Walk-in Slide: AU 2014 Social Media Feed

1. Click on the link below, this will open your web browser

http://aucache.autodesk.com/social/visualization.html

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Vehicle Load Optimisation in Structural Bridge Design

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Class summary

- This class will examine the difference between the traditional methods used to calculate traffic load effects on bridge structures and a load optimisation methods that we use in Autodesk Structural Bridge Design.
- We will examine the techniques and parameters that the program uses to define the most adverse loading patterns according to the specification of a variety of bridge design codes.

Agenda

- Short Introduction
- Basic Theory of Influence diagrams and how to create them in Autodesk Structural Bridge Design
- Load models for different design standards
- Load optimisation - parameters, analysis and results
- Demonstration of workflow

Key learning objectives

At the end of this class, you will be able to:

- Understand the techniques behind the method of load optimization
- Have a basic understanding of a variety of load models for different design standards
- Correctly set the optimisation parameters for efficiency and accuracy and check results efficiently.
- Use load optimisation to improve the workflow for bridge girder design.

Introduction

What is Traffic Load Optimisation and does it have any benefits?

What are the issues
What is the current solution
A new Approach
The benefits

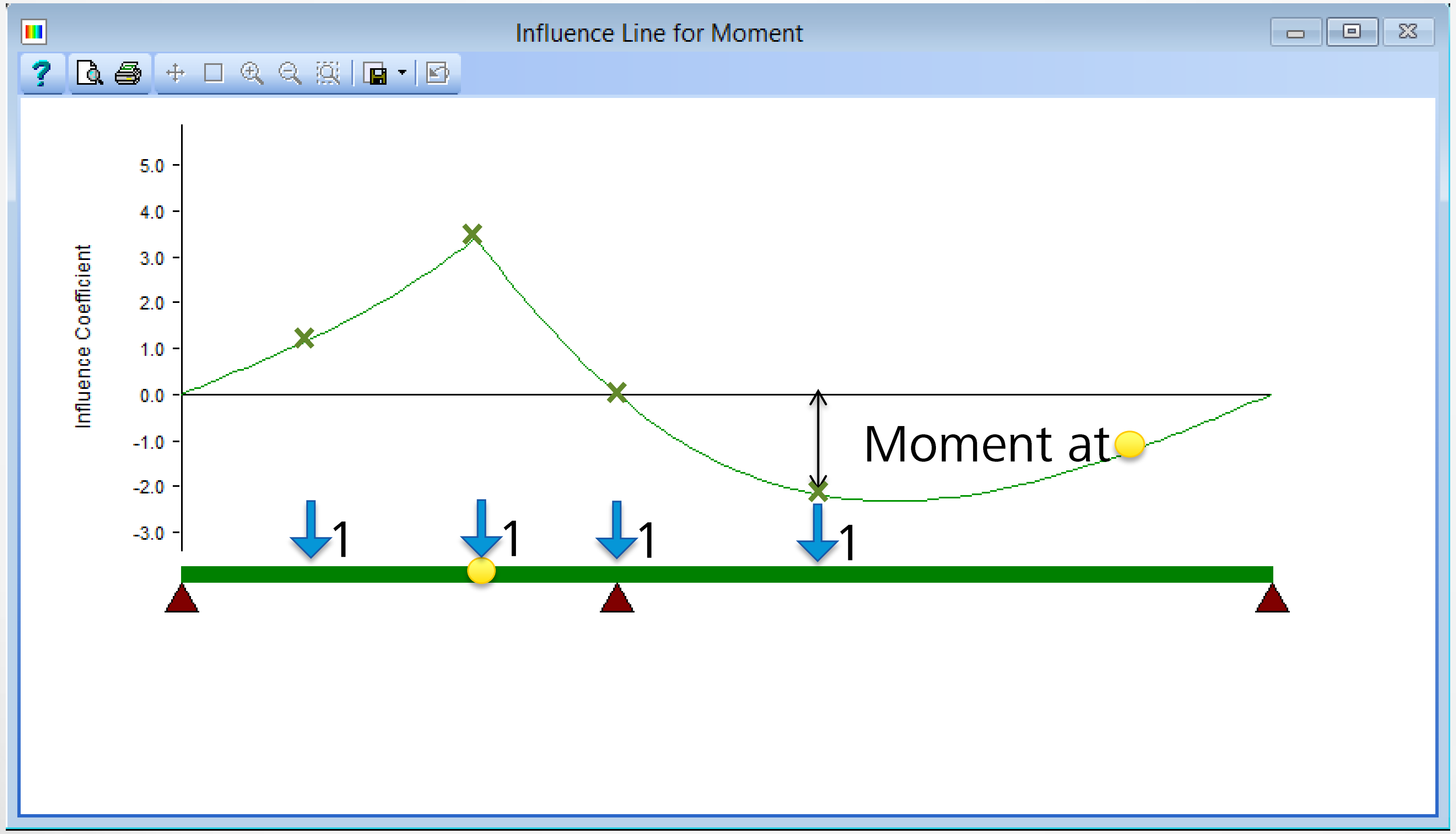
Influence Lines and Surfaces

Basic Theory

- An influence diagram describes the "effect", at a particular point in the structure, due to a **unit point load** being applied anywhere on the structure.

Basic Theory

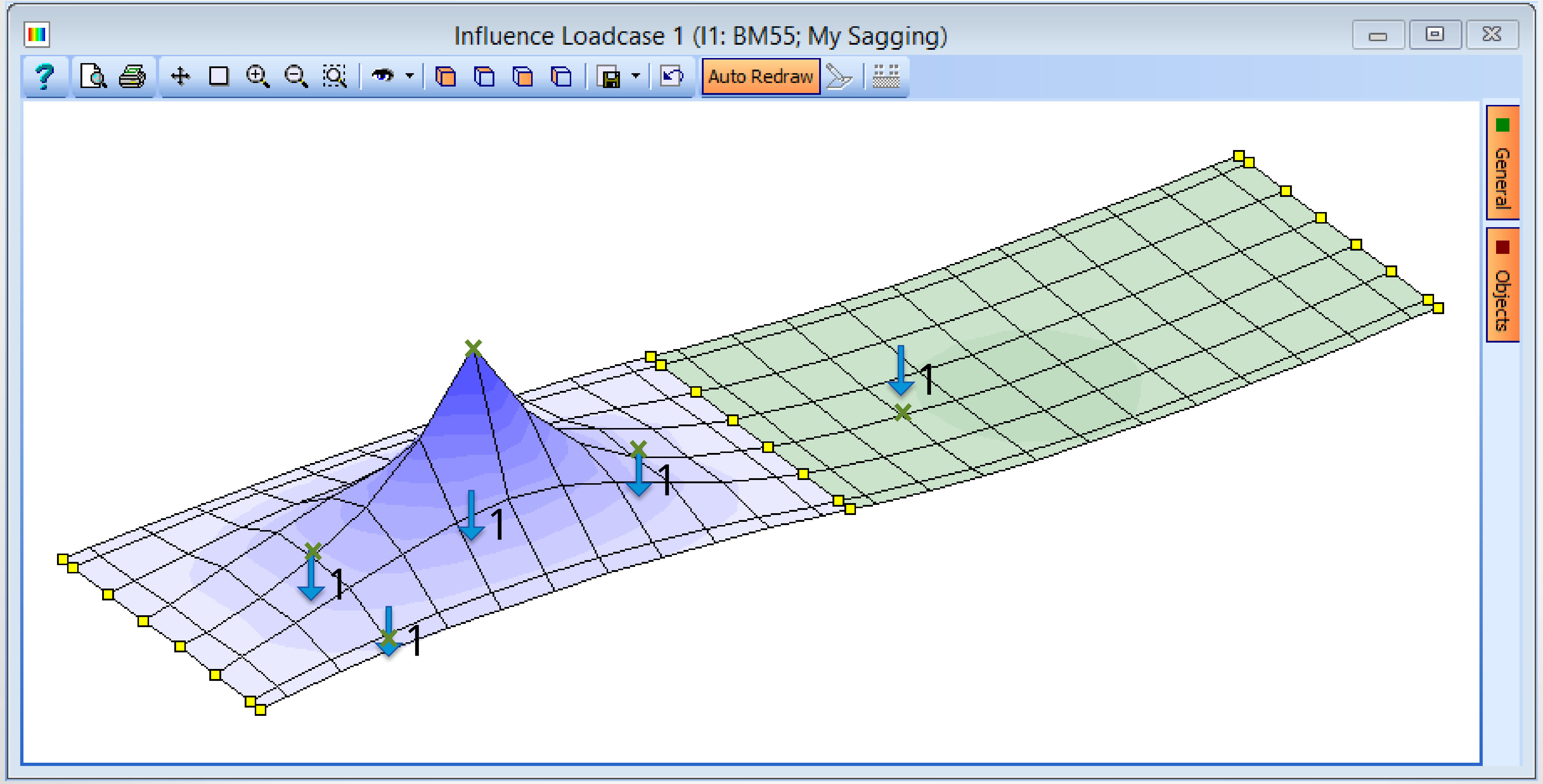
- If we consider a two span line beam and plot the bending moment at a point ● due to a unit point load applied at any point along the beam


Influence Line for Moment
Influence Coefficient
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
Moment at ●
1
1
1
1

Basic Theory

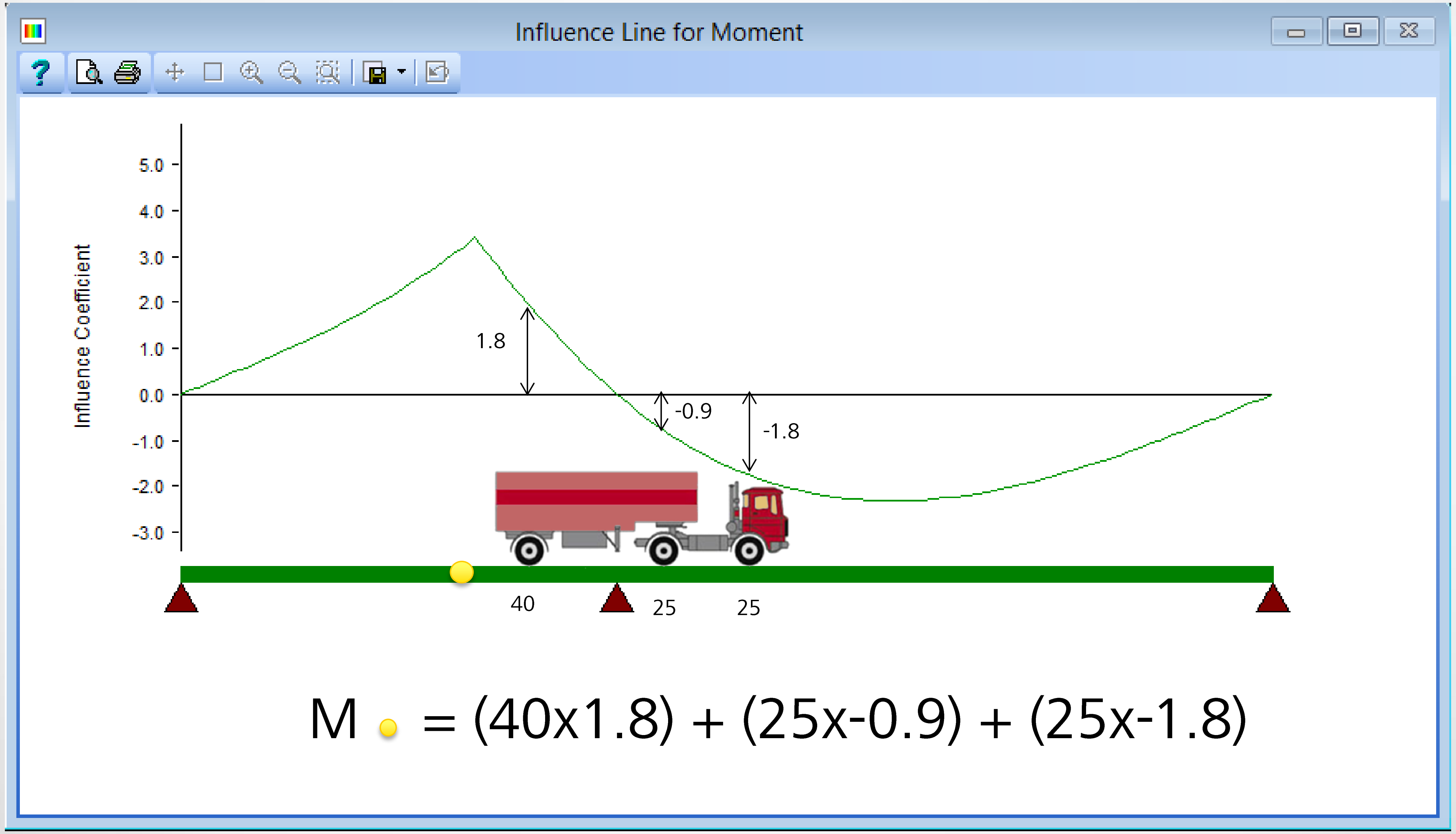
- Consider a grillage of beams representing the surface of a 2 span slab deck. Apply a series of point loads as before.

An influence “Surface” is a 2D representation of how a longitudinal influence line varies transversely.


Influence Loadcase 1 (I1: BM55; My Sagging)
Auto Redraw
General
Objects
1
1
1
1
1

Influence of Axle type loads

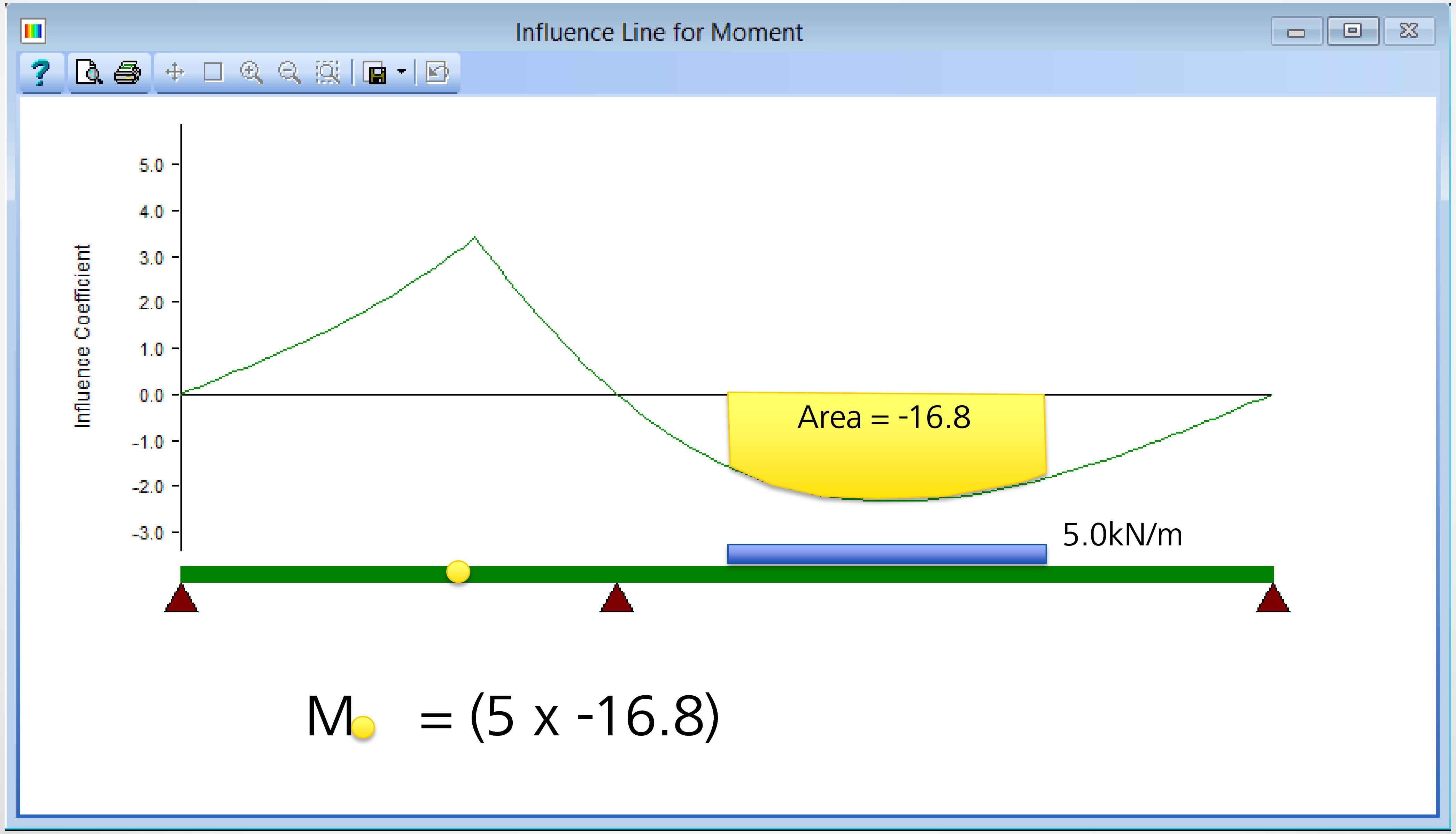
- [illegible]


Influence Line for Moment
Influence Coefficient
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
1.8
-0.9
-1.8
40
25
25

$$M_{\bullet} = (40x1.8) + (25x\text{-}0.9) + (25x\text{-}1.8)$$

Influence of UDL loads

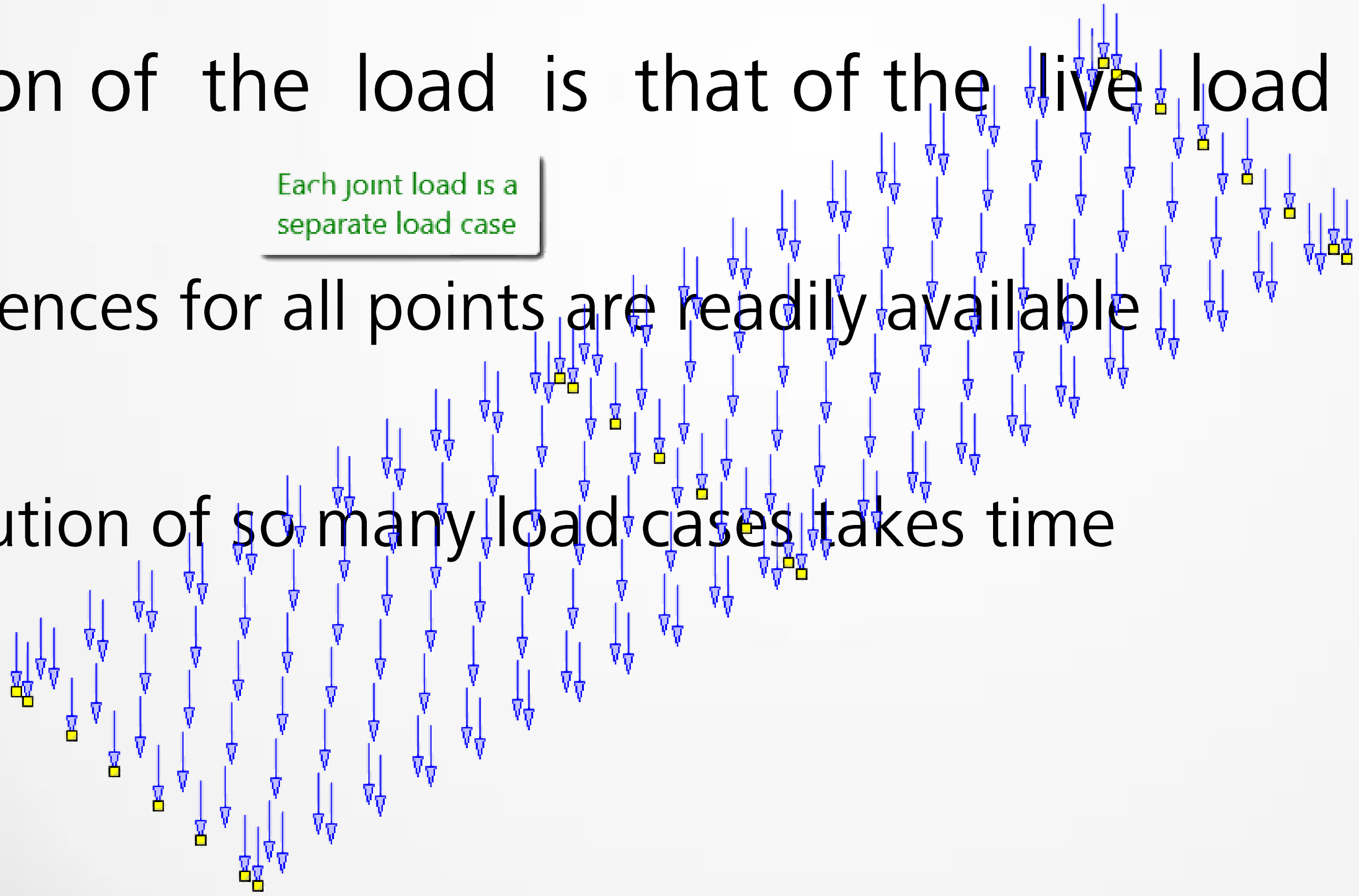
- The uniformly distributed load (UDL) applied over a specified length multiplied by the area under the influence line being loaded.


Influence Line for Moment
Influence Coefficient
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
Area = -16.8
5.0kN/m

M = (5 x -16.8)

Methods of Creating Influence Lines/Surfaces

- Direct Method
  - This applies a unit point load to all joints in the bridge deck that form the influence surface. The results for a particular design detail are then obtained for each load case and these form the coefficients of influence.
  - The direction of the load is that of the live load to which it applies.
  - Pros
    - All influences for all points are readily available
  - Cons
    - The solution of so many load cases takes time

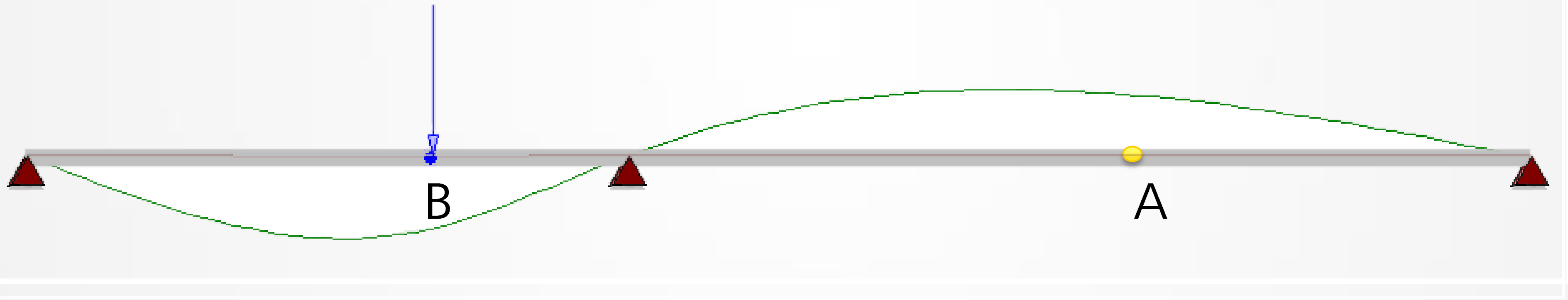


Each joint load is a separate load case

Methods of Creating Influence Lines/Surfaces

- Indirect Method
  - Clerk-Maxwell's reciprocal theorem state that:

    "In a linearly elastic structure, the deflection at any point. A due to a load applied at some other point B will be equal to the deflection at B when the same load is applied at A."



  - This implies that we can create the influence line for deflection at a specific point by solving just one load case of an applied unit load at the point

Methods of Creating Influence Lines/Surfaces

- Indirect Method
  - Muller Breslau principle state that:

"The ordinates of the influence line for force or moment in any element of a structure are equal to those of the deflected shape of the structure when the action under consideration is replaced by a force or moment whose value is such that the displacement or rotation in its direction and

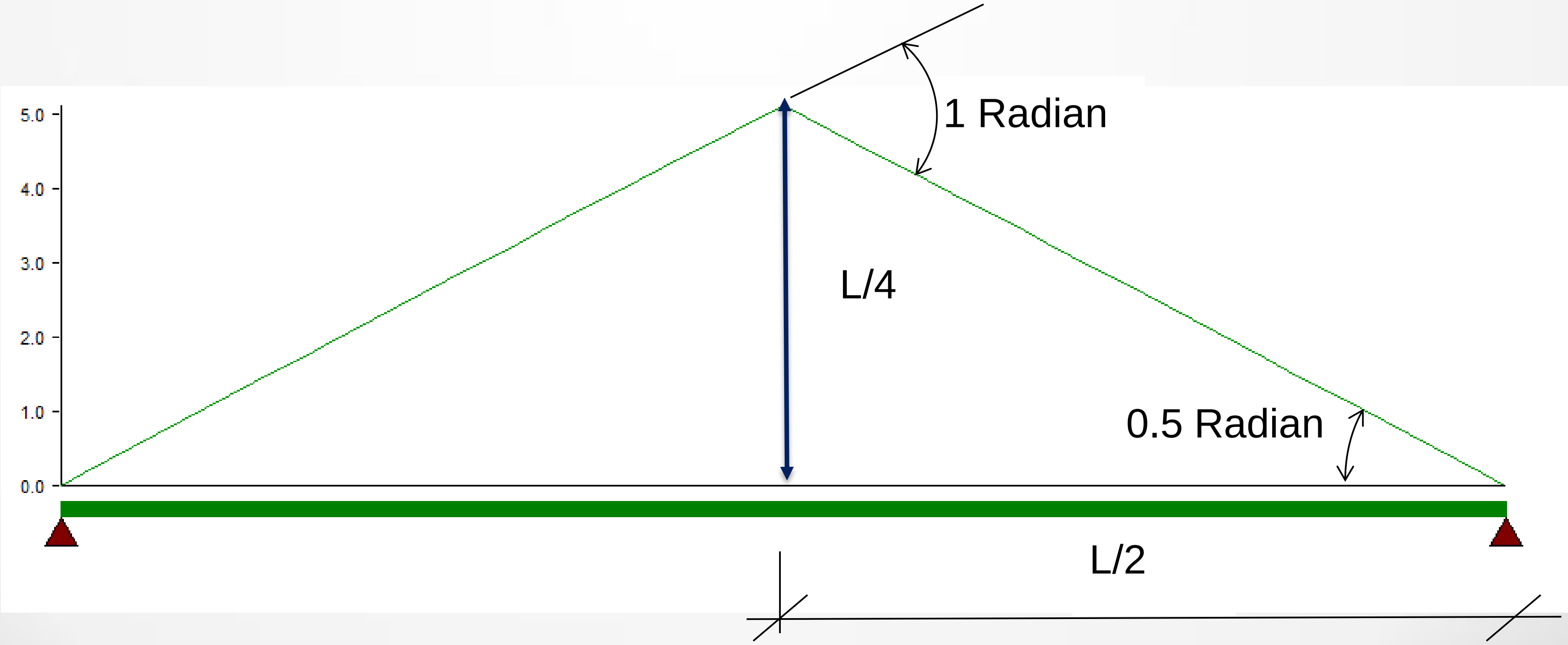
at its point of application is unity".

Methods of Creating Influence Lines/Surfaces

- Indirect Method
- Consider a simple example:

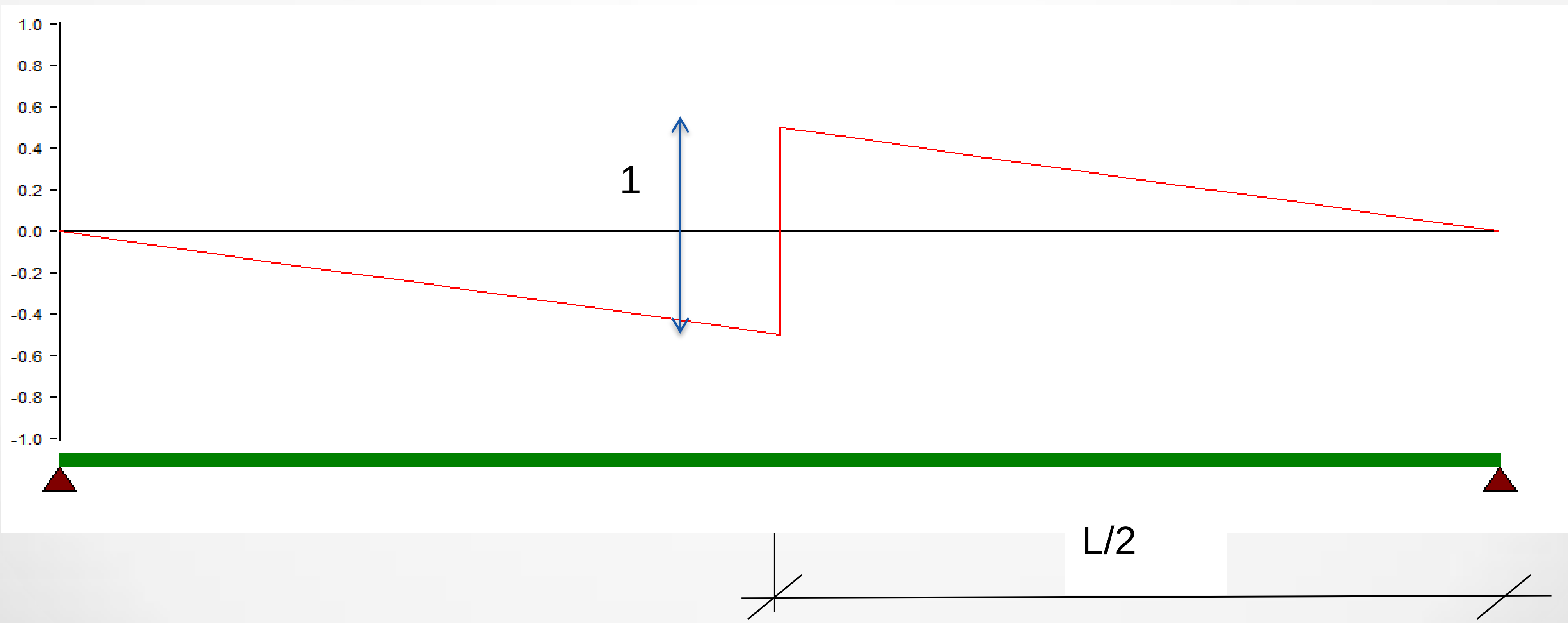
  Take a simply supported beam and apply a kink in the beam at mid span, such that the beam distorts by an angular rotation of 1 radian

  By simple mathematics and considering small displacement theory we can see that the resulting displaced shape is that of the influence of bending



Methods of Creating Influence Lines/Surfaces

- Indirect Method
- Another example may be Shear:
  - The reciprocity between shear and transverse displacement
  - The displacement is not a deflection at that point but a lateral distortion
  - Consider a simply supported beam and apply a lateral distortion of 1 at mid span



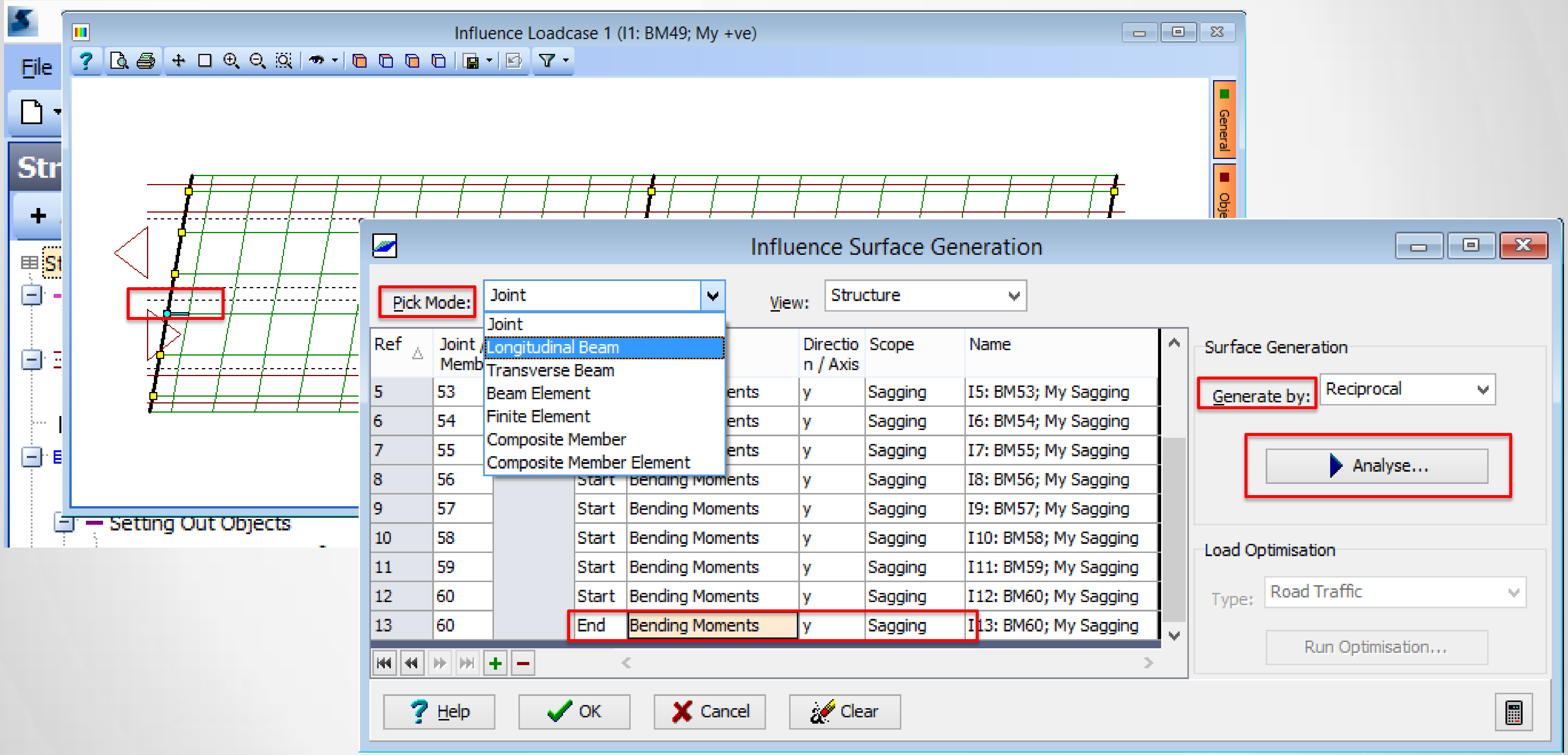
Methods of Creating Influence Lines/Surfaces

- Indirect Method
- In fact most design effect have a reciprocal value

Influence For	Applied Action
Moment	Unit Rotation Distortion
Shear	Unit Transverse Distortion
Axial Force	Unit axial Distortion
Deflection	Unit direct Force
Rotation	Unit applied Moment
Reaction	Unit Initial Displacement

Creating Influences in Structural Bridge Design

- For Grillages and Frames


Influence Loadcase 1 (I1: BM49; My +ve)
File
General
Setting Out Objects
Influence Surface Generation
Joint
Longitudinal Beam
Transverse Beam
Beam Element
Finite Element
Composite Member
Composite Member Element
Surface Generation
Analyse...
Load Optimisation
Run Optimisation...
Help
OK
Cancel
Clear

Pick Mode: Joint

View: Structure

Ref	Joint / Memb				Directio n / Axis	Scope	Name
5	53			ents	y	Sagging	I5: BM53; My Sagging
6	54			ents	y	Sagging	I6: BM54; My Sagging
7	55			ents	y	Sagging	I7: BM55; My Sagging
8	56		Start	Bending Moments	y	Sagging	I8: BM56; My Sagging
9	57		Start	Bending Moments	y	Sagging	I9: BM57; My Sagging
10	58		Start	Bending Moments	y	Sagging	I10: BM58; My Sagging
11	59		Start	Bending Moments	y	Sagging	I11: BM59; My Sagging
12	60		Start	Bending Moments	y	Sagging	I12: BM60; My Sagging
13	60		End	Bending Moments	y	Sagging	I13: BM60; My Sagging

Generate by: Reciprocal

Type: Road Traffic

Creating Influences in Structural Bridge Design

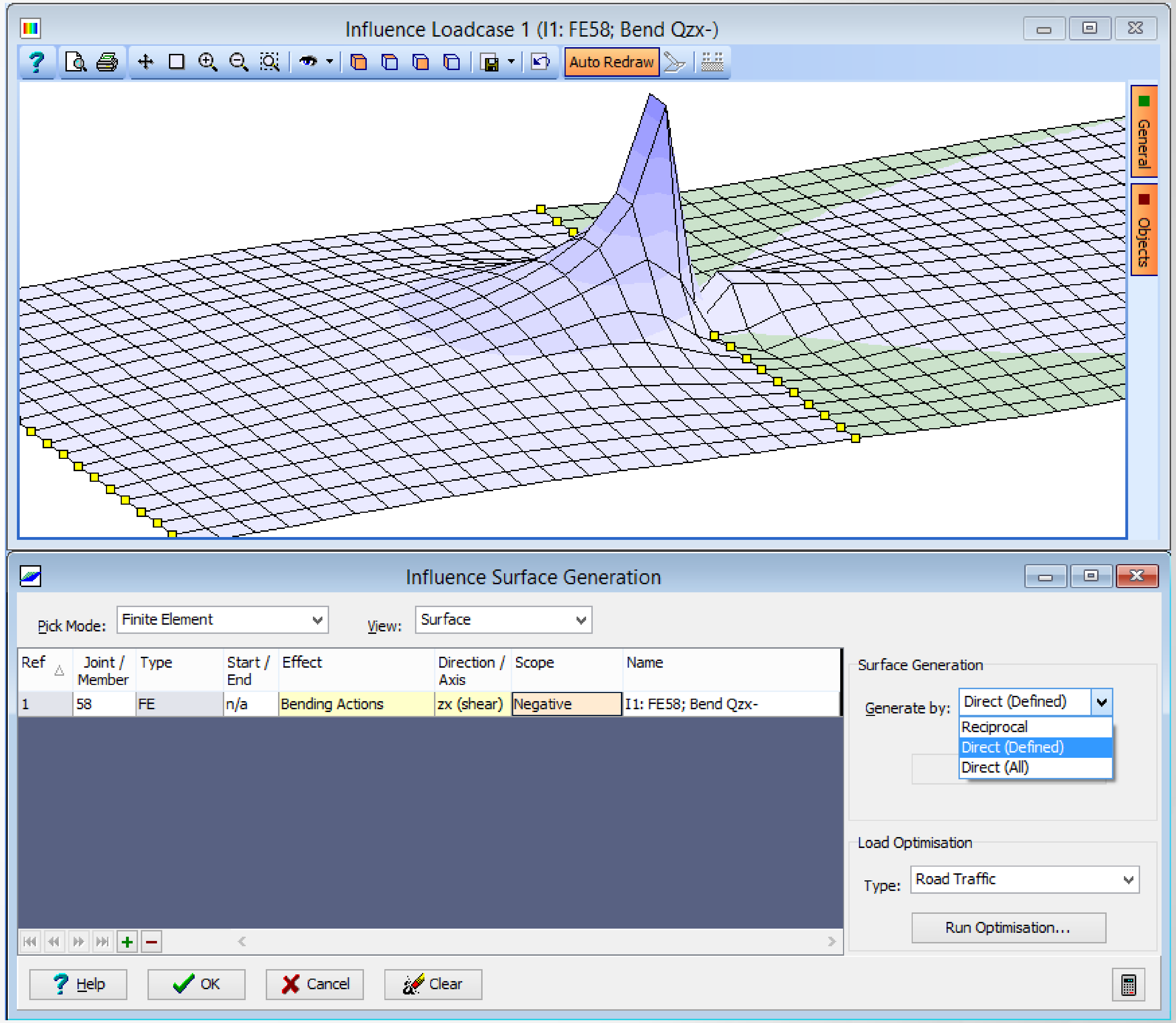
- For Shell Finite Element Structures

  Direct method is necessary

  Influence is for the element centroid

  Influence is a value per unit width

  The effect for shear appears as a bending effect



Influence Loadcase 1 (I1: FE58; Bend Qzx-)

Influence Surface Generation

Pick Mode: Finite Element

View: Surface

Ref	Joint / Member	Type	Start / End	Effect	Direction / Axis	Scope	Name
1	58	FE	n/a	Bending Actions	zx (shear)	Negative	I1: FE58; Bend Qzx-

Surface Generation

Generate by: Direct (Defined)

Load Optimisation

Type: Road Traffic

Auto Redraw
General
Objects
Reciprocal
Direct (Defined)
Direct (All)
Run Optimisation...
Help
OK
Cancel
Clear

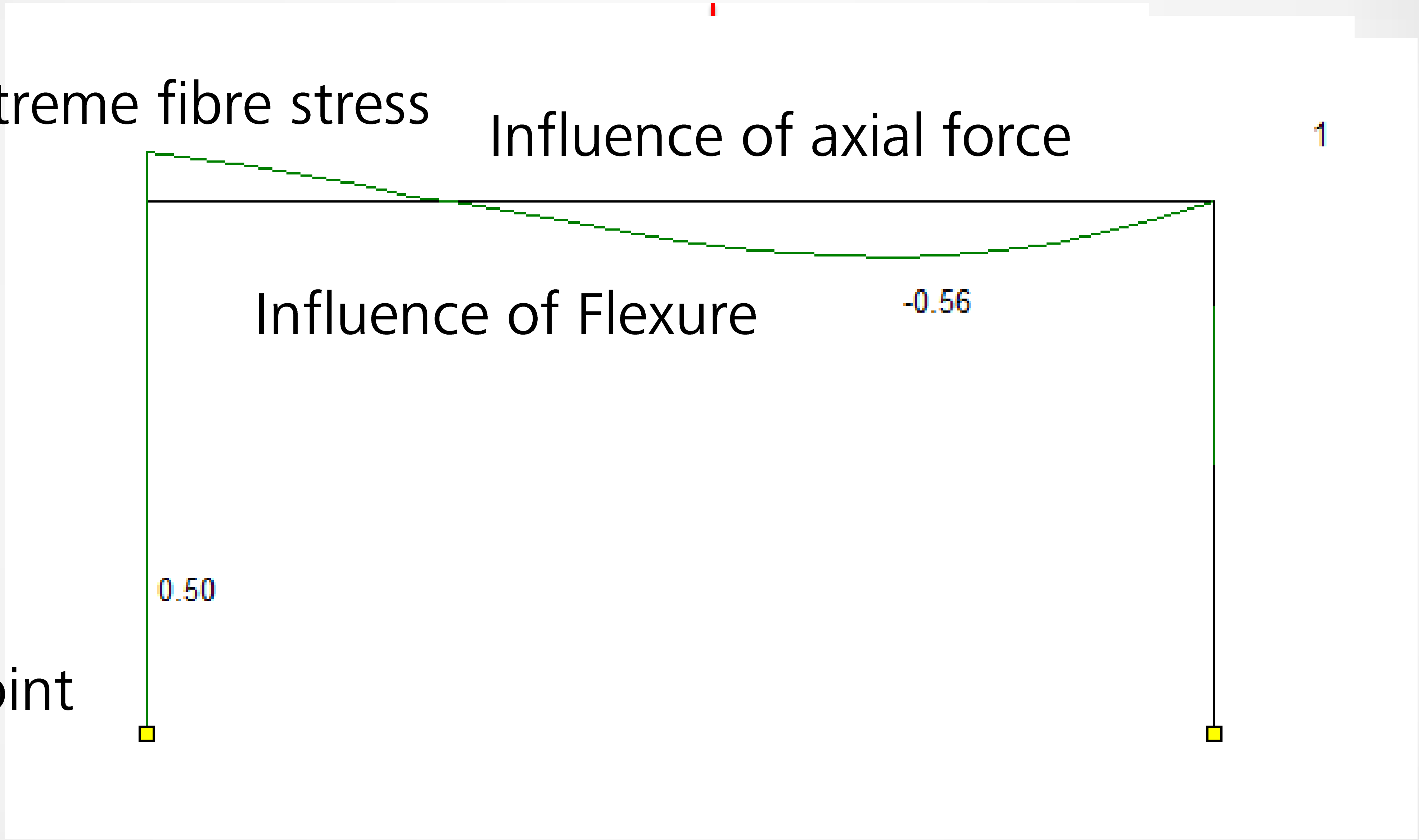
Combining Influences

- If a particular design detail can be defined as a linear function of any of the main design components listed in the previous slide, then individual influences can be factored and combined to produce an influence for the design detail.
- For example, if a structural component resisted both flexure and axial force we may want to produce an influence for extreme fibre stress which can be defined as:

$$\sigma_{top} = F/A + M/Z$$

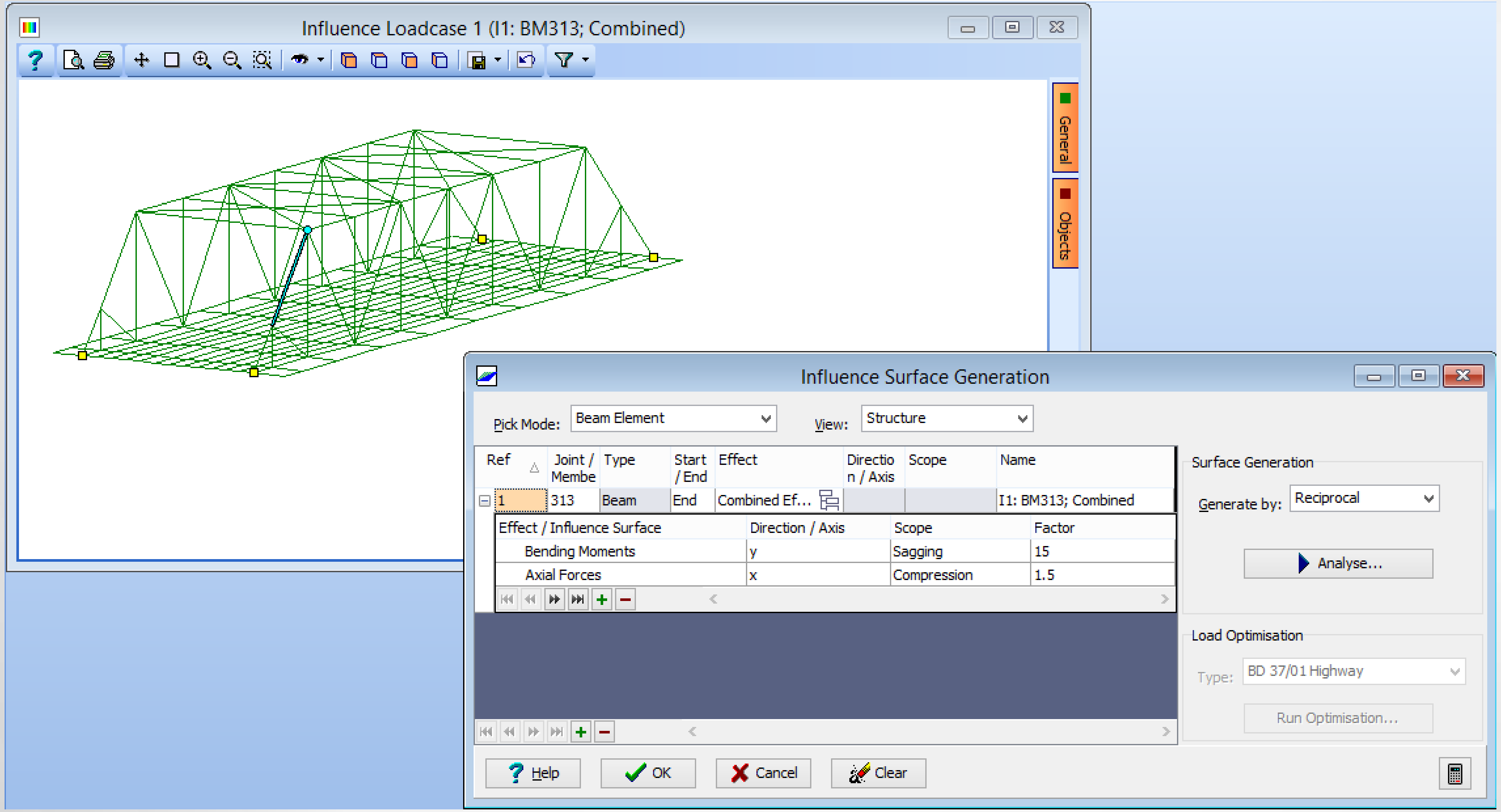
where A is the section area and Z is the section modulus

Combining Influences


Influence of extreme fibre stress
Influence of axial force
1
-0.56
Influence of Flexure
0.50
For this Point

Creating Influences in Structural Bridge Design

- Combined Influences



Influence Loadcase 1 (I1: BM313; Combined)

Influence Surface Generation

Pick Mode: Beam Element

View: Structure

Ref	Joint / Membe	Type	Start / End	Effect	Directio n / Axis	Scope	Name
1	313	Beam	End	Combined Ef...			I1: BM313; Combined

Effect / Influence Surface	Direction / Axis	Scope	Factor
Bending Moments	y	Sagging	15
Axial Forces	x	Compression	1.5

Surface Generation

Generate by: Reciprocal

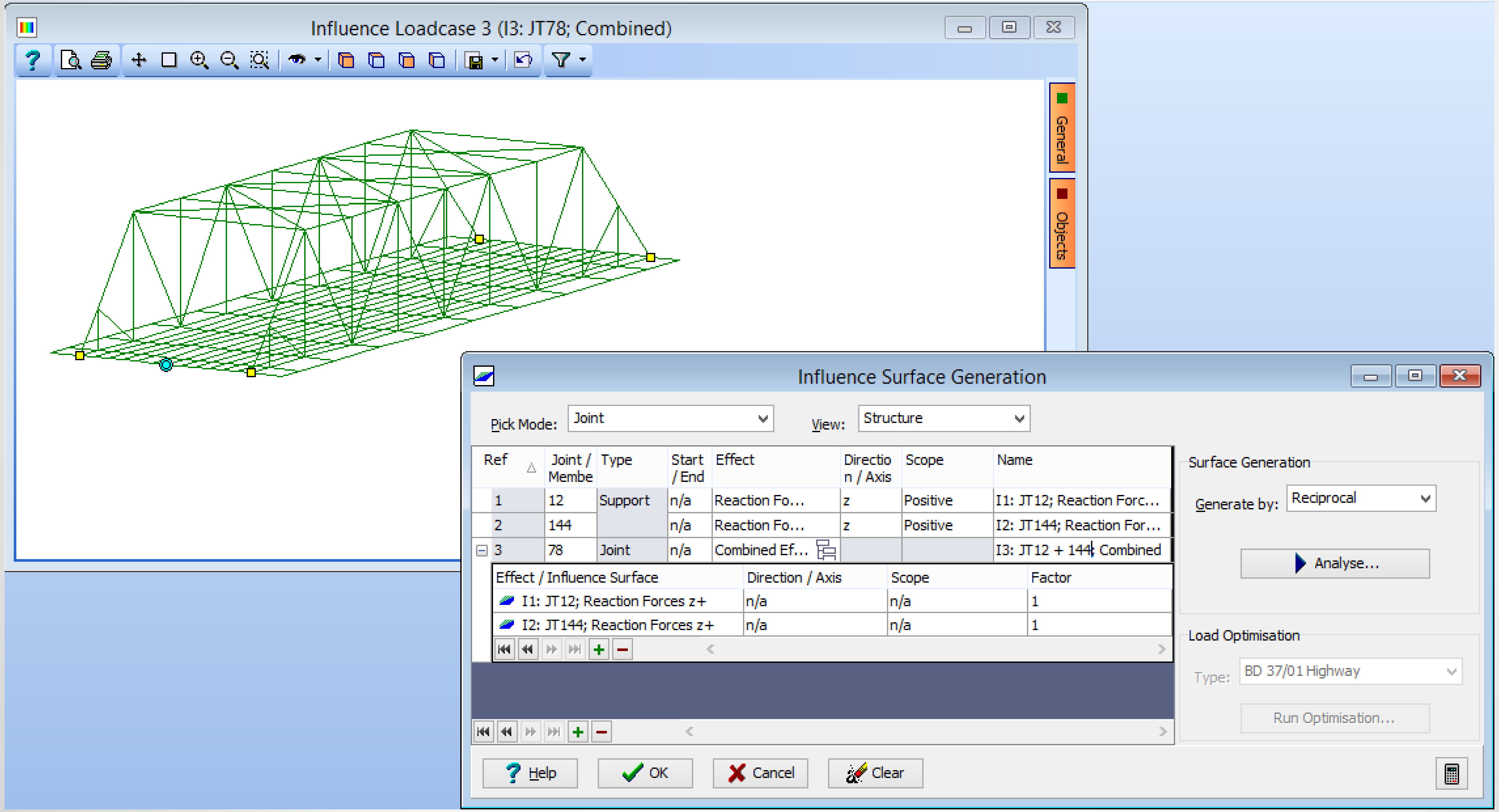
Load Optimisation

Type: BD 37/01 Highway

General
Objects
Analyse...
Run Optimisation...
Help
OK
Cancel
Clear

Creating Influences in Structural Bridge Design

- Combined Influences


Influence Loadcase 3 (I3: JT78; Combined)
General
Objects
Influence Surface Generation

Pick Mode: Joint

View: Structure

Ref	Joint / Membe	Type	Start / End	Effect	Direction / Axis	Scope	Name
1	12	Support	n/a	Reaction Fo…	z	Positive	I1: JT12; Reaction Forc…
2	144		n/a	Reaction Fo…	z	Positive	I2: JT144; Reaction For…
3	78	Joint	n/a	Combined Ef…			I3: JT12 + 144; Combined

Effect / Influence Surface	Direction / Axis	Scope	Factor
I1: JT12; Reaction Forces z+	n/a	n/a	1
I2: JT144; Reaction Forces z+	n/a	n/a	1

Surface Generation

Generate by: Reciprocal

Load Optimisation

Type: BD 37/01 Highway

Analyse…
Run Optimisation…
Help
OK
Cancel
Clear

Traffic Loads for different National Standards

Loading Model Considerations

- Traffic Loading is complex and a few things that need considering when design a traffic model scheme are:
    - It can generally be considered to act in Lanes
    - The Loading is Dynamic
    - There will be normal and abnormal loading conditions
    - The intensity in each lane is based upon extensive statistical research
    - Traffic load content may be very different for different highways and different regions around the world

Highway Traffic Load models

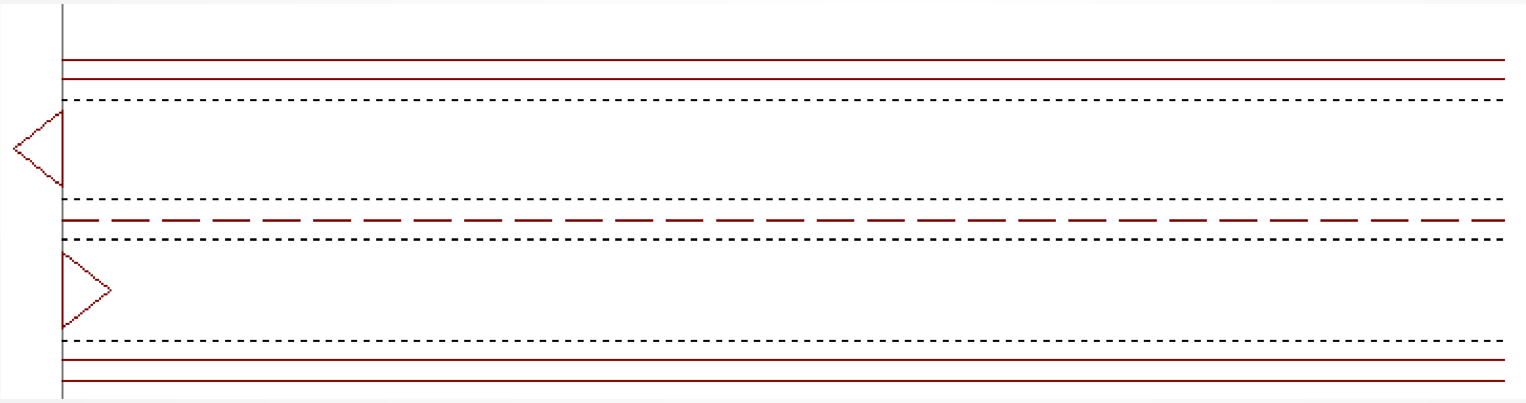
- Highway traffic load models can be very different for different countries and these are reflected in the various national design standards
- In the next few slides we will briefly examine the models in:
  - AASHTO LRFD6
  - BS5400
  - Eurocodes
  - AS5100
- And for each we will consider
  - Notional lane positioning and multiple presence factors
  - The normal load models
  - And how they are combined to form the design loading patterns

ASSHTO LRFD6

- Roadway Configuration

Carriageway width w in ft	Number of design Lanes	Width of a design Lane
12ft $\leq$ w < 20ft	n = 1	w
20ft $\leq$ w < 24ft	n = 2	w/2
24ft $\leq$ w	n = Int(w/12)	w/n

Number of loaded Lanes	Multiple Presence Factor
1	1.2
2	1.0
3	0.85
>3	0.65

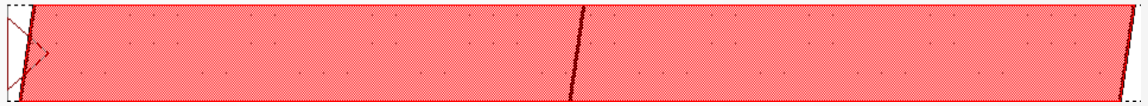


- Traffic loads occupy a loaded width of 10ft within the lanes and will be located transversely so as to produce the most adverse effect

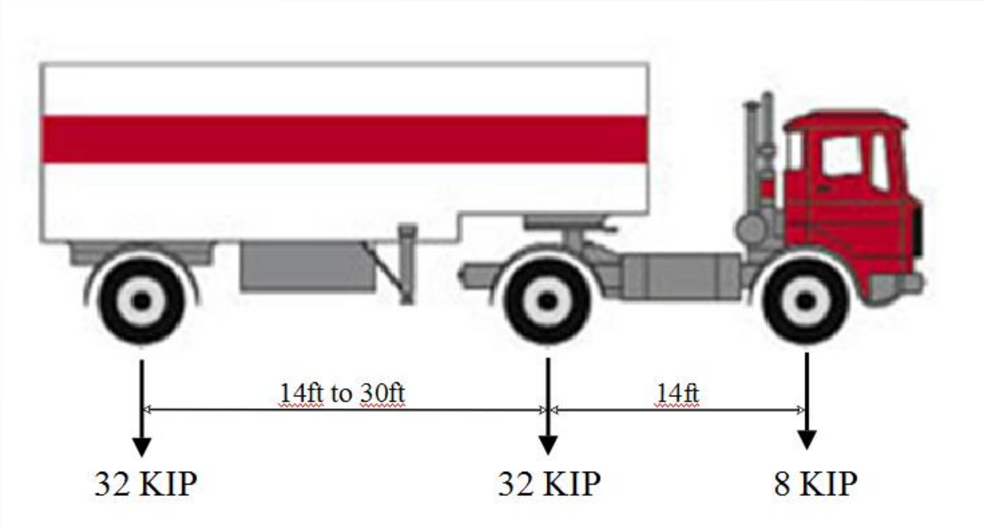
ASSHTO LRFD6

- Load Models consists of three components

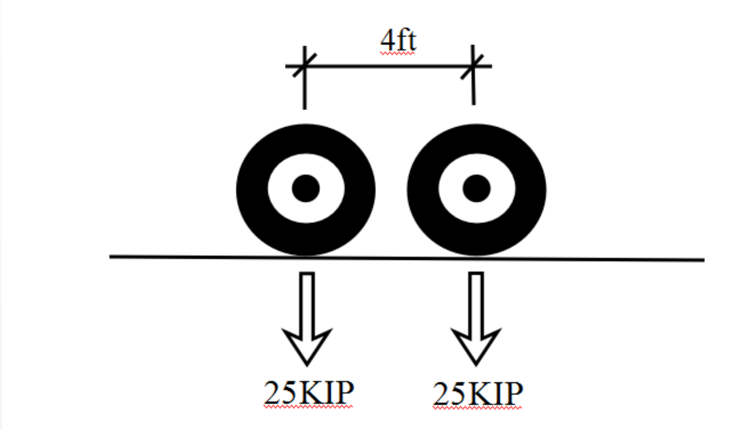
1. UDL of 0.64KLP over 10ft width



1. A Design truck with 6ft between wheels

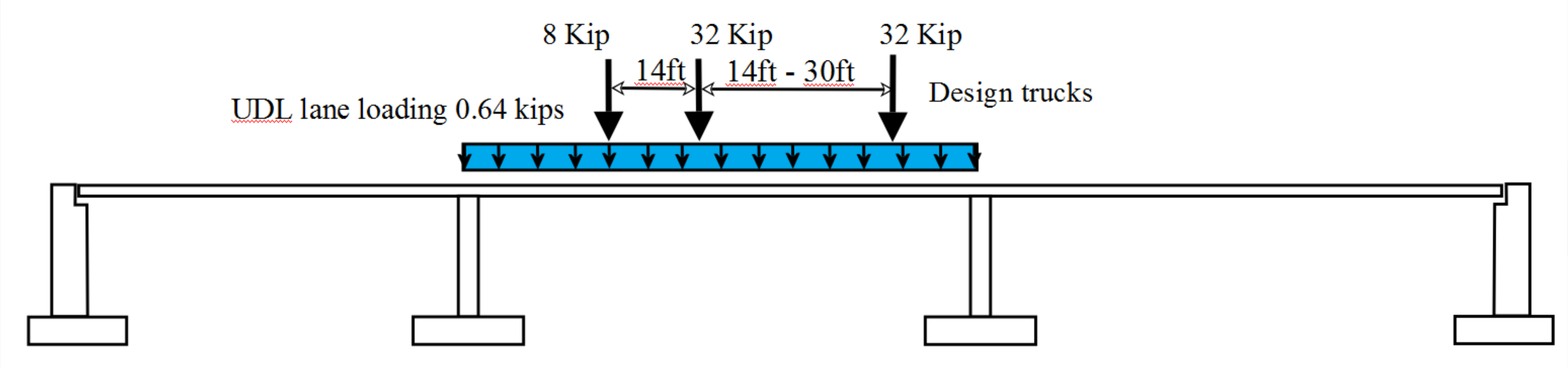

14ft to 30ft
14ft
32 KIP
32 KIP
8 KIP

2. A Design Tandem (6ft width between wheels)

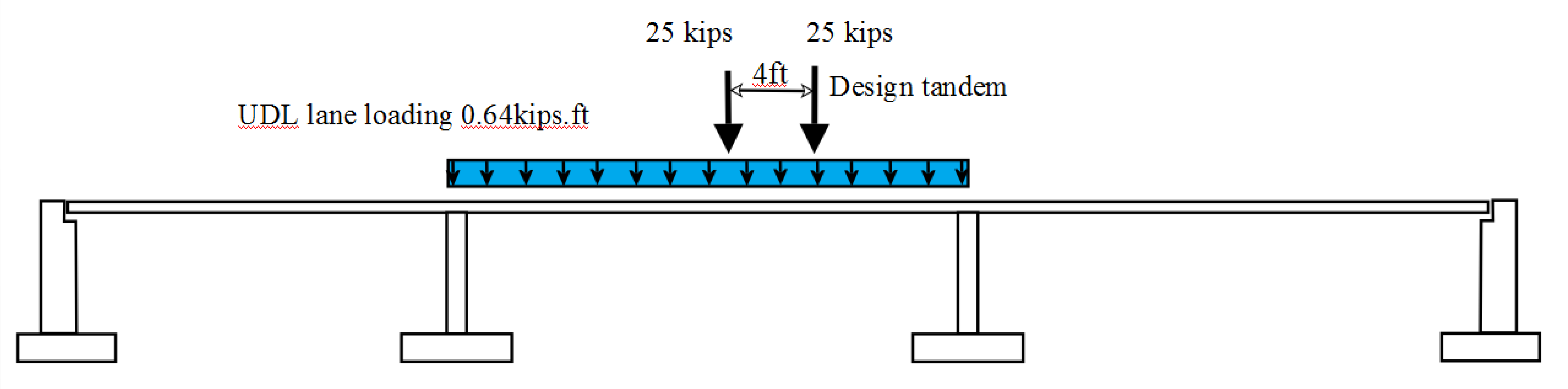

4ft
25KIP
25KIP

ASSHTO LRFD6

- Application of Load Models on Roadway
  - Generally each design lane is loaded with either:

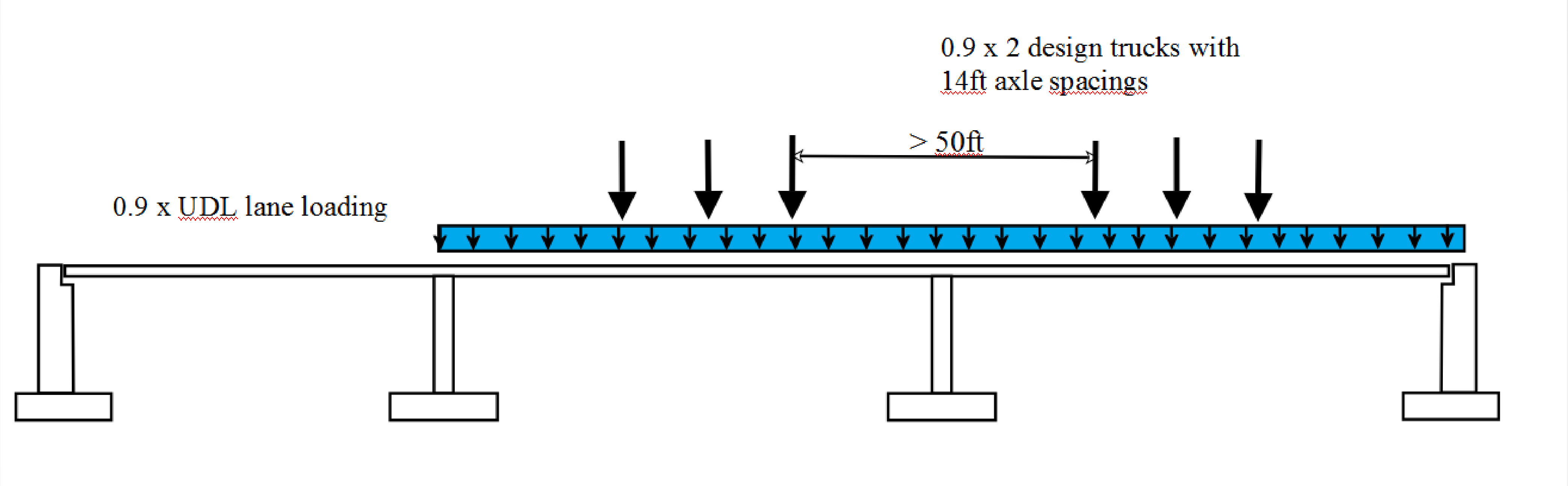

8 Kip
32 Kip
32 Kip
14ft
14ft - 30ft
Design trucks
UDL lane loading 0.64 kips

  - Or

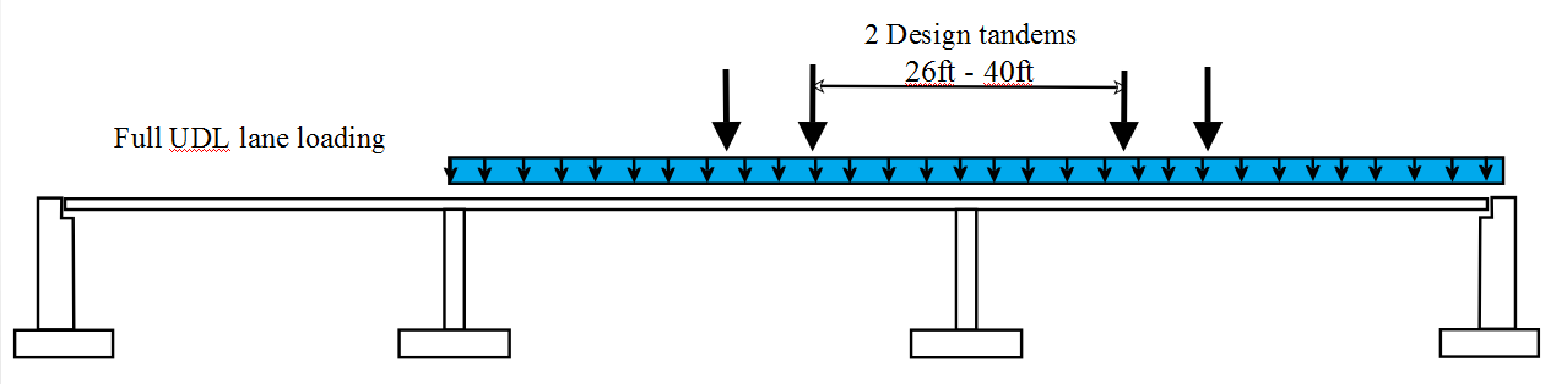

25 kips
25 kips
4ft
Design tandem
UDL lane loading 0.64kips.ft

ASSHTO LRFD6

- Application of Load Models on Roadway
    - For negative moment and support reactions of piers and abutments either:


0.9 x 2 design trucks with
14ft axle spacings
> 50ft
0.9 x UDL lane loading

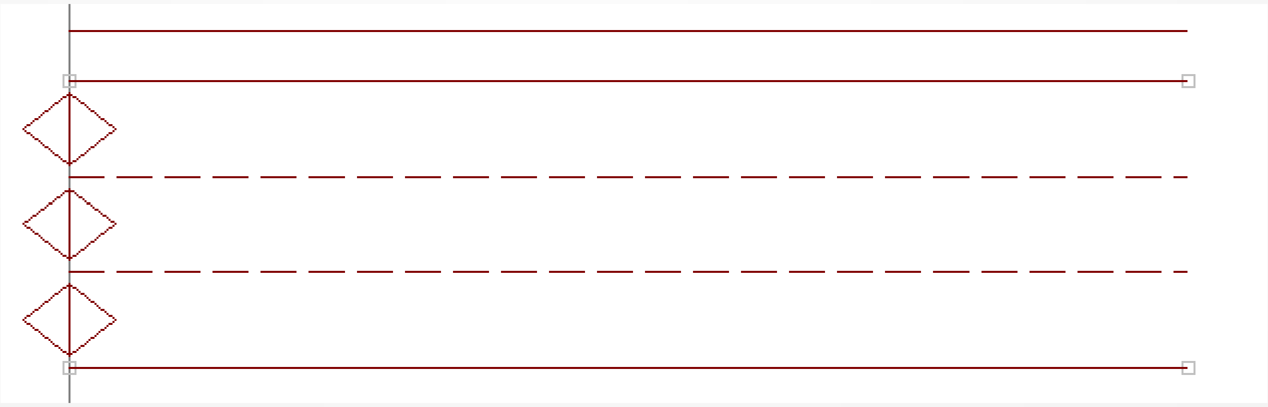
    - Or


2 Design tandems
26ft - 40ft
Full UDL lane loading

BS5400

- Carriageway Configuration

Carriageway width w in m	Number of notional lanes	Width of a notional lane
$2.50m \leq w < 5.00m$	$n = 1$	2.5m
$5.00m \leq w < 7.50m$	$n = 2$	w/2
$7.50m \leq w < 10.95m$	$n = 3$	w/3
$10.95m \leq w < 14.60m$	$n = 4$	w/4
$14.60m \leq w < 18.25m$	$n = 5$	w/5
$18.25m \leq w < 21.90m$	$n = 6$	w/6



BS5400

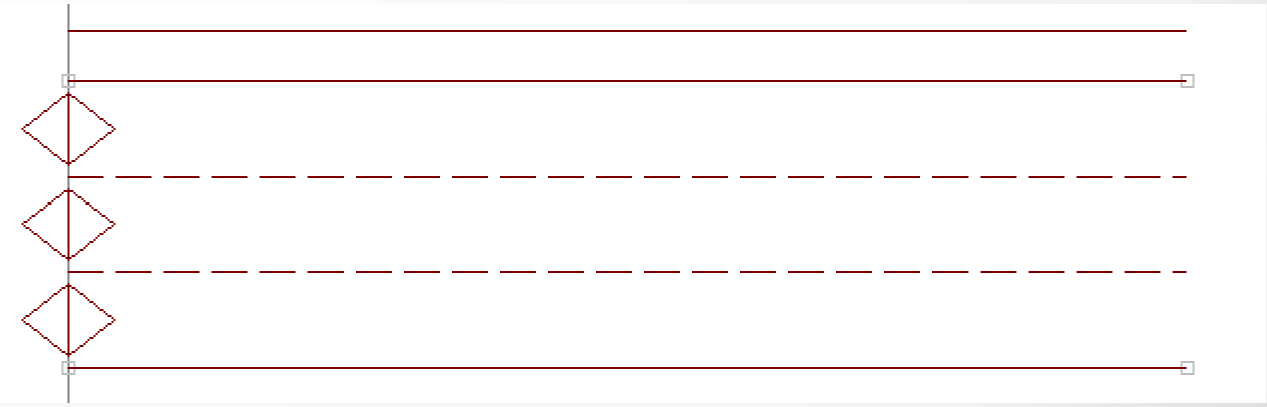
- Lane Factors

Loaded length L m	First Lane Factor β_1	Second Lane Factor β_2	Third Lane Factor β_3	Forth and subsequent lane factors β_n
$0 < L \leq 20$	α_1	α_1	0.6	$0.6\alpha_1$
$20 < L \leq 40$	α_2	α_2	0.6	$0.6\alpha_2$
$40 < L \leq 50$	1.0	1.0	0.6	0.6

$\alpha_1 = 0.27b_L$ but must be less than 1.0

$\alpha_2 = 0.0137\{b_L(40-L) + 3.65(L-20)\}$

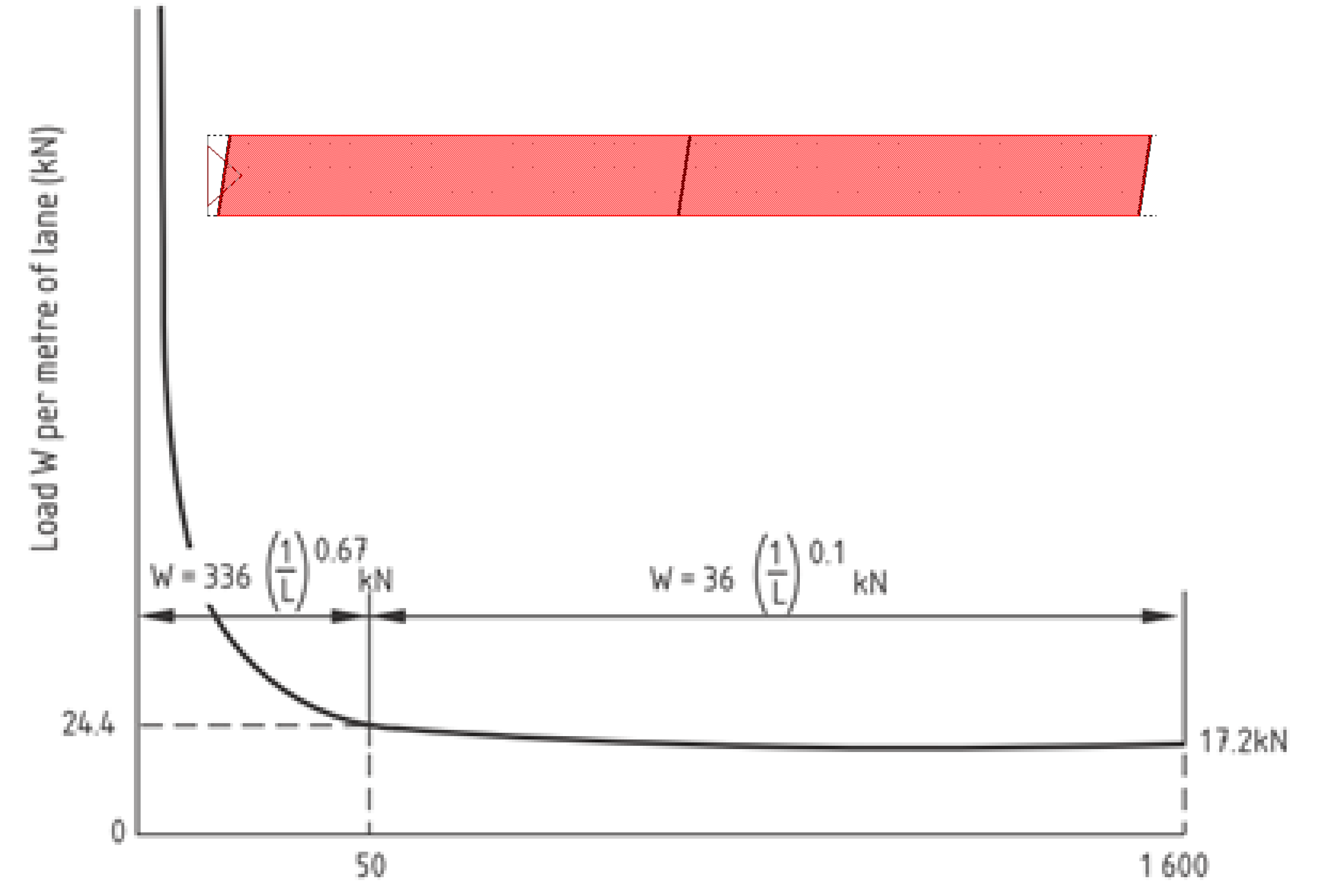
b_L = the notional lane width (m)



BS5400

- 2 Load Models consists of three components

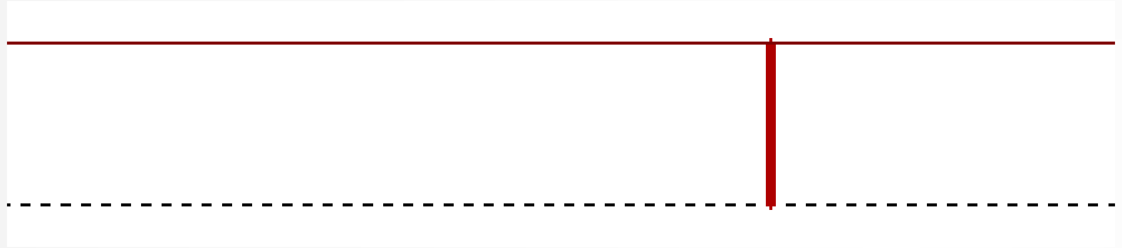
  1. HA Uniformly distributed load with a varying intensity based on the loaded length



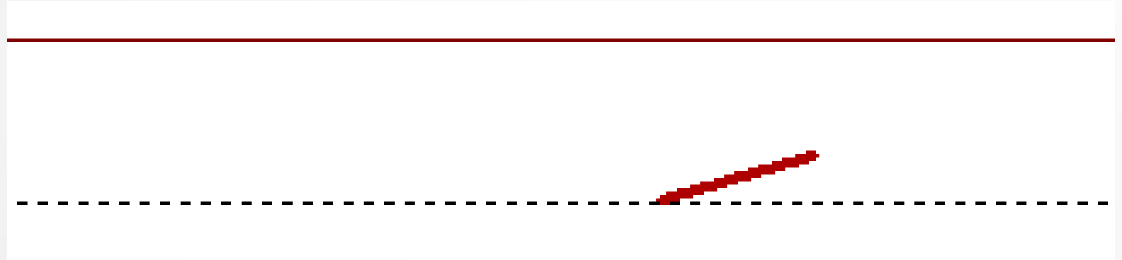
BS5400

- 2 Load Models consists of three components

2. HA Concentrated knife edge load of 120kN having a length of the notional lane width



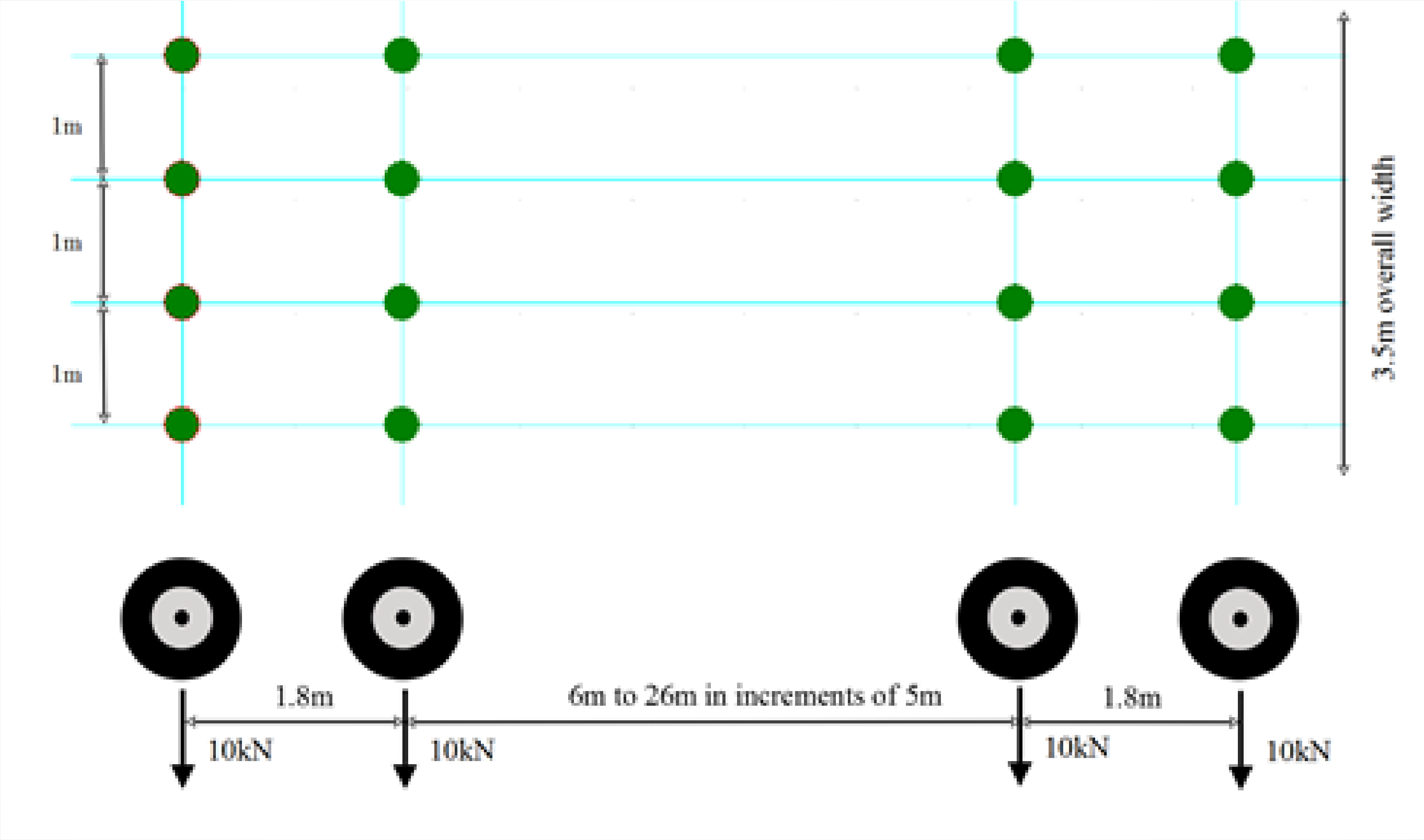
For certain design effects, such as bending of a transverse cantilever slab, the KE load should be orientated and positioned laterally to give the worst effect



BS5400

- 2 Load Models consists of three components

3. HB - A notional representation of a multi axle tractor and trailer vehicle used to convey heavy loads. It has four axles with four wheels on each axle and has a unit axle load of 10kN. It is normal to apply 30 to 45 units depending on the roadway type.


1m
1m
1m
3.5m overall width
1.8m
6m to 26m in increments of 5m
1.8m
10kN
10kN
10kN
10kN

BS5400

- Application of Load Models on Carriageway
  - There are two main combinations of traffic load that we generally consider and each one should be tested for the worst effect

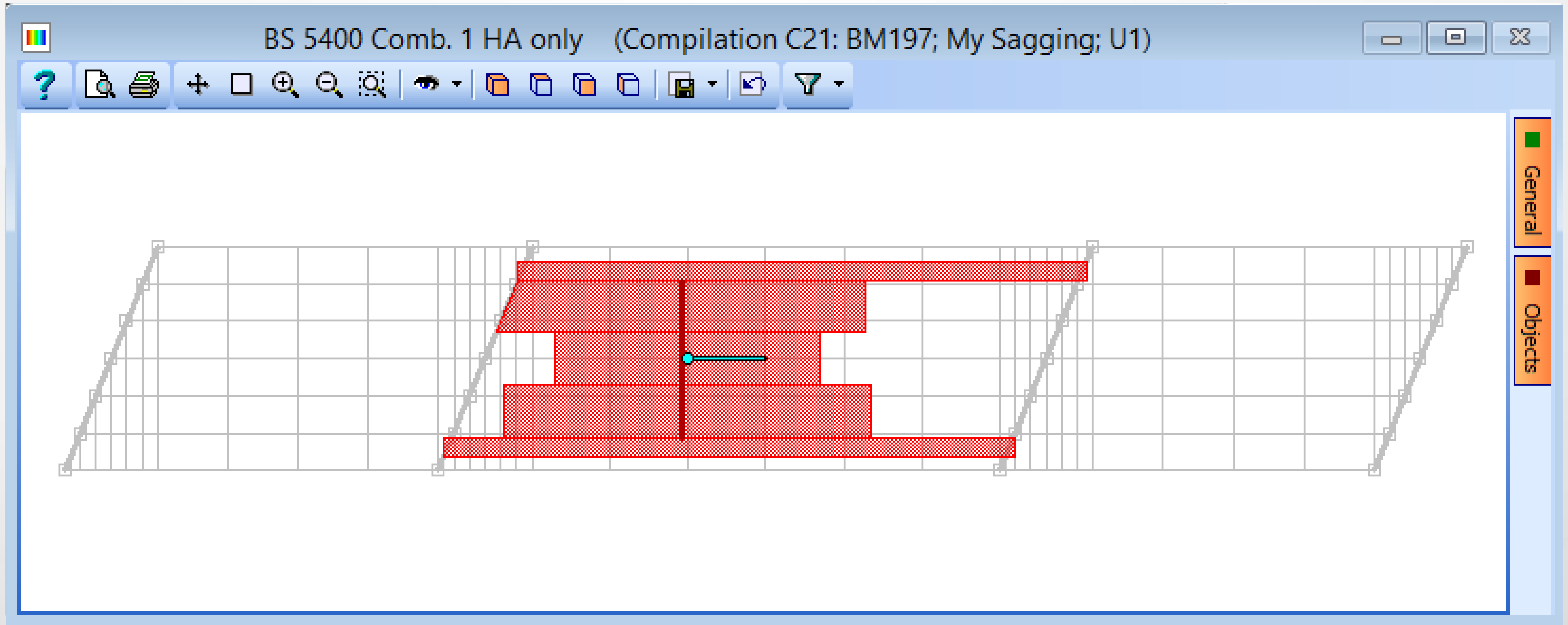
1. HA UDL + HA KE loads only
2. N units of HB Load with associated HA UDL + HA KE loads

  - These may or may not be combined with thermal loads, with different factors, forming combinations 1 and 3 according to BS5400 part 2

BS5400

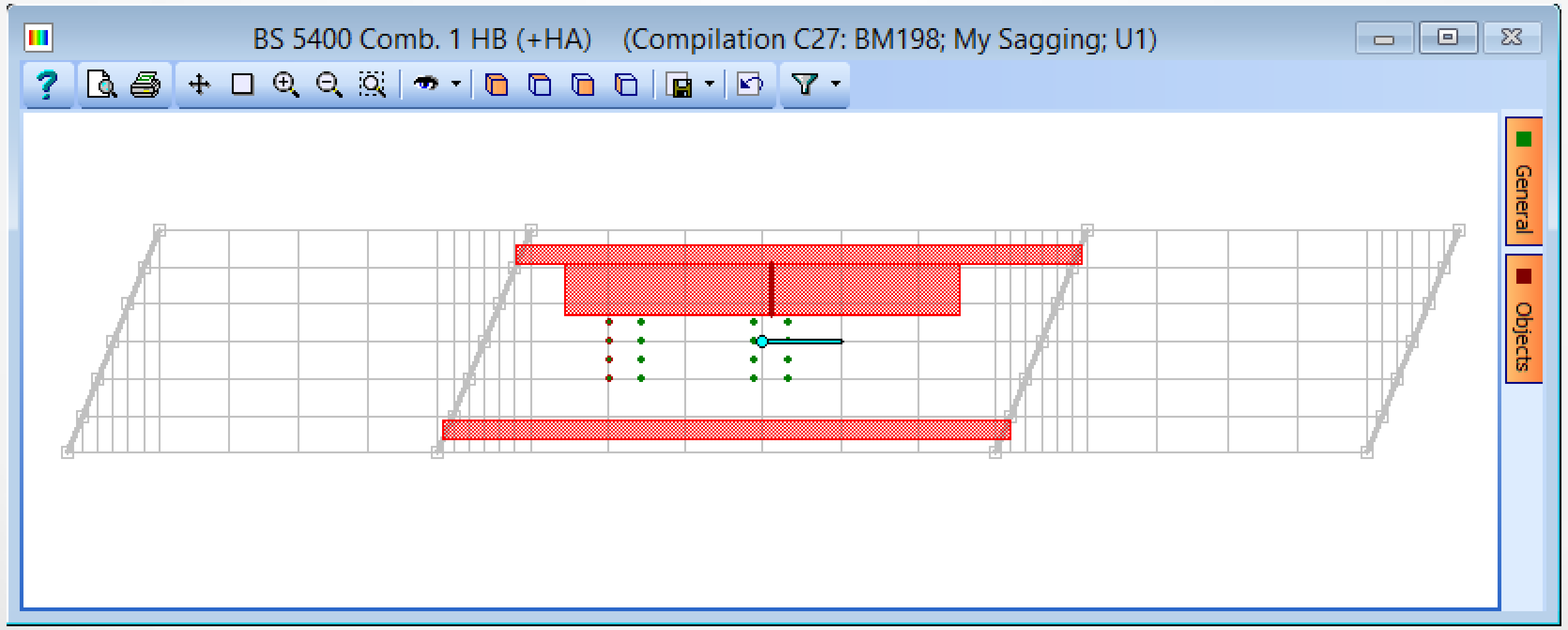
- Application of Load Models on Carriageway
  - HA Loading Only

Simply a UDL and a KEL in each lane but only applied to the adverse areas of the influence diagram. The intensity of the UDL will depend on the loaded length which is calculated from the total adverse length of influence on the deck – reduced to take into account any cusped shape of the influence diagram.


BS 5400 Comb. 1 HA only (Compilation C21: BM197; My Sagging; U1)
General
Objects

BS5400

- Application of Load Models on Carriageway
  - HB Loading with associated HA Loading
    - The deck is loaded with HA(plus KE) first and then an HB load is applied anywhere on the deck, irrespective of the notional lanes. The HB load displaces the HA + KE load such that:
      - In lanes where the HB load is encroaching then the KE load will be removed
      - In lanes where the HB load is encroaching, then, if the remaining HA width is less than 2.5m then the UDL will be truncated 25m in front and behind the HB vehicle in those lanes.

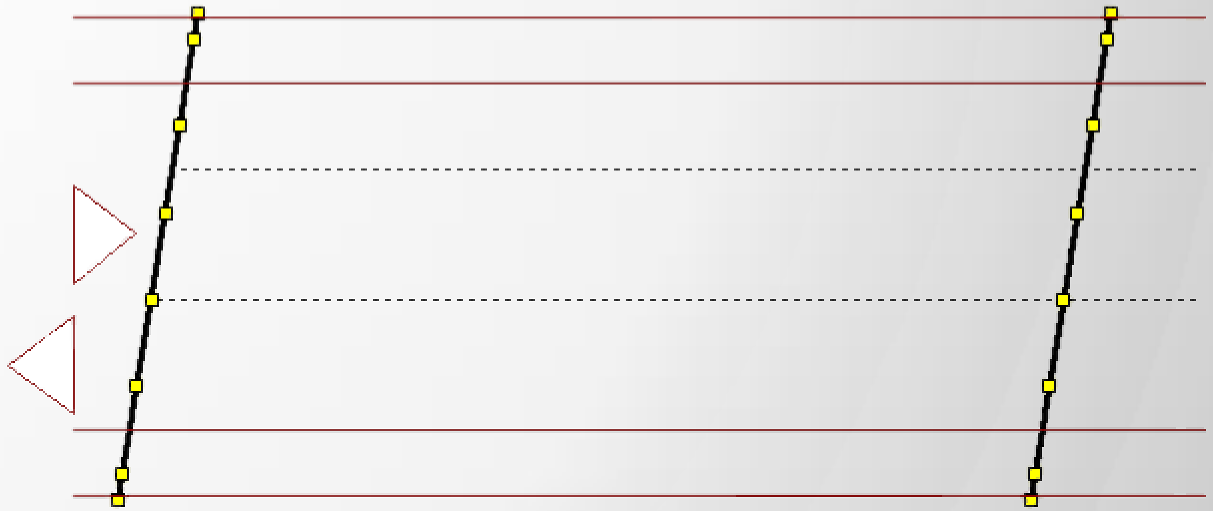

BS 5400 Comb. 1 HB (+HA)   (Compilation C27: BM198; My Sagging; U1)
General
Objects

Eurocodes

- Carriageway Layout
  - The number and widths of lanes is shown below

Carriageway width w	Number of notional Lanes	Width of a notional Lane	Width of the remaining area
w < 5.4m	n1 = 1	3m	w-3m
5.4m ≤ w < 6m	n1 = 2	w/2	0
6m ≤ w	n1 = Int(w/3)	3m	w-(3 x n1)m

  - The full width is loaded
  - Positioned transversely for max effect
  - There will generally be a remaining area
  - The lanes are ranked in order of effect



Eurocodes

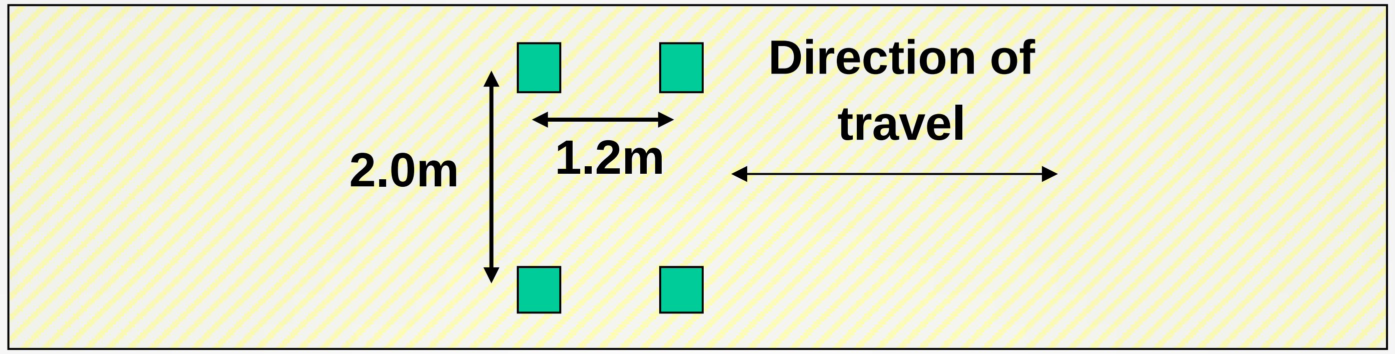
- Load Models

  - There are 4 load models specified for testing

    - LM1 – a UDL and tandem System
    - LM2 – a single axle load generally used for local verification
    - LM3 – Special Vehicles
    - LM4 – Crowd Loading

Eurocodes

- LM1



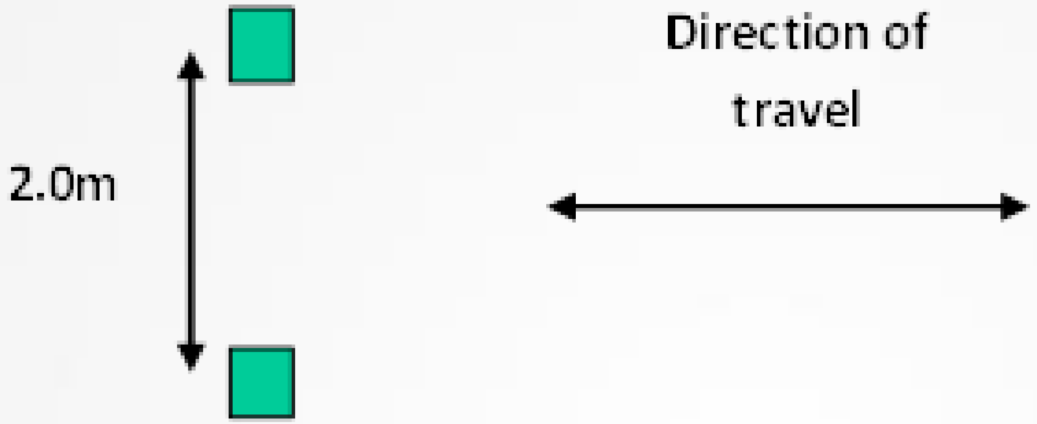
  - Each axle has a total load of $\alpha_{Qi}Q_{ik}$
  - The UDL has a value of $\alpha_{qi}q_{ik}$

Lane	Q_{ik} kN	Table A.2	q_{ik} kN/m2	α_{qi} Table A.2
1	300	1.0	9.0	0.61
2	200	1.0	2.5	2.2
3	100	1.0	2.5	2.2
Other Lanes	0	0	2.5	2.2
Remaining Areas	0	0.0	2.5	2.2

  - α_{Qi} and α_{qi} are nationally determined parameters (above are for UK)

Eurocodes

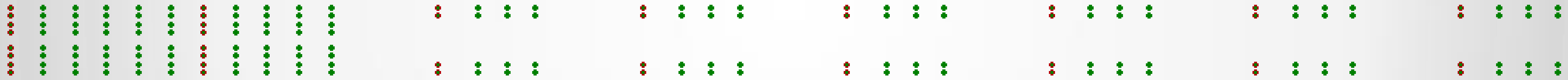
- LM2


2.0m
Direction of travel

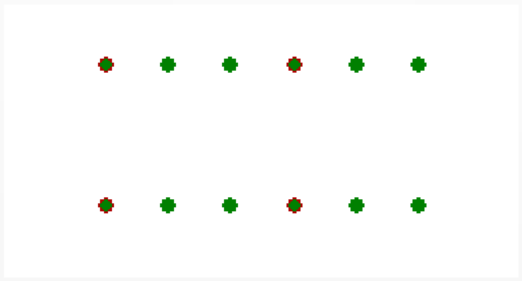
- The axle has a total load of $\beta_Q Q_{ak}$
- Q_{ak} has a value of 400kN
- β_Q is a nationally determined parameters (1.0 for UK)

Eurocodes

- LM3
  - Special Vehicle
  - Recommended vehicles and application are given in Annex A of EN1991-2
  - Most National Annexes have very specific special vehicles defined
  - The UK NA has about 40 different vehicles ranging from



  - To

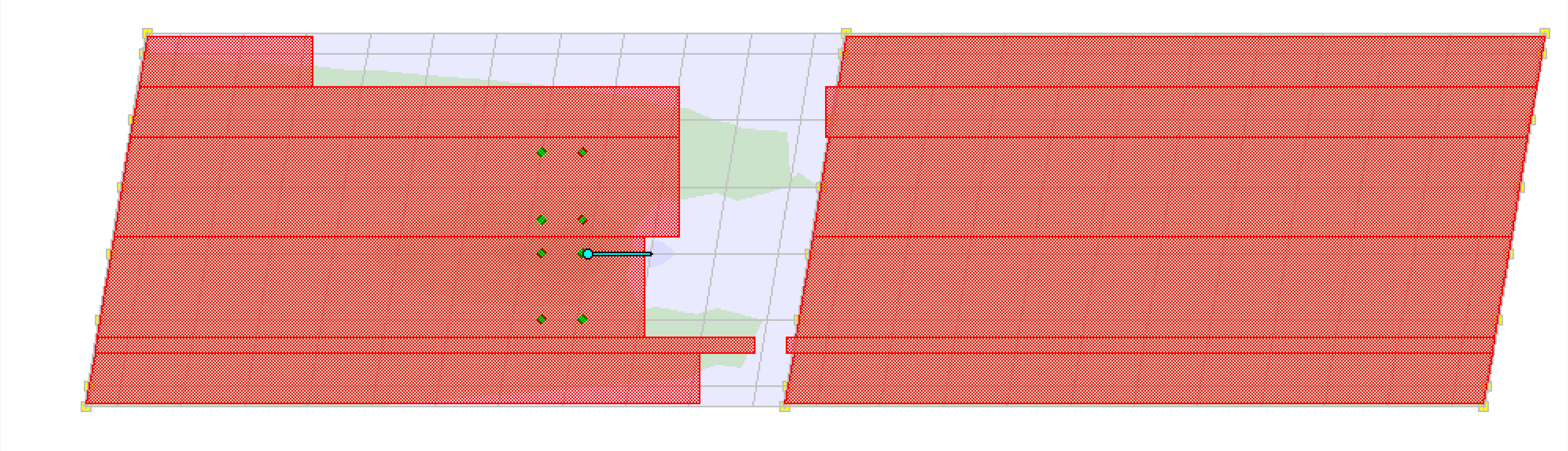


Eurocodes

- Application of Load Models on Carriageway
  - Load models are applied to the carriageway in certain combinations defined in EN1992-2
  - For vertical load it is normal to examine 3 combinations
    1. Gr1a – considers LM1 in each design lane + remaining area and footways
    2. Gr1b – considers LM2 applied anywhere on the carriageway with wheels possibly hard up against the kerb and relieving wheels removed – local verification
    3. Gr5 – is a combination of LM3 (special vehicles) and a reduced value of LM1
    4. For global design of flexure and shear it is normal to consider Gr1a and Gr5

Eurocodes

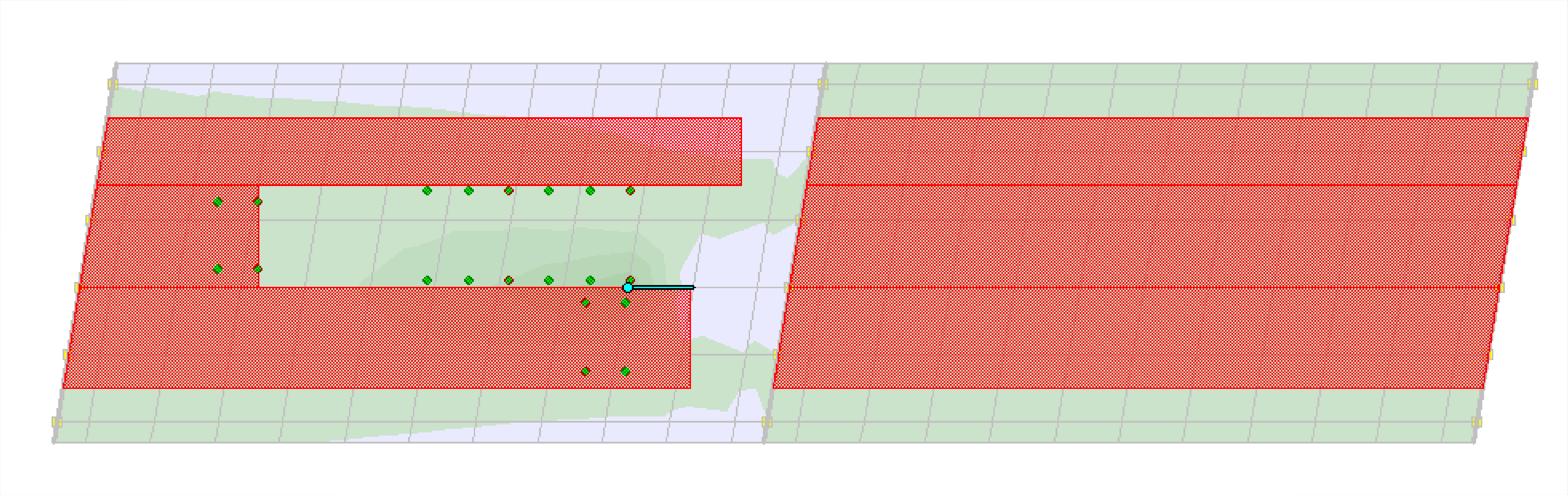
- Application of Load Models on Carriageway
  - Gr1a



  - UDL only in adverse areas – one tandem per lane
  - Lateral position of lanes adjusted to give maximum effect
  - Footway loading applied in adverse areas
  - Lane numbering defined to give max effect

Eurocodes

- Application of Load Models on Carriageway
  - Gr5



  - Only One LM3 on the structure
  - LM1 loading reduced to from characteristic to “frequent” values
  - LM3 vehicle can straddle lanes but may reduce LM1 effects
  - Clear distance in front and behind of LM3
  - No footway loading

AS5100 (Australian)

- Design Lanes on Roadway
  - The number and widths of lanes is shown below

Road width w	No. of notional Lanes	Width of lane
w > 3.2m	n = int(w/3.2)	3.2m

  - The lanes shall be position laterally to produce maximum effect
  - Remaining areas are unloaded
  - For some loads (A160, M/S1600) there are accompanying lane factors

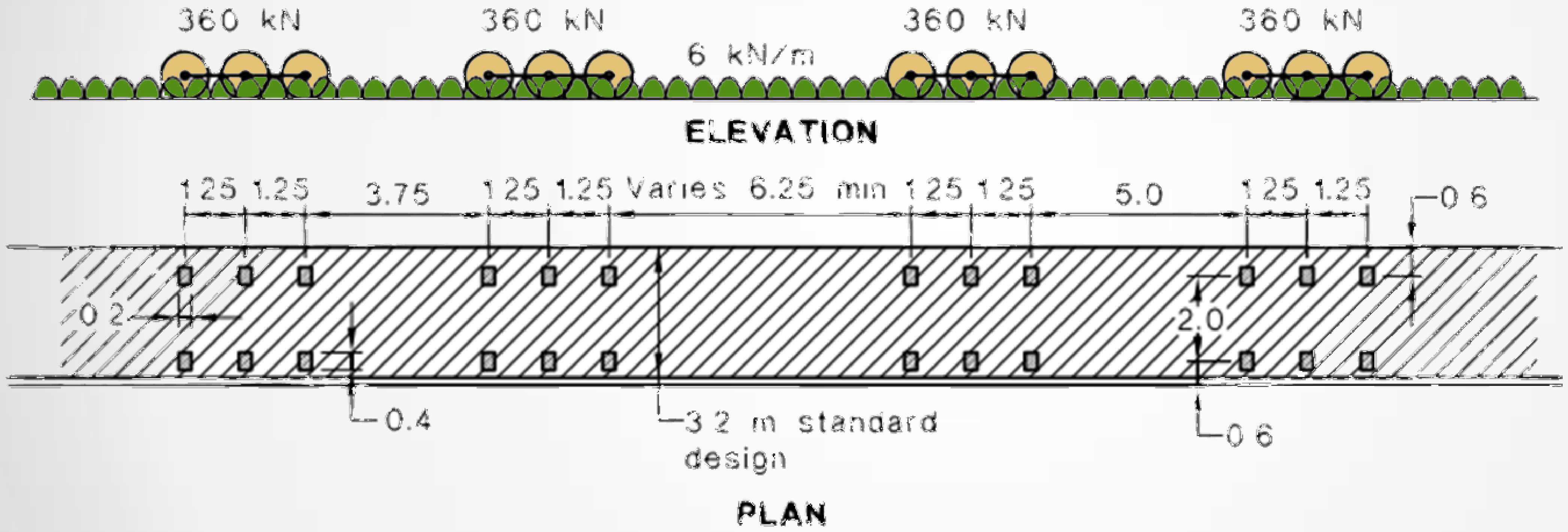
Standard Design Lane number n	**Accompanying Lane Factor ALF**
1 Lane Loaded	1.0
2 Lanes Loaded	1.0 for first lane , and 0.8 for second lane
3 or More lanes loaded	1.0 for first lane 0.8 for second lane 0.4 for third and subsequent lanes

AS5100 (Australian)

- Load Models
  - There are 5 load models specified for validation
    - W80 – a single Wheel Load of 80kN
    - A160 – a single axle of 160kN with two wheels 2m apart
    - M1600 – Moving Traffic Load
    - S1600 – Stationary Traffic Load
    - HLP320/400 – Heavy Load Platform

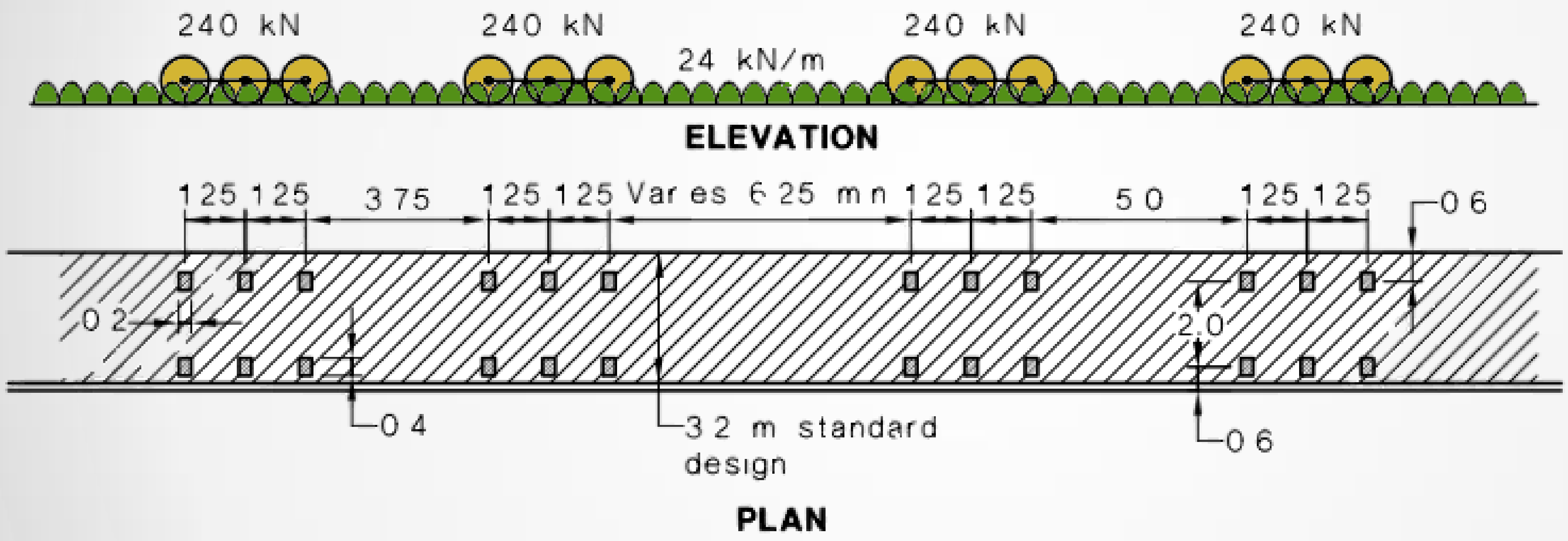
AS5100 (Australian)

- Load Models – M1600


360 kN
360 kN
6 kN/m
360 kN
360 kN
ELEVATION
1.25 1.25
3.75
1.25 1.25
Varies 6.25 min
1.25 1.25
5.0
1.25 1.25
0.6
0.2
2.0
0.4
3.2 m standard design
0.6
PLAN

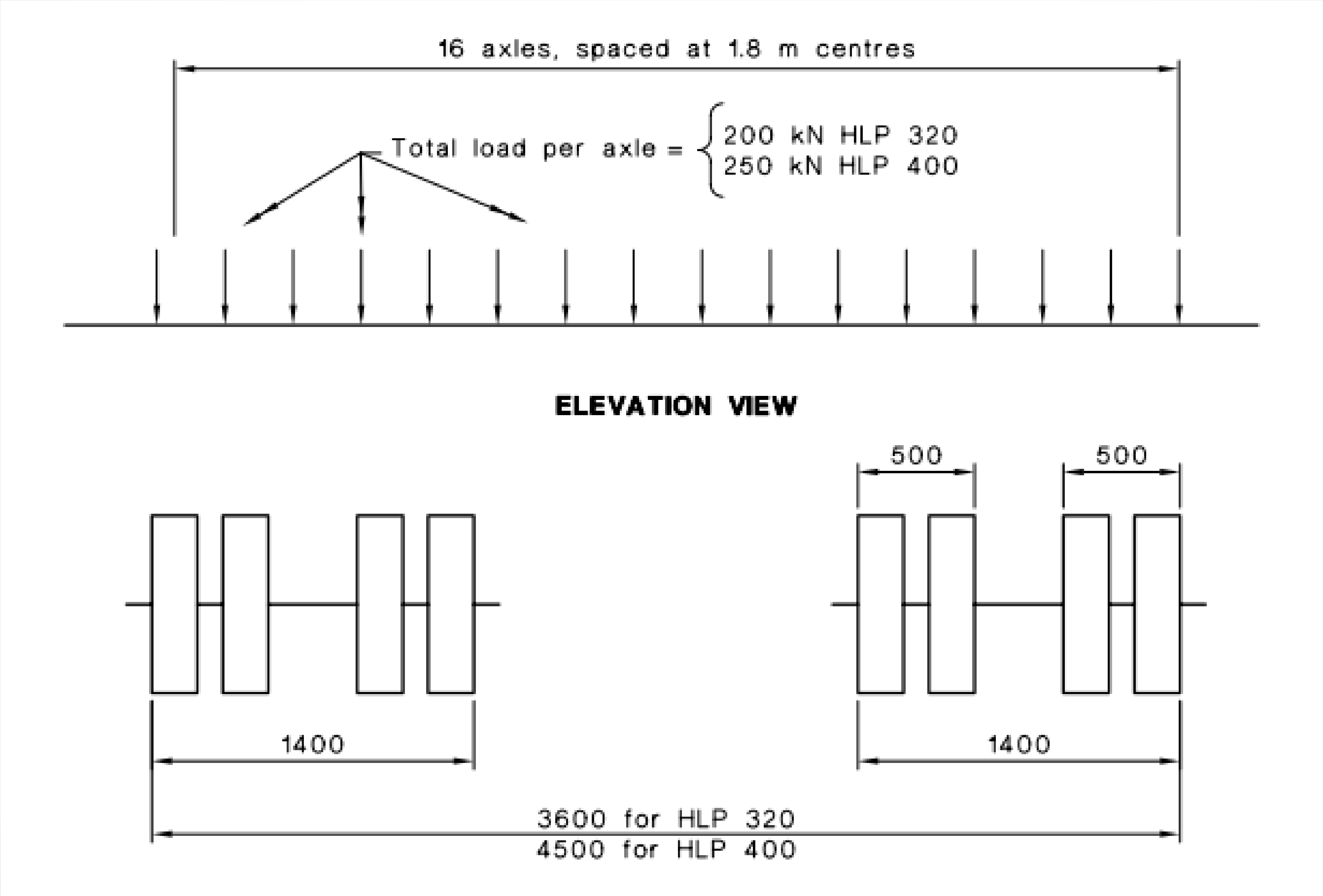
AS5100 (Australian)

- Load Models – S1600


240 kN
240 kN
24 kN/m
240 kN
240 kN
ELEVATION
1 25 1 25
3 75
1 25 1 25
Varies 6 25 min
1 25 1 25
5 0
1 25 1 25
0 6
0 2
2.0
0 4
3 2 m standard design
0 6
PLAN

AS5100 (Australian)

- Heavy Load Platform HLP320 or HLP400
  - My be specified by authority but configuration specified in AS5100.7

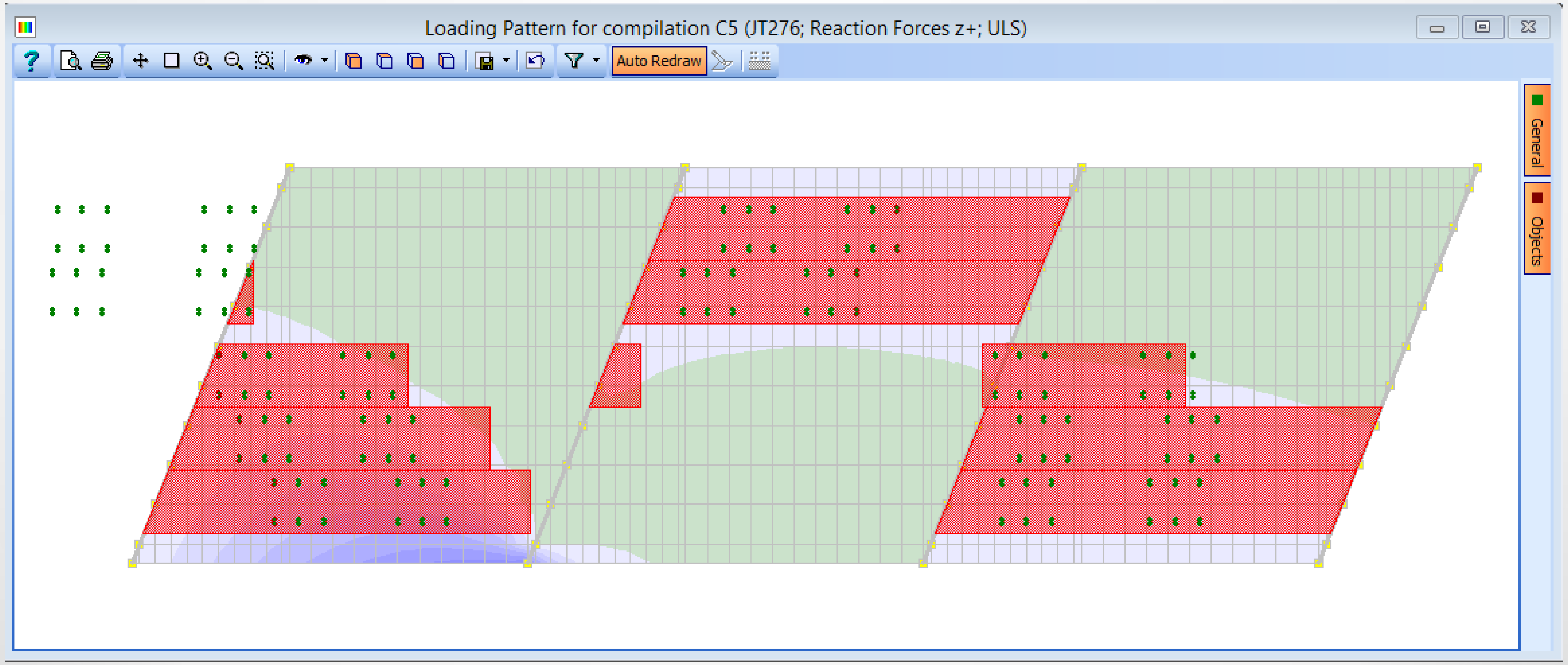

16 axles, spaced at 1.8 m centres
Total load per axle = 200 kN HLP 320
250 kN HLP 400
ELEVATION VIEW
500
500
1400
1400
3600 for HLP 320
4500 for HLP 400

Eurocodes

- Application of Load Models on Roadway
    - Load models are applied to the carriageway in certain combinations defined in AS5100.2 section 22
    - For Ultimate Limit State footway and traffic are treated separately
    - For Service Limit States they are combined with a factor
    - Each Traffic model is applied in turn and the most adverse selected
        - The W80 wheel load is applied once anywhere on the roadway with an appropriate DAF
        - The A160 axle load is applied once in each design lane with a DAF with the lanes in the most adverse lateral position and the most adverse number of lanes loaded should be considered

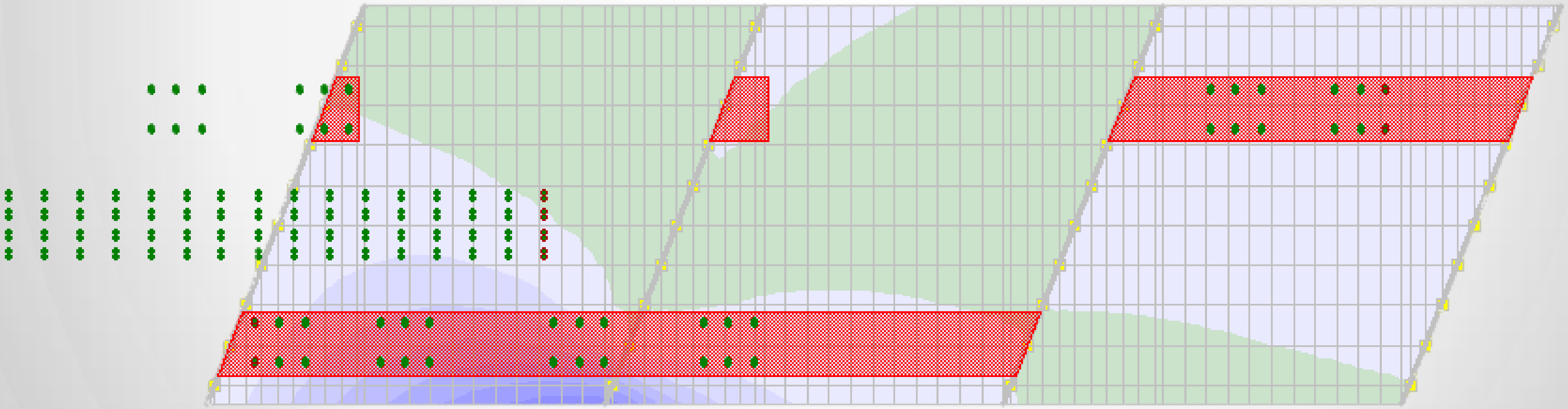
Eurocodes

- Application of Load Models on Roadway
  - The M1600 or S1600 Truck is applied in each design lane with the variable spacing of the axes set to give the most adverse effect
  - The UDL shall be place only in adverse areas of the influence diagram
  - The number of lanes loaded should be chosen to give the most adverse effect


Loading Pattern for compilation C5 (JT276; Reaction Forces z+; ULS)
Auto Redraw
General
Objects

Eurocodes

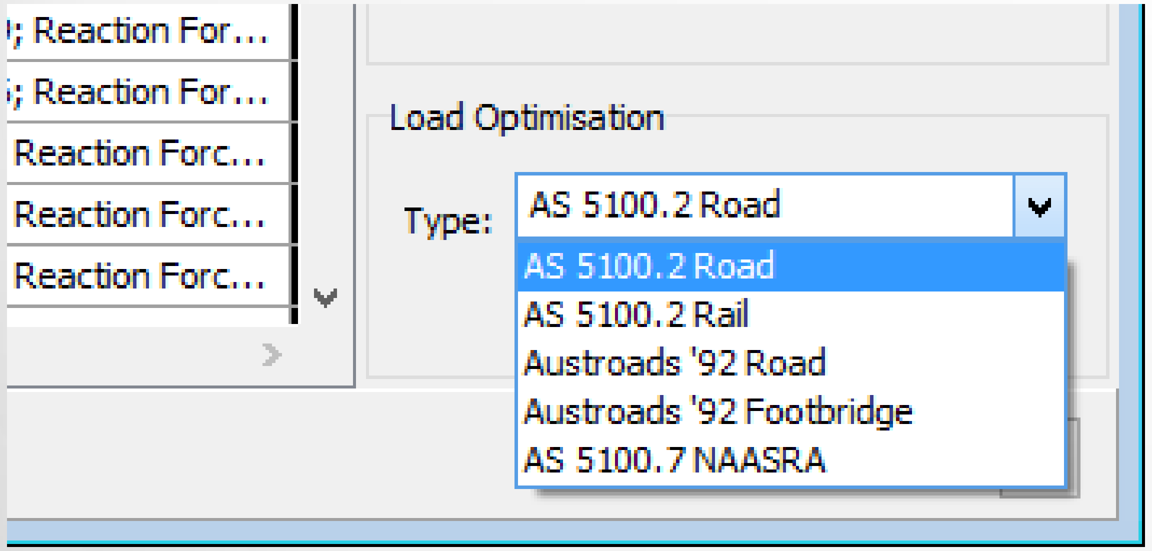
- Application of Load Models on Roadway
  - The HLP loads shall be positioned laterally (+/- 1.0m) as specified by the authority and is assumed to occupy two design lanes.
  - Any unobstructed lanes should be loaded with M/S1600 loading unless the authority specifies otherwise
  - For continuous decks the HLP should be split into two with variable spacing.



Traffic Load Optimisation in Structural Bridge Design

General Procedure

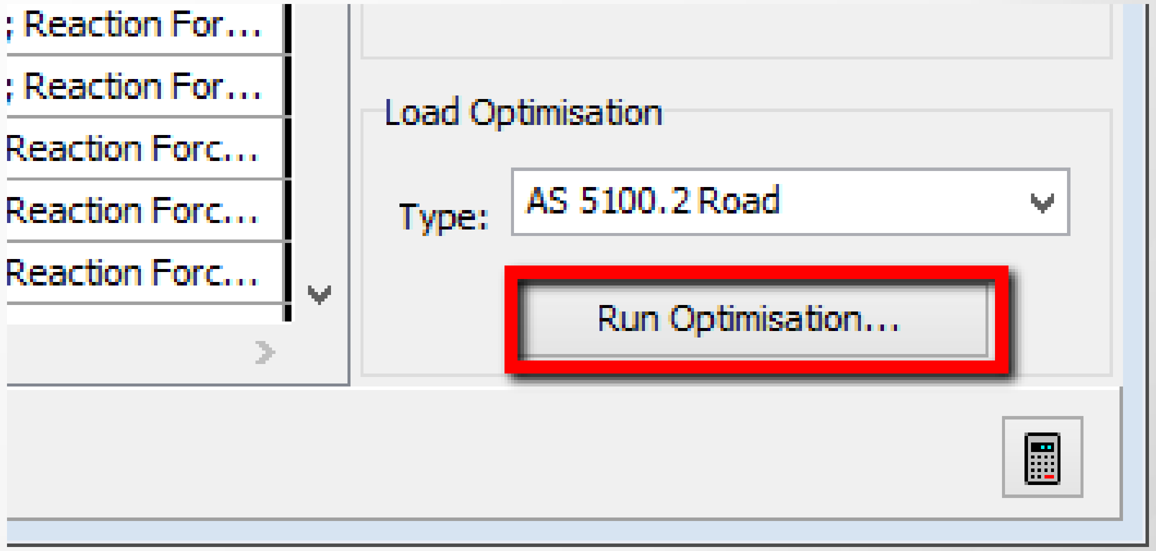
- Selecting a set of influences
  - Influences can be analysed one by one but it is more usual to specify a group that relate to a particular set of design features for a particular component of the structure. For example, the moment analysis for all points along a girder in a particular span.
  - Once the influences surfaces have been produced we open the Load Optimisation form by selecting the “Type” and then clicking on the “Run Optimisation” button



Load Optimisation

Type: AS 5100.2 Road

; Reaction For...
; Reaction For...
Reaction Forc...
Reaction Forc...
Reaction Forc...
AS 5100.2 Road
AS 5100.2 Rail
Austroads '92 Road
Austroads '92 Footbridge
AS 5100.7 NAASRA



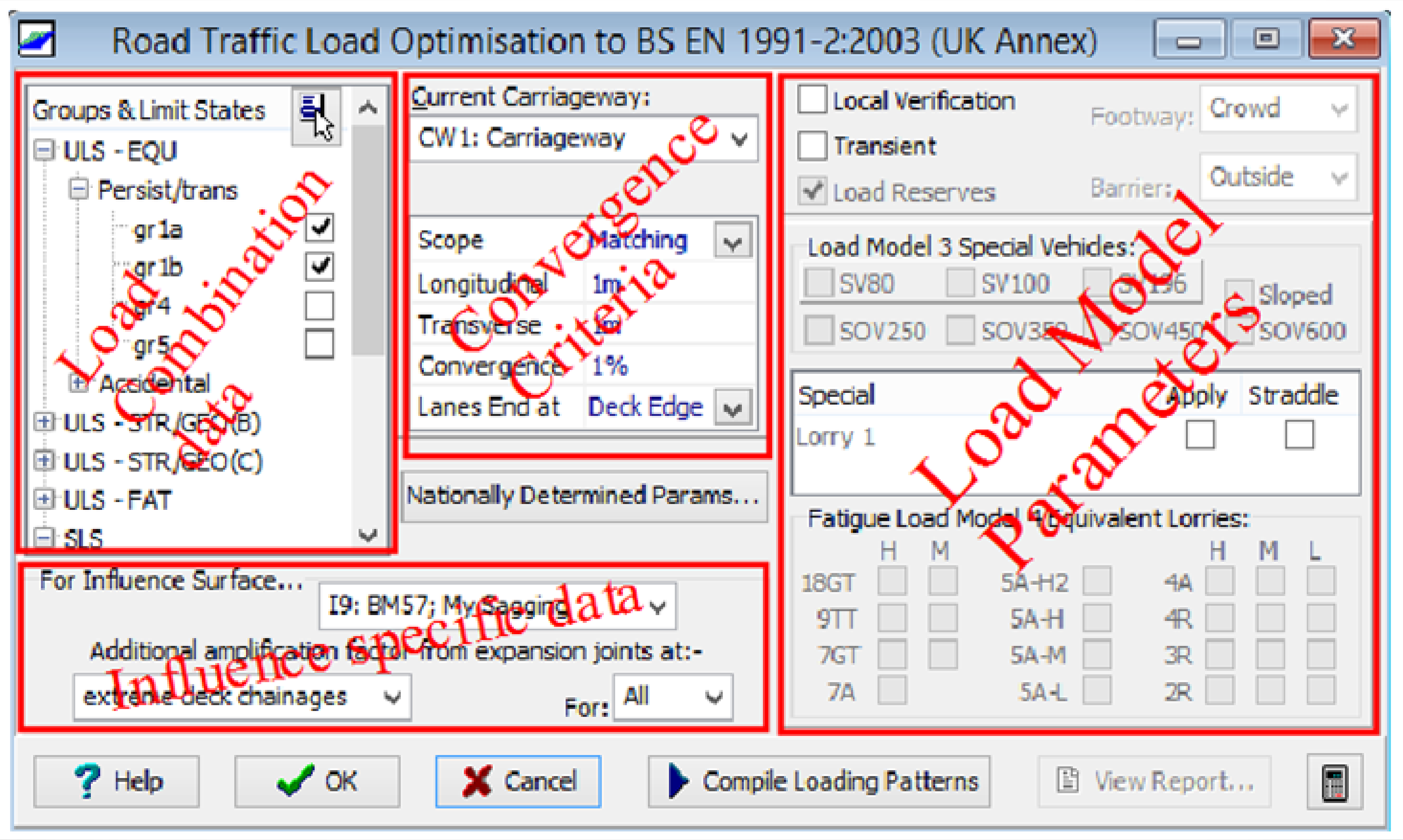
Load Optimisation

Type: AS 5100.2 Road

; Reaction For...
; Reaction For...
Reaction Forc...
Reaction Forc...
Reaction Forc...
Run Optimisation...

General Procedure

- Setting the parameters
  - Many of the parameters are design code specific and the form may look different for each standard, but, the form is generally arranged so that certain parameters are in groups, as shown below



Road Traffic Load Optimisation to BS EN 1991-2:2003 (UK Annex)

Current Carriageway: CW1: Carriageway

Scope: Matching
Longitudinal: 1m
Transverse: 1m
Convergence: 1%
Lanes End at: Deck Edge

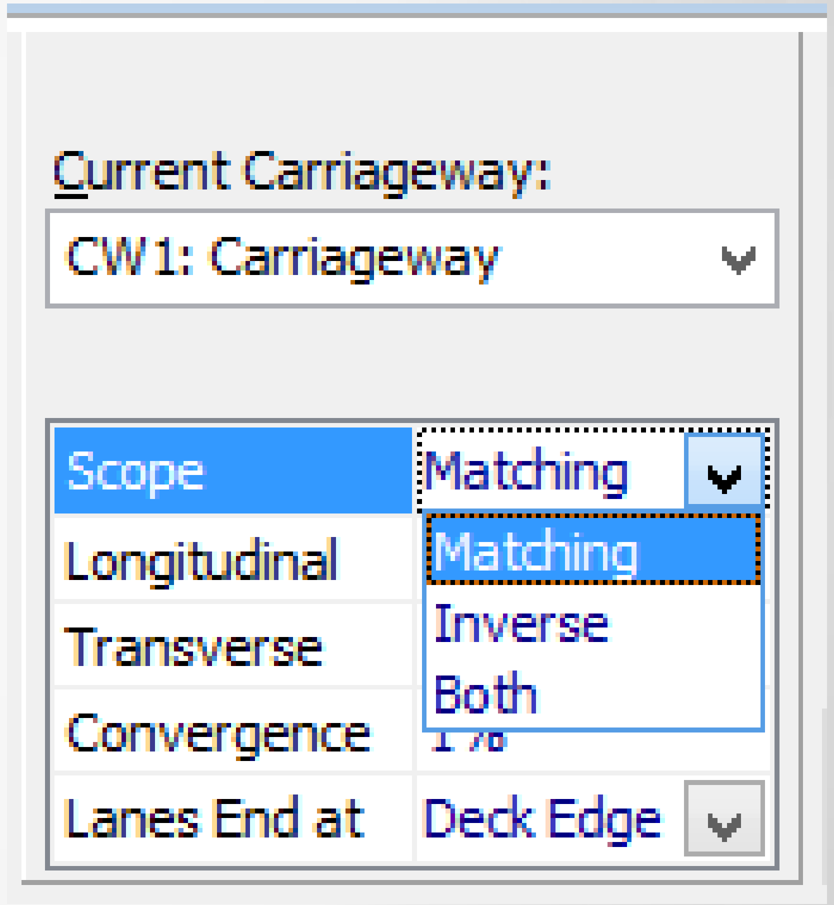
☐ Local Verification
☐ Transient
☑ Load Reserves
Footway: Crowd
Barrier: Outside

For Influence Surface... I9: BM57; My Sagging
Additional amplification factor from expansion joints at:- extreme deck chainages
For: All

Groups & Limit States
ULS - EQU
Persist/trans
gr1a ☑
gr1b ☑
gr4 ☐
gr5 ☐
Accidental
ULS - STR/GEO(B)
ULS - STR/GEO(C)
ULS - FAT
SLS
Nationally Determined Params...
Load Model 3 Special Vehicles:
☐ SV80
☐ SV100
☐ SV196
☐ Sloped
☐ SOV250
☐ SOV350
☐ SOV450
☐ SOV600
Special
Apply
Straddle
Lorry 1 ☐ ☐
Fatigue Load Model 4 Equivalent Lorries:
H
M
18GT
9TT
7GT
7A
5A-H2
5A-H
5A-M
5A-L
H
M
L
4A
4R
3R
2R
Help
OK
Cancel
Compile Loading Patterns
View Report...
Load Combination data
Convergence Criteria
Load Model Parameters
Influence specific data

General Procedure

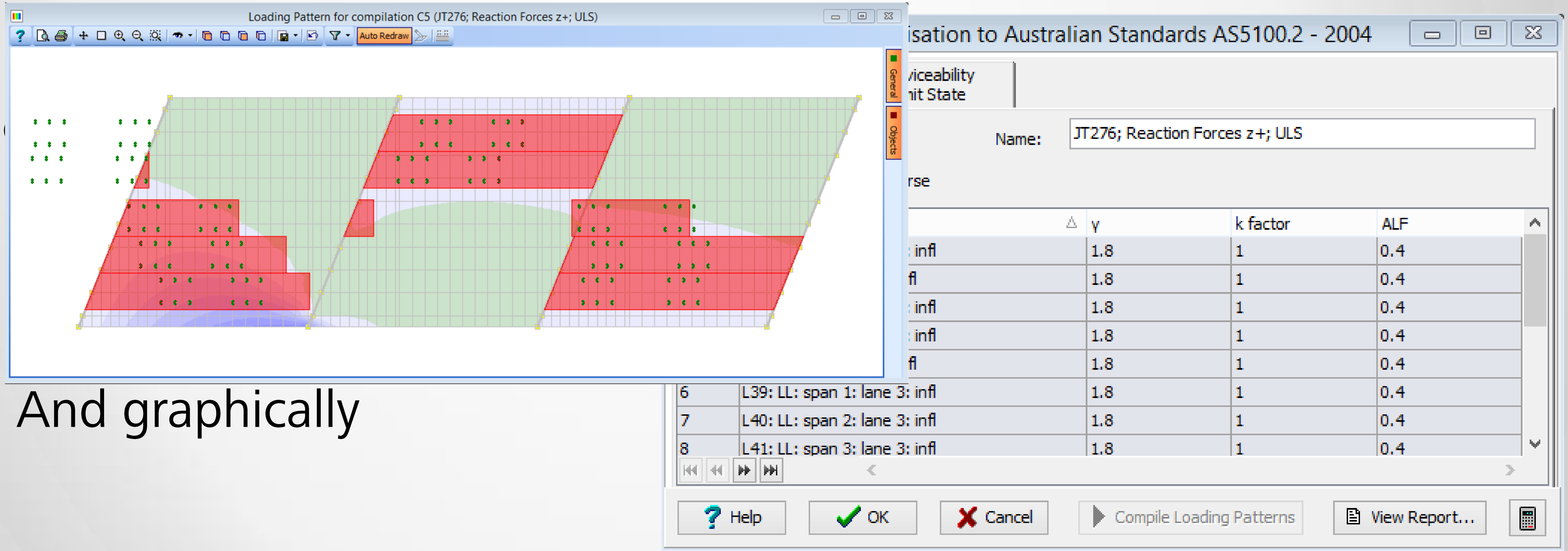
- Convergence parameters
  - Carriageway selection if multi defined
  - Scope – matching, inverse, both
  - Initial Longitudinal increment of vehicles
  - Initial transverse increment of vehicles
  - Convergence – criteria for accuracy
  - Lane loading extends to either deck ends or span end lines


Current Carriageway: CW1: Carriageway

Scope	Matching
Longitudinal	
Transverse	
Convergence	
Lanes End at	Deck Edge

General Procedure

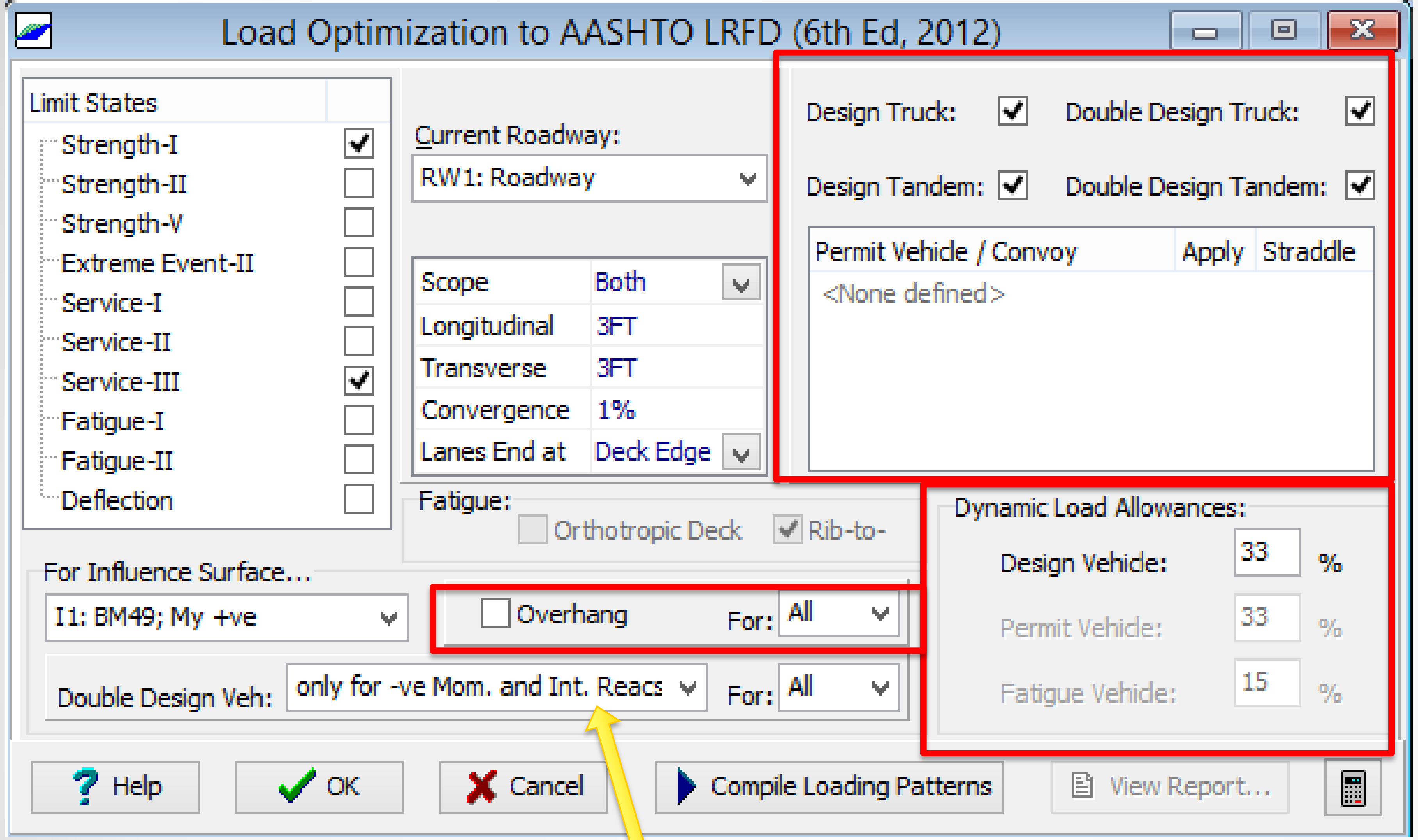
- Analysis and Results
  - Once the parameters are set then then clicking on “Compile Loading Patterns” will start the optimisation process for all the influences in the influence table.
  - And graphically


Loading Pattern for compilation C5 (JT276; Reaction Forces z+; ULS)
Auto Redraw
General
Objects
isation to Australian Standards AS5100.2 - 2004
viceability
nit State
rse
Help
OK
Cancel
Compile Loading Patterns
View Report...

Name: JT276; Reaction Forces z+; ULS

		γ	k factor	ALF
	: infl	1.8	1	0.4
	fl	1.8	1	0.4
	: infl	1.8	1	0.4
	: infl	1.8	1	0.4
	fl	1.8	1	0.4
6	L39: LL: span 1: lane 3: infl	1.8	1	0.4
7	L40: LL: span 2: lane 3: infl	1.8	1	0.4
8	L41: LL: span 3: lane 3: infl	1.8	1	0.4

Parameters for AASHTO Bridges


Load Optimization to AASHTO LRFD (6th Ed, 2012)
Help
OK
Cancel
Compile Loading Patterns
View Report...

Limit States
Strength-I ☑
Strength-II ☐
Strength-V ☐
Extreme Event-II ☐
Service-I ☐
Service-II ☐
Service-III ☑
Fatigue-I ☐
Fatigue-II ☐
Deflection ☐

Current Roadway: RW1: Roadway

Scope	Both
Longitudinal	3FT
Transverse	3FT
Convergence	1%
Lanes End at	Deck Edge

Fatigue: ☐ Orthotropic Deck ☑ Rib-to-

Design Truck: ☑ Double Design Truck: ☑
Design Tandem: ☑ Double Design Tandem: ☑

Permit Vehicle / Convoy	Apply	Straddle
<None defined>		

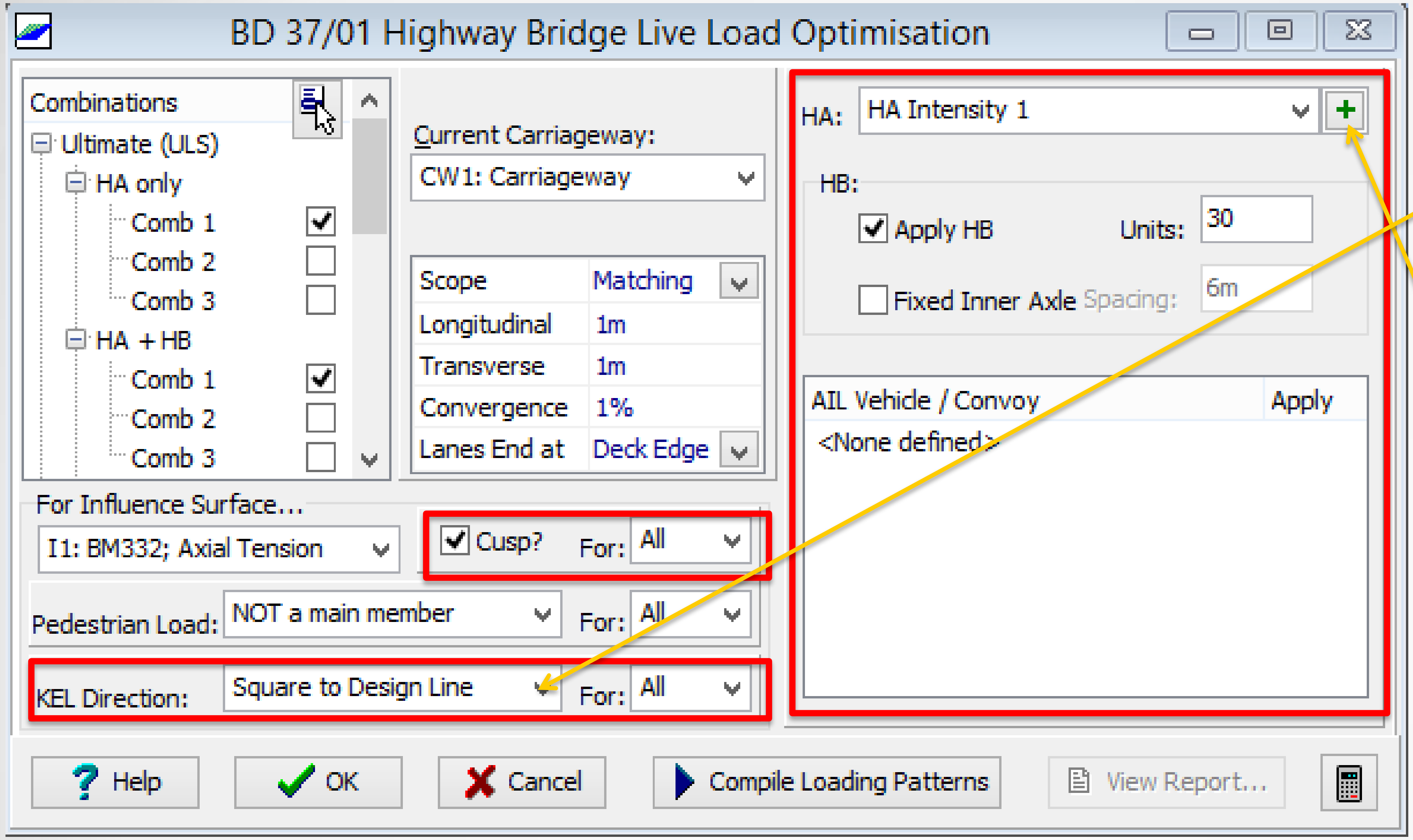
Dynamic Load Allowances:
Design Vehicle: 33 %
Permit Vehicle: 33 %
Fatigue Vehicle: 15 %

For Influence Surface...
I1: BM49; My +ve
☐ Overhang For: All
Double Design Veh: only for -ve Mom. and Int. Reacs For: All

- Select Overhang / Dynamic Allowance / Design Vehicles

  [illegible] ranges for the “Design Vehicle” in accordance with Article 3.6.1.3.1

Parameters for BS5400 Bridges



BD 37/01 Highway Bridge Live Load Optimisation
Combinations
Ultimate (ULS)
HA only
Comb 1 ☑
Comb 2 ☐
Comb 3 ☐
HA + HB
Comb 1 ☑
Comb 2 ☐
Comb 3 ☐
? Help
OK
Cancel
Compile Loading Patterns
View Report...

Current Carriageway: CW1: Carriageway

Scope	Matching
Longitudinal	1m
Transverse	1m
Convergence	1%
Lanes End at	Deck Edge

For Influence Surface... I1: BM332; Axial Tension

☑ Cusp? For: All

Pedestrian Load: NOT a main member For: All

KEL Direction: Square to Design Line For: All

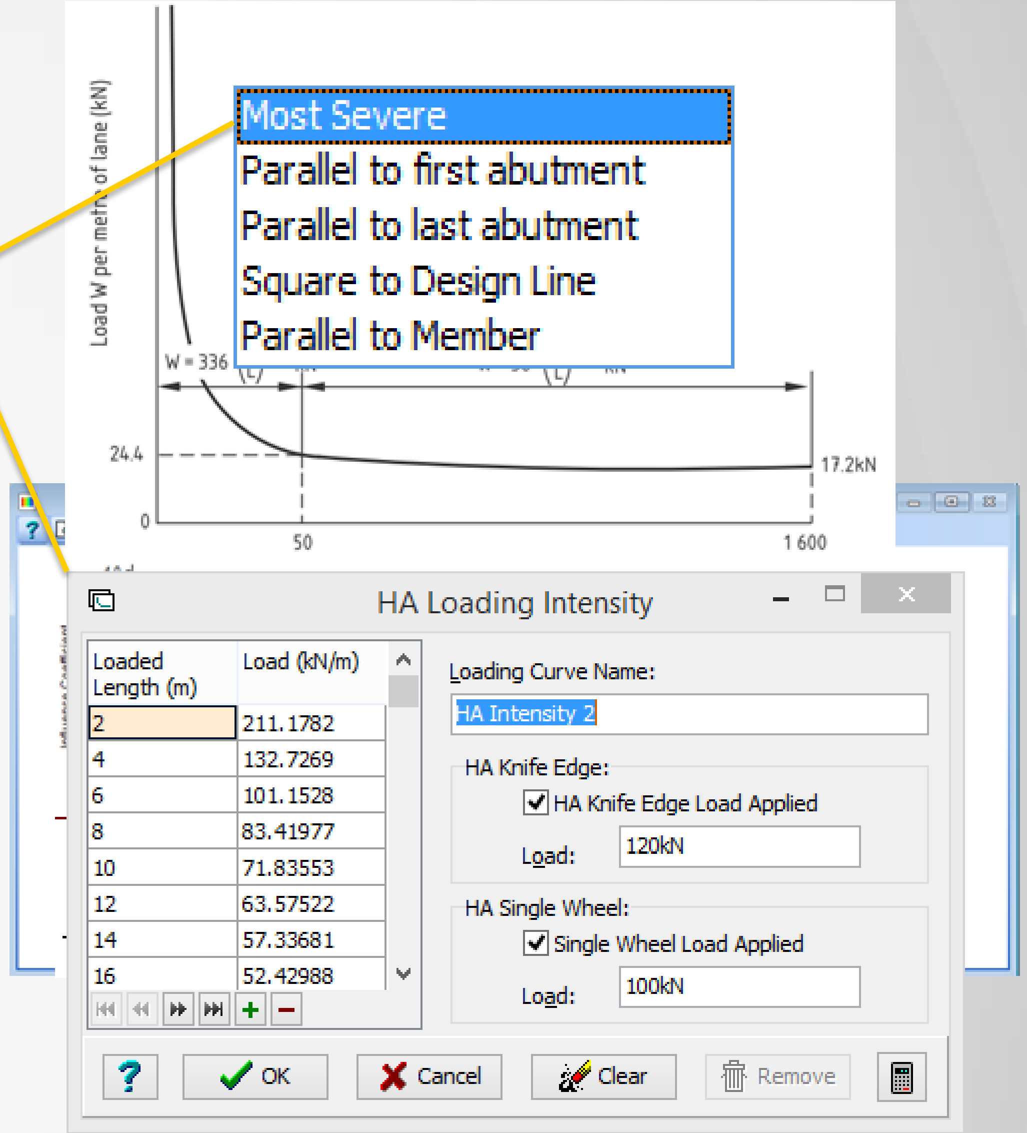
HA: HA Intensity 1

HB:

☑ Apply HB Units: 30

☐ Fixed Inner Axle Spacing: 6m

AIL Vehicle / Convoy	Apply
<None defined>	



Load W per metre of lane (kN)
W = 336
24.4
0
50
1 600
17.2kN
Most Severe
Parallel to first abutment
Parallel to last abutment
Square to Design Line
Parallel to Member
HA Loading Intensity
OK
Cancel
Clear
Remove

Loaded Length (m)	Load (kN/m)
2	211.1782
4	132.7269
6	101.1528
8	83.41977
10	71.83553
12	63.57522
14	57.33681
16	52.42988

Loading Curve Name: HA Intensity 2

HA Knife Edge:

☑ HA Knife Edge Load Applied

Load: 120kN

HA Single Wheel:

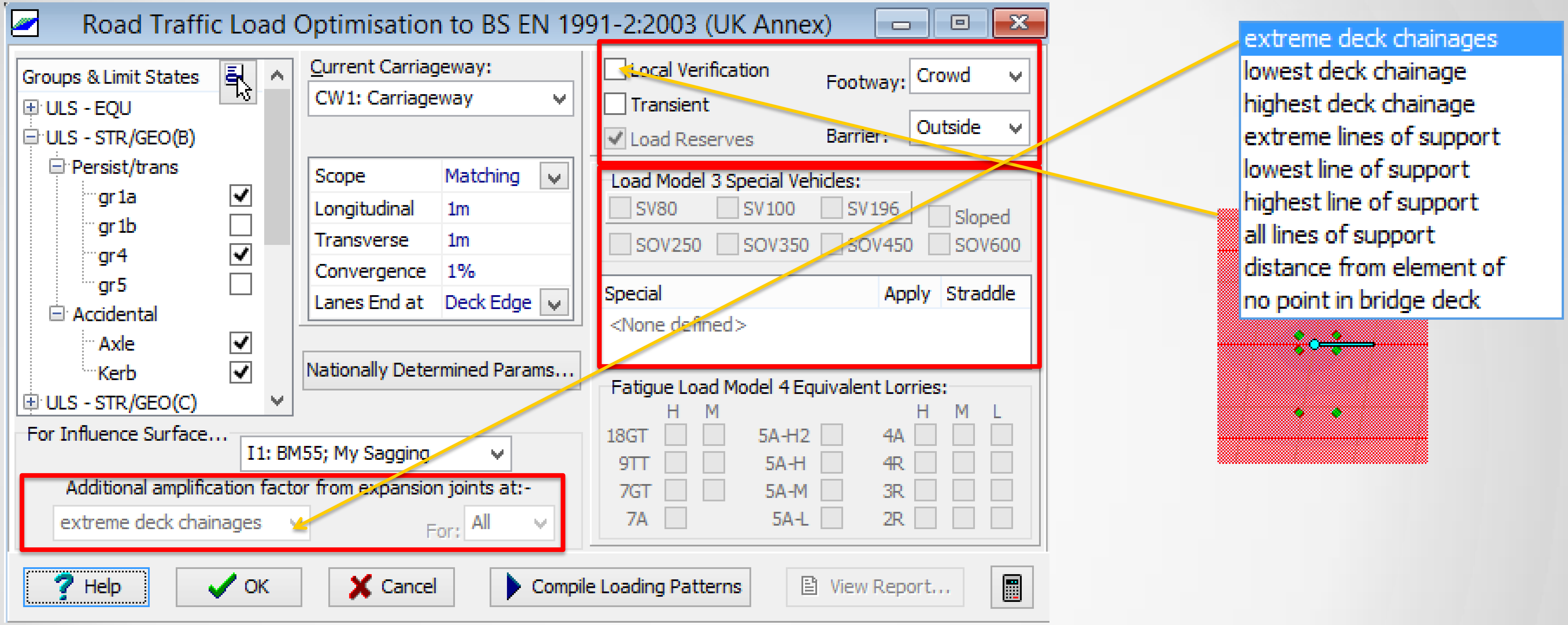
☑ Single Wheel Load Applied

Load: 100kN

- [illegible]aces

  [illegible] variable axle spacing to a set value.

Parameters for Eurocode Bridges



Road Traffic Load Optimisation to BS EN 1991-2:2003 (UK Annex)

Groups & Limit States
- ULS - EQU
- ULS - STR/GEO(B)
  - Persist/trans
    - gr1a ☑
    - gr1b ☐
    - gr4 ☑
    - gr5 ☐
  - Accidental
    - Axle ☑
    - Kerb ☑
- ULS - STR/GEO(C)

Current Carriageway: CW1: Carriageway

Scope	Matching
Longitudinal	1m
Transverse	1m
Convergence	1%
Lanes End at	Deck Edge

☐ Local Verification
☐ Transient
☑ Load Reserves

Footway: Crowd

Barrier: Outside

Load Model 3 Special Vehicles:

☐ SV80 ☐ SV100 ☐ SV196 ☐ Sloped
☐ SOV250 ☐ SOV350 ☐ SOV450 ☐ SOV600

Special	Apply	Straddle
<None defined>		

Fatigue Load Model 4 Equivalent Lorries:

	H	M			H	M	L
18GT	☐	☐	5A-H2 ☐	4A	☐	☐	☐
9TT	☐	☐	5A-H ☐	4R	☐	☐	☐
7GT	☐	☐	5A-M ☐	3R	☐	☐	☐
7A	☐		5A-L ☐	2R	☐	☐	☐

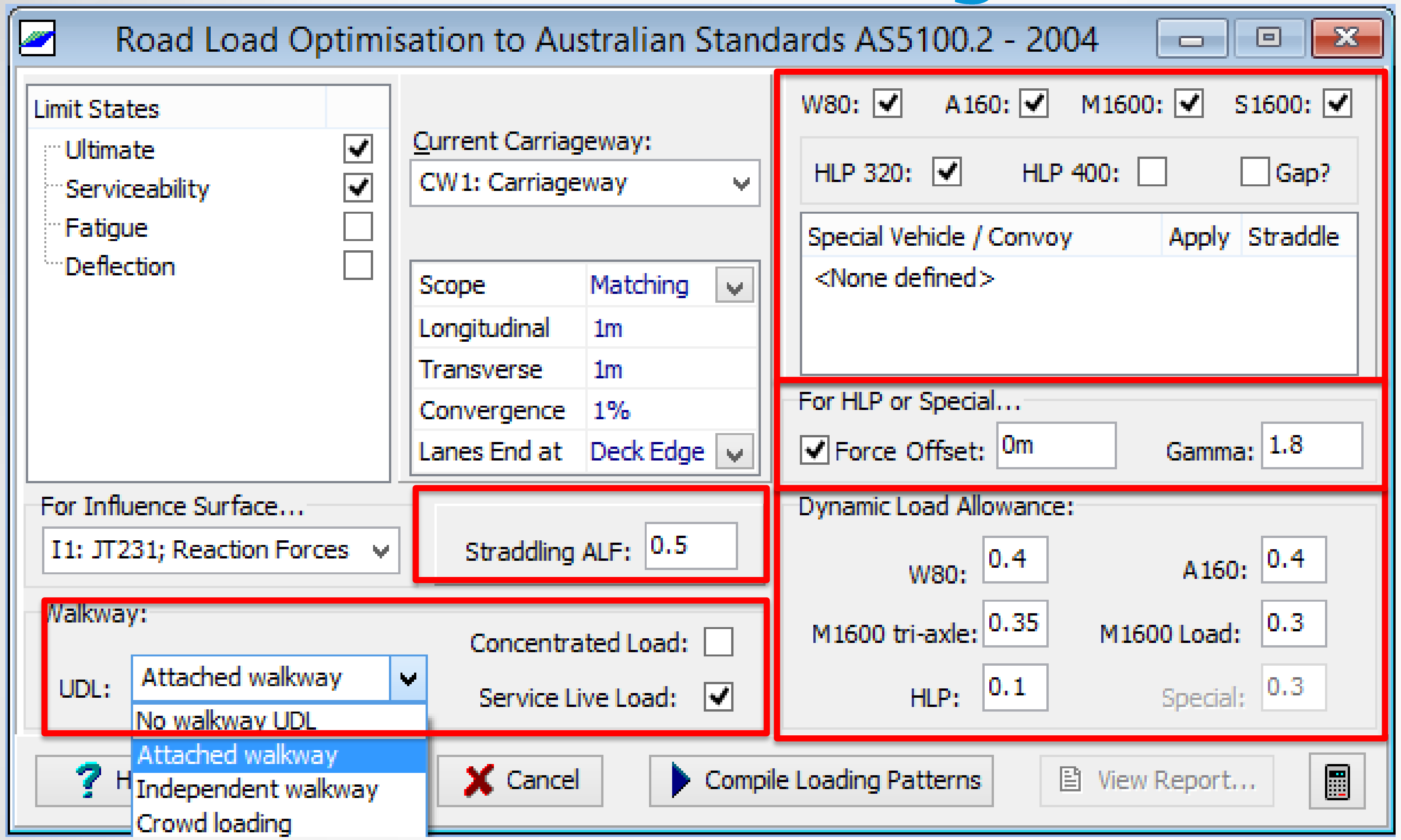
For Influence Surface… I1: BM55; My Sagging

Additional amplification factor from expansion joints at:- extreme deck chainages For: All

extreme deck chainages
lowest deck chainage
highest deck chainage
extreme lines of support
lowest line of support
highest line of support
all lines of support
distance from element of
no point in bridge deck

- [illegible] Amplification Factors
- Load Model 3 special vehicles [illegible] National Annex [illegible] local verification.

Parameters for AS5100 Bridges


Road Load Optimisation to Australian Standards AS5100.2 - 2004
Cancel
Compile Loading Patterns
View Report...

Limit States
- Ultimate ☑
- Serviceability ☑
- Fatigue ☐
- Deflection ☐

Current Carriageway: CW1: Carriageway

Scope	Matching
Longitudinal	1m
Transverse	1m
Convergence	1%
Lanes End at	Deck Edge

W80: ☑ A160: ☑ M1600: ☑ S1600: ☑

HLP 320: ☑ HLP 400: ☐ ☐ Gap?

Special Vehicle / Convoy	Apply	Straddle
<None defined>		

For HLP or Special...

☑ Force Offset: 0m Gamma: 1.8

For Influence Surface... I1: JT231; Reaction Forces

Straddling ALF: 0.5

Dynamic Load Allowance:

W80: 0.4
A160: 0.4
M1600 tri-axle: 0.35
M1600 Load: 0.3
HLP: 0.1
Special: 0.3

Walkway:

UDL: Attached walkway (No walkway UDL / Attached walkway / Independent walkway / Crowd loading)

Concentrated Load: ☐

Service Live Load: ☑

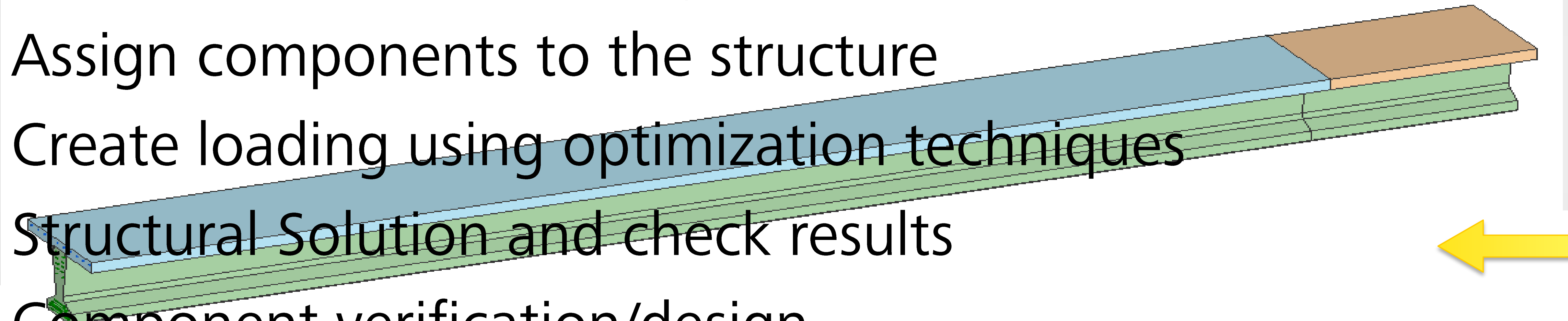
- [illegible]

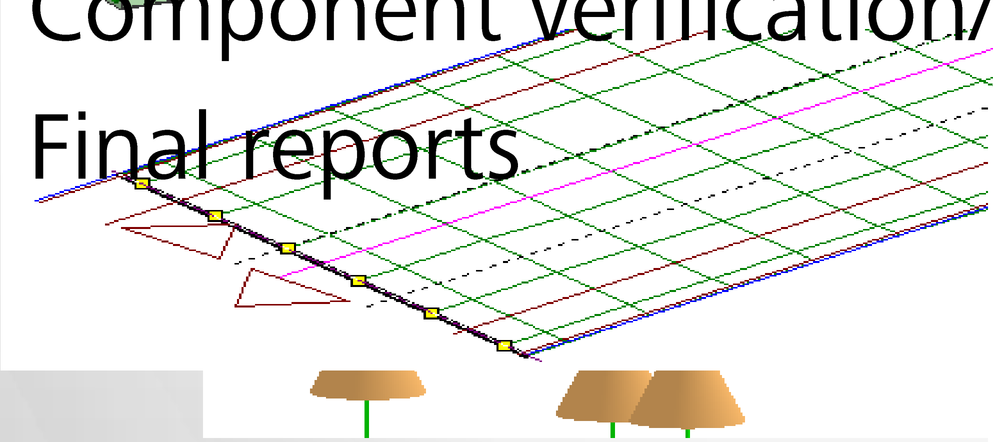
  [illegible] that is [illegible] option

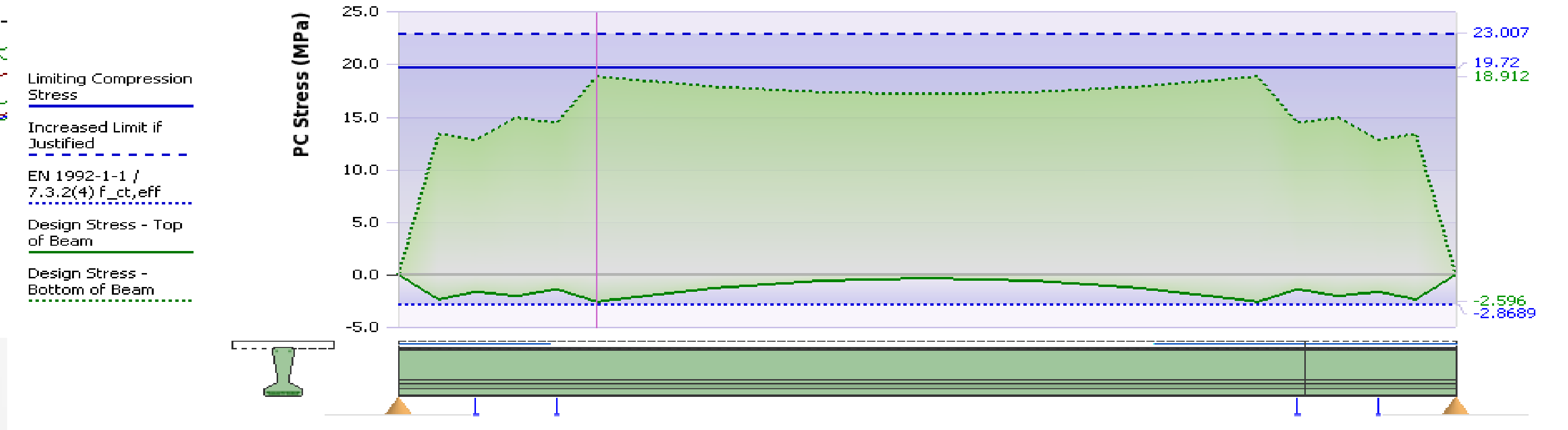
The General Design Workflow Using Load Optimisation

General Workflow

- Define structural design components
- Create structural model layout
- Assign components to the structure
- Create loading using optimization techniques
- Structural Solution and check results
- Component verification/design
- Final reports






Limiting Compression Stress
Increased Limit if Justified
EN 1992-1-1 / 7.3.2(4) f_ct,eff
Design Stress - Top of Beam
Design Stress - Bottom of Beam
PC Stress (MPa)
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
23.007
19.72
18.912
-2.596
-2.8689

Demonstration

Summary

- Bridge Loading models around the world are relatively complex and varied
- Influence line methods provide a powerful way to understand structural behaviour and to apply traffic loads acurately
- Load optimisation techniques provide efficiencies in the analysis/design workflow

- Thank you for your attention

Session Feedback

- Via the Survey Stations, email or mobile device
- AU 2015 passes given out each day!
- Best to do it right after the session
- Instructors see results in real-time

Survey:
Excellent:
Good:
Fair:
Poor:

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