

Dynamic analysis: Pedstrian bridge

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1. GENERAL / MEASUREMENT

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1.1 CONSTRUCTION TYPE

Bridge is a steel arch bridge.

1.2 DAMPNING

Mass Rayleigh dampning konstant: 0.0028 1/s

Stiffness Rayleigh dampning constant: 0.0002 s

1.3 MATERIAL

Steel \Rightarrow $E_{sk} = 210 \text{ GPa}$ & $\nu = 0.30$.

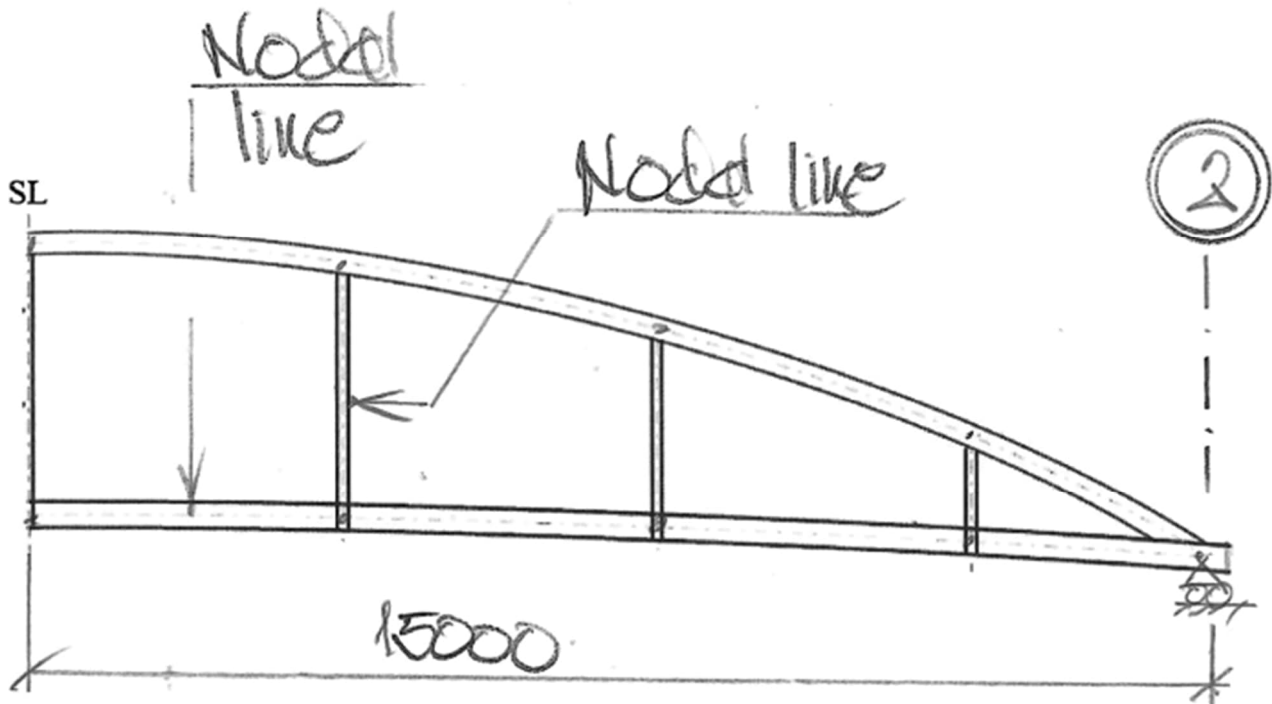
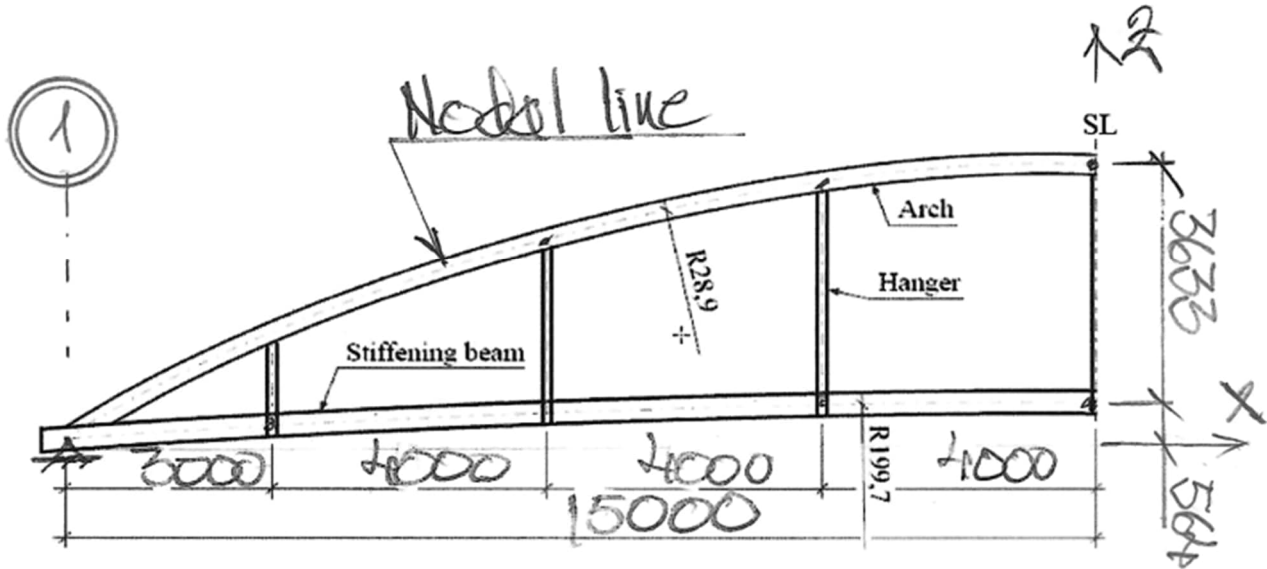
	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A1:3
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1.4 MEASUREMENTS



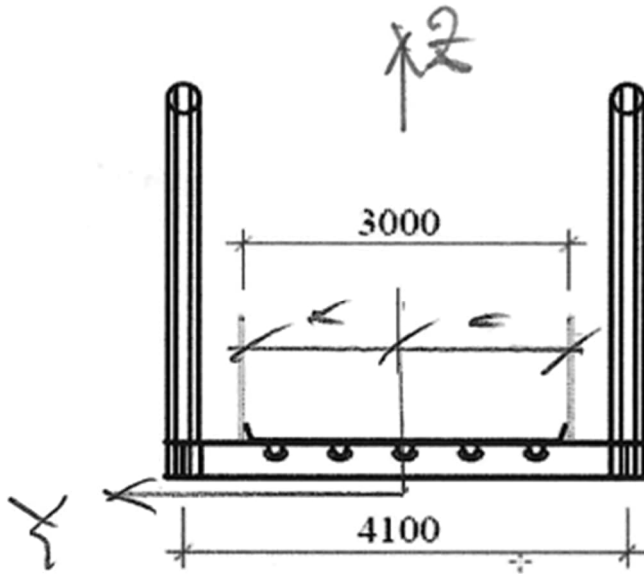
PLAN

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ELEVATION

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A1:5
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Cross section

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1.5 FOUNDATION

Not included in modell.

1.6 CODE OCH TENDER DOCUMENTS

Documents	Version	Name
SS-EN 1990-1997	-	Svensk Standard Eurokod 1-7
TRVINFRA-00226	2.0	KRAV, Bro och broliknande konstruktion, Allmänna krav
TRVINFRA-00227	2.0	KRAV, Bro och broliknande konstruktion, Byggande
TRVINFRA-00228	2.0	KRAV, Bro och broliknande konstruktion, Brounderhåll
TRVINFRA-00331	2.0	KRAV, Bro och broliknande konstruktion, Bärighetsberäkning
TSFS 2018:57		Transportstyrelsens föreskrifter och allmänna råd om tillämpning av eurokoder
TDOK 2013:0667	2.0	Trafikverkets tekniska krav för geokonstruktioner. TK Geo 13
TDOK 2013:0668	2.0	Trafikverkets tekniska råd för geokonstruktioner. TR Geo 13
AMA Anläggning 23		AMA, Svensk Byggtjänst
TDOK 2023:0125	2.0	TRVAMA Anläggning 23
SS 137006:2015	-	Betongkonstruktioner – Utförande – Tillämpning av SS-EN 13670:2009 i Sverige

	Part A – CALCULATION ASSUMPTIONS Dynamic analysis: Pedestrian bridge	Status :	Page: A2:1
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2. SYSTEM ANALYSIS

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	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A2:2
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2.1 GENERAL

The bridge is a steel arch bridge.

The bridge is modelled in 3D using beam elements

The deck is only modelled with mass but no structural stiffness.

In total 4 different analysis are performed as seen below.

Analysis 1 (Base analysis):

Linear static analysis of bridge

Analysis 2 (Inherits properties from Base analysis unless changed):

Eigenvalue analysis.

Analysis 3 (Inherits properties from Base analysis unless changed):

Transient analysis of moving cyclic pedestrian load (point load).

Analysis 4 (Inherits properties from Base analysis unless changed):

Transient analysis of moving cyclic pedestrian load (point load).

Appendices:

Appendix	Name
1	Input receipt
2	Results

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A2:3
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2.2 SKETCH SYSTEM ANALYSIS

To describe geometry first POINTS are defined.

Beam elements are defined by applying attributes to LINES.

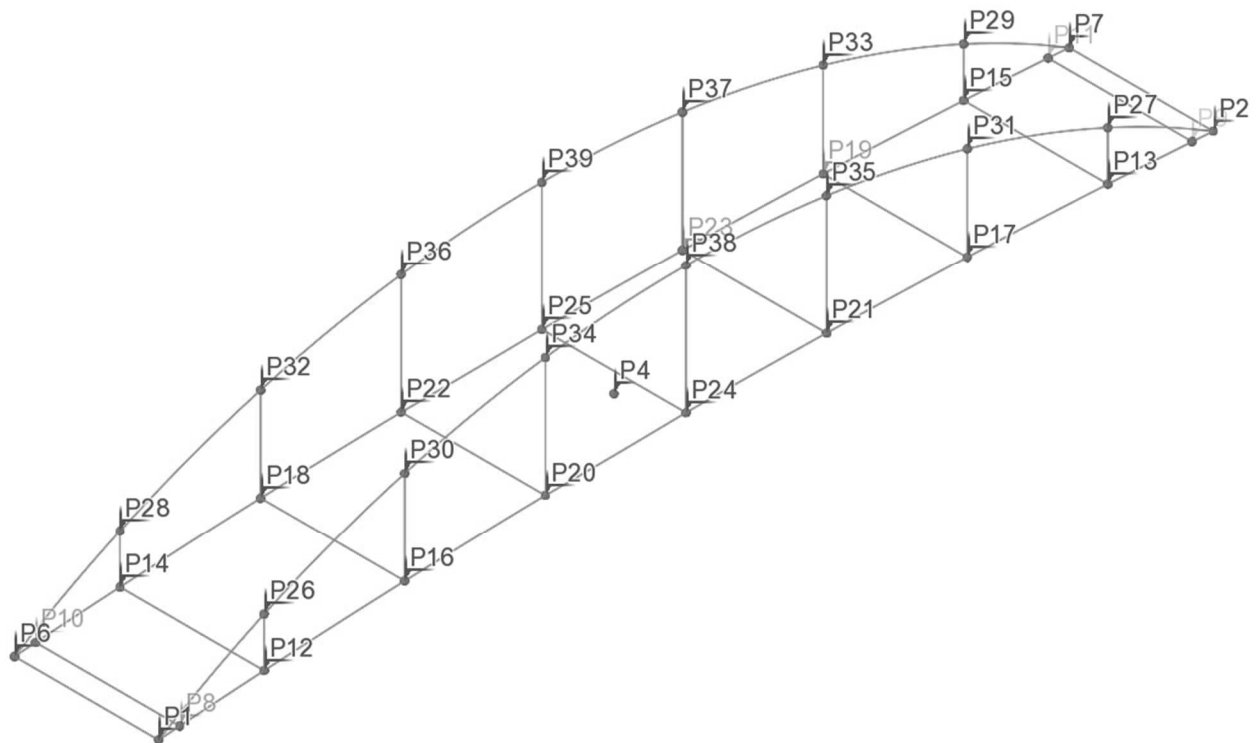
Shell elements are defined by applying attributes to SURFACES.

Attached pictures are retrieved from graphical sketches generated by FEM program using POINT and LINES.

All coordinates needed to describe POINTS are found in appendix 1.

All POINTS needed to describe LINES are found in appendix 1.

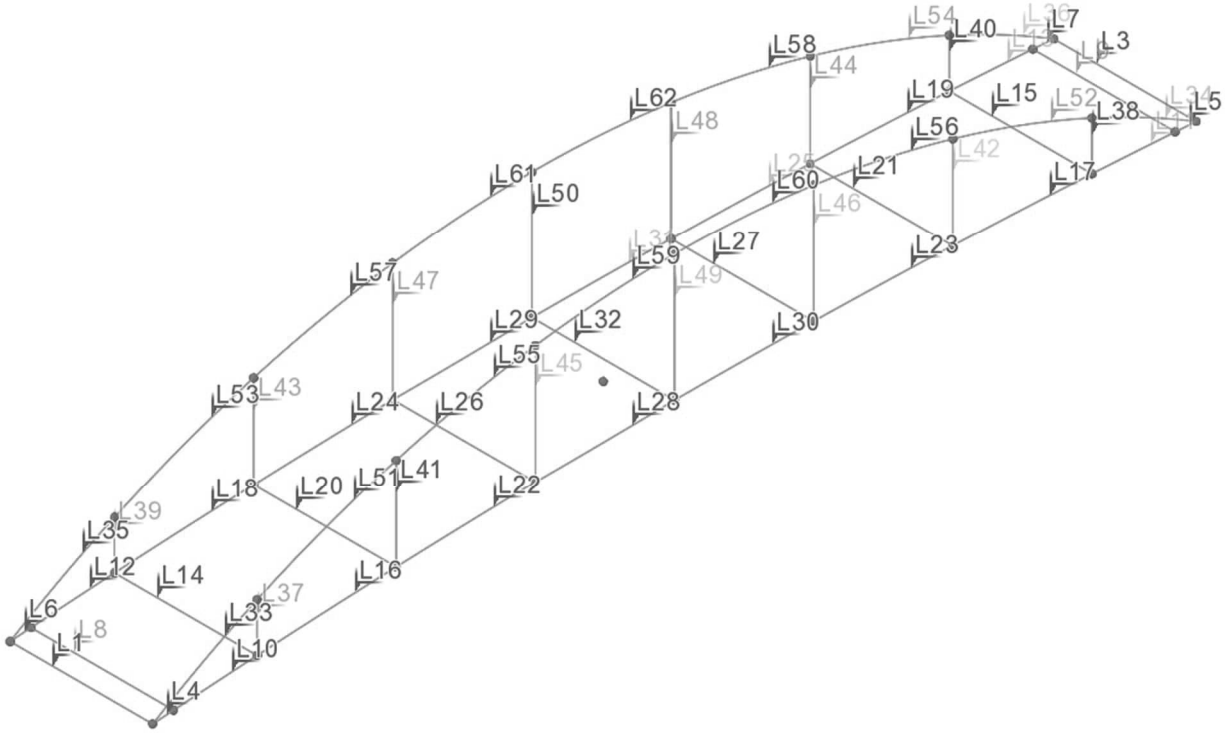
2.2.1 Geometry : POINTS



Overview 3D

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2.2.2 Geometry : LINES

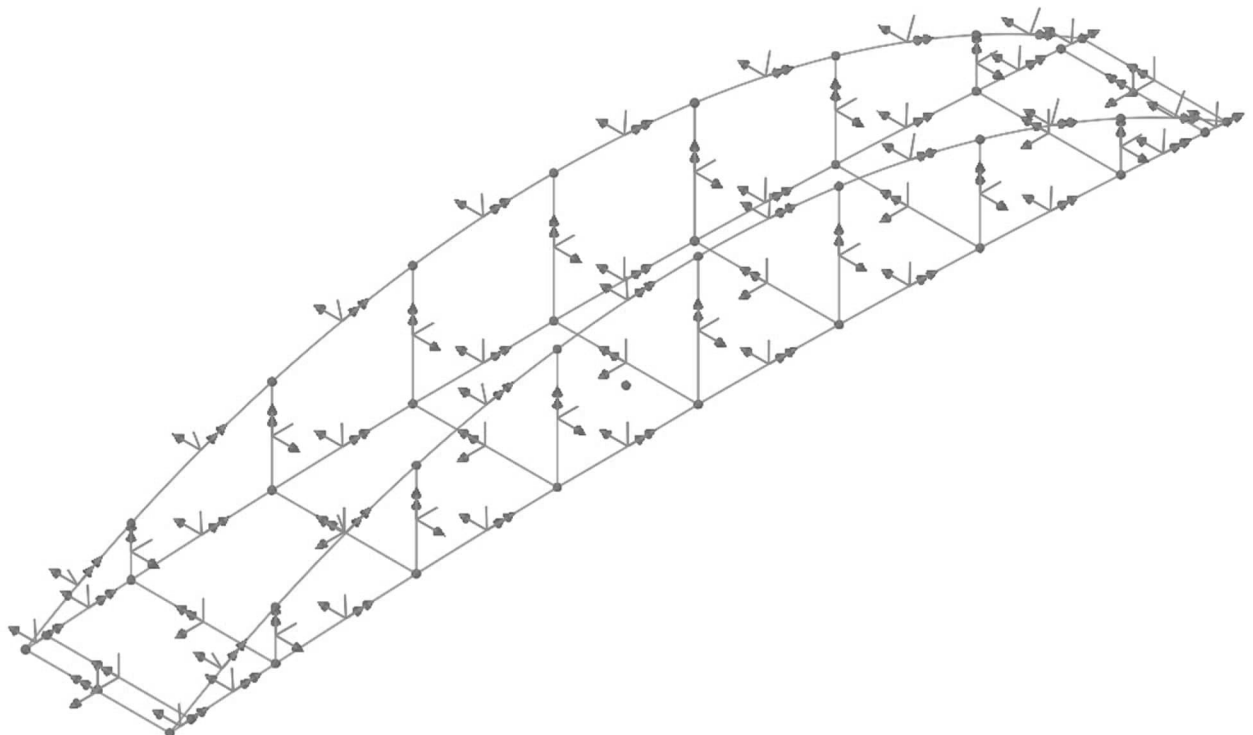
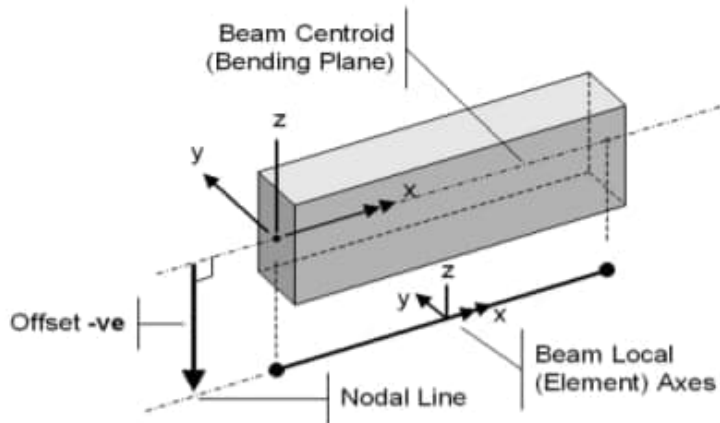


Overview 3D

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A2:5
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2.3 CROSS SECTION PROPERTIES

Principal sketch of geometry associated to 3D beam elements are seen below.



Overview 3D
Local line axis

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A2:6
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2.3.1 Arch

Analysis category

Definition

From library / calculator

Enter properties


Rotation about centroid ° Mirrored about axis

EU Sections

Pipes (EN10210)

273x20 CHS

100%



Reinforcement (only used for RC design checks)

ez origin ey origin

	Value
Cross sectional area (A)	0.016
Second moment of area about y axis (I _{yy})	0.128E-3
Second moment of area about z axis (I _{zz})	0.128E-3
Product moment of area (I _{yz})	0.000
Torsional constant (J)	0.256E-3
Effective shear area in y direction (A _{sy})	0.008
Effective shear area in z direction (A _{sz})	0.008
Eccentricity in y direction (e _y)	0.000
Eccentricity in z direction (e _z)	0.000

Name (1)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A2:7
	Dynamic analysis: Pedestrian bridge	Date :	Created :

2.3.2 Hanger

Geometric Line ✕

Analysis category

Definition

From library / calculator
 Enter properties

Rotation about centroid ° Mirrored about axis

EU Sections
 Pipes (EN10210)
 114.3x10 CHS

100%

Reinforcement (only used for RC design checks)

ez origin ey origin

	Value
Cross sectional area (A)	0.003
Second moment of area about y axis (Iyy)	4.497E-6
Second moment of area about z axis (Izz)	4.497E-6
Product moment of area (Iyz)	0.000
Torsional constant (J)	8.986E-6
Effective shear area in y direction (Asy)	0.002
Effective shear area in z direction (Asz)	0.002
Eccentricity in y direction (ey)	0.000
Eccentricity in z direction (ez)	0.000

Name (2)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A2:8
	Dynamic analysis: Pedestrian bridge	Date :	Created :

2.3.3 Beams

Used for beams at bottom in longitudinal & transversal direction.

Geometric Line
✕

Analysis category 3D

Definition

From library / calculator

Enter properties

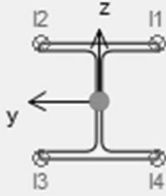
Rotation about centroid 0 ° Mirrored about axis None

EU Sections ▼

HE Shapes (EN53-62) ▼

HE 280 A ▼

100%



Reinforcement (only used for RC design checks)

None ▼

ez origin Centroid ▼ ey origin Same as ez ▼

	Value
Cross sectional area (A)	0.010
Second moment of area about y axis (Iyy)	0.137E-3
Second moment of area about z axis (Izz)	0.048E-3
Product moment of area (Iyz)	0.000
Torsional constant (J)	0.621E-6
Effective shear area in y direction (Asy)	0.007
Effective shear area in z direction (Asz)	0.002
Eccentricity in y direction (ey)	0.000
Eccentricity in z direction (ez)	0.000

Visualise...
Section details...

Name Beams ▼ ▲ ▼ (3)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A2:9
	Dynamic analysis: Pedestrian bridge	Date :	Created :

2.4 MATERIAL

2.4.1 Steel

For analysis 1-2 the properties below are used.

Material Library ✕

Material type

Country

Standard

Grade

Properties

Young's modulus

Poisson's ratio

Density

Thermal expansion

Name ▲▼ (3)

Isotropic



Plastic Creep Damage Shrinkage Viscous Two phase Ko Initialisation

Elastic

Dynamic properties

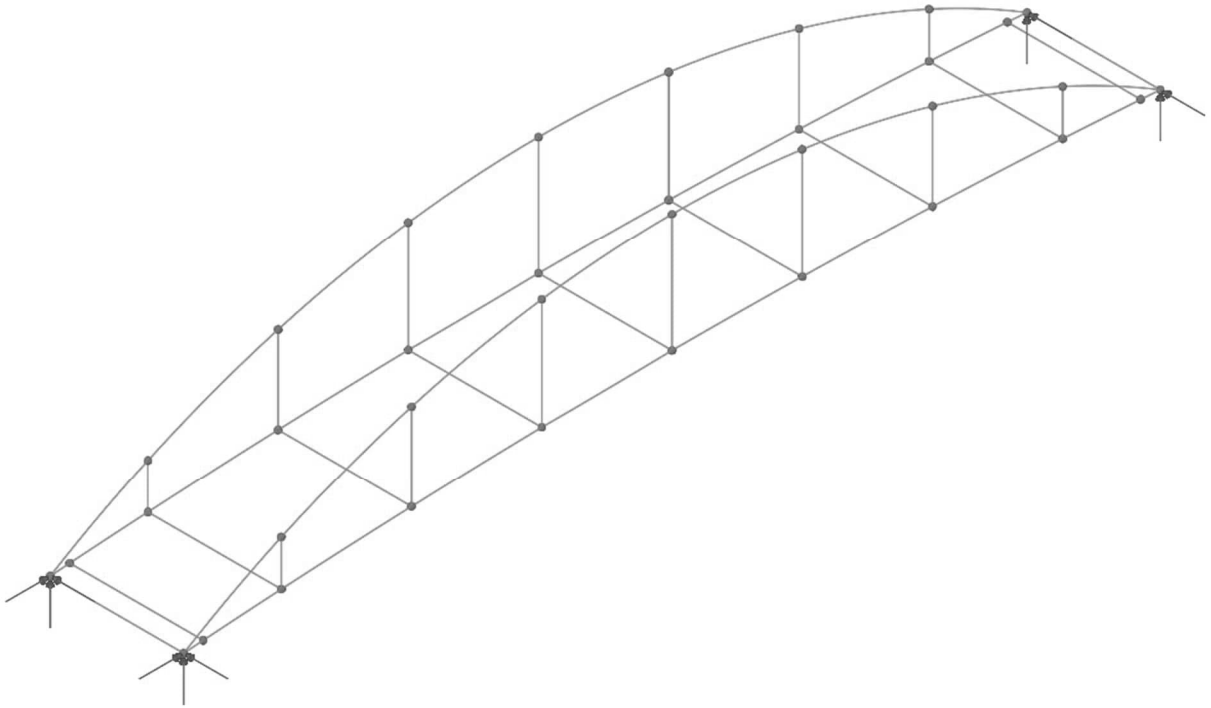
Thermal expansion

	Value
Young's modulus	210.0E9
Poisson's ratio	0.3
Mass density	7.849134E3
Mass Rayleigh damping constant	0.028
Stiffness Rayleigh damping constant	0.2E-3

Name (1)

	Part A – CALCULATION ASSUMPTIONS Dynamic analysis: Pedestrian bridge	Status :	Page: A2:11
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2.5 BOUNDARY CONDITIONS



Overview 3D

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A2:12
	Dynamic analysis: Pedestrian bridge	Date :	Created :

2.5.1 Support 1

Structural Supports

Analysis category

		Free	Fixed	Spring	Spring stiffness	
Translation in	X	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="text"/>	
	Y	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="text"/>	
	Z	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="text"/>	
Rotation about	X	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>	
	Y	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>	
	Z	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>	
Hinge rotation	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>		
Torsional warping	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>		
Pore pressure		<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>

Name (1)

2.5.2 Support 2

Structural Supports

Analysis category

		Free	Fixed	Spring	Spring stiffness	
Translation in	X	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>	
	Y	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="text"/>	
	Z	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="text"/>	
Rotation about	X	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>	
	Y	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>	
	Z	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>	
Hinge rotation	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>		
Torsional warping	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>		
Pore pressure		<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="text"/>

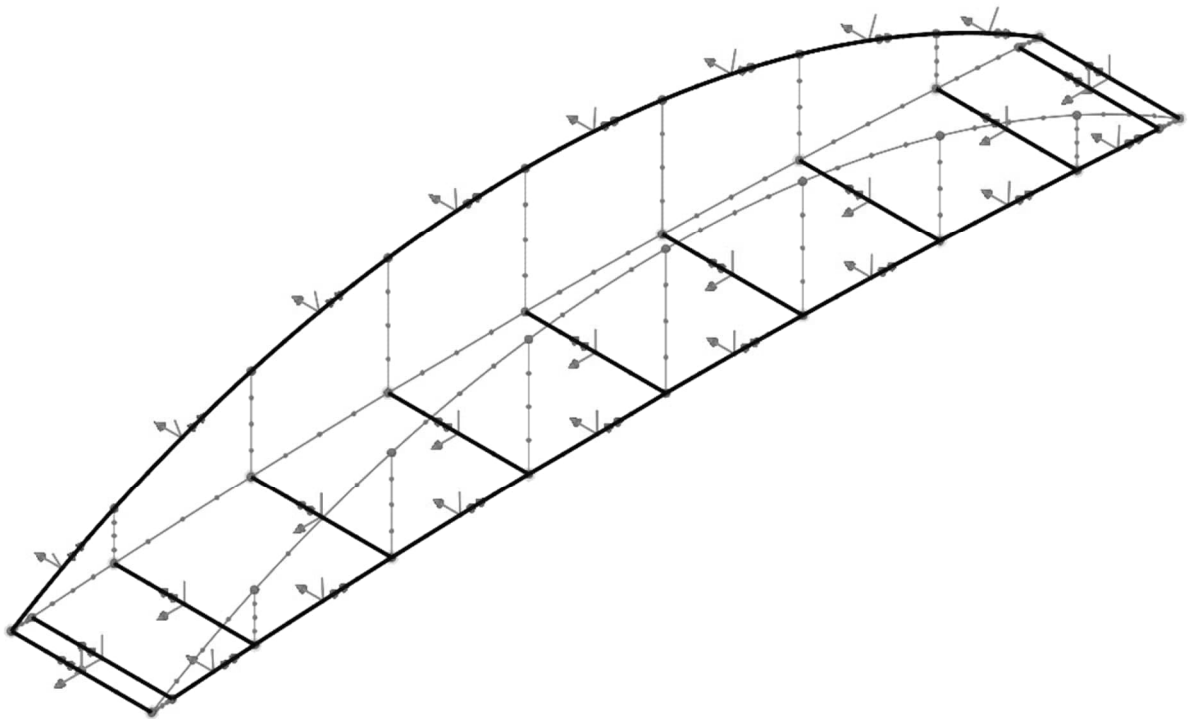
Name (2)

	Part A – CALCULATION ASSUMPTIONS Dynamic analysis: Pedestrian bridge	Status :	Page: A2:13
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2.6 MESH

Studied bridge uses beam elements ("Beam element" / BMI21) for support beam..

Type	Divisions	End release: Start	End release: End	Structure
Element 4	4	None	None	All structure



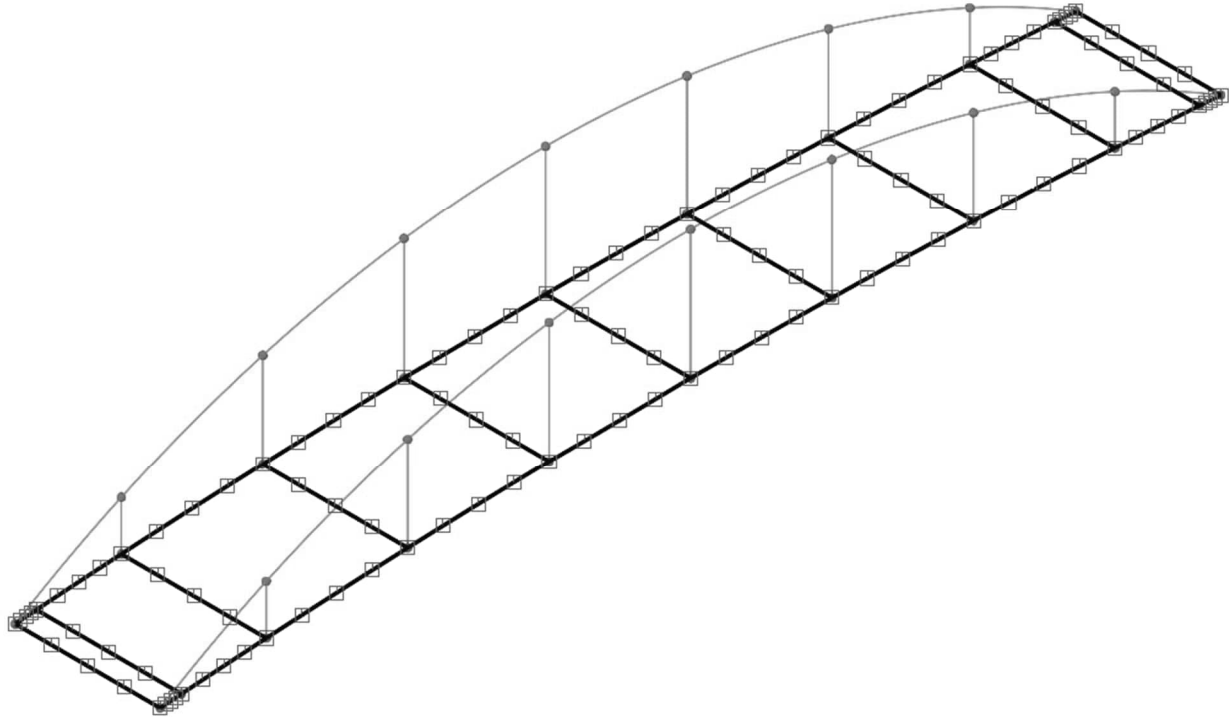
3D overview

Local element axles are visualized.

	Part A – CALCULATION ASSUMPTIONS Dynamic analysis: Pedestrian bridge	Status :	Page: A2:14
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2.7 SEARCH AREA

Discrete load can be applied to structure as chosen structural load area, termed Search Area.



3D overview

Search Area : Deck

	Part A - CALCULATION ASSUMPTIONS Dynamic analysis: Pedestrian bridge	Status :	Page: A3:1
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3. LOADS

3.1	DEAD WEIGHT	page 3:2
3.2	MASS WEIGHT	page 3:3
3.3	CYCLIC CROWD LOAD	page 3:4-9
3.4	CYCLIC MOVING VERTICAL LOAD	page 3:10-14

	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A3:2
	Dynamic analysis: Pedestrian bridge	Date :	Created :

3.1 DEAD WEIGHT

Load case is defined using cross section properties of structural elements.

Load case : Dead weight

Structural loading : Body force

Linear acceleration in Z (a_z) : $-10 \frac{m}{s^2}$

Body Force ✕

Analysis category

Component	Value
Linear acceleration in X	0.0
Linear acceleration in Y	0.0
Linear acceleration in Z	-10.0
Angular velocity about X axis	0.0
Angular velocity about Y axis	0.0
Angular velocity about Z axis	0.0
Angular acceleration about X axis	0.0
Angular acceleration about Y axis	0.0
Angular acceleration about Z axis	0.0

Name (1)

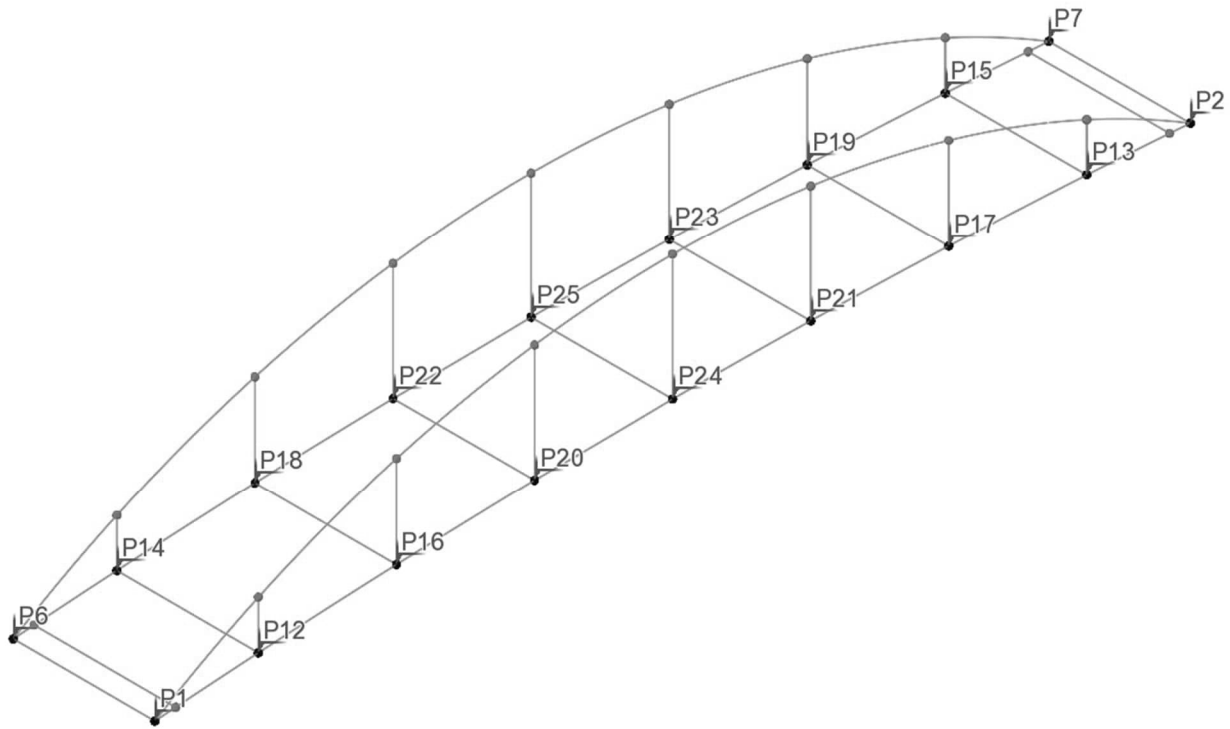
	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A3:3
	Dynamic analysis: Pedestrian bridge	Date :	Created :

3.2 MASS WEIGHT

Since railing, deck and surfacing is not included as structural element their weight is not included in structural model, thus dead weight is not considered in load “Dead weight”

Instead, these loads are handled using point mass weights. They are defined as “Point Mass elements” (PM3). These non-structural elements are applied at points seen below.

Every mass element has a weight of 500 kg. The mass weight is included into structure as a point element with material properties corresponding to its weight.



3D Overview

	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A3:4
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3.3 CYCLIC CROWD LOAD

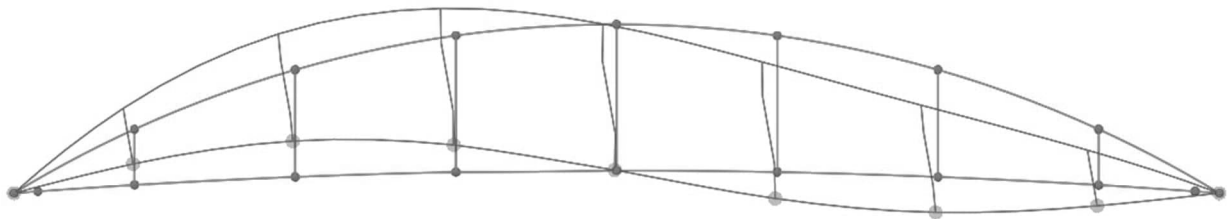
The general document Eurocode 1991-2 does not contain definition of dynamic pedestrian loads-I this analysis national annex NA to BS EN 1991-2 is used.

3.3.1 Vertical cyclic surface load according NA section 2.44.5

$$w = 1.8 \left(\frac{F_0}{A} \right) \cdot k(f_v) \cdot \sqrt{\gamma \cdot N / \lambda} \cdot \sin(2\pi \cdot f_v \cdot t)$$

The is applied to most dangerous eigenvalue frequency in vertical direction ($f_v = 3.053$).

Scale: 1: 135.950
Zoom: 100.000
Eye: (0.000, -1.000, 0.000)
Eigenvalue analysis
Analysis: Analysis 2: Eigenvalue
Loadcase: 2: Loadcase 1, 2: Mode 3 Frequency = 3.05285
Results file: P4~Analysis 2_ Eigenvalue.mys
Eigenvalue: 367.934
Natural frequency: 3.053
Error norm: 9.639E-12
Maximum displacement 0.010 at node 21
Deformation exaggeration: 101.944



$$\rightarrow w(t) = 2.542 \frac{N}{m^2} \cdot \sin(2\pi \cdot f_v \cdot t)$$

	Part A - CALCULATION ASSUMPTIONS Dynamic analysis: Pedestrian bridge	Status :	Page: A3:5
		Date :	Created :

3.3.2 Definition load curve

The load curve is defined as transient cyclic (see definition below). This load curve is applied to a discrete static surface load.

Name: "Load curve: pedestrian crowd"

Type: Sine

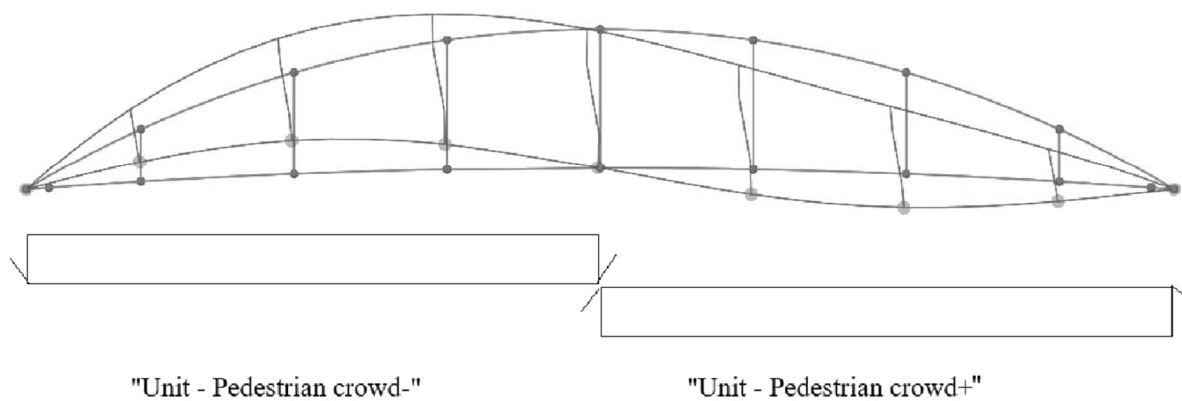
Amplitude: 2.542

Frequency: 3.053

	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A3:6
	Dynamic analysis: Pedestrian bridge	Date :	Created :

3.3.3 Definition discrete surface load

The surface load are defined so follows most dangerous eigenvalue frequency, see sketch below. Since intensity is given by load curve only a unit load is applied.



Definition of discrete surface load:

Analysis; "Analysis 3: Pedestrian crowd"

Search area: "Deck"

Analysis: "Analysis 3: Pedestrian crowd"

Load curve: "Load curve: pedestrian crowd"

	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A3:7
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Discrete surface load: "Unit – Pedestrian crowd-"

Patch ✕

Analysis category

Patch type

8 node patch
 4 node patch
 Multi-patch
 Straight
 Curve
 Multi-straight

Load direction

X
 Z
 Y
 XYZ global
 Patch x
 Patch y
 Surface normal
 XYZ transformable

Projection vector

Project in load direction
 Project for prestress

X component
 Y component
 Z component

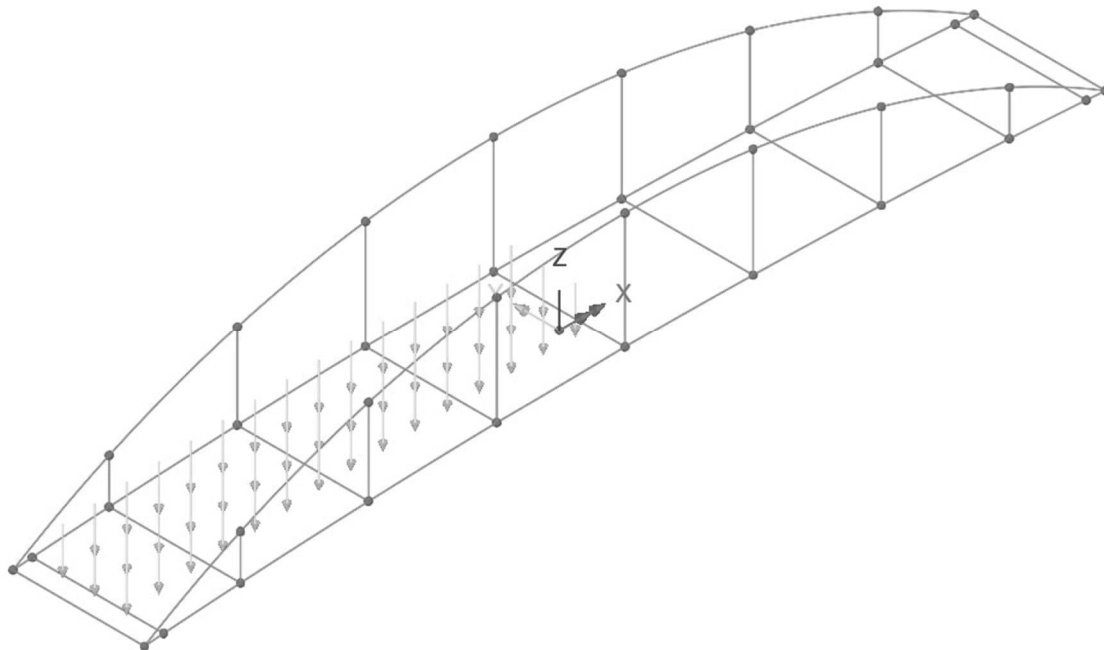
Patch load divisions

Use default

 Number of divisions in x
 Number of divisions in y

	X	Y	Z	Load
1	-15.000	-1.500	0.000	-1.0
2	0.000	-1.500	0.000	-1.0
3	0.000	1.500	0.000	-1.0
4	-15.000	1.500	0.000	-1.0

Name (2)



3D Overview

	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A3:8
	Dynamic analysis: Pedestrian bridge	Date :	Created :

Discrete surface load: "Unit - Pedestrian crowd"

Patch ✕

Analysis category

Patch type
 8 node patch 4 node patch Multi-patch Straight Curve Multi-straight

Load direction

 X Z
 Y XYZ global
 Patch x
 Patch y
 Surface normal
 XYZ transformable

Projection vector

 Project in load direction
 Project for prestress

X component

Y component

Z component

Patch load divisions

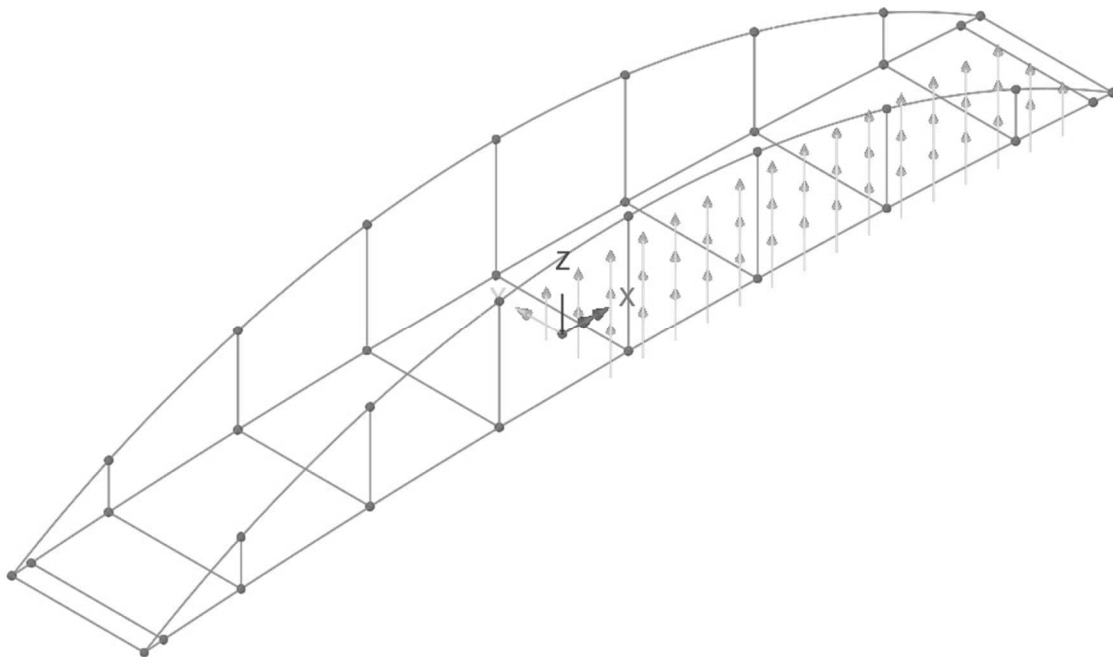
 Use default

Number of divisions in x

Number of divisions in y

	X	Y	Z	Load
1	0.000	-1.500	0.000	1.0
2	15.000	-1.500	0.000	1.0
3	15.000	1.500	0.000	1.0
4	0.000	1.500	0.000	1.0

Name (3)



3D Overview

	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A3:9
	Dynamic analysis: Pedestrian bridge	Date :	Created :

3.3.4 Definition transient load cases

The surface load are defined so follows most dangerous eigenvalue frequency

Load case t1

Load case: Load cast t1
 Analysis: Analysis 3: Pedestrian crowd
 Load curve: Load curve: pedestrian crowd
 Time domain: Implicit dynamics
 Step time: 0.01 s
 Initial time: 0 s
 Total time: 10 s
 Stored results: No

Load case t2

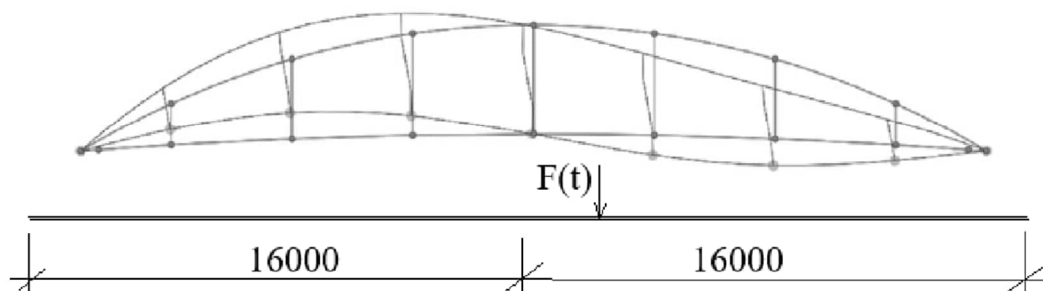
Load case: Load cast t2
 Analysis; Analysis 3: Pedestrian crowd
 Load curve: Load curve: pedestrian crowd
 Time domain: Implicit dynamics
 Step time: 0.01 s
 Initial time: 10 s
 Total time: 11 s
 Stored results: No

	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A3:10
	Dynamic analysis: Pedestrian bridge	Date :	Created :

3.4 CYCLIC MOVING VERTICAL LOAD

The general document Eurocode 1991-2 does not contain definition of dynamic pedestrian loads-I this analysis national annex NA to BS EN 1991-2 is used.

The is applied to most dangerous eigenvalue frequency in vertical direction ($f_v = 3.053$).



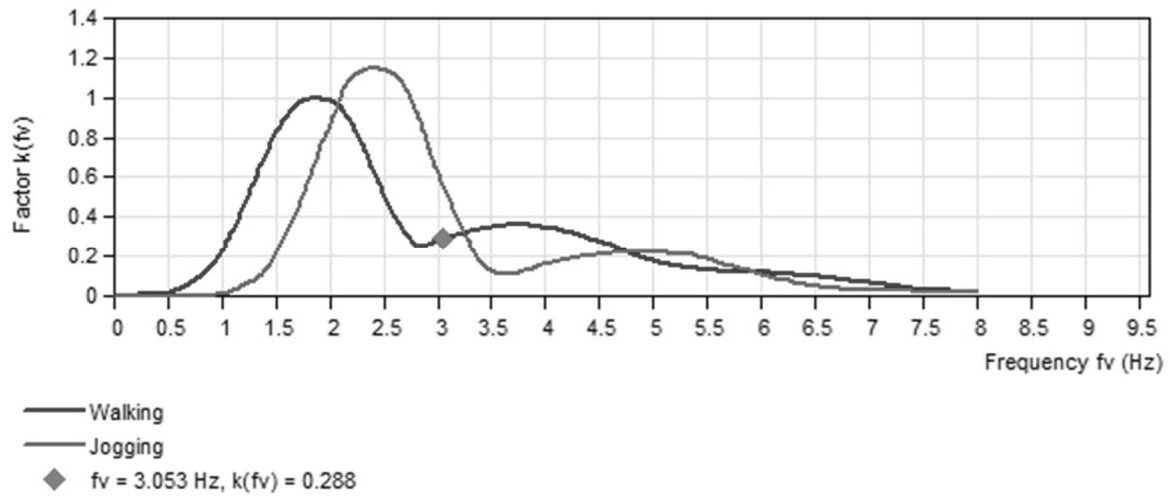
3.4.1 Vertical cyclic moving point load according NA section 2.44.4

$$F = F_0 \cdot k(f_v) \cdot \sqrt{1 + \gamma \cdot (N - 1)} \cdot \sin(2\pi \cdot f_v \cdot t)$$

$F_0 = 280 \text{ N}$: table NA.8 (Walking)

$v_t = 1.7 \text{ m/s}$: table NA.8 (Walking)

	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A3:11
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Pedestrian Load Definition [X]

Design code: EN 1991-2:2003 | UK:2008 and 2020

NA UK:2003 and 2020, Clause NA.2.44.4

Pedestrian activity: Walking

Reference load F_0 : 280.000 N

Pedestrian speed: 1.700 m/s

Bridge class: C

Group size (N): Override 8.000

Vertical natural frequency of mode, f_v : 3.053 Hz

Combined population and harmonic factor, $k(f_v)$: 0.288 [Graph]

Unsynchronised reduction factor, γ : 0.230

Vertical $F(t)$: 130.504 sin(6.106 n t) N

Name: Pedestrian moving pulsating load (1)

$$\rightarrow F(t) = 280 \text{ N} \cdot 0.288 \cdot \sqrt{1 + 0.23 \cdot (8 - 1)} \cdot \sin(2\pi \cdot f_v \cdot t) = 130.5 \text{ N} \cdot \sin(2\pi \cdot f_v \cdot t)$$

	Part A - CALCULATION ASSUMPTIONS Dynamic analysis: Pedestrian bridge	Status :	Page: A3:12
		Date :	Created :

3.4.2 Definition load curve

The load curve is defined as transient cyclic (see definition below). This load curve is applied to a discrete static moving point load.

Name: "Load curve: pedestrian vertical load"

Type: Sine

Amplitude: 130.5

Frequency: 3.053

	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A3:13
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3.4.3 Definition of path of moving load

Pedestrian Moving Load Analysis ✕

Pedestrian load definition: 1:Pedetrian moving pulsating load (EN 1991-2:2) ▾

Assignment

Project onto line (2D line beams and frames)

Project over area (grillages, shells, and 3D space frames)

Search area: 1:Deck ▾

Options for loads outside search area: Exclude All Load ▾

Moments to include: All ▾

Pedestrian path definition

Reference path: Pedestrian path ▾

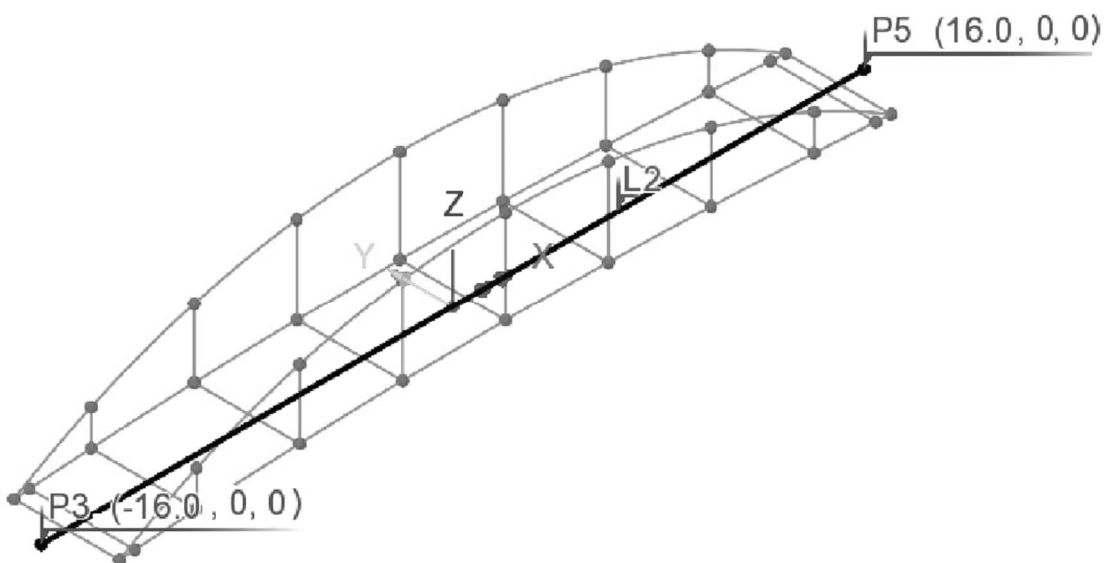
Direction of travel: Forward ▾

Path divisions

Time step to be used for analysis: 0.010 s

Number of time steps: 2352, Incremental distance: 0.017m

Name: Analysis 4: Pedestrian point load ▾



3D Overview

	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A3:14
	Dynamic analysis: Pedestrian bridge	Date :	Created :

3.4.4 Definition discrete point load

The point load is moved along pedestrian path at speed of 1.7 m/s with step time 0.010 s a discrete point load is generated every 0.017 m → 1765 static load case (∴ 30 m / 0.017 m).

Total time on bridge : 17.65 s (∴ 30 m ÷ 1.7 m/s).

Point

Analysis category: 3D

Arbitrary (selected) / Grid (x: 1, y: 1)

Untransformed load direction: X, Y, Z (selected), Surface normal, XYZ global, XYZ transformable

Projection vector: Project in load direction (checked), X component: 0.000, Y component: 0.000, Z component: 1.000

	X	Y	Z	Load
1	0.000	0.000	0.000	1.000
2				

Name: Pedestrian unit load (Vertical) (4)

3.4.5 Definition transient load cases

Transient load cases are generated.

Load case: LC 4716 → LC 4680

Analysis: Analysis 4: Pedestrian moving load

Load curve: Load curve: pedestrian vertical load

Time domain: Implicit dynamics

Step time: 0.01 s

Initial time: 0 s

Total time: 20 s

	Part A - CALCULATION ASSUMPTIONS Dynamic analysis: Pedestrian bridge	Status :	Page: A4:1
		Date :	Created :

4. RESULTS

4.1	WORKFLOW	page 4:2
4.2	ACCELERATION: CYCLIC CROWD LOAD	page 4:2
4.3	ACCELERATION: CYCLIC MOVING LOAD	page 4:2

	Part A - CALCULATION ASSUMPTIONS	Status :	Page: A4:2
	Dynamic analysis: Open RC frame bridge	Date :	Created :

4.1 WORKFLOW

Workflow for dynamic analysis of cyclic crowd load (surface load):

1. Generate static model and perform linear analysis (Analysis 1)
2. Perform *eigenvalue* analysis (Analysis 2)
3. Determine lowest frequency in z-direction.
4. Create unit discrete static surface loads that corresponds to nodal deflection (Analysis 3).
5. Create a transient cyclic load curve (Analysis 3).
6. Perform transient analysis of stationary loads (Analysis 3).

Workflow for dynamic analysis of cyclic crowd load (surface load):

1. Generate static model and perform linear analysis (Analysis 1)
2. Perform *eigenvalue* analysis (Analysis 2)
3. Determine lowest frequency in z-direction.
4. Create unit discrete moving point load along pedestrian track (Analysis 4).
5. Create a transient cyclic load curve (Analysis 4).
6. Perform transient analysis of moving loads (Analysis 4).

4.2 ACCELERATION: CYCLIC CROWD LOAD

Largest vertical acceleration (Z-direction) is $|A_z| = 0.27 \text{ m/s}^2$, see appendix 2 page 7.

4.3 ACCELERATION: CYCLIC MOVING LOAD

Largest vertical acceleration (Z-direction) is $|A_z| = 0.45 \text{ m/s}^2$, see appendix 2 page 8.

-

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 1
		Date :	Created:

Title: Input receipt

Model Units: N,m,kg,s,C
Report Units: N,m,kg,s,C

Model Title: System 001
Model File: System 001

Clarification of definitions.

In the report, the letter “T” is used to describe a range. The letter is an abbreviation of “to”.

See example of assignment below.

Assignment to Lines:
105T110;114T119

This expression means that the assignment occurs to the lines L105 → L110 and L114 → L119.

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 2
		Date :	Created:

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1. Points

Point	X coordinate	Y coordinate	Z coordinate
1	-15.0	-2.0	0.0
2	15.0	-2.0	0.0
3	-16.0	0.0	0.0
4	0.0	0.0	0.0
5	16.0	0.0	0.0
6	-15.0	2.0	0.0
7	15.0	2.0	0.0
8	-14.4	-2.0	0.0
9	14.4	-2.0	0.0
10	-14.4	2.0	0.0
11	14.4	2.0	0.0
12	-12.0	-2.0	0.2
13	12.0	-2.0	0.2
14	-12.0	2.0	0.2
15	12.0	2.0	0.2
16	-8.0	-2.0	0.4
17	8.0	-2.0	0.4
18	-8.0	2.0	0.4
19	8.0	2.0	0.4
20	-4.0	-2.0	0.5
21	4.0	-2.0	0.5
22	-4.0	2.0	0.5
23	4.0	2.0	0.5
24	0.0	-2.0	0.6
25	0.0	2.0	0.6
26	-12.0	-2.0	1.6
27	12.0	-2.0	1.6
28	-12.0	2.0	1.6
29	12.0	2.0	1.6
30	-8.0	-2.0	3.1
31	8.0	-2.0	3.1
32	-8.0	2.0	3.1
33	8.0	2.0	3.1
34	-4.0	-2.0	3.9
35	4.0	-2.0	3.9
36	-4.0	2.0	3.9
37	4.0	2.0	3.9
38	0.0	-2.0	4.2
39	0.0	2.0	4.2
Moving Load	0.0	0.0	0.0

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 4
		Date :	Created:

2. Lines

Line	Points	Line	Points
1	1,6	3	2,7
4	1,8	5	9,2
6	6,10	7	11,7
8	8,10	9	9,11
10	8,12	11	13,9
12	10,14	13	15,11
14	12,14	15	13,15
16	12,16	17	17,13
18	14,18	19	19,15
20	16,18	21	17,19
22	16,20	23	21,17
24	18,22	25	23,19
26	20,22	27	21,23
28	20,24	29	22,25
30	24,21	31	25,23
32	24,25	33	1,26
34	27,2	35	6,28
36	29,7	37	12,26
38	13,27	39	14,28
40	15,29	41	16,30
42	17,31	43	18,32
44	19,33	45	20,34
46	21,35	47	22,36
48	23,37	49	24,38
50	25,39	51	26,30
52	31,27	53	28,32
54	33,29	55	30,34
56	35,31	57	32,36
58	37,33	59	34,38
60	38,35	61	36,39
62	39,37		

3. MESH: Line

Attribute: 1 Title: Element 4

Sub Type = Line Mesh

Element Type = BMI21

Mesh spacing	Nr. of elements	Start node end releases:	End node end releases:
Uniform	4	None	None

Assignment to Lines: Beta angle = 0.000

1;3;4T62

4. MESH: Mass

Attribute: 2 Title: Mass elements

Sub Type = Point Mesh

Element Type = PM3

Property	Symbol	Value
Element defined by name	DefinedByName	false
Single feature joint	isSingleFtrJnt	false

Assignment to Points Beta angle = 0.000

1;2;6;7;12T25

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 5
		Date :	Created:

5. Geometric: Line

Attribute: 1 **Title: Arch (273x20 CHS)** Sub Type = Line Geometric

Assigned in: Analysis 1: Linear static

Property	Symbol	Value
Cross sectional area	A	0.0
Second moment of area about y axis	Iyy	0.0
Second moment of area about z axis	Izz	0.0
Product moment of area	Iyz	0.0
Torsional constant	J	0.0
Eccentricity in local z direction, relative to specified origin	ez0	0.0
Eccentricity in local y direction, relative to specified origin	ey0	0.0
Eccentricity in local z direction, relative to beam centroid	ez	0.0
Eccentricity in local y direction, relative to beam centroid	ey	0.0
Wagner constant 1st moment of square radius about y (Iyr)	Iyr	0.0
Wagner constant 1st moment of square radius about z (Izr)	Izr	0.0
Wagner constant 4th moment of area about origin (Irr)	Irr	0.0
Wagner constant 2nd moment of warping about origin (Iwr)	Iwr	0.0
Effective shear area in local z direction	Asz	0.0
Effective shear area in local y direction	Asy	0.0
Plastic area	Ap	0.0
Plastic modulus for bending about y	Zpy	0.0
Plastic modulus for bending about z	Zpz	0.0
Plastic neutral axis, distance from centroid along y axis	yp	0.0
Plastic neutral axis, distance from centroid along z axis	zp	0.0
Plastic torsional section modulus	Zpt	0.0
Warping torsional constant about shear centre	Cw	0.0
Shear centre about y axis	yo	0.0
Shear centre about z axis	zo	0.0
Monosymmetry constant about y	betay	0.0
Monosymmetry constant about z	betaz	0.0
Radius of gyration about y axis	ky	0.1
Radius of gyration about z axis	kz	0.1
y axis extreme fibre, top	yt	0.1
y axis extreme fibre, bottom	yb	-0.1
z axis extreme fibre, top	zt	0.1
z axis extreme fibre, bottom	zb	-0.1
Shape code identifier	Type	4
Outer diameter of this section	D	0.3
Thickness of this section	t	0.0
Element type	elementType	"3D Thick Beam"
Reinforcement	reinforcement	None

Assignment to Lines:

33T36;51T62

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 6
		Date :	Created:

Attribute: 2 Title: Hanger (114.3x10

CHS) Sub Type = Line Geometric

Assigned in: Analysis 1: Linear static

Property	Symbol	Value
Cross sectional area	A	0.0
Second moment of area about y axis	Iyy	0.0
Second moment of area about z axis	Izz	0.0
Product moment of area	Iyz	0.0
Torsional constant	J	0.0
Eccentricity in local z direction, relative to specified origin	ez0	0.0
Eccentricity in local y direction, relative to specified origin	ey0	0.0
Eccentricity in local z direction, relative to beam centroid	ez	0.0
Eccentricity in local y direction, relative to beam centroid	ey	0.0
Wagner constant 1st moment of square radius about y (Iyr)	Iyr	0.0
Wagner constant 1st moment of square radius about z (Izr)	Izr	0.0
Wagner constant 4th moment of area about origin (Irr)	Irr	0.0
Wagner constant 2nd moment of warping about origin (Iwr)	Iwr	0.0
Effective shear area in local z direction	Asz	0.0
Effective shear area in local y direction	Asy	0.0
Plastic area	Ap	0.0
Plastic modulus for bending about y	Zpy	0.0
Plastic modulus for bending about z	Zpz	0.0
Plastic neutral axis, distance from centroid along y axis	yp	0.0
Plastic neutral axis, distance from centroid along z axis	zp	0.0
Plastic torsional section modulus	Zpt	0.0
Warping torsional constant about shear centre	Cw	0.0
Shear centre about y axis	yo	0.0
Shear centre about z axis	zo	0.0
Monosymmetry constant about y	betay	0.0
Monosymmetry constant about z	betaz	0.0
Radius of gyration about y axis	ky	0.0
Radius of gyration about z axis	kz	0.0
y axis extreme fibre, top	yt	0.1
y axis extreme fibre, bottom	yb	-0.1
z axis extreme fibre, top	zt	0.1
z axis extreme fibre, bottom	zb	-0.1
Shape code identifier	Type	4
Outer diameter of this section	D	0.1
Thickness of this section	t	0.0
Element type	elementType	"3D Thick Beam"
Reinforcement	reinforcement	None

Assignment to Lines:

37T50

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 7
		Date :	Created:

Attribute: 3 Title: Beams (HE 280 A)

Sub Type = Line Geometric

Assigned in: Analysis 1: Linear static

Property	Symbol	Value
Cross sectional area	A	0.0
Second moment of area about y axis	Iyy	0.0
Second moment of area about z axis	Izz	0.0
Product moment of area	Iyz	0.0
Torsional constant	J	0.0
Eccentricity in local z direction, relative to specified origin	ez0	0.0
Eccentricity in local y direction, relative to specified origin	ey0	0.0
Eccentricity in local z direction, relative to beam centroid	ez	0.0
Eccentricity in local y direction, relative to beam centroid	ey	0.0
Wagner constant 1st moment of square radius about y (Iyr)	Iyr	0.0
Wagner constant 1st moment of square radius about z (Izr)	Izr	0.0
Wagner constant 4th moment of area about origin (Irr)	Irr	0.0
Wagner constant 2nd moment of warping about origin (Iwr)	Iwr	0.0
Effective shear area in local z direction	Asz	0.0
Effective shear area in local y direction	Asy	0.0
Plastic area	Ap	0.0
Plastic modulus for bending about y	Zpy	0.0
Plastic modulus for bending about z	Zpz	0.0
Plastic neutral axis, distance from centroid along y axis	yp	0.0
Plastic neutral axis, distance from centroid along z axis	zp	0.0
Plastic torsional section modulus	Zpt	0.0
Warping torsional constant about shear centre	Cw	0.0
Shear centre about y axis	yo	0.0
Shear centre about z axis	zo	0.0
Monosymmetry constant about y	betay	0.0
Monosymmetry constant about z	betaz	0.0
Radius of gyration about y axis	ky	0.1
Radius of gyration about z axis	kz	0.1
y axis extreme fibre, top	yt	0.1
y axis extreme fibre, bottom	yb	-0.1
z axis extreme fibre, top	zt	0.1
z axis extreme fibre, bottom	zb	-0.1
Shape code identifier	Type	5
Breadth of this section	B	0.3
Depth of this section	D	0.3
Thickness of flange of this section	tf	0.0
Thickness of web of this section	tw	0.0
Radius of fillet of this section		0.0
Element type	elementType	"3D Thick Beam"
Reinforcement	reinforcement	None

Assignment to Lines:

1;3;4T32

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 8
		Date :	Created:

6. Isotropic material

Attribute: 1 Title: Steel (damping)

Sub Type = Isotropic Material

Property	Symbol	Value
Young's modulus	E	210000000000.0
Poisson's ratio	nu	0,3
Density	rho	7849.1
Mass Rayleigh damping constant	ar	0,028
Stiffness Rayleigh damping constant	br	0.0004

Assigned in: Analysis 3: Pedestrian crowd; Analysis 4: Pedestrian moving load

Assignment to Lines:

1T62

Attribute: 3 Title: Steel (Steel - Structural | EN1993-1-1:2005) Sub

Type = Isotropic Material

Property	Symbol	Value
Young's modulus	E	210000000000.0
Poisson's ratio	nu	0,3
Density	rho	7849.1
Coefficient of thermal expansion	alpha	0.0

Assigned in: Analysis 1: Linear static

Assignment to Lines:

1T62

Attribute: 2 Title: 500 kg

Sub Type = Mass

Property	Symbol	Value
Mass in X	massX	500.0
Mass in Y	massY	500.0
Mass in Z	massZ	500.0
3D	is3d	true
Type	type	"point"

Assigned in: Analysis 1: Linear static

Assignment to Points:

1;2;6;7;12T25

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 9
		Date :	Created:

7. Support

Attribute: 1 **Title: Fixed**

Sub Type = Structural Support

Property	Symbol	Value
Translation in X	U	"R"
Translation in Y	V	"R"
Translation in Z	W	"R"
Rotation about X	THX	"F"
Rotation about Y	THY	"F"
Rotation about Z	THZ	"F"
Torsional warping	Torsion	"F"
Moment about hinge	L1	"F"
Pore pressure	pore	"C"

Assignment to Points:

1;6

Attribute: 2 **Title: Free**

Sub Type = Structural Support

Property	Symbol	Value
Translation in X	U	"F"
Translation in Y	V	"R"
Translation in Z	W	"R"
Rotation about X	THX	"F"
Rotation about Y	THY	"F"
Rotation about Z	THZ	"F"
Torsional warping	Torsion	"F"
Moment about hinge	L1	"F"
Pore pressure	pore	"C"

Assignment to Points:

2;7

8. Search Area

Attribute: 1

Title: Ddeck

Sub Type = Search Area

Assignment to Lines: 1T32

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 10
		Date :	Created:

13. Body load

Attribute: 1

Title: Dead weight

Sub Type = Body Force Load

Property	Symbol	Value
Linear acceleration in X	AccX	0.0
Linear acceleration in Y	AccY	0.0
Linear acceleration in Z	AccZ	-10.0
Angular velocity about X axis	AngVelX	0.0
Angular velocity about Y axis	AngVelY	0.0
Angular velocity about Z axis	AngVelZ	0.0
Angular acceleration about X axis	AngAccX	0.0
Angular acceleration about Y axis	AngAccY	0.0
Angular acceleration about Z axis	AngAccZ	0.0
Linear acceleration In X fluid phase	InFlAccX	0.0
Linear acceleration In Y fluid phase	InFlAccY	0.0
Linear acceleration In Z fluid phase	InFlAccZ	-10.0

Assignment to Lines:

1T62

Property	Symbol	Value
Linear acceleration in X	AccX	0.0
Linear acceleration in Y	AccY	0.0
Linear acceleration in Z	AccZ	-10.0
Angular velocity about X axis	AngVelX	0.0
Angular velocity about Y axis	AngVelY	0.0
Angular velocity about Z axis	AngVelZ	0.0
Angular acceleration about X axis	AngAccX	0.0
Angular acceleration about Y axis	AngAccY	0.0
Angular acceleration about Z axis	AngAccZ	0.0
Linear acceleration In X fluid phase	InFlAccX	0.0
Linear acceleration In Y fluid phase	InFlAccY	0.0
Linear acceleration In Z fluid phase	InFlAccZ	-10.0

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 11
		Date :	Created:

14. Discrete point load

Symbol	Property
dirType	Load direction
pDir	Projection vector
nGridX	X Grid size
nGridY	Y Grid size
pos	Coordinates
P	Load

Attribute: 4 Title: Pedstrian unit load (Vertical)

Sub Type = Discrete Point Load

dirType	pDir_x	pDir_y	pDir_z	nGridX	nGridY
Z	0.0	0.0	1.0	0	0
pos_x	pos_y	pos_z	Pz		
0.0	0.0	0.0	1.0		

Search area= Deck

Moving status = Yes

Step length: 0.017

Load outside search area = Include

Assignment to Line: L2

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 12
		Date :	Created:

15. Discrete patch load

Symbol	Property
patchType	Patch type
sweptAngle	Swept angle
xDivisions	Number of local x divisions
yDivisions	Number of local y divisions
dirType	Load direction
pDir	Projection vector
nGridX	X Grid size
nGridY	Y Grid size
pos	Coordinates
P	Load

Attribute: 2 Title: Unit pedestrian crowd-

Sub Type = Discrete Patch Load

Patch type: 4-noded quadrilateral

dirType	pDir_x	pDir_y	pDir_z	nGridX	nGridY
Z	0	0	1	0	0
pos_x	pos_y	pos_z	Pz		
-15.0	-1.5	0	-1		
0	-1.5	0	-1		
0	1.5	0	-1		
-15.0	1.5	0	-1		

Search area= Deck

Moving status = No

Load outside search area = Include

Assignment to Point: 4

Attribute: 3 Title: Unit pedestrian crowd+

Sub Type = Discrete Patch Load

Patch type: 4-noded quadrilateral

dirType	pDir_x	pDir_y	pDir_z	nGridX	nGridY
Z	0	0	1	0	0
pos_x	pos_y	pos_z	Pz		
0	-1.5	0	1		
15.0	-1.5	0	1		
15.0	1.5	0	1		
0	1.5	0	1		

Search area= Deck

Moving status = No

Load outside search area = Include

Assignment to Point: 4

	Appendix 1: Input receipt SYSTEM 001 Dynamic analysis: Pedestrian bridge	Status :	Page: 13
		Date :	Created:

16. Load curves

Attribute 1

Title: Load curve: Pedestrian crowd
Type: Sine
Amplitude: 2.542
Mean value: 0
Frequency: 3.053
Activation time: 0

Attribute: 2

Title: Load curve: Pedestrian vertical load
Type: Sine
Amplitude: 130.5
Mean value: 0
Frequency: 3.053
Activation time: 0

17. Transient analysis

Title: Analysis 3: Cyclic crowd load
Loadcase: Loadcase t1
Factor = "Load curve: Pedestrian crowd"
Assigned in: Analysis 3: Pedestrian crowd
Time domain: Implicit dynamics
Activation time: 0
Step time: 0.01
Total response time: 10

Title: Analysis 3: Cyclic crowd load
Loadcase: Loadcase t2
Factor = "Load curve: Pedestrian crowd"
Assigned in: Analysis 3: Pedestrian crowd
Time domain: Implicit dynamics
Activation time: 10
Step time: 0.01
Total response time: 11

Title: Analysis 4: Cyclic moving load
Loadcases: LC 4716... LC 8480
Factor = "Load curve: Pedestrian crowd"
Assigned in: Analysis 4: Pedestrian vertical load
Time domain: Implicit dynamics
Activation time: 0
Step time: 0.01
Total response time: 20

	Appendix 2: Results SYSTEM 001	Status :	Page: 1
	Dynamic analysis: Pedestrian bridge	Date :	Created:

Title: Results

Model Units: N,m,kg,s,C
Report Units: N,m,kg,s,C

Model Title: System 001
Model File: System 001

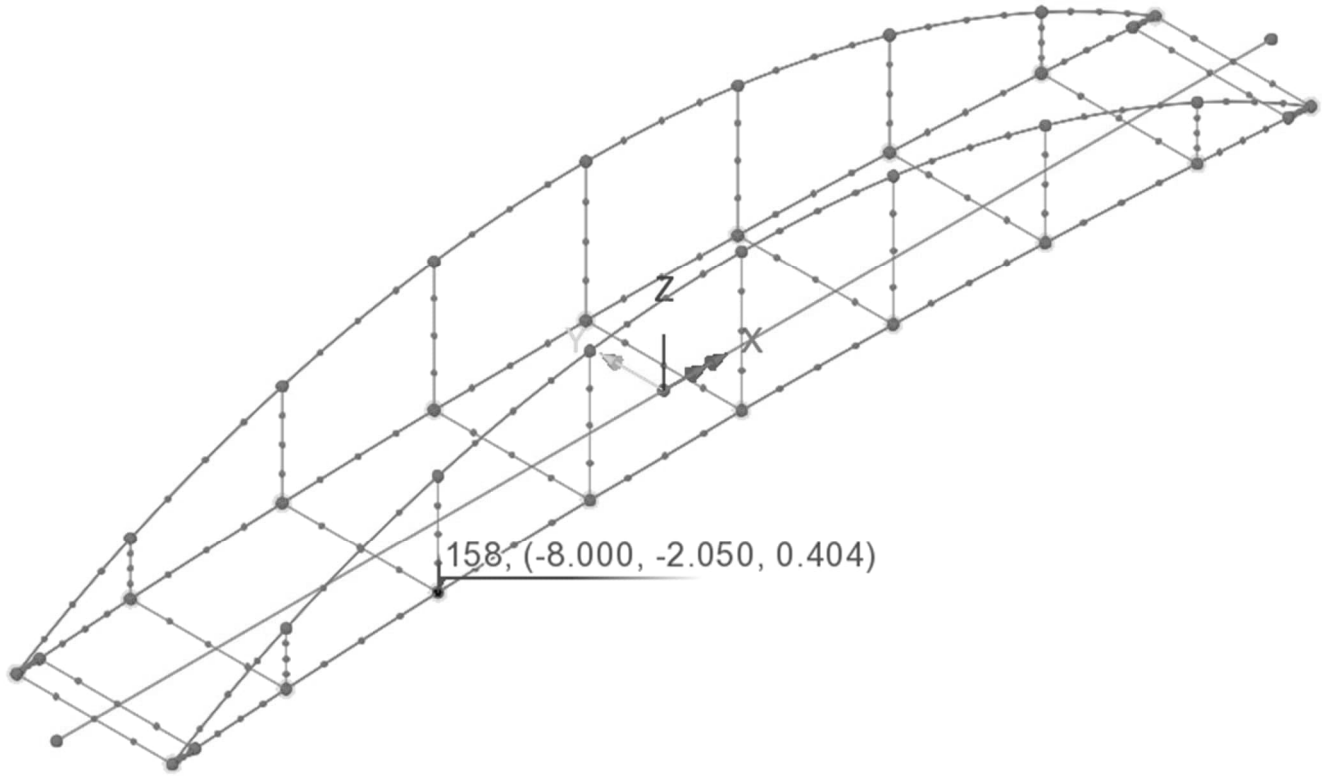
	Appendix 2: Results SYSTEM 001	Status :	Page: 2
	Dynamic analysis: Pedestrian bridge	Date :	Created:

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3.	Analysis 3: Cyclic crowd load	7
4.	Analysis 4: Cyclic moving vertical load	8

	Appendix 2: Results SYSTEM 001	Status :	Page: 3
	Dynamic analysis: Pedestrian bridge	Date :	Created:

1. Result nodes



3D Overview
Location N158

	Appendix 2: Results SYSTEM 001	Status :	Page: 4
	Dynamic analysis: Pedestrian bridge	Date :	Created:

2. Analysis 2: Eigenvalues

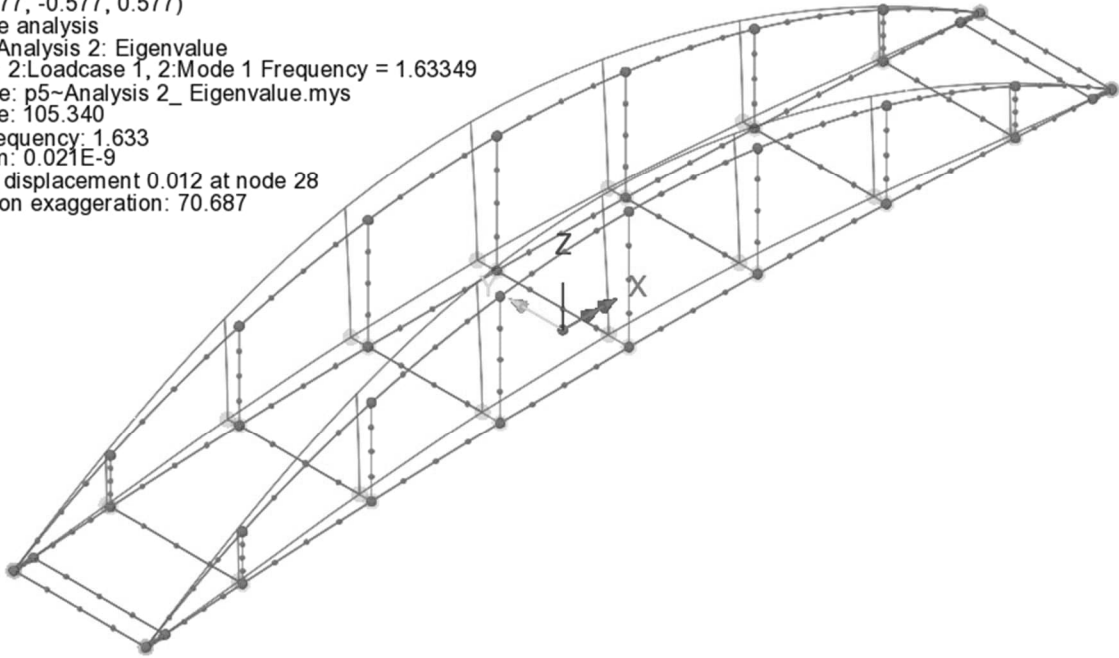
2.1 Table

Mode	Eigenvalue	Frequency
1	105	1.633
2	368	3.052
3	368	3.053
4	463	3.424
5	585	3.851
6	612	3.936
7	1148	5.392
8	1336	5.817
9	1403	5.962
10	1796	6.744
-	-	Hz

	Appendix 2: Results SYSTEM 001	Status :	Page: 5
	Dynamic analysis: Pedestrian bridge	Date :	Created:

2.2 Deformed mesh

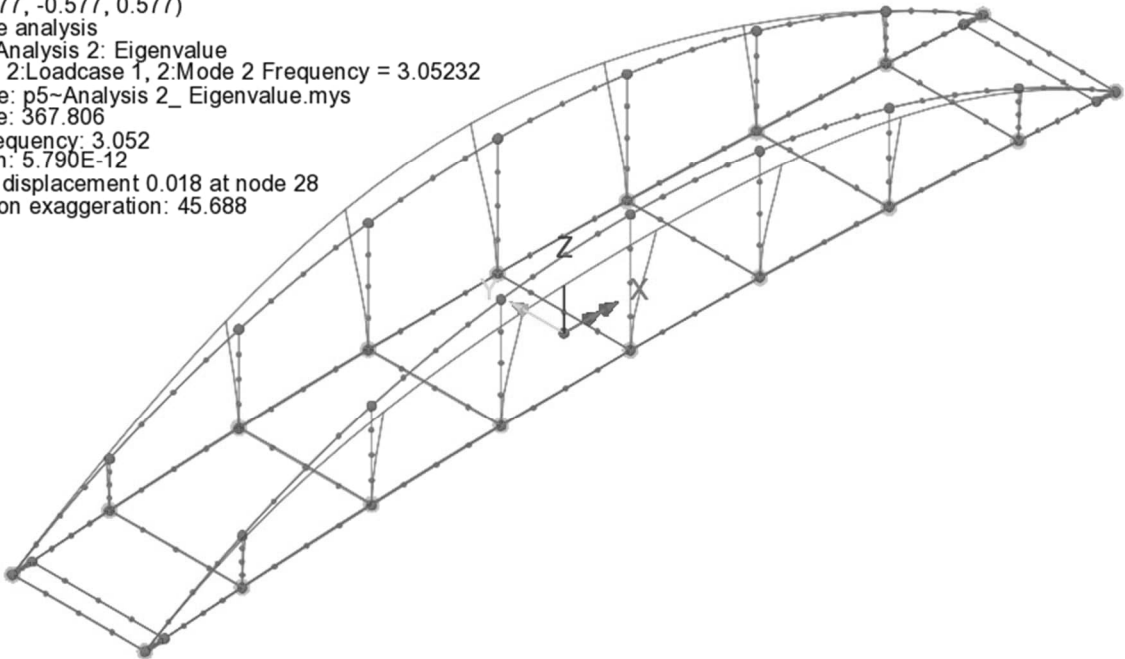
Scale: 1: 136.816
Zoom: 79.719
Eye: (-0.577, -0.577, 0.577)
Eigenvalue analysis
Analysis: Analysis 2: Eigenvalue
Loadcase: 2:Loadcase 1, 2:Mode 1 Frequency = 1.63349
Results file: p5-Analysis 2_ Eigenvalue.mys
Eigenvalue: 105.340
Natural frequency: 1.633
Error norm: 0.021E-9
Maximum displacement 0.012 at node 28
Deformation exaggeration: 70.687



3D view

Mode 1: deformation y-direction

Scale: 1: 136.816
Zoom: 79.719
Eye: (-0.577, -0.577, 0.577)
Eigenvalue analysis
Analysis: Analysis 2: Eigenvalue
Loadcase: 2:Loadcase 1, 2:Mode 2 Frequency = 3.05232
Results file: p5-Analysis 2_ Eigenvalue.mys
Eigenvalue: 367.806
Natural frequency: 3.052
Error norm: 5.790E-12
Maximum displacement 0.018 at node 28
Deformation exaggeration: 45.688

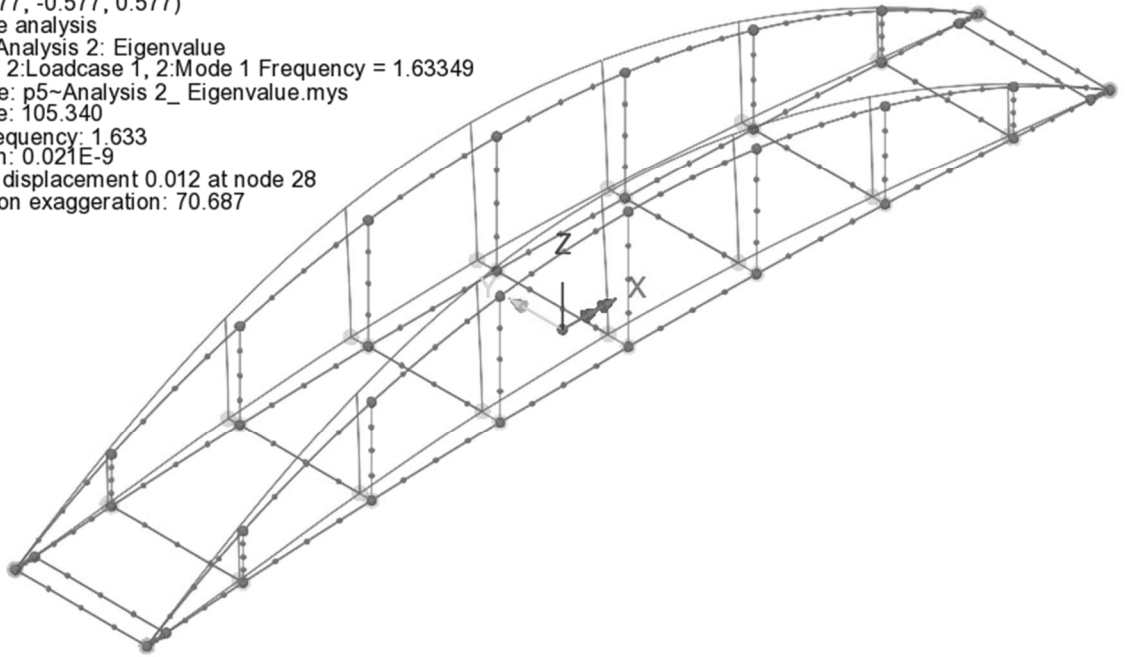


3D view

Mode 2: deformation y-direction

	Appendix 2: Results SYSTEM 001	Status :	Page: 6
	Dynamic analysis: Pedestrian bridge	Date :	Created:

Scale: 1: 136.816
Zoom: 79.719
Eye: (-0.577, -0.577, 0.577)
Eigenvalue analysis
Analysis: Analysis 2: Eigenvalue
Loadcase: 2: Loadcase 1, 2: Mode 1 Frequency = 1.63349
Results file: p5~Analysis 2_ Eigenvalue.mys
Eigenvalue: 105.340
Natural frequency: 1.633
Error norm: 0.021E-9
Maximum displacement 0.012 at node 28
Deformation exaggeration: 70.687

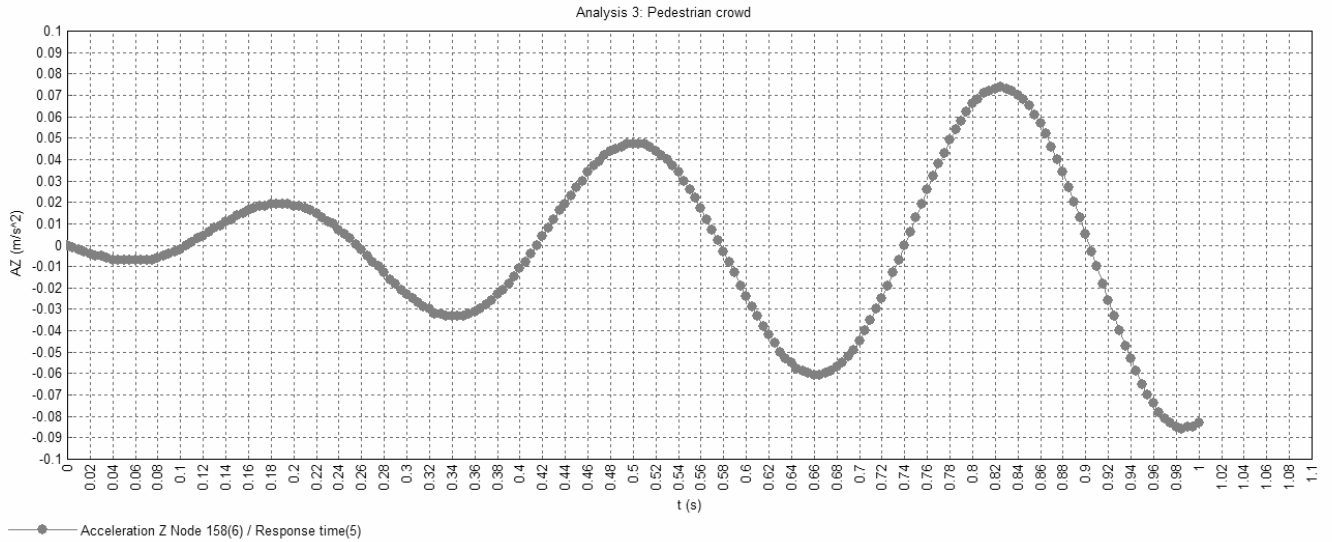


3D view

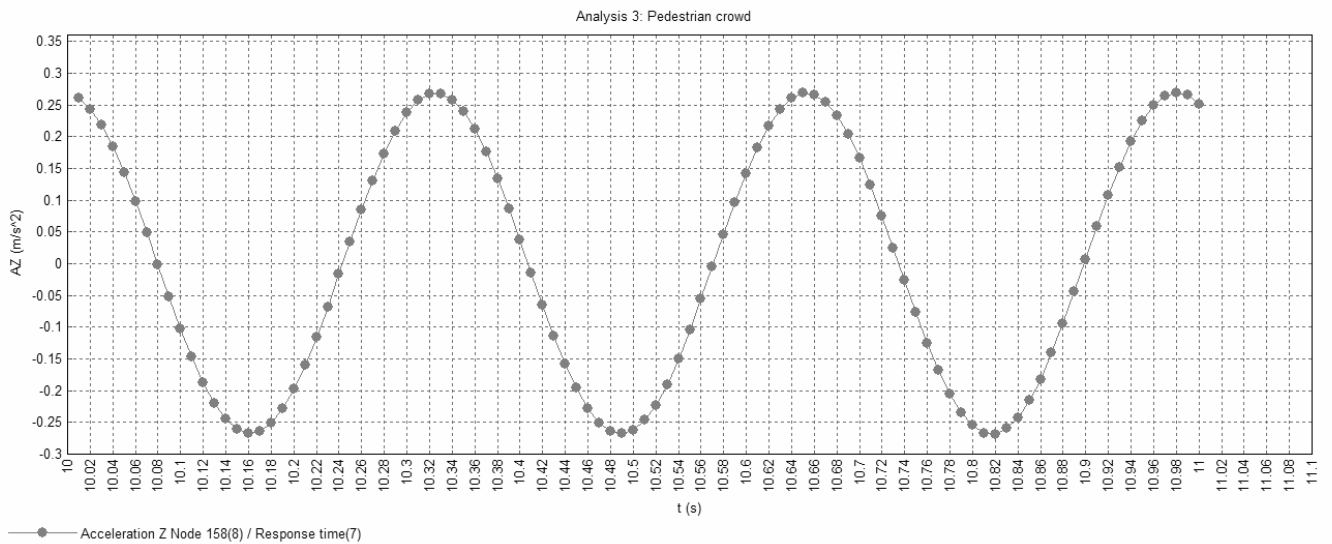
Mode 3: deformation z-direction

3. Analysis 3: Cyclic crowd load

Time 0 s → 1.0 s (time step 0.005 s):



Time 10.0 s → 11.0 s (time step 0.005 s):



	Appendix 2: Results SYSTEM 001	Status :	Page: 8
	Dynamic analysis: Pedestrian bridge	Date :	Created:

4. Analysis 4: Cyclic moving vertical load

Time 0 s → 20 s (time step 0.005 s):

