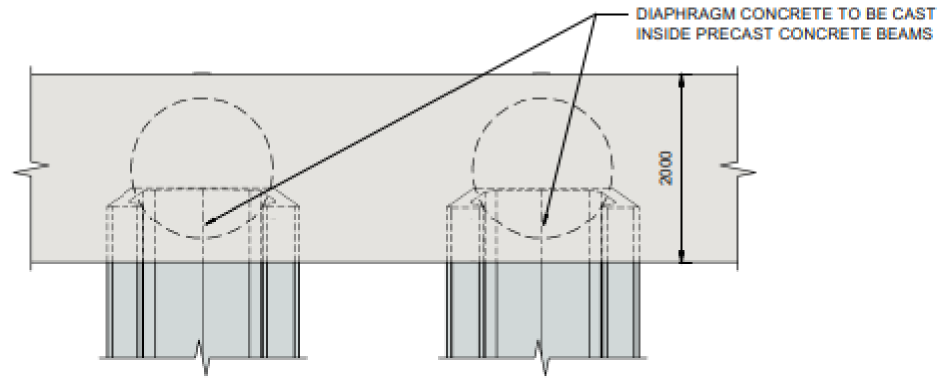
Abutment elevation view



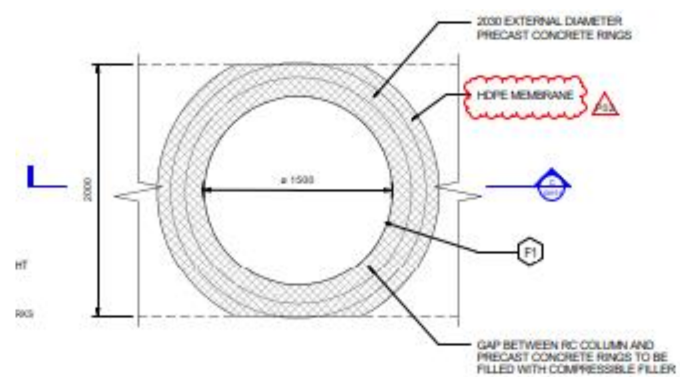
Abutment longitudinal section & Plan view



TYPICAL ABUTMENT SECTION
1 : 50

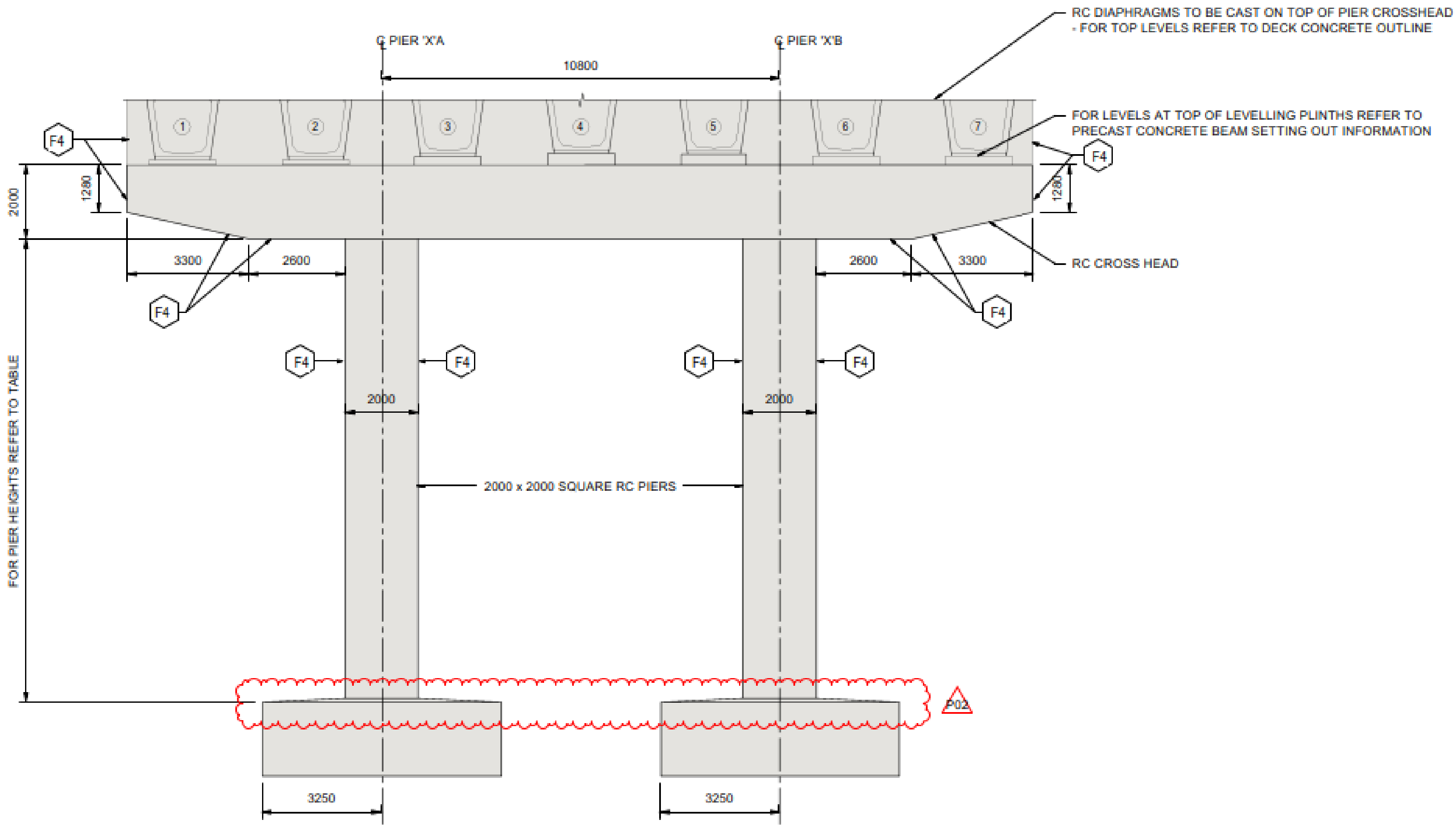


ABUTMENT DIAPHRAGM PLAN DETAIL
1 : 50



TYPICAL ABUTMENT PIER SECTION
1 : 25

Pier section



3D Visuals

3D Visuals

3D Visuals

3 (ii) Shrinkage and Creep

- A brief introduction
- Shrinkage and Creep definition in MIDAS Civil
- Compressive strength definition in MIDAS Civil
- Time dependent material link

Shrinkage & Creep– A brief

- *Shrinkage and Creep are time –dependent properties of concrete*
- *Creep and Shrinkage of the concrete depend on the ambient humidity, the dimensions of the element and the composition of concrete.*
- *Creep is also influenced by the maturity of the concrete when the load is first applied and depends on the duration and magnitude of the loading.*
- *These effects are generally considered in to account for the verification of serviceability limit states*
- *The effects of shrinkage and creep should be considered at ultimate limit states only where their effects are significant, for example in the verification of ultimate limit states of stability where second order effects are of importance.*
- *In building structures, temperature and shrinkage effects may be omitted in global analysis provided joints are incorporated at every 30.0m to accommodate resulting deformations.*

Creep Coefficient and Shrinkage Strain for construction stage analysis

Creep Coefficient

→Cl. 3.1.4 BS EN 1992-1-1 explains about Creep Coefficient and Shrinkage strain

a) *Annex B gives basic equations to determine creep coefficient at t_o days*

B.1 Basic equations for determining the creep coefficient

(1) The creep coefficient $\varphi(t,t_0)$ may be calculated from:

$$\varphi(t,t_0) = \varphi_0 \cdot \beta_c(t,t_0)$$

Shrinkage Strain

→ Cl 3.1.4 (6) BS EN 1992-1-1

→ The total shrinkage strain is composed of two components, autogenous and drying shrinkage strain.

a) Drying shrinkage strain develops slowly – function of the migration of water through hardened concrete

b) Autogenous shrinkage strain develops during hardening of the concreteThe total shrinkage strain is:

$$\varepsilon_{cs} = \varepsilon_{cd} + \varepsilon_{ca}$$

where:

ε_{cs} is the total shrinkage strain

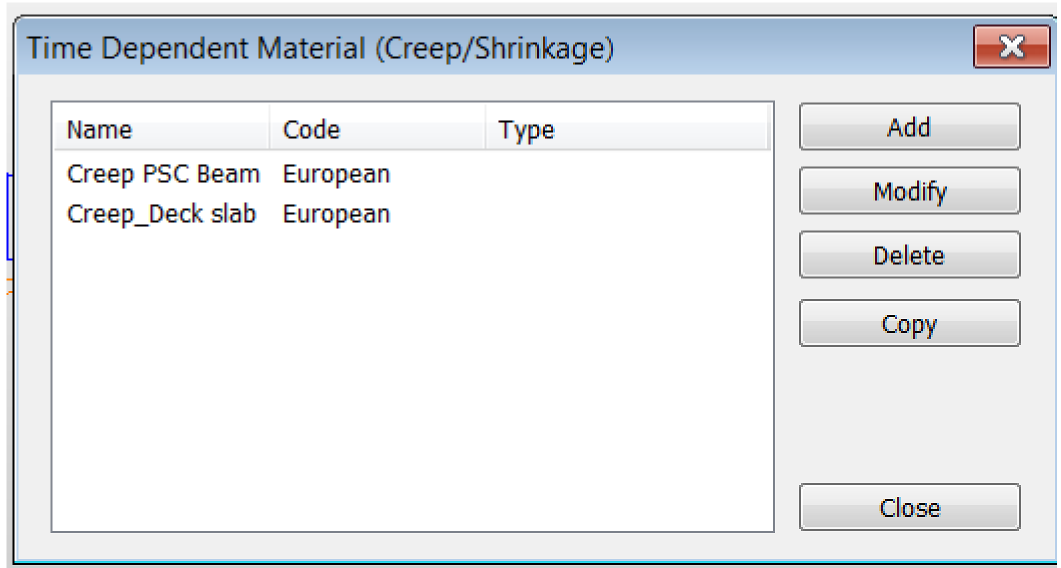
ε_{cd} is the drying shrinkage strain

ε_{ca} is the autogenous shrinkage strain

- Refer equation 3.11 to calculate autogenous shrinkage strain
- Refer Annex B for equations to calculate drying shrinkage strain

MIDAS slide to show Time Dependent material C&S

Creep Coefficient
Shrinkage Strain



Generally **Class R** should be assumed unless the cement contains additions as follows;

35 to 65% ground granulated blastfurnace slag, use **Class N**
exceeds 65% ground granulated blastfurnace slag; use **Class S**

Compressive strength at t days for construction stage analysis

Compressive strength

→*Cl. 3.1.2 (6) BS EN 1992-1-1 gives the basic equation to calculate the compressive strength at t days*

$$f_{cm}(t) = \beta_{cc}(t)\, f_{cm} \tag{3.1}$$

with

$$\beta_{cc}(t) = \exp\left\{ s\left[1 - \left(\frac{28}{t}\right)^{1/2}\right]\right\} \tag{3.2}$$

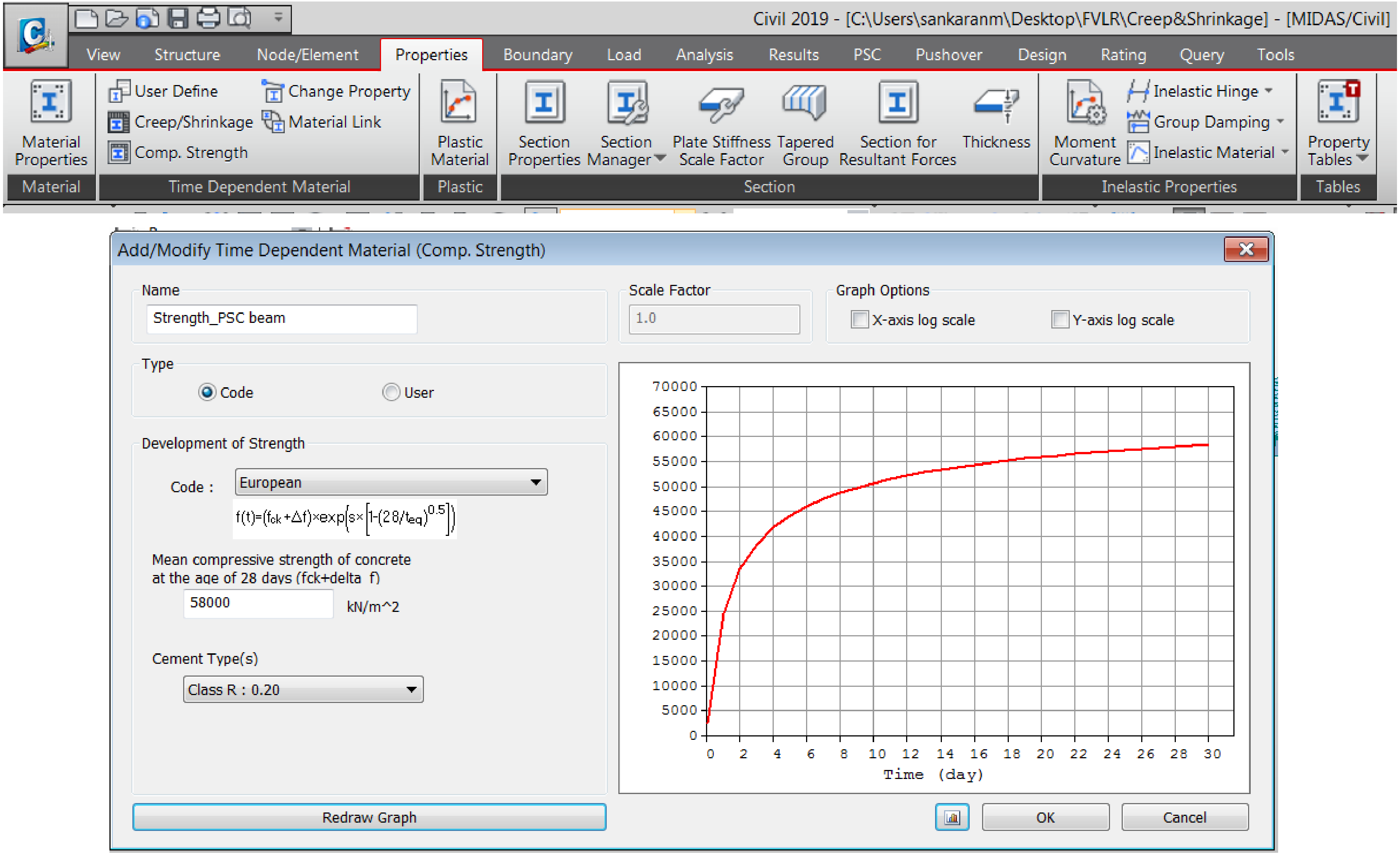
where:

$f_{cm}(t)$ is the mean concrete compressive strength at an age of t days

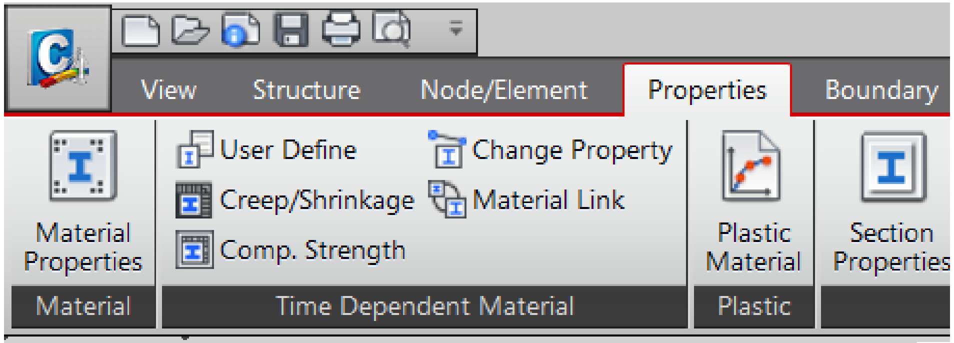
f_{cm} is the mean compressive strength at 28 days according to Table 3.1
$\beta_{cc}(t)$ is a coefficient which depends on the age of the concrete t
t is the age of the concrete in days
s is a coefficient which depends on the type of cement:
= 0,20 for cement of strength Classes CEM 42,5 R, CEM 52,5 N and CEM 52,5 R (Class R)
= 0,25 for cement of strength Classes CEM 32,5 R, CEM 42,5 N (Class N)
= 0,38 for cement of strength Classes CEM 32,5 N (Class S)

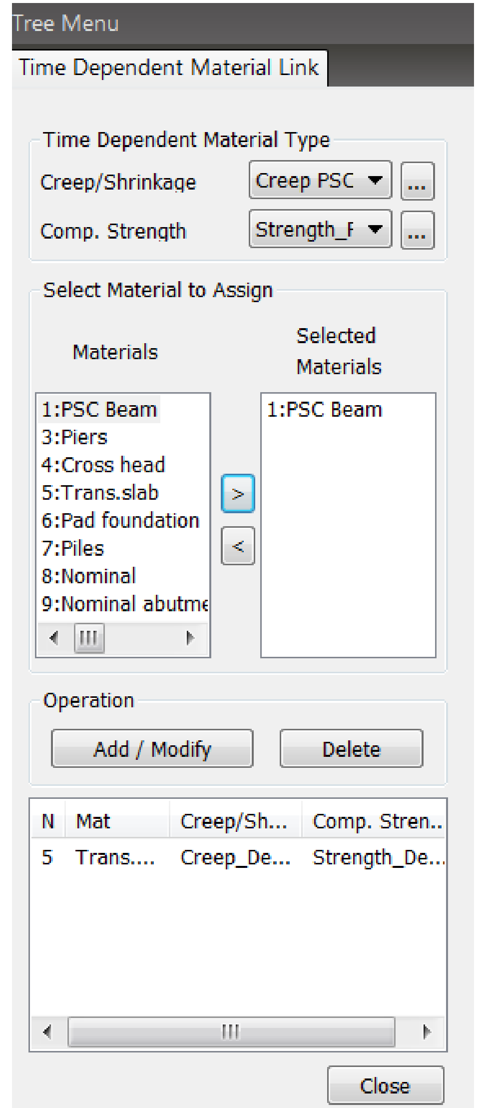
Note: exp{ } has the same meaning as $e^{(\ )}$

MIDAS slide to show Compressive strength C&S



MIDAS slide to show Time Dependent Material Link



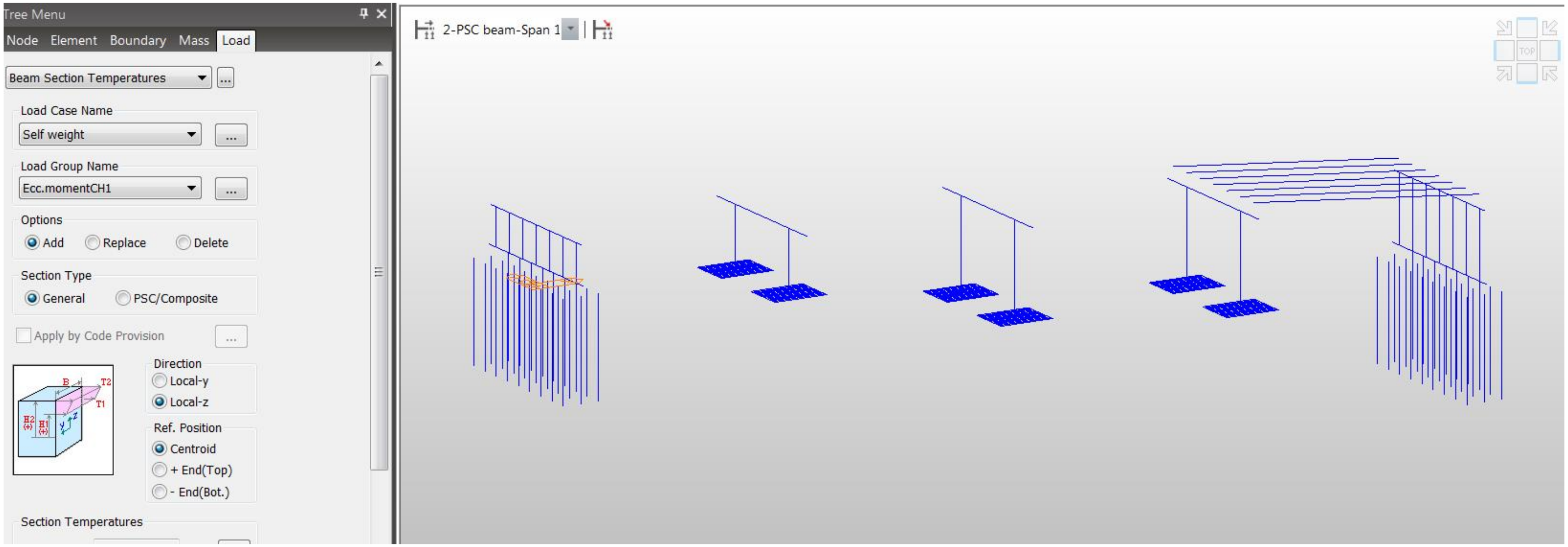


3 (iii) Construction Stage analysis

A glimpse of construction stages of Forder Valley Viaduct

- **Construct foundation and substructure**
- **Erect span 1 beams to span 4 beams progressively**
- **Concrete deck pour except at pier regions and abutment ends (simply supported condition)**
- **Deck pour stitch in concrete to make the structure fully integral**
- **Install surfacing**
- **Service condition – Open to traffic**

Construction stage analysis



3 (iv)Thermal action and its application in MIDAS Civil

- **Representation of actions**
- **Uniform temperature component**
- **Vertical temperature components with non-linear effects**

- *Thermal contraction will lead to minimum earth pressures. It is not necessary to worry about a gap forming behind the abutment; the daily thermal movements will ensure that this does not occur.*

- *Thermal expansion of the deck leads to the maximum earth pressures, which will be a critical design condition for the abutment wall*

Representation of actions

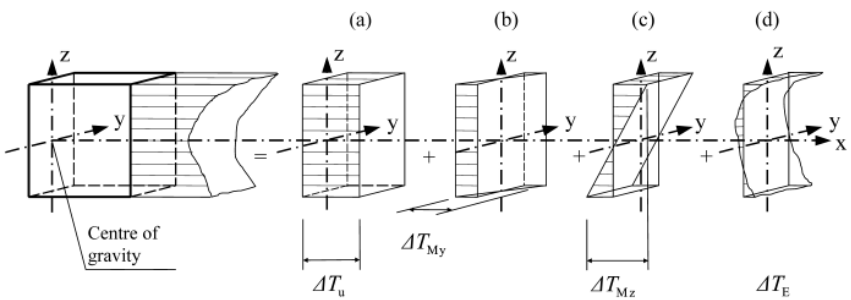
- *Daily and seasonal changes in shade air temperature, solar radiation etc. will result in variations of the temperature distribution within individual elements of the structure.*
- *The magnitude of thermal effects will be dependent on local climatic conditions, together with the orientation of structure, finishes and overall mass.*
- *The temperature distribution within an individual structural element may be split in to the following four essential components, Figure 4.1 BS EN 1995-1-5-Thermal actions*

a) A uniform temperature component, ΔT_u ;

b) A linearly varying temperature difference component about the *z-z* axis, ΔT_{MY} ;

c) A linearly varying temperature difference component about the *y-y* axis, ΔT_{MZ} ;

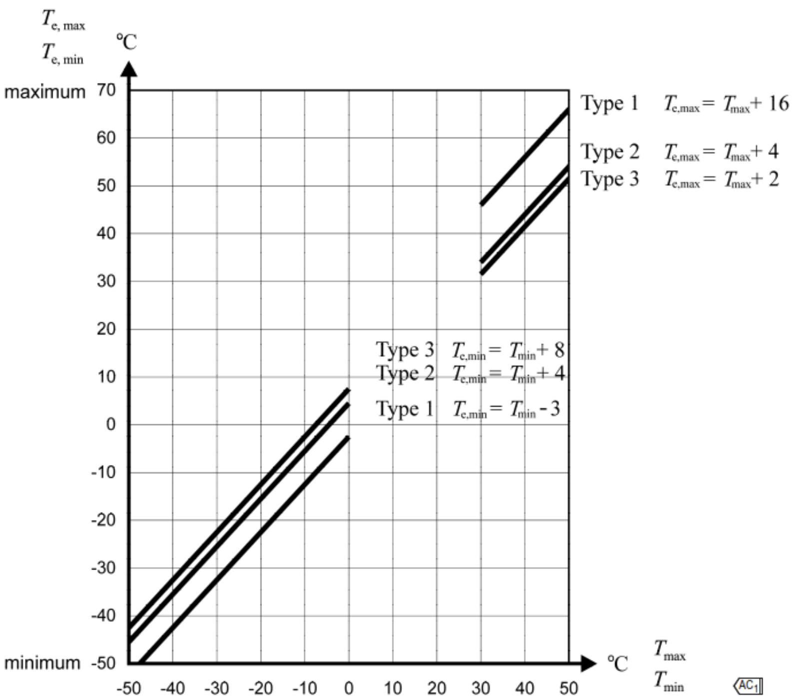
d) A non-linear temperature difference component, ΔT_E. This results in a system of self-equilibrated stresses which produce no net load effect on the element.



- *The strains and therefore any resulting stresses are dependent on the geometry and boundary conditions of the element being considered and on the physical properties of the material used.*

Uniform temperature component-Cl.6.1.3 BS EN 1991-1-5:2003

- *Minimum and Maximum air shade temperatures (Tmin and Tmax) for the site shall be derived from isotherms – Figure NA.1&NA.2 NA to BS EN 1991-1-5:2003*
- *The air shade temperatures shall be adjusted for height above sea level. Refer A.1 (1) Note 2 BS EN 1991-1-5:2003*
- *The minimum and maximum uniform bridge temperature components Temin.and Temax shall be determined using the type of bridge deck*



Type of Deck
Type 1: Steel deck
Type 2: Composite deck
Type 3: Concrete deck: - concrete box girder - concrete beam - concrete slab

Uniform temperature component-Cl.6.1.3 BS EN 1991-1-5:2003

- *NA 2.4 BS EN 1991-1-5:2003 says the values of Temin. and Temax. Shall be adjusted for deck surfacing.*

Table NA.1 **Adjustment to uniform bridge temperature for deck surfacing**

Deck surface	**Addition to minimum uniform bridge temperature component, °C**			**Addition to maximum uniform bridge temperature component, °C**		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
Unsurfaced	0	–3	–1	+4 [C)]	0	0
Water-proofed [A)]	0	–3	–1	+4 [C)]	+4	+2
40 mm surfacing [B)]	0	–2	–1	0	+2	+1
100 mm surfacing [B)]	N/A	0	0	N/A	0	0
200 mm surfacing [B)]	N/A	+3	+1	N/A	–4	–2

A) Waterproofed deck values are conservative, assuming dark material; there may be some alleviation when light coloured waterproofing is used; specialist advice should be sought if required.

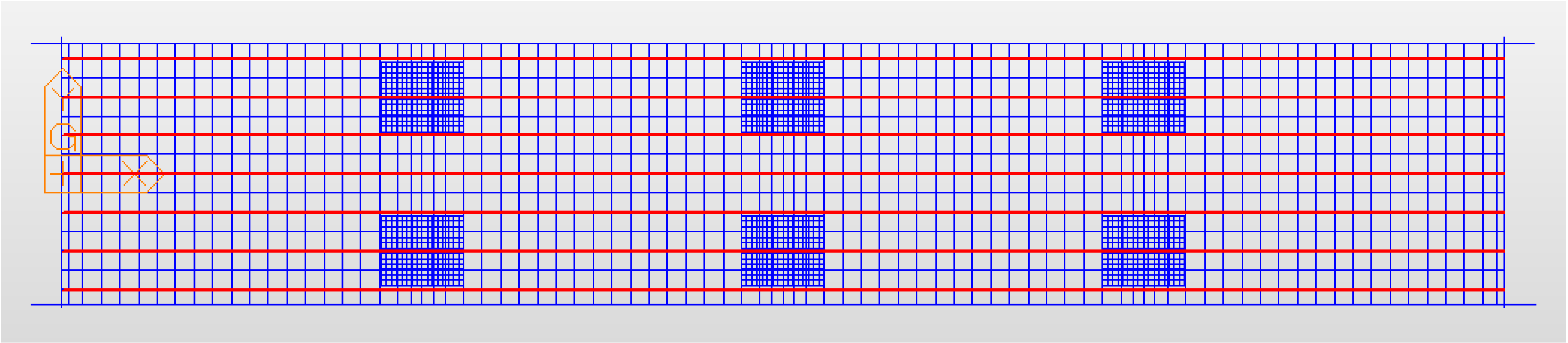
B) Surfacing depths include waterproofing.

C) For steel truss and plate girders the values for unsurfaced and waterproofed deck surfaces may be reduced to +2 °C.

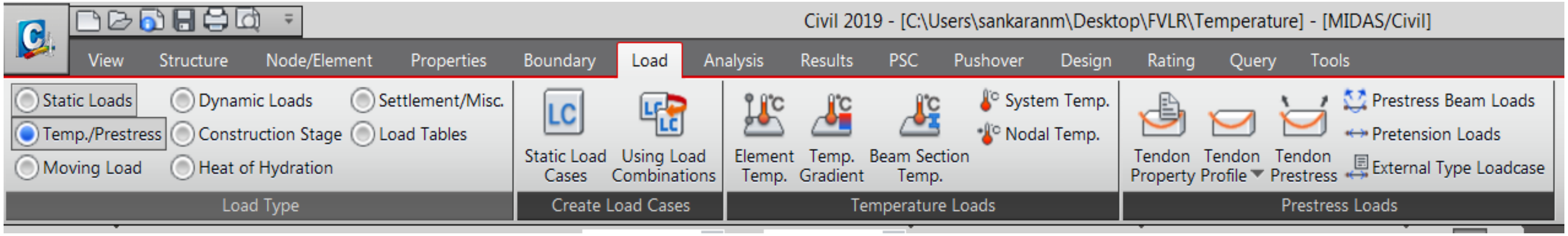
- *The adjusted Temin. And Temax shall be considered as the final uniform temperature components that shall be applied in to the model.*

MIDAS slide to show application of Uniform temperature

- *Step 1*

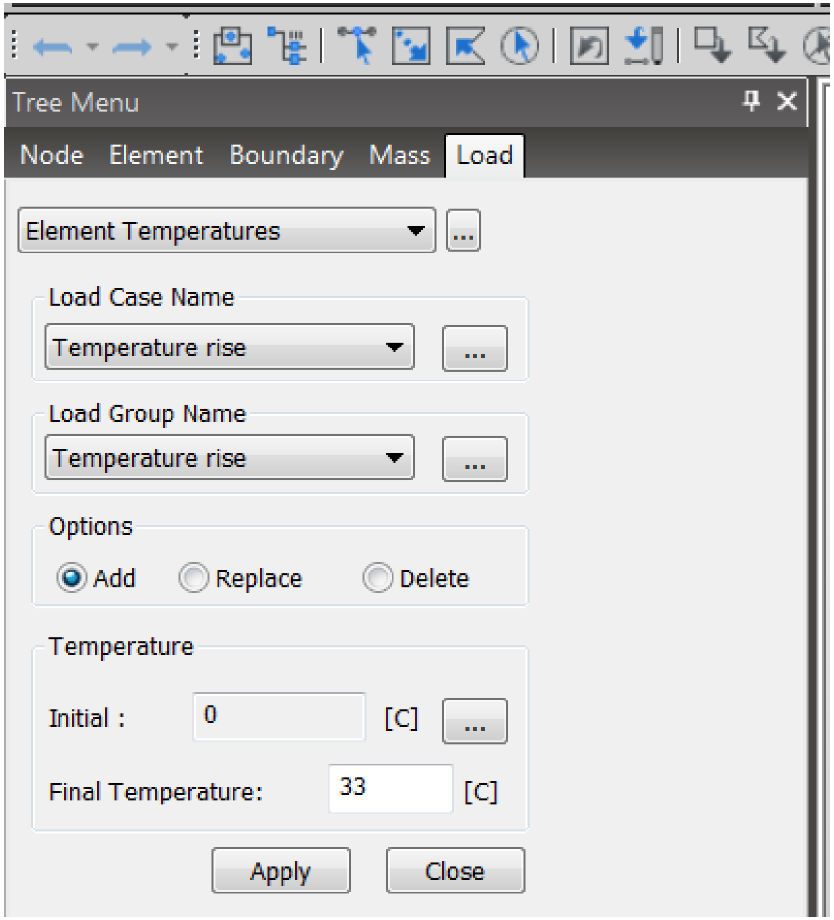


- *Step 2*

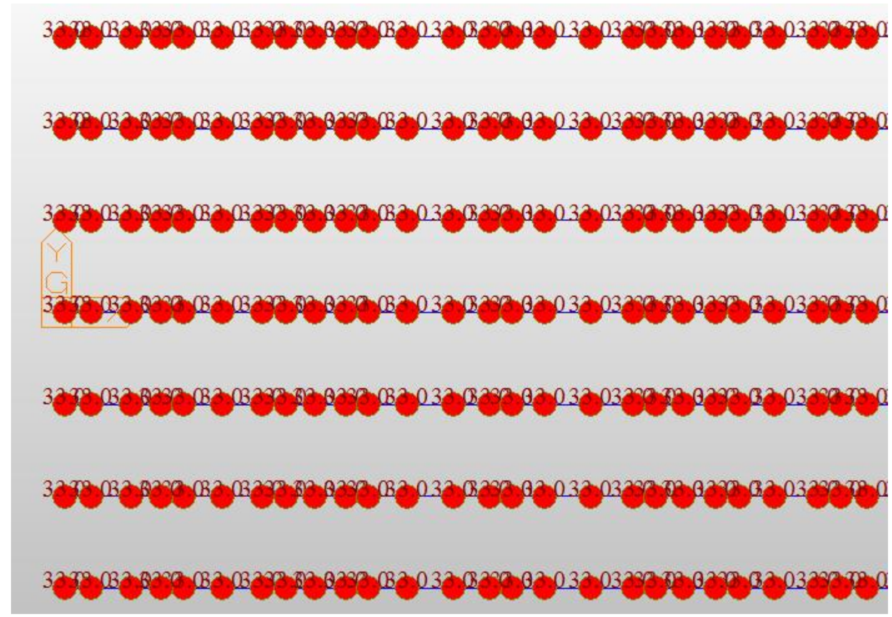


MIDAS slide to show application of Uniform temperature

- *Step 3*



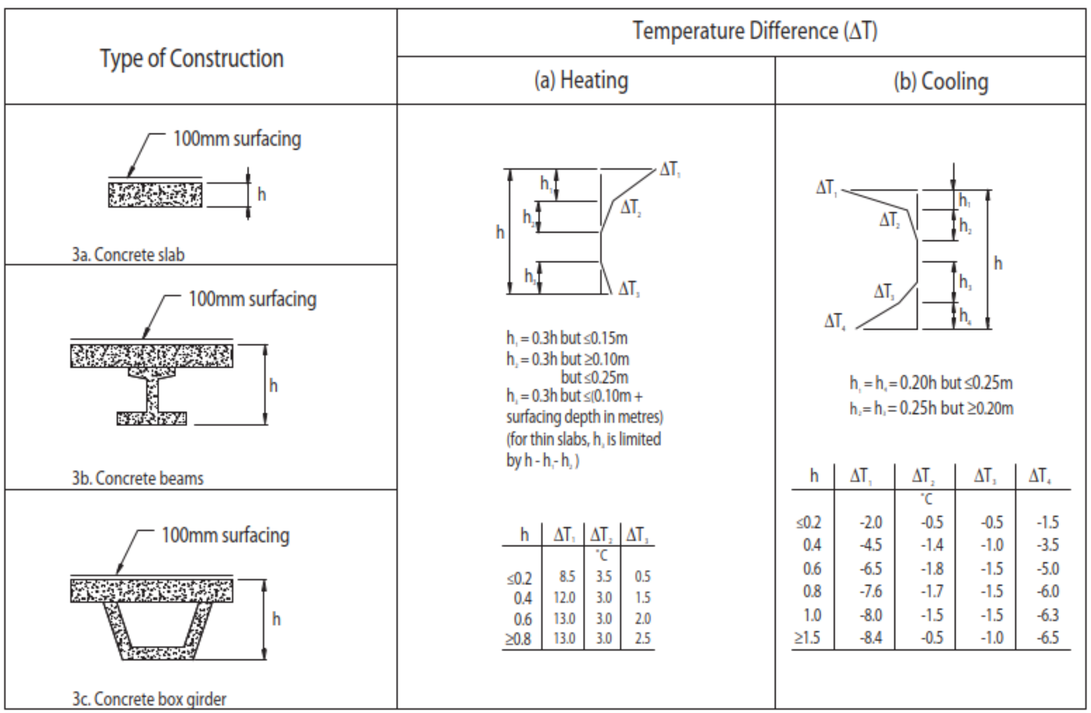
- *Step 4*



Vertical temperature components with non-linear effects

- *The vertical temperature component with linear effect (Approach 1) is not suitable for Forder Valley deck, as W beams are used. Not a standard rectangular section. The composite section is non linear. Hence non-linear effect (Approach 2) is used.*

- *The effect of the vertical temperature differences shall be considered by including a non-linear temperature difference component as per Figure 6.2c BS EN 1991-1-5:2003*



(a) Heating

h	ΔT_1	ΔT_2	ΔT_3
		°C	
≤0.2	8.5	3.5	0.5
0.4	12.0	3.0	1.5
0.6	13.0	3.0	2.0
≥0.8	13.0	3.0	2.5

(b) Cooling

h	ΔT_1	ΔT_2	ΔT_3	ΔT_4
		°C		
≤0.2	-2.0	-0.5	-0.5	-1.5
0.4	-4.5	-1.4	-1.0	-3.5
0.6	-6.5	-1.8	-1.5	-5.0
0.8	-7.6	-1.7	-1.5	-6.0
1.0	-8.0	-1.5	-1.5	-6.3
≥1.5	-8.4	-0.5	-1.0	-6.5

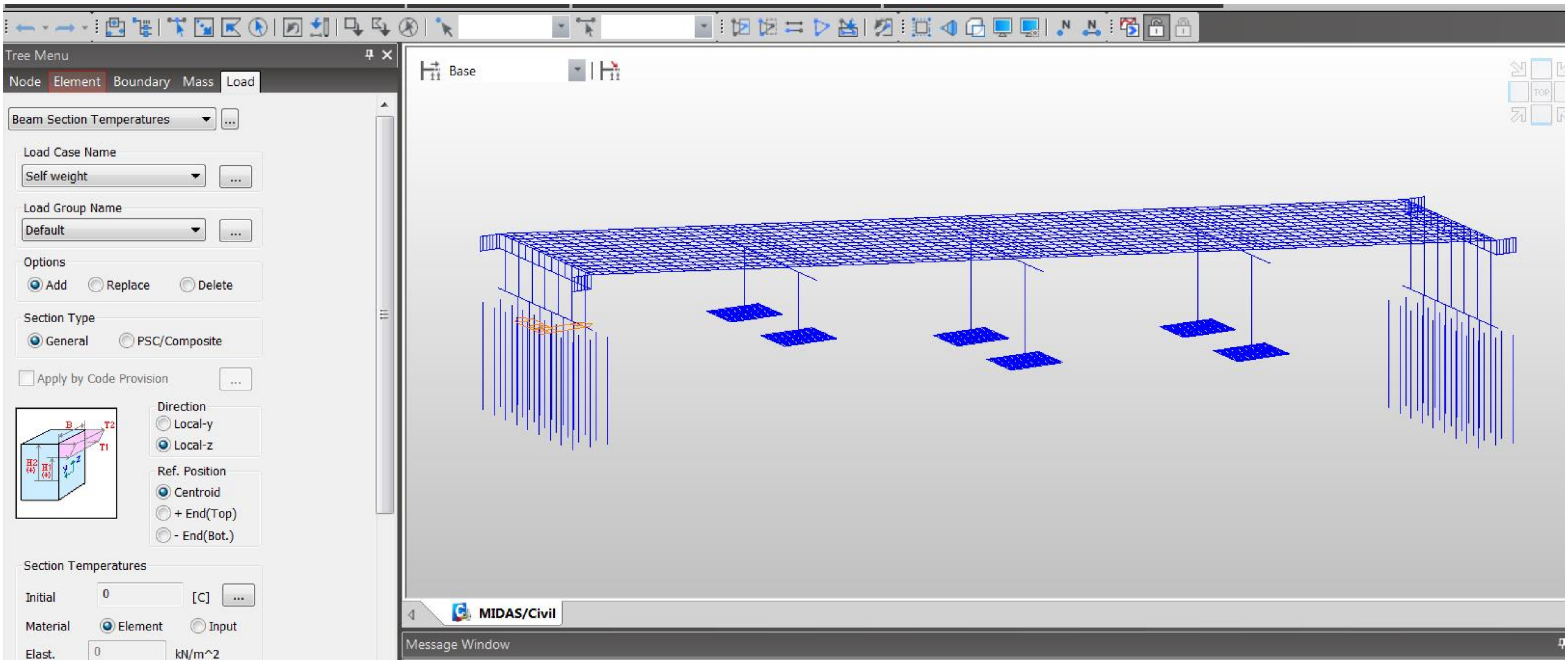
Figure 6.2c: Temperature differences for bridge decks - Type 3 : Concrete Decks

*Note: The temperature difference ΔT incorporates ΔT_M and ΔT_E (see 4.3) together with a small part of component ΔT_N: this latter part has been included in the uniform bridge temperature component (see 6.1.3).

MIDAS

AECOM

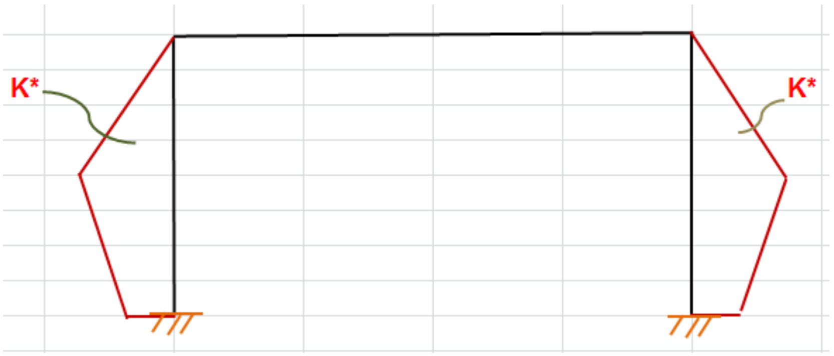
MIDAS slide to show application of non linear temperature



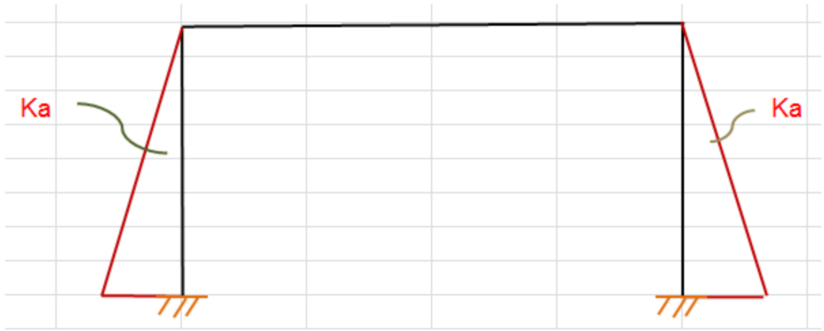
3 (v) Earth Pressure distribution and its application in MIDAS Civil

- Earth Pressure design to abutment walls
- Earth pressure application in MIDAS Civil to Frame abutments
- Earth pressure application in MIDAS Civil to Flexible abutments

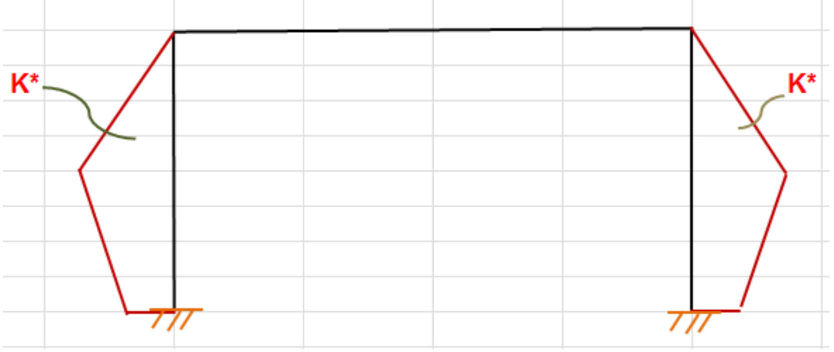
Earth Pressure design to abutment walls



Case 1:-Max.Thermal expansion +
max. bridge loads
Creep is relieving effect in this load case and h
ence it may be omitted



Case 2:-Max.Thermal contraction +
min. bridge loads
Creep +differential temperature
should be included

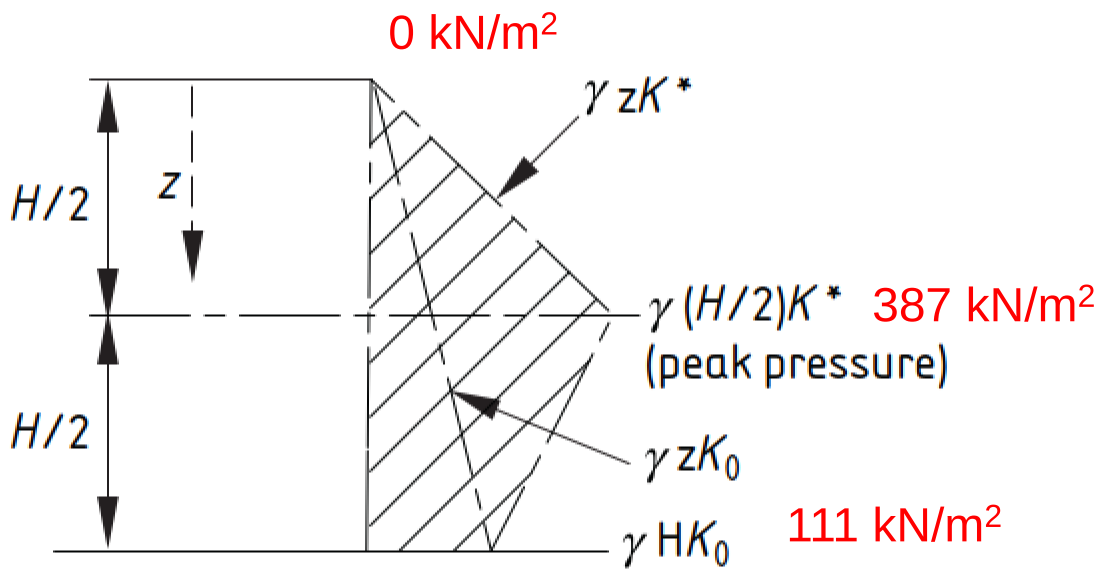


Case 3:-Max.Thermal expansion +
min. bridge loads
Creep +differential temperature
should be included

QUICK FACTS:

- *Traffic surcharge loads need not be applied in conjunction wit K* pressure*
- *Traffic surcharge loads shall be applied to one abutment in conjunction with active pressure when the structure is designed for longitudinal loads such as braking.*

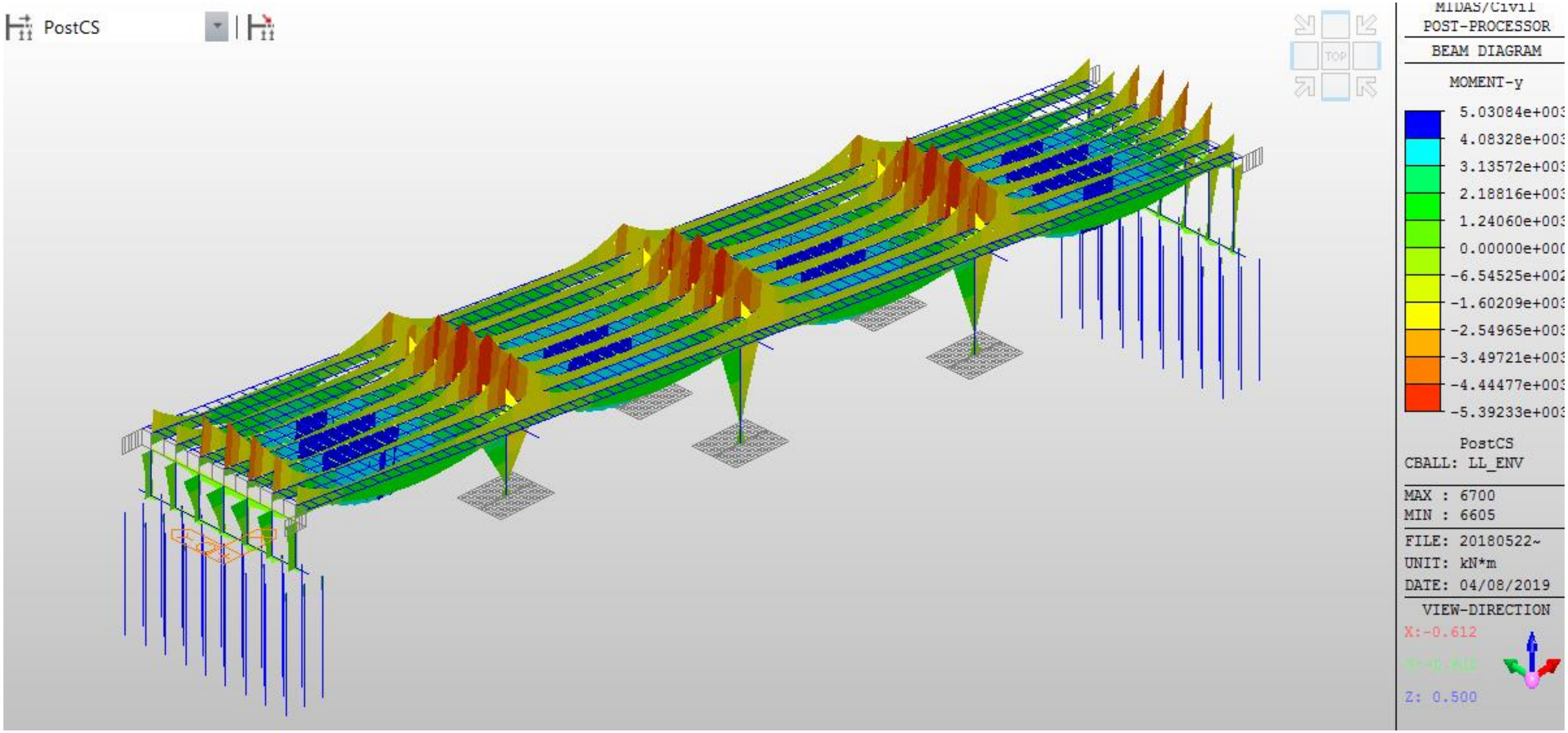
MIDAS slide to show application of EP FRAME ABUTMENTS



3 (vi) Global static analysis and results discussion at construction stage and Post construction stage

- **Construction stage results discussion**
- **Post construction stage results discussion**

Construction stage results discussion



Section 4 - Conclusion

	Utilisation of MIDAS Civil in Forder Valley Viaduct
MIDAS Civil	• Flexible support abutments Vs Frame abutment walls
	• Complex structure • Many number of elements to model • Different section properties – beam only & composite • Lot of parameters to define (creep, shrinkage) • Different load inputs – includes earth pressures, thermal actions etc. • Various construction stages • Number of boundary conditions, beam end release, rigid links, elastic links, spring supports, activation and deactivation • Different moving load combinations • Number of results to be extracted from the model and verified • Sophisticated load combination

Question and Answers

Further questions – Please email to

Global technical support platform:
http://globalsupport.midasuser.com/helpdesk/

UK email:
uksupport@midasuser.com

Thank you