FEM Design Verification Checklist for MidasCivil 2019 (Summary)

Project Title		Job No.	
Discipline	Structural	File Ref.	
Review Date		Reviewer	
Project Stage		Circulation	

Abbreviations
TM = Tree Menu
D&D = Drag and Drop

Note "say" refers to user input based on designed bridge in question. The figures are marked in red.

Legend
Pass √
Fail X
Not Applicable NA

ITEM	CONTENT	√
1.0	**COMPANY STANDARD TEMPLATE**	
1.1	**General**	
1.11	Company template file	☐
1.2	**Model Units**	
1.21	Set model units to kN and m	☐
2.0	**MATERIAL DEFINITIONS**	
2.1	**Concrete [C60] Material Definition**	
2.11	Properties → Material Properties → Add → define material with • Name = MAT-C60 • Type of Design → Concrete • Standard → BS(RC) • DB → C60 say • Standard → None • Weight Density = 25 kN/m^3	☐
2.12	Properties → Creep/Shrinkage → Add → define creep/shrinkage time dependent material with • Name = MAT-C60-CREEP • Code → CEB-FIP(1990) • fck = 60,000 kN/m^2 say • RH = 80 % • h = 0.2 m default representative • Type of cement = Normal or rapid hardening cement (N, R) • Age = 3 days	☐
2.13	Properties → Comp. Strength → Add → define comp. strength time dependent material with • Name = MAT-C60-STR • Type → Code • Code → CEB-FIP(1990) • fck+Δf = 68,000 kN/m^2 say • Cement type → N, R : 0.25	☐
2.14	Properties → Material Link → link time dependent material with • Time Dependent Material Type (Creep/Shrinkage) → MAT-C60-CREEP • Time Dependent Material Type (Comp. Strength) → MAT-C60-STR • Select Material to Assign → MAT-C60 → Operation Add / Modify → Close	☐
2.2	**Concrete [C50] Material Definition**	
2.21	Properties → Material Properties → Add → define material with • Name = MAT-C50 • Type of Design → Concrete • Standard → BS(RC) • DB → C50 say • Standard → None • Weight Density = 25 kN/m^3	☐
2.22	Properties → Creep/Shrinkage → Add → define creep/shrinkage time dependent material with • Name = MAT-C50-CREEP • Code → CEB-FIP(1990) • fck = 50,000 kN/m^2 say • RH = 80 % • h = 0.2 m default representative • Type of cement = Normal or rapid hardening cement (N, R) • Age = 3 days	☐

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ITEM	CONTENT	√
2.23	Properties → Comp. Strength → Add → define comp. strength time dependent material with • Name = MAT-C50-STR • Type → Code • Code → CEB-FIP(1990) • fck+Δf = 58,000 kN/m^2 say • Cement type → N, R : 0.25	☐
2.24	Properties → Material Link → link time dependent material with • Time Dependent Material Type (Creep/Shrinkage) → MAT-C50-CREEP • Time Dependent Material Type (Comp. Strength) → MAT-C50-STR • Select Material to Assign → MAT-C50 → Operation Add / Modify → Close	☐
2.3	**Concrete [C40] Material Definition**	
2.31	Properties → Material Properties → Add → define material with • Name = MAT-C40 • Type of Design → Concrete • Standard → BS(RC) • DB → C40 say • Standard → None • Weight Density = 25 kN/m^3	☐
2.32	Properties → Creep/Shrinkage → Add → define creep/shrinkage time dependent material with • Name = MAT-C40-CREEP • Code → CEB-FIP(1990) • fck = 40,000 kN/m^2 say • RH = 80 % • h = 0.2 m default representative • Type of cement = Normal or rapid hardening cement (N, R) • Age = 3 days	☐
2.33	Properties → Comp. Strength → Add → define comp. strength time dependent material with • Name = MAT-C40-STR • Type → Code • Code → CEB-FIP(1990) • fck+Δf = 48,000 kN/m^2 say • Cement type → N, R : 0.25	☐
2.34	Properties → Material Link → link time dependent material with • Time Dependent Material Type (Creep/Shrinkage) → MAT-C40-CREEP • Time Dependent Material Type (Comp. Strength) → MAT-C40-STR • Select Material to Assign → MAT-C40 → Operation Add / Modify → Close	☐
2.4	**Concrete [C40-PSEUDO] Material Definition**	
2.41	Properties → Material Properties → Add → define material with • Name = MAT-C40-PSEUDO • Type of Design → Concrete • Standard → BS(RC) to generate standard stiffness properties • DB → C40 say to generate standard stiffness properties • Standard → None • Weight Density → 0 kN/m^3	☐
2.42	Properties → Creep/Shrinkage → Add → define creep/shrinkage time dependent material with • Name = MAT-C40-PSEUDO-CREEP • Code → CEB-FIP(1990) • fck = 40,000 kN/m^2 say • RH = 80 % • h = 0.2 m default representative • Type of cement = Normal or rapid hardening cement (N, R) • Age = 3 days	☐
2.43	Properties → Comp. Strength → Add → define comp. strength time dependent material with • Name = MAT-C40-PSEUDO-STR • Type → Code • Code → CEB-FIP(1990) • fck+Δf = 48,000 kN/m^2 say • Cement type → N, R : 0.25	☐
2.44	Properties → Material Link → link time dependent material with • Time Dependent Material Type (Creep/Shrinkage) → MAT-C40-PSEUDO-CREEP • Time Dependent Material Type (Comp. Strength) → MAT-C40-PSEUDO-STR • Select Material to Assign → MAT-C40-PSEUDO → Operation Add / Modify → Close	☐

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ITEM	CONTENT	√
2.5	**Tendon Material Definition**	
2.51	Properties → Material Properties → Add → define material with • Name = MAT-TENDON • Type of Design → Steel • Standard → EN05(S) • DB → Y1860S7(15.7mm)	☐
3.0	**SECTION DEFINITIONS**	
3.1	**Beam Girder Section Definition**	

3.11	Properties → Section Properties → Add → PSC → PSC-Value → define non-composite section with
	• Name = SECT-BG
	• Section Data → DB → PSC DB with
	  ○ Code → UK
	  ○ Type → UK-M, UK-T or UK-U_SU → girder section
	• Offset = Centre-Centre
	
	OR
	
	Tools → Sectional Property Calculator (SPC) → Unit Settings (Force → kN, Length → mm) → OK → define non-composite section with
	• File → Import → AutoCAD DXF → select girder section dxf file → OK
	• Model → Section → Generate → define section properties with
	  ○ Type → Plane
	  ○ select Calculate Properties Now
	  ○ window select section in graphic view → Apply
	• Model → Section → Export → export section with
	  ○ insert File Name
	  ○ select MIDAS Section File
	  ○ window select section in graphic view → Apply
	Properties → Section Properties → Add → PSC → PSC-Value → define non-composite section with
	• Name = SECT-BG
	• Section Data → Import from SPC → select girder MIDAS Section File → Open → OK
	• Param. for Design → T1 = 1000 mm say | Param. for Design → T2 = 1000 mm say
	• Param. for Design → BT = 1000 mm say | Param. for Design → HT = 1000 mm say
	• Offset = Centre-Centre
		☐

3.12	Properties → Section Properties → Add → Composite → define composite section with
	• Name = C-SECT-BG
	• Section Type → Composite-PSC
	• Slab Bc = 2.400 m say to match beam girder spacing | Slab tc = 0.200 m say | Slab Hh = 0.000 m
	• Girder → PSC Value Type → SECT-BG
	• Material → Select Material from DB → select material for slab and girder with
	  ○ Concrete Material for Slab → DB → BS(RC)
	  ○ Concrete Material for Slab → Name → C40 say
	  ○ Concrete Material for Girder → DB → BS(RC)
	  ○ Concrete Material for Girder → Name → C60 say
	• Offset = Centre-Top
		☐

3.2	**Link Slab Section Definition**	
3.21	Properties → Section Properties → Add → DB/User → define section with • Name = SECT-LINK-SLAB • Type → Solid Rectangle • Type → User • H = 0.200 m say | B = 2.400 m say to match beam girder spacing • Offset = Centre-Top	☐
3.3	**Null Beam Section Definition**	
3.31	Properties → Section Properties → Add → DB/User → define section with • Name = SECT-NULL-SLAB • Type → Solid Rectangle • Type → User • H = 0.200 m say | B = 0.200 m say • Offset = Left-Top or Right-Top	☐
3.4	**Cross Head Section Definition**	
3.41	Properties → Section Properties → Add → DB/User → define section with • Name = SECT-CH-M1 | SECT-CH-M2 | SECT-CH-M3 | SECT-CH-M4 | SECT-CH-M5	☐

ITEM	CONTENT	√

	• Type → Solid Rectangle
	• Type → User
	• H = 4.200 m say | B = 1.800 m say
	• Offset = Centre-Top | Centre Loc. = Centre of Section | Vertical Offset → User I|J = 1.5 m say to model offset to corbel bearing level | User Offset Reference → Extreme Fibre(s)
	
	OR
	
	Tools → Sectional Property Calculator (SPC) → Unit Settings (Force → kN, Length → mm) → OK → define section with
	• File → Import → AutoCAD DXF → select cross head section dxf file → OK
	• Model → Section → Generate → define section properties with
	  ○ Type → Plane
	  ○ select Calculate Properties Now
	  ○ window select section in graphic view → Apply
	• Model → Section → Export → export section with
	  ○ insert File Name
	  ○ select MIDAS Section File
	  ○ window select section in graphic view → Apply
	Properties → Section Properties → Add → Value → define prismatic section with
	• Name = SECT-CH-M1 | SECT-CH-M2 | SECT-CH-M3 | SECT-CH-M4 | SECT-CH-M5
	• Type → General Section
	• Import SEC Files → select cross head MIDAS Section File → Open → OK
	• Offset = Centre-Top | Centre Loc. = Centre of Section | Vertical Offset → User I|J = 1.5 m say to model offset to corbel bearing level | User Offset Reference → Extreme Fibre(s)
	
	OR
	
	Properties → Section Properties → Add → Tapered → define non-prismatic section with
	• Name = SECT-CH-M1 | SECT-CH-M2 | SECT-CH-M3 | SECT-CH-M4 | SECT-CH-M5
	• Type → General Section
	• Section-i → Import → Select Regular Section → Import
	• Section-j → Import → Select Regular Section → Import
	• Offset = Centre-Top | Centre Loc. = Centre of Section | Vertical Offset → User I|J = 1.5 m say to model offset to corbel bearing level | User Offset Reference → Extreme Fibre(s)
	Note for non-prismatic sections, it is crucial that both sections i and j have the **same number of nodes**. For tapered section definitions across multiple elements, select the elements that have been predefined with the non-prismatic section and Right-Click → Properties → Tapered Section Group → Add → Convert to Tapered Section.	

3.5	**Pier Section Definition**	

3.51	Properties → Section Properties → Add → DB/User → define section with
	• Name = SECT-PIER
	• Type → Solid Rectangle
	• Type → User
	• H = 3.600 m say | B = 1.600 m say
	• Offset = Centre-Centre
	
	OR
	
	Tools → Sectional Property Calculator (SPC) → Unit Settings (Force → kN, Length → mm) → OK → define section with
	• File → Import → AutoCAD DXF → select pier section dxf file → OK
	• Model → Section → Generate → define section properties with
	  ○ Type → Plane
	  ○ select Calculate Properties Now
	  ○ window select section in graphic view → Apply
	• Model → Section → Export → export section with
	  ○ insert File Name
	  ○ select MIDAS Section File
	  ○ window select section in graphic view → Apply
	Properties → Section Properties → Add → Value → define section with
	• Name = SECT-PIER
	• Type → General Section
	• Import SEC Files → select pier MIDAS Section File → Open → OK
	• Offset = Centre-Centre
		☐

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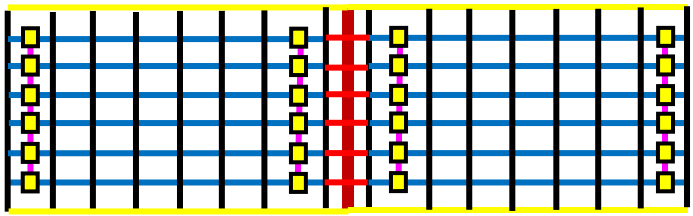
ITEM	CONTENT	√
3.6	**Pile Cap Section Definition**	
3.61	Properties → Section Properties → Add → DB/User → define section with • Name = SECT-PILECAP • Type → Solid Rectangle • Type → User • H = 2.500 m say | B = 1.500 m say • Offset = Centre-Top	☐
3.7	**Pile Section Definition**	
3.71	Properties → Section Properties → Add → DB/User → define section with • Name = SECT-PILE • Type → Solid Round • Type → User • D = 1.000 m say • Offset = Centre-Centre	☐
3.8	**Deck Section Definition**	
3.81	Properties → Section Properties → Add → DB/User → define section with • Name = SECT-DECK • Type → Solid Rectangle • Type → User • H = 0.200 m say | B = 2.400 m say to match deck spacing • Offset = Centre-Top	☐
3.9	**Diaphragm Beam Section Definition**	
3.91	Properties → Section Properties → Add → DB/User → define section with • Name = SECT-DIAPHRAGM • Type → Solid Rectangle • Type → User • H = 1.800 m say | B = 0.800 m say • Offset = Centre-Top	☐
4.0	**GEOMETRY MODELLING**	
4.1	**Geometry Modelling**	
4.11	File → Import → AutoCAD dxf → select dxf file → select relevant layers → OK to generate nodes and elements  • C-SECT-BG • SECT-LINK-SLAB • SECT-NULL-SLAB • SECT-CH-M1 | SECT-CH-M2 | SECT-CH-M3 | SECT-CH-M4 | SECT-CH-M5 • SECT-DECK • SECT-DIAPHRAGM • ELASTIC-BEARING-SUPPPORT Note that: - • the beam girders span between elastic bearing supports • the link slabs span between the ends of beam girders across (without connecting to) the cross head • multiple deck sections (potentially) required to represent their varying transverse deck widths • multiple beam girder sections (potentially) required to represent their varying composite deck widths • multiple beam girder groups (potentially) required to represent their staged construction • multiple cross head sections (potentially) required to represent its non-prismatic profile • multiple cross head groups (potentially) required to represent its staged construction	☐
4.2	**Section Assignment**	
4.21	Right-Click → Select → Window → select corresponding elements TM → Works → Properties → Section → D&D sections to assign onto elements: - • C-SECT-BG • SECT-LINK-SLAB • SECT-NULL-SLAB	☐

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ITEM	CONTENT	√
	• SECT-CH-M1 | SECT-CH-M2 | SECT-CH-M3 | SECT-CH-M4 | SECT-CH-M5 • SECT-PIER • SECT-PILECAP • SECT-PILE • SECT-DECK • SECT-DIAPHRAGM	
4.3	**Group Definition and Assignment**	
4.31	TM → Works → Properties → Section → select corresponding elements by section TM → Group → Right-Click Structure Group → New → Rename Group to define group → D&D group to assign onto elements: - • GROUP-BG-M2 | GROUP-BG-M3 | GROUP-BG-M4 | GROUP-BG-M5 onto C-SECT-BG • GROUP-LINK-SLAB onto SECT-LINK-SLAB • GROUP-CH-M1 | GROUP-CH-M2 | GROUP-CH-M3 | GROUP-CH-M4 | GROUP-CH-M5 onto SECT-CH-M1 | SECT-CH-M2 | SECT-CH-M3 | SECT-CH-M4 | SECT-CH-M5 • GROUP-SUBSTR onto SECT-PIER | SECT-PILECAP | SECT-PILE • GROUP-DECK onto SECT-NULL-SLAB | SECT-DECK • GROUP-DIAPHRAGM onto SECT-DIAPHRAGM	☐
4.32	Right-Click → Select → Window → select abutment bearing nodes TM → Group → Right-Click Structure Group → New → Rename Group to define group → D&D group to assign onto nodes: - • GROUP-NODES-ABUTMENT Right-Click → Select → Window → select cross head bearing nodes TM → Group → Right-Click Structure Group → New → Rename Group to define group → D&D group to assign onto nodes: - • GROUP-NODES-BEARING	☐
4.33	TM → Group → Right-Click Boundary Group → New → Rename Group to define group: - • GROUP-SUPPORT-BEARING • GROUP-SUPPORT-CH-PIER • GROUP-SUPPORT-PILE • GROUP-SUPPORT-ABUTMENT	☐
4.34	TM → Group → Right-Click Load Group → New → Rename Group to define group: - • GROUP-LOAD-SELF-WEIGHT • GROUP-LOAD-WET-CONCRETE • GROUP-LOAD-SURFACING • GROUP-LOAD-PARAPET • GROUP-LOAD-TENDON-BG-L | GROUP-LOAD-TENDON-BG-R | GROUP-LOAD-TENDON-BG-M • GROUP-LOAD-TENDON-CH-M2 | GROUP-LOAD-TENDON-CH-M3 • GROUP-LOAD-TENDON-CH-M4 | GROUP-LOAD-TENDON-CH-M5 • GROUP-LOAD-TENDON-CH-STAGE3	☐
4.4	**Material Assignment**	
4.41	TM → Group → select corresponding elements by group TM → Works → Properties → Material → D&D materials to assign onto elements: - • MAT-C60 onto GROUP-BG-M2 | GROUP-BG-M3 | GROUP-BG-M4 | GROUP-BG-M5 • MAT-C50 onto GROUP-CH-M1 | GROUP-CH-M2 | GROUP-CH-M3 | GROUP-CH-M4 | GROUP-CH-M5 • MAT-C40 onto GROUP-LINK-SLAB | GROUP-SUBSTR | GROUP-DIAPHRAGM • MAT-C40-PSEUDO onto GROUP-DECK	☐
5.0	**BOUNDARY CONDITION DEFINITIONS**	
5.1	**Cross Head Bearing Elastic Link**	
5.11	Right-Click → Select → Window → select girder to cross head bearing nodes Boundary → Elastic Link → define boundary condition with • Boundary Group Name → GROUP-SUPPORT-BEARING • Options → Add • Type → General • SDx = 5,000 kN/m say | SDy = 5,000 kN/m say | SDz = 2,000,000 kN/m say • SRx = 10 kNm/[rad] | SRy = 0 kNm/[rad] | SRz = 10 kNm/[rad] • Beta Angle = 0 deg	☐
5.12	Right-Click → Select → Window → select cross head bearing nodes to cross head Boundary → Elastic Link → define boundary condition with • Boundary Group Name → GROUP-SUPPORT-BEARING • Options → Add • Type → Rigid • Beta Angle = 0 deg	☐

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ITEM	CONTENT	√
5.2	**Cross Head to Pier Rigid Link**	
5.21	Right-Click → Select → Window → select cross head to top of pier nodes Boundary → Elastic Link → define boundary condition with • Boundary Group Name → GROUP-SUPPORT-CH-PIER • Options → Add • Type → Rigid • Beta Angle = 0 deg	☐
5.3	**Pile Elastic or Rigid Support**	
5.31	TM → Works → Properties → Section → select pile elements by section SECT-PILE Boundary → Integral Bridge → define boundary condition with • Boundary Group Name → GROUP-SUPPORT-PILE • Soil Spring Type → Pile Spring • Soil Type → Stiff Clay say • Ground Level = -3.5 m say • Pile Diameter (D) = 1.000 m say • Unit Weight of Soil (r) = 19 kN/m^3 say • Earth Pressure Coeff. At Rest (K_O) = 0.40 say • Coeff. of Subgrade Reaction (Kh) = 80000 kN/m^3 say • ½ Strain at Max Stress Point in Tri. Comp. Test (e50) = 0.01 say • Undrained Cohesion (cu) = 110 kN/m^2 say OR Right-Click → Select → Window → select pier base nodes Boundary → Define Supports → define boundary condition with • Boundary Group Name → GROUP-SUPPORT-PILE • Options → Add • D-ALL → select • R-ALL → select	☐
5.4	**Abutment Bearing Elastic Support**	
5.41	TM → Group → select abutment bearing nodes by group GROUP-NODES-ABUTMENT Boundary → Point Spring → define boundary condition with • Boundary Group Name → GROUP-SUPPORT-ABUTMENT • Options → Add • Type → Linear • SDx = 5,000 kN/m say | SDy = 5,000 kN/m say | SDz = 2,000,000 kN/m say • SRx = 0 kNm/[rad] | SRy = 0 kNm/[rad] | SRz = 0 kNm/[rad]	☐
6.0	**LOAD CASE AND LOADING DEFINITIONS**	
6.1	**Dead Load [Self-Weight]**	
6.11	Load → Static Loads → Static Load Cases → define load case with • Name = LC-SELF-WEIGHT • Case → All Load Case • Type → Construction Stage Load (CS)	☐
6.12	Load → Static Loads → Self Weight → define load with • Load Case Name = LC-SELF-WEIGHT • Load Group Name = GROUP-LOAD-SELF-WEIGHT • X = 0 | Y = 0 | Z = -1	☐
6.2	**Dead Load [Wet Concrete]**	
6.21	Load → Static Loads → Static Load Cases → define load case with • Name = LC-WET-CONCRETE • Case → All Load Case • Type → Construction Stage Load (CS)	☐
6.22	TM → Group → select beam girder and link slab elements by groups GROUP-BG-M2 | GROUP-BG-M3 | GROUP-BG-M4 | GROUP-BG-M5 Load → Static Loads → Element → define load with • Load Case Name = LC-WET-CONCRETE • Load Group Name = GROUP-LOAD-WET-CONCRETE • Options → Add • Load Type → Uniform Loads • Direction → Global Z • Projection → No • Value → Relative	☐

ITEM	CONTENT	√
	• x1 = 0 and w = width x 200mm x 25kN/m^3 say = width x 5.0kN/m^2 say = -12.0 kN/m say • x2 = 1	
6.3	**Superimposed Dead Load [Surfacing]**	
6.31	Load → Static Loads → Static Load Cases → define load case with • Name = LC-SURFACING • Case → All Load Case • Type → Construction Stage Load (CS)	☐
6.32	TM → Group → select beam girder and link slab elements by groups GROUP-BG-M2 | GROUP-BG-M3 | GROUP-BG-M4 | GROUP-BG-M5 and GROUP-LINK-SLAB Load → Static Loads → Element → define load with • Load Case Name = LC-SURFACING • Load Group Name = GROUP-LOAD-SURFACING • Options → Add • Load Type → Uniform Loads • Direction → Global Z • Projection → No • Value → Relative • x1 = 0 and w = width x 75mm x 22kN/m^3 say = width x 1.65kN/m^2 say = -4.0 kN/m say • x2 = 1	☐
6.4	**Superimposed Dead Load [Parapet]**	
6.41	Load → Static Loads → Static Load Cases → define load case with • Name = LC-PARAPET • Case → All Load Case • Type → Construction Stage Load (CS)	☐
6.42	TM → Works → Properties → Section → select parapet elements by section SECT-NULL-SLAB Load → Static Loads → Element → define load with • Load Case Name = LC-PARAPET • Load Group Name = GROUP-LOAD-PARAPET • Options → Add • Load Type → Uniform Loads • Direction → Global Z • Projection → No • Value → Relative • x1 = 0 and w = -10 kN/m say • x2 = 1	☐
6.5	**Tendon Load**	
6.51	Load → Static Loads → Static Load Cases → define load case with • Name = LC-TENDON • Case → All Load Case • Type → Construction Stage Load (CS)	☐

6.52	Load → Temp./Prestress → Tendon Property → Add → define tendon property with
	• Tendon Name = TENDON-12S15.2 | TENDON-19S15.2 | TENDON-27S15.2
	• Tendon Type → Internal(Pre-Tension) or Internal(Post-Tension)
	• Material → MAT-TENDON
	• Total Tendon Area = Click <…> to specify tendon area with
	  ○ Strand Diameter → 15.2 mm say
	  ○ Number of Strands = 12 | 19 | 27
	• Duct Diameter = 0.087 m | 0.102 m | 0.127 m
	• Relaxation Coefficient → CEB-FIP 1990 with
	  ○ rho1000 = 2.5 % say
	• Ultimate Strength = 1.86326e+006 kN/m^2 say
	• Yield Strength = 1.56906e+006 kN/m^2 say
	• Curvature Friction Factor = 0.30 say
	• Wobble Friction Factor = 0.0033 1/m say
	• Anchorage Slip(Draw in) Begin = 0.006 m say
	• Anchorage Slip(Draw in) End = 0 m say
	• Bond Type → Bonded say
		☐

6.53	Load → Temp./Prestress → Tendon Profile → Add → define tendon profile with • Tendon Name = C1-ZL | C1-ZR | C2-ZL | C2-ZR | C3-ZL | C3-ZR | C4-ZL | C4-ZR | C5-ZL | C5-ZR • Group → Default • Tendon Property → TENDON-12S15.2 | TENDON-19S15.2 | TENDON-27S15.2	☐

ITEM	CONTENT	√
	• Assigned Elements = [TM → Group → select cross head elements by group GROUP-CH-M1 | GROUP-CH-M2 | GROUP-CH-M3 | GROUP-CH-M4 | GROUP-CH-M5] • Input Type → 2D • Curve Type → Spline • Lead Length → User Defined Length	

6.54	Load → Temp/Prestress → Tendon Prestress → define tendon prestress load with
	• Load Case Name → LC-TENDON
	• Load Group Name → GROUP-LOAD-TENDON-CH-M2 | GROUP-LOAD-TENDON-CH-M3 | GROUP-LOAD-TENDON-CH-M4 | GROUP-LOAD-TENDON-CH-M5 | GROUP-LOAD-TENDON-CH-STAGE3
	• Select Tendon for Loading = C1-ZL | C1-ZR | C2-ZL | C2-ZR | C3-ZL | C3-ZR | C4-ZL | C4-ZR | C5-ZL | C5-ZR
	• Stress Value → select Force → define tendon force with
	  ○ Begin = 75% x no. of strands x 15.2 mm strand breaking load of 260.7 kN say
	  ○ End = 0 kN say
	  ○ 1st Jacking → Begin say
		☐

6.6	**Temperature Load**	
6.61	Load → Static Loads → Static Load Cases → define load case with • Name = LC-TEMP(+) | LC-TEMP(-) • Case → All Load Case • Type → Temperature (T)	☐
6.62	TM → Works → Properties → Section → select beam girder, link slab, cross head, pier and diaphragm beam elements by sections C-SECT-BG, SECT-LINK-SLAB, SECT-CH-M1 | SECT-CH-M2 | SECT-CH-M3 | SECT-CH-M4 | SECT-CH-M5, SECT-PIER and SECT-DIAPHRAGM Load → Temp./Prestress → Element Temp → define load with • Load Case Name → LC-TEMP(+) • Load Group Name → Default • Options → Add • Temperature → Initial = 70 °F [21 °C] • Temperature → Final = 100 °F [38 °C] Load → Temp./Prestress → Element Temp → define load with • Load Case Name → LC-TEMP(-) • Load Group Name → Default • Options → Add • Temperature → Initial = 100 °F [38 °C] • Temperature → Final = 70 °F [21 °C]	☐
6.7	**HA Braking, HB Braking and HA Skidding Load**	
6.71	Load → Static Loads → Static Load Cases → define load case with • Name = LC-HA-BRAKING | LC-HB-BRAKING | LC-HA-SKIDDING • Case → All Load Case • Type → Braking Load (BRK)	☐
6.72	TM → Group → select cross head elements by groups GROUP-CH-M1 | GROUP-CH-M2 | GROUP-CH-M3 | GROUP-CH-M4 | GROUP-CH-M5 Load → Static Loads → Element → define load with • Load Case Name → LC-HA-BRAKING • Load Group Name → Default • Options → Add • Load Type → Uniform Loads • Direction → Global X • Value → Relative • x1 = 0 and w = 750 kN / bridge width say = 25 kN/m say • x2 = 1 Load → Static Loads → Element → define load with • Load Case Name → LC-HB-BRAKING • Load Group Name → Default • Options → Add • Load Type → Uniform Loads • Direction → Global X • Value → Relative • x1 = 0 and w = 450 kN / bridge width say = 15 kN/m say • x2 = 1 Load → Static Loads → Element → define load with • Load Case Name → LC-HA-SKIDDING • Load Group Name → Default	☐

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ITEM	CONTENT	√
	• Options → Add • Load Type → Uniform Loads • Direction → Global X • Value → Relative • x1 = 0 and w = 300 kN / bridge width say = 10 kN/m say • x2 = 1	
6.8	**Collision Load**	
6.81	Load → Static Loads → Static Load Cases → define load case with • Name = LC-COLLISION • Case → All Load Case • Type → Collision Load (CO)	☐
6.82	TM → Works → Properties → Section → select pier elements by section SECT-PIER Load → Static Loads → Element → define load with • Load Case Name → LC-COLLISION • Load Group Name → Default • Options → Add • Load Type → Concentrated Forces • Direction → Global X • Value → Absolute • x1 = 1.5 m | P1 = 1000 kN • x1 = 3.0 m | P1 = 500 kN Load → Static Loads → Element → define load with • Load Case Name → LC-COLLISION • Load Group Name → Default • Options → Add • Load Type → Concentrated Forces • Direction → Global Y • Value → Absolute • x1 = 1.5 m | P1 = 500 kN • x1 = 3.0 m | P1 = 250 kN	☐
6.9	**Wind Load**	
6.91	Load → Static Loads → Static Load Cases → define load case with • Name = LC-WIND-TRANS | LC-WIND-LONG | LC-WIND-VERT(+) | LC-WIND-VERT(-) • Case → All Load Case • Type → Wind Load on Structure (W)	☐
6.92	TM → Group → select cross head elements by groups GROUP-CH-M1 | GROUP-CH-M2 | GROUP-CH-M3 | GROUP-CH-M4 | GROUP-CH-M5 Load → Static Loads → Element → define load with • Load Case Name → LC-WIND-TRANS • Load Group Name → Default • Options → Add • Load Type → Uniform Loads • Direction → Global Y • Value → Relative • x1 = 0 and w = bridge span x girder height / bridge width x 1.0 kPa say = 1.6 kN/m say • x2 = 1 Load → Static Loads → Element → define load with • Load Case Name → LC-WIND-LONG • Load Group Name → Default • Options → Add • Load Type → Uniform Loads • Direction → Global X • Value → Relative • x1 = 0 and w = girder height x 1.0 kPa say = 1.6 kN/m say • x2 = 1 Load → Static Loads → Element → define load with • Load Case Name → LC-WIND-VERT(+) • Load Group Name → Default • Options → Add • Load Type → Uniform Loads • Direction → Global Z • Value → Relative • x1 = 0 and w = bridge span x 1.0 kPa say = 30 kN/m say	☐

ITEM	CONTENT	√
	• x2 = 1 Load → Static Loads → Element → define load with • Load Case Name → LC-WIND-VERT(-) • Load Group Name → Default • Options → Add • Load Type → Uniform Loads • Direction → Global Z • Value → Relative • x1 = 0 and w = bridge span x -1.0 kPa say = -30 kN/m say • x2 = 1	
6.10	**Seismic Load**	
6.101	Load → Dynamic Loads → RS Functions → Add → define response spectrum function with • Function Name = EURO2004 H-DESIGN | EURO2004 V-DESIGN • Spectral Data Type → Normalized Accel. • Scale Factor = 1 • Gravity = 9.806m/s^2 • Damping Ratio = 0.05 say • Design Spectrum → Eurocode-8(2004) • National Annex → Recommended • Spectrum Type → Horizontal Design Spectrum | Vertical Design Spectrum • Ground Type → C say • Spectrum Parameters → Type1 say • Ref. Peak Ground Acc. (AgR) = 0.07 g say • Importance Factor (I) → 1.0 say • Behaviour Factor (q) = 1.5 say • Lower Bound Factor (b) = 0.2 say • Max. period = 6 sec say Load → Dynamic Loads → RS Functions → Add → define response spectrum function with • Function Name = EURO2004 H-ELASTIC | EURO2004 V-ELASTIC • Spectral Data Type → Normalized Accel. • Scale Factor = 1 • Gravity = 9.806m/s^2 • Damping Ratio = 0.05 say • Design Spectrum → Eurocode-8(2004) • National Annex → Recommended • Spectrum Type → Horizontal Elastic Spectrum | Vertical Elastic Spectrum • Ground Type → C say • Spectrum Parameters → Type1 say • Ref. Peak Ground Acc. (AgR) = 0.07 g say • Importance Factor (I) → 1.0 say • Viscous Damping Ratio = 5 % say • Max. period = 6 sec say	☐
6.102	Load → Dynamic Loads → RS Load Cases → Add → define seismic load cases with • Load Case = LC-EQ-LONG-DESIGN | LC-EQ-TRANS-DESIGN • Direction → X-Y • Excitation Angle → 0 | 90 • Scale Factor = 1 • Period Modification = 1 • Modal Combination → Modal Combination Type → CQC • Spectrum Functions → Function Name → EURO2004 H-DESIGN • Interpolation of Spectral Data → Logarithmic Load → Dynamic Loads → RS Load Cases → Add → define seismic load cases with • Load Case = LC-EQ-VERT-DESIGN • Direction → Z • Scale Factor = 1 • Period Modification = 1 • Modal Combination → Modal Combination Type → CQC • Spectrum Functions → Function Name → EURO2004 V-DESIGN • Interpolation of Spectral Data → Logarithmic Load → Dynamic Loads → RS Load Cases → Add → define seismic load cases with • Load Case = LC-EQ-LONG-ELASTIC | LC-EQ-TRANS-ELASTIC • Direction → X-Y • Excitation Angle → 0 | 90 • Scale Factor = 1	☐

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ITEM	CONTENT	√
	• Period Modification = 1 • Modal Combination → Modal Combination Type → CQC • Spectrum Functions → Function Name → EURO2004 H-ELASTIC • Interpolation of Spectral Data → Logarithmic Load → Dynamic Loads → RS Load Cases → Add → define seismic load cases with • Load Case = LC-EQ-VERT-ELASTIC • Direction → Z • Scale Factor = 1 • Period Modification = 1 • Modal Combination → Modal Combination Type → CQC • Spectrum Functions → Function Name → EURO2004 V-ELASTIC • Interpolation of Spectral Data → Logarithmic	
6.103	Analysis → Eigenvalue → define Eigenvalue Analysis Control with • Type of Analysis → select Eigen Vectors → Lanczos • Eigen Vectors → Number of Frequencies → 30 say	☐
6104	Structure → Structure Type → define structure type and mass control with • Structure Type → 3-D • Mass Control Parameter → Lumped Mass | Consistent Mass • Mass Control Parameter → select Convert Self-Weight into Masses → select Convert to X, Y, Z • Gravity Acceleration = 9.806 m/s^2 • Initial Temperature = 21 [C]	☐
6.11	**Live Load [HA and HB]**	
6.111	TM → Works → Properties → Section → select corresponding elements by section TM → Group → Right-Click Structure Group → New → Rename Group to define group → D&D group to assign onto elements: - • GROUP-TRANSVERSE-ELEMENTS onto SECT-DECK and SECT-DIAPHRAGM	☐
6.112	Load → Moving Load → Moving Load Code → BS → Vehicles → Add Standard → define Standard Vehicular Load with • Standard Name → BD37/01 Standard Load • Vehicular Load Name = HA • Vehicular Load Type → HA • HA Lane Factor → BD 37/01 Load → Moving Load → Moving Load Code → BS → Vehicles → Add Standard → define Standard Vehicular Load with • Standard Name → BD37/01 Standard Load • Vehicular Load Name = HB30 • Vehicular Load Type → HB HA Lane Factor → BD 37/01Load → Moving Load → Moving Load Code → BS → Vehicles → Add Standard → define Standard Vehicular Load with • Standard Name → BD37/01 Standard Load • Vehicular Load Name = HB45 • Vehicular Load Type → HB • HA Lane Factor → BD 37/01	☐
6.113	Load → Moving Load → Moving Load Code → BS → Traffic Line Lanes → Add → define Design Traffic Line Lane with • Lane Name → NL1 | NL2 | NL3 | NL4 | NL5 | NL6 | NL7 | NL8 | NL9 | NL10 • Lane Width = Carriageway Width / No. of Notional Lanes say Note No. of Notional Lanes = ROUNDUP {Carriageway Width / 3.65m} • Eccentricity = - < distance to centre of notional lane from edge of deck > • Wheel Spacing = 1.0 m say • Vehicular Load Distribution → Cross Beam • Cross Beam Group → GROUP-TRANSVERSE-ELEMENTS • Moving Direction → Both • Selection by → 2 Points → < left-click edge of deck to define longitudinal extent of loading >	☐
6.114	Load → Moving Load → Moving Load Cases → Add → define moving load cases with • Load Case Name = HA | HA+HB30-NL1 | HA+HB30-NL2 | HA+HB30-NL3 | HA+HB30-NL4 | HA+HB30-NL5 | HA+HB30-NL6 | HA+HB30-NL7 | HA+HB30-NL8 • Select Load Model → Standard Load (BD 37/01, BS 5400) • Auto Live Load Combination → deselect • Sub-Load Cases → Loading Effects → select Combined → Add HA | HB30 loading to notional lanes Load → Moving Load → Moving Load Cases → Add → define moving load cases with • Load Case Name = HA | HA+HB45-NL1 | HA+HB45-NL2 | HA+HB45-NL3 | HA+HB45-NL4 | HA+HB45-NL5 | HA+HB45-NL6 | HA+HB45-NL7 | HA+HB45-NL8	☐

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ITEM	CONTENT	√
	• Select Load Model → Standard Load (BD 37/01, BS 5400) • Auto Live Load Combination → deselect • Sub-Load Cases → Loading Effects → select Combined → Add HA | HB45 loading to notional lanes	
6.115	TM → Group → select corresponding elements by group TM → Group → D&D group to assign onto elements: - • GROUP-REACTIONS onto GROUP-SUPPORT-PILE | GROUP-NODES-ABUTMENT • GROUP-DISPLACEMENTS onto GROUP-CH-M1 | GROUP-CH-M2 | GROUP-CH-M3 | GROUP-CH-M4 | GROUP-CH-M5 • GROUP-FORCES onto GROUP-BG-M2 | GROUP-BG-M3 | GROUP-BG-M4 | GROUP-BG-M5 | GROUP-CH-M1 | GROUP-CH-M2 | GROUP-CH-M3 | GROUP-CH-M4 | GROUP-CH-M5 | GROUP-SUBSTR Analysis → Moving Load → define Moving Load Analysis Control Data with • Influence Generation Method → Distance Between Points = 1.0 m say • Analysis Results → Plate → select Centre + Nodal | Stress | Concurrent Force • Analysis Results → Frame → select Normal + Concurrent Force / Stress | Combined Stress • Calculation Filters → select Reactions → Group → GROUP-REACTIONS • Calculation Filters → select Displacements → Group → GROUP-DISPLACEMENTS • Calculation Filters → select Forces/Moments → Group → GROUP-FORCES • Number of Notional Lanes, N for HA Lane Factor (BD 37/01) → N >=6 say	☐
7.0	**CONSTRUCTION STAGE DEFINITIONS**	
7.1	**Construction Stage CS-0 [Pile, Pile Cap and Pier]**	
7.11	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-0 • Duration = 30 day(s) • Element → select GROUP-SUBSTR → Activation with Age = 30 day(s) → Add • Element → select GROUP-NODES-ABUTMENT → Activation with Age = 0 day(s) → Add • Boundary → select GROUP-SUPPORT-PILE → Activation with Deformed Support / Spring Position → Add • Boundary → select GROUP-SUPPORT-ABUTMENT → Activation with Deformed Support / Spring Position → Add • Boundary → select GROUP-SUPPORT-CH-PIER → Activation with Deformed Support / Spring Position → Add • Load → select GROUP-LOAD-SELF-WEIGHT → Activation with Active Day = First → Add	☐
7.2	**Construction Stage(s) CS-M1 [Cross Head]**	
7.21	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M1 • Duration = 2 day(s) • Element → select GROUP-CH-M1 → Activation with Age = 10 day(s) → Add • Boundary → none • Load → none	☐
7.3	**Construction Stage(s) CS-M2 [Cross Head] | CS-M2-T [Cross Head Tendons] | CS-M2-TBG [Beam Girders | Beam Girder Tendons]**	
7.31	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M2 • Duration = 2 day(s) • Element → select GROUP-CH-M2 → Activation with Age = 10 day(s) → Add • Boundary → none • Load → none	☐
7.32	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M2-T • Duration = 2 day(s) • Element → none • Boundary → none • Load → select GROUP-LOAD-TENDON-CH-M2 → Activation with Active Day = First → Add	☐
7.33	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M2-TBG • Duration = 2 day(s) • Element → select GROUP-BG-M2 → Activation with Age = 10 day(s) → Add • Element → select GROUP-NODES-BEARING → Activation with Age = 0 day(s) → Add • Boundary → select GROUP-SUPPORT-BEARING → Activation with Deformed Support / Spring Position → Add • Load → select GROUP-LOAD-TENDON-BG-M2 → Activation with Active Day = First → Add	☐

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ITEM	CONTENT	√
7.4	**Construction Stage(s) CS-M3 [Cross Head] | CS-M3-T [Cross Head Tendons] | CS-M3-TBG [Beam Girders | Beam Girder Tendons]**	
7.41	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M3 • Duration = 2 day(s) • Element → select GROUP-CH-M3 → Activation with Age = 10 day(s) → Add • Boundary → none • Load → none	☐
7.42	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M3-T • Duration = 2 day(s) • Element → none • Boundary → none • Load → select GROUP-LOAD-TENDON-CH-M3 → Activation with Active Day = First → Add	☐
7.43	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M3-TBG • Duration = 2 day(s) • Element → select GROUP-BG-M3 → Activation with Age = 10 day(s) → Add • Load → select GROUP-LOAD-TENDON-BG-M3 → Activation with Active Day = First → Add	☐
7.5	**Construction Stage(s) CS-M4 [Cross Head] | CS-M4-T [Cross Head Tendons] | CS-M4-TBG [Beam Girders | Beam Girder Tendons]**	
7.51	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M4 • Duration = 2 day(s) • Element → select GROUP-CH-M4 → Activation with Age = 10 day(s) → Add • Boundary → none • Load → none	☐
7.52	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M4-T • Duration = 2 day(s) • Element → none • Boundary → none • Load → select GROUP-LOAD-TENDON-CH-M4 → Activation with Active Day = First → Add	☐
7.53	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M4-TBG • Duration = 2 day(s) • Element → select GROUP-BG-M4 → Activation with Age = 10 day(s) → Add • Load → select GROUP-LOAD-TENDON-BG-M4 → Activation with Active Day = First → Add	☐
7.6	**Construction Stage(s) CS-M5-T [Cross Head | Cross Head Tendons] | CS-M5-TBG [Beam Girders | Beam Girder Tendons]**	
7.61	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M5-T • Duration = 2 day(s) • Element → select GROUP-CH-M5 → Activation with Age = 10 day(s) → Add • Boundary → none • Load → select GROUP-LOAD-TENDON-CH-M5 → Activation with Active Day = First → Add	☐
7.62	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-M5-TBG • Duration = 2 day(s) • Element → select GROUP-BG-M5 → Activation with Age = 10 day(s) → Add • Load → select GROUP-LOAD-TENDON-BG-M5 → Activation with Active Day = First → Add	☐
7.7	**Construction Stage(s) CS-DECK-T [Cross Head Tendons] | CS-DECK-TWET [Deck | Diaphragm Beam] | CS-DECK-TDB [Deck | Diaphragm Beam]**	
7.71	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-DECK-T • Duration = 2 day(s) • Element → none • Boundary → none • Load → select GROUP-LOAD-TENDON-CH-DECK → Activation with Active Day = First → Add	☐
7.72	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-DECK-TWET • Duration = 10 day(s)	☐

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ITEM	CONTENT	√
	• Element → none • Boundary → none • Load → select GROUP-LOAD-WET-CONCRETE → Activation with Active Day = First → Add	
7.73	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-DECK-TDB • Duration = 10 day(s) • Element → select GROUP-DECK → Activation with Age = 10 day(s) → Add • Element → select GROUP-LINK-SLAB → Activation with Age = 10 day(s) → Add • Element → select GROUP-DIAPHRAGM → Activation with Age = 10 day(s) → Add • Boundary → none • Load → select GROUP-LOAD-WET-CONCRETE → Deactivation with Inactive Day = First → Add	☐
7.8	**Construction Stage(s) CS-PRT-T [Cross Head Tendons] | CS-PRT-TPRT [Parapet]**	
7.81	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-PRT-T • Duration = 2 day(s) • Element → none • Boundary → none • Load → select GROUP-LOAD-TENDON-CH-PARAPET → Activation with Active Day = First → Add	☐
7.82	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-PRT-TPRT • Duration = 5 day(s) • Element → none • Boundary → none • Load → select GROUP-LOAD-PARAPET → Activation with Active Day = First → Add	☐
7.9	**Construction Stage(s) CS-SURF-T [Cross Head Tendons] | CS-SURF-TSURF [Surfacing]**	
7.91	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-SURF-T • Duration = 2 day(s) • Element → none • Boundary → none • Load → select GROUP-LOAD-TENDON-CH-SURFACING → Activation with Active Day = First → Add	☐
7.92	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-SURF-TSURF • Duration = 10 day(s) • Element → none • Boundary → none • Load → select GROUP-LOAD-SURFACING → Activation with Active Day = First → Add	☐
7.10	**Construction Stage CS-LT [Long Term]**	
7.101	Load → Construction Stage → Define C.S → Add → define construction stage with • Name = CS-LT • Duration = 10000 day(s) • Element → none • Boundary → none • Load → none	☐
7.11	**Additional Creep Material and Construction Stage Settings**	
7.111	Properties → Change Property → select all elements → automatically calculate the notional size of all frame members with • Element Dependent Material → Notional Size of Member • Code → CEB-FIP(1990)	☐

7.112	Analysis → Construction Stage → define construction stage settings with
	• Final Stage → Last Stage
	• Analysis Option → Analysis Type → Linear Analysis → select Accumulative Stage
	• Include Time Dependent Effect
	• Load Cases to be Distinguished from Dead Load for C.S. Output → define erection load cases with
	  ○ Load Case Name = Wearing Course | Load Type for C.S. = Dead Load of Wearing Surfaces and Utilities (DW) | Selected Load Case = LC-SURFACING
	  ○ Load Case Name = Parapet | Load Type for C.S. = Dead Load of Components and Attachments (DC) | Selected Load Case = LC-PARAPET
	• Cable-Pretension Force Control → Internal Force
	• Frame Output → select Calculate Output of Each Part of Composite Section → select Self-Constrained Forces & Stresses
		☐

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7.113	Load → Construction Stage → Composite Section for C.S. → Add → define Composite Section for Construction Stage with
	• Active Stage → CS-M2-TBG | CS-M3-TBG | CS-M4-TBG | CS-M5-TBG
	• Section → C-SECT-BG
	• Composite Type → Normal
	• Define Construction Sequence with
	  ○ Part 1 → Material Type → Element | Comp. Stage : Active Stage | Age : 10
	  ○ Part 2 → Material Type → Material | Material → MAT-C40 | Comp. Stage : CS-DECK-TDB | Age : 10
	Load → Construction Stage → Composite Section for C.S. → Update all H | Update Long Term
		☐

8.0	**ANALYSIS**	
8.1	**Perform Analysis**	
8.11	Analysis → Perform Analysis	☐
8.2	**Load Combinations**	

8.21	Results → Load Combination → define additional ULS, SLS and NOM load combinations with
	• [ULS] DL+SDL → Type : Add →
	  ○ Dead Load(CS) :1.265
	  ○ Wearing Course(CS) :1.925
	  ○ Parapet(CS) :1.32
	  ○ Tendon Secondary(CS) :1.0
	  ○ Creep Secondary(CS) :1.0
	  ○ Shrinkage Secondary(CS) :1.0
	• [SLS] DL+SDL → Type : Add →
	  ○ Dead Load(CS) :1.0
	  ○ Wearing Course(CS) :1.2
	  ○ Parapet(CS) :1.0
	  ○ Tendon Primary(CS) :1.0
	  ○ Tendon Secondary(CS) :1.0
	  ○ Creep Secondary(CS) :1.0
	  ○ Shrinkage Secondary(CS) :1.0
	• [NOM] DL+SDL → Type : Add →
	  ○ Dead Load(CS) :1.0
	  ○ Wearing Course(CS) :1.0
	  ○ Parapet(CS) :1.0
	  ○ Tendon Primary(CS) :1.0
	  ○ Tendon Secondary(CS) :1.0
	  ○ Creep Secondary(CS) :1.0
	  ○ Shrinkage Secondary(CS) :1.0
	• [SLS] WL:T → Type : Add →
	  ○ LC-WIND-TRANS(ST) :1.0
	• [SLS] WL:T+V → Type : Add →
	  ○ LC-WIND-TRANS(ST) :1.0
	  ○ LC-WIND-VERT(+)(ST) :1.0
	• [SLS] WL:T-V → Type : Add →
	  ○ LC-WIND-TRANS(ST) :1.0
	  ○ LC-WIND-VERT(-)(ST) :1.0
	• [SLS] WL:L → Type : Add →
	  ○ LC-WIND-LONG(ST) :1.0
	• [SLS] WL:L+0.5T+0.5V → Type : Add →
	  ○ LC-WIND-LONG(ST) :1.0
	  ○ LC-WIND-TRANS(ST) :0.5
	  ○ LC-WIND-VERT(+)(ST) :0.5
	• [SLS] WL:L+0.5T-0.5V → Type : Add →
	  ○ LC-WIND-LONG(ST) :1.0
	  ○ LC-WIND-TRANS(ST) :0.5
	  ○ LC-WIND-VERT(-)(ST) :0.5
	• [SLS] WL:ENV → Type : Envelope →
	  ○ [SLS] WL:T(CB) :1.0
	  ○ [SLS] WL:T+V(CB) :1.0
	  ○ [SLS] WL:T-V(CB) :1.0
	  ○ [SLS] WL:L(CB) :1.0
	  ○ [SLS] WL:L+0.5T+0.5V(CB) :1.0
	  ○ [SLS] WL:L+0.5T-0.5V(CB) :1.0
		☐

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ITEM	CONTENT	√

	• [SLS] TL:ENV → Type : Envelope →
	  ○ LC-TEMP(+)(ST) :1.0
	  ○ LC-TEMP(-)(ST) :1.0
	
	• [ULS] EQ:L+0.3T+0.3V → Type : Add →
	  ○ LC-EQ-LONG-DESIGN(RS) :1.0
	  ○ LC-EQ-TRANS-DESIGN-DESIGN(RS) :0.3
	  ○ LC-EQ-VERT-DESIGN-DESIGN(RS) :0.3
	• [ULS] EQ:0.3L+T+0.3V → Type : Add →
	  ○ LC-EQ-LONG-DESIGN(RS) :0.3
	  ○ LC-EQ-TRANS-DESIGN(RS) :1.0
	  ○ LC-EQ-VERT-DESIGN(RS) :0.3
	• [ULS] EQ:0.3L+0.3T+V → Type : Add →
	  ○ LC-EQ-LONG-DESIGN(RS) :0.3
	  ○ LC-EQ-TRANS-DESIGN(RS) :0.3
	  ○ LC-EQ-VERT-DESIGN(RS) :1.0
	• [ULS] EQ:ENV → Type : Envelope →
	  ○ [ULS] EQ:L+0.3T+0.3V(CB) :1.0
	  ○ [ULS] EQ:0.3L+T+0.3V(CB) :1.0
	  ○ [ULS] EQ:0.3L+0.3T+V(CB) :1.0
	• [SLS] EQ:L+0.3T+0.3V → Type : Add →
	  ○ LC-EQ-LONG-ELASTIC(RS) :1.0
	  ○ LC-EQ-TRANS-ELASTIC(RS) :0.3
	  ○ LC-EQ-VERT-ELASTIC(RS) :0.3
	• [SLS] EQ:0.3L+T+0.3V → Type : Add →
	  ○ LC-EQ-LONG-ELASTIC(RS) :0.3
	  ○ LC-EQ-TRANS-ELASTIC(RS) :1.0
	  ○ LC-EQ-VERT-ELASTIC(RS) :0.3
	• [SLS] EQ:0.3L+0.3T+V → Type : Add →
	  ○ LC-EQ-LONG-ELASTIC(RS) :0.3
	  ○ LC-EQ-TRANS-ELASTIC(RS) :0.3
	  ○ LC-EQ-VERT-ELASTIC(RS) :1.0
	• [SLS] EQ:ENV → Type : Envelope →
	  ○ [SLS] EQ:L+0.3T+0.3V(CB) :1.0
	  ○ [SLS] EQ:0.3L+T+0.3V(CB) :1.0
	  ○ [SLS] EQ:0.3L+0.3T+V(CB) :1.0
	
	• [NOM] HA:ENV → Type : Envelope →
	  ○ LC-HA(MV) :1.0
	• [NOM] HA+HB30:ENV → Type : Envelope →
	  ○ LC-HA+HB30-NL1(MV) :1.0
	  ○ LC-HA+HB30-NL2(MV) :1.0
	  ○ LC-HA+HB30-NL3(MV) :1.0
	  ○ LC-HA+HB30-NL4(MV) :1.0
	  ○ LC-HA+HB30-NL5(MV) :1.0
	  ○ LC-HA+HB30-NL6(MV) :1.0
	  ○ LC-HA+HB30-NL7(MV) :1.0
	  ○ LC-HA+HB30-NL8(MV) :1.0
	• [NOM] HA+HB45:ENV → Type : Envelope →
	  ○ LC-HA+HB45-NL1(MV) :1.0
	  ○ LC-HA+HB45-NL2(MV) :1.0
	  ○ LC-HA+HB45-NL3(MV) :1.0
	  ○ LC-HA+HB45-NL4(MV) :1.0
	  ○ LC-HA+HB45-NL5(MV) :1.0
	  ○ LC-HA+HB45-NL6(MV) :1.0
	  ○ LC-HA+HB45-NL7(MV) :1.0
	  ○ LC-HA+HB45-NL8(MV) :1.0	

8.22	Results → Load Combination → define ULS load combinations with
	• [ULS] COMBO1A:DL+SDL+HA → Type : Add →
	  ○ [ULS] DL+SDL(CB) :1.0
	  ○ [NOM] HA:ENV(CB) :1.65
	• [ULS] COMBO1B:DL+SDL+HA+HB45 → Type : Add →
	  ○ [ULS] DL+SDL(CB) :1.0
	  ○ [NOM] HA+HB45:ENV(CB) :1.43
		☐

FEM Design Verification Checklist for MidasCivil 2019 (Summary)

ITEM	CONTENT	√

	• [ULS] COMBO2A:DL+SDL+HA+WL → Type : Add →
	  ○ [ULS] DL+SDL(CB) :1.0
	  ○ [NOM] HA:ENV(CB) :1.375
	  ○ [SLS] WL:ENV(CB) :1.54
	• [ULS] COMBO2B:DL+SDL+HA+HB45+WL → Type : Add →
	  ○ [ULS] DL+SDL(CB) :1.0
	  ○ [NOM] HA+HB45:ENV(CB) :1.21
	  ○ [SLS] WL:ENV(CB) :1.54
	
	• [ULS] COMBO3A:DL+SDL+HA+TL → Type : Add →
	  ○ [ULS] DL+SDL(CB) :1.0
	  ○ [NOM] HA:ENV(CB) :1.375
	  ○ [SLS] TL:ENV(CB) :1.1 [No Restraint]
	  ○ [SLS] TL:ENV(CB) :1.43 [With Restraint]
	• [ULS] COMBO3B:DL+SDL+HA+HB45+TL → Type : Add →
	  ○ [ULS] DL+SDL(CB) :1.0
	  ○ [NOM] HA+HB45:ENV(CB) :1.21
	  ○ [SLS] TL:ENV(CB) :1.1 [No Restraint]
	  ○ [SLS] TL:ENV(CB) :1.43 [With Restraint]
	
	• [ULS] COMBO4A:DL+SDL+HA-BRAKING → Type : Add →
	  ○ [ULS] DL+SDL(CB) :1.0
	  ○ LC-HA-BRAKING(ST) :1.375
	• [ULS] COMBO4B:DL+SDL+HB-BRAKING → Type : Add →
	  ○ [ULS] DL+SDL(CB) :1.0
	  ○ LC-HB-BRAKING(ST) :1.21
	• [ULS] COMBO4C:DL+SDL+HA-SKIDDING → Type : Add →
	  ○ [ULS] DL+SDL(CB) :1.0
	  ○ LC-HA-SKIDDING(ST) :1.375
	
	• [ULS] COMBO6:DL+SDL+HA+EQ → Type : Add →
	  ○ [ULS] DL+SDL(CB) :1.0
	  ○ [NOM] HA:ENV(CB) :1.375
	  ○ [ULS] EQ:ENV(CB) :1.375	

8.23	Results → Load Combination → define SLS load combinations with
	• [SLS] COMBO1A:DL+SDL+HA → Type : Add →
	  ○ [SLS] DL+SDL(CB) :1.0
	  ○ [NOM] HA:ENV(CB) :1.2
	• [SLS] COMBO1B:DL+SDL+HA+HB30 → Type : Add →
	  ○ [SLS] DL+SDL(CB) :1.0
	  ○ [NOM] HA+HB30:ENV(CB) :1.1
	
	• [SLS] COMBO2A:DL+SDL+HA+WL → Type : Add →
	  ○ [SLS] DL+SDL(CB) :1.0
	  ○ [NOM] HA:ENV(CB) :1.0
	  ○ [SLS] WL:ENV(CB) :1.0
	• [SLS] COMBO2B:DL+SDL+HA+HB30+WL → Type : Add →
	  ○ [SLS] DL+SDL(CB) :1.0
	  ○ [NOM] HA+HB30:ENV(CB) :1.0
	  ○ [SLS] WL:ENV(CB) :1.0
	
	• [SLS] COMBO3A:DL+SDL+HA+TL → Type : Add →
	  ○ [SLS] DL+SDL(CB) :1.0
	  ○ [NOM] HA:ENV(CB) :1.0
	  ○ [SLS] TL:ENV(CB) :1.0
	• [SLS] COMBO3B:DL+SDL+HA+HB30+TL → Type : Add →
	  ○ [SLS] DL+SDL(CB) :1.0
	  ○ [NOM] HA+HB30:ENV(CB) :1.0
	  ○ [SLS] TL:ENV(CB) :1.0
	
	• [SLS] COMBO4A:DL+SDL+HA-BRAKING → Type : Add →
	  ○ [SLS] DL+SDL(CB) :1.0
	  ○ LC-HA-BRAKING(ST) :1.0
	• [SLS] COMBO4B:DL+SDL+HB-BRAKING → Type : Add →
		☐

ITEM	CONTENT	√
	○ [SLS] DL+SDL(CB) :1.0 ○ LC-HB-BRAKING(ST) :1.0 • [SLS] COMBO4C:DL+SDL+HA-SKIDDING → Type : Add → ○ [SLS] DL+SDL(CB) :1.0 ○ LC-HA-SKIDDING(ST) :1.0 • [SLS] COMBO6:DL+SDL+HA+EQ → Type : Add → ○ [SLS] DL+SDL(CB) :1.0 ○ [NOM] HA:ENV(CB) :1.0 ○ [SLS] EQ:ENV(CB) :1.0	
8.24	Results → Load Combination → define NOM load combinations with • [NOM] COMBO1A:DL+SDL+HA → Type : Add → ○ [NOM] DL+SDL(CB) :1.0 ○ [NOM] HA:ENV(CB) :1.0 • [NOM] COMBO1B:DL+SDL+HA+HB45 → Type : Add → ○ [NOM] DL+SDL(CB) :1.0 ○ [NOM] HA+HB45:ENV(CB) :1.0 • [NOM] COMBO2A:DL+SDL+HA+WL → Type : Add → ○ [NOM] DL+SDL(CB) :1.0 ○ [NOM] HA:ENV(CB) :1.0 ○ [SLS] WL:ENV(CB) :1.0 • [NOM] COMBO2B:DL+SDL+HA+HB45+WL → Type : Add → ○ [NOM] DL+SDL(CB) :1.0 ○ [NOM] HA+HB45:ENV(CB) :1.0 ○ [SLS] WL:ENV(CB) :1.0 • [NOM] COMBO3A:DL+SDL+HA+TL → Type : Add → ○ [NOM] DL+SDL(CB) :1.0 ○ [NOM] HA:ENV(CB) :1.0 ○ [SLS] TL:ENV(CB) :1.0 • [NOM] COMBO3B:DL+SDL+HA+HB45+TL → Type : Add → ○ [NOM] DL+SDL(CB) :1.0 ○ [NOM] HA+HB45:ENV(CB) :1.0 ○ [SLS] TL:ENV(CB) :1.0 • [NOM] COMBO4A:DL+SDL+HA-BRAKING → Type : Add → ○ [NOM] DL+SDL(CB) :1.0 ○ LC-HA-BRAKING(ST) :1.0 • [NOM] COMBO4B:DL+SDL+HB-BRAKING → Type : Add → ○ [NOM] DL+SDL(CB) :1.0 ○ LC-HB-BRAKING(ST) :1.0 • [NOM] COMBO4C:DL+SDL+HA-SKIDDING → Type : Add → ○ [NOM] DL+SDL(CB) :1.0 ○ LC-HA-SKIDDING(ST) :1.0 • [NOM] COMBO6:DL+SDL+HA+EQ → Type : Add → ○ [NOM] DL+SDL(CB) :1.0 ○ [NOM] HA:ENV(CB) :1.0 ○ [SLS] EQ:ENV(CB) :1.0	☐
8.25	Results → Load Combination → define load combinations envelope with • [ULS] ALL:ENV → Type : Envelope → ○ [ULS] COMBO1A:DL+SDL+HA(CB) :1.0 ○ [ULS] COMBO1B:DL+SDL+HA+HB45(CB) :1.0 ○ [ULS] COMBO2A:DL+SDL+HA+WL(CB) :1.0 ○ [ULS] COMBO2B:DL+SDL+HA+HB45+WL(CB) :1.0 ○ [ULS] COMBO3A:DL+SDL+HA+TL(CB) :1.0 ○ [ULS] COMBO3B:DL+SDL+HA+HB45+TL(CB) :1.0 ○ [ULS] COMBO4A:DL+SDL+HA-BRAKING(CB) :1.0 ○ [ULS] COMBO4B:DL+SDL+HB-BRAKING(CB) :1.0 ○ [ULS] COMBO4C:DL+SDL+HA-SKIDDING(CB) :1.0 ○ [ULS] COMBO6:DL+SDL+HA+EQ(CB) :1.0 • [SLS] ALL:ENV → Type : Envelope → ○ [SLS] COMBO1A:DL+SDL+HA(CB) :1.0	☐

<table>
<tr><th>ITEM</th><th>CONTENT</th><th>√</th></tr>
<tr><td></td><td>

[SLS] COMBO1B:DL+SDL+HA+HB30(CB) :1.0
[SLS] COMBO2A:DL+SDL+HA+WL(CB) :1.0
[SLS] COMBO2B:DL+SDL+HA+HB30+WL(CB) :1.0
[SLS] COMBO3A:DL+SDL+HA+TL(CB) :1.0
[SLS] COMBO3B:DL+SDL+HA+HB30+TL(CB) :1.0
[SLS] COMBO4A:DL+SDL+HA-BRAKING(CB) :1.0
[SLS] COMBO4B:DL+SDL+HB-BRAKING(CB) :1.0
[SLS] COMBO4C:DL+SDL+HA-SKIDDING(CB) :1.0
[SLS] COMBO6:DL+SDL+HA+EQ(CB) :1.0

[NOM] ALL:ENV → Type : Envelope →

[NOM] COMBO1A:DL+SDL+HA(CB) :1.0
[NOM] COMBO1B:DL+SDL+HA+HB45(CB) :1.0
[NOM] COMBO2A:DL+SDL+HA+WL(CB) :1.0
[NOM] COMBO2B:DL+SDL+HA+HB45+WL(CB) :1.0
[NOM] COMBO3A:DL+SDL+HA+TL(CB) :1.0
[NOM] COMBO3B:DL+SDL+HA+HB45+TL(CB) :1.0
[NOM] COMBO4A:DL+SDL+HA-BRAKING(CB) :1.0
[NOM] COMBO4B:DL+SDL+HB-BRAKING(CB) :1.0
[NOM] COMBO4C:DL+SDL+HA-SKIDDING(CB) :1.0
[NOM] COMBO6:DL+SDL+HA+EQ(CB) :1.0

</td><td></td></tr>
<tr><td>9.0</td><td>DESIGN</td><td></td></tr>
<tr><td>9.1</td><td>Overall Effects Check</td><td></td></tr>
<tr><td>9.11</td><td>Results → Reaction → Reaction Forces/Moments → check reactions with

Load Cases / Combinations → CS Min/Max → CSmax: Summation | Post CS → CBall: [NOM] ALL:ENV
Components → FXYZ | MXYZ
Type of Display → select Values | Legend
</td><td>☐</td></tr>
<tr><td>9.12</td><td>Results → Deformations → Displacement Contour → check displacements with

Load Cases / Combinations → CS Min/Max → CSmin: Summation | Post CS → CBmin: [NOM] ALL:ENV
Components → DZ
Type of Display → select Contour | Deform | Legend
</td><td>☐</td></tr>
<tr><td>9.2</td><td>TLS Stress Check</td><td></td></tr>
<tr><td>9.21</td><td>
<table>
<tr><th>Element</th><th>TLS Stress Check [Class 1]
– Tension 1.00 MPa
– Comp 0.50f_{ci} MPa</th></tr>
<tr><td>Beam Girder</td><td>Construction Stage(s): CS-M2-TBG | CS-M3-TBG | CS-M4-TBG | CS-M5-TBG | CS-DECK-TDB | CS-PRT-TPRT | CS-SURF-TSURF → CS: Summation [#1]</td></tr>
<tr><td>Cross Head</td><td>Construction Stage(s): CS-M2 | CS-M2-T | CS-M2-TBG | CS-M3 | CS-M3-T | CS-M3-TBG | CS-M4 | CS-M4-T | CS-M4-TBG | CS-M5-T | CS-M5-TBG | CS-DECK-T | CS-DECK-TDB | CS-PRT-T | CS-PRT-TPRT | CS-SURF-T | CS-SURF-TSURF → CS: Summation [#2]</td></tr>
</table>
[#1] Results → Stresses → Beam Stresses Diagram → check axial precompression and combined stresses with

Load Cases / Combinations → CS-M2-TBG | CS-M3-TBG | CS-M4-TBG | CS-M5-TBG | CS-DECK-TDB | CS-PRT-TPRT | CS-SURF-T SURF → CS: Summation
Components → Part → Total
Components → Sax | Combined [1|2|3|4]
Fill Type → Solid
Type of Display → select Contour | Legend

[#2] Results → Stresses → Beam Stresses Diagram → check axial precompression and combined stresses with

Load Cases / Combinations → CS-M2 | CS-M2-T | CS-M2-TBG | CS-M3 | CS-M3-T | CS-M3-TBG | CS-M4 | CS-M4-T | CS-M4-TBG | CS-M5-T | CS-M5-TBG | CS-DECK-T | CS-DECK-TDB | CS-PRT-T | CS-PRT-TPRT | CS-SURF-T | CS-SURF-TSURF → CS: Summation
Components → Part → Total
Components → Sax | Combined [1|2|3|4]
Fill Type → Solid
Type of Display → select Contour | Legend

</td><td>☐</td></tr>
<tr><td>9.3</td><td>ULS Design, SLS Crack Width and SLS Stress Checks</td><td></td></tr>
<tr><td>9.31</td><td>
<table>
<tr><th>Element</th><th>ULS Design</th><th>SLS Crack Width Check [0.25mm]
SLS Foundation Load Check</th><th>SLS Stress Check [Class 1]
– Tension 0.00 MPa
– Comp 0.40f_{cu} MPa</th><th>SLS Stress Check [Class 2]
– Tension 0.36$\sqrt{f_{cu}}$ MPa [Post-Tensioned]
– Tension 0.45$\sqrt{f_{cu}}$ MPa [Pre-Tensioned]
– Comp 0.40f_{cu} MPa</th></tr>
<tr><td>Deck</td><td>[ULS] ALL:ENV</td><td>[SLS] ALL:ENV</td><td>N / A</td><td>N / A</td></tr>
</table>
</td><td>☐</td></tr>
</table>

FEM Design Verification Checklist for MidasCivil 2019 (Summary)

ITEM	CONTENT					√
	Beam Girder	[ULS] ALL:ENV #1A	[SLS] COMBO1A:DL+SDL+HA(CB) #2A	[SLS] COMBO1A:DL+SDL+HA(CB) #3A	[SLS] ALL:ENV #4A	
	Cross Head	[ULS] ALL:ENV #1A	[SLS] COMBO1A:DL+SDL+HA(CB) #2A	[SLS] COMBO1A:DL+SDL+HA(CB) #3A	[SLS] ALL:ENV #4A	
	Pier	[ULS] ALL:ENV	[SLS] COMBO1A:DL+SDL+HA(CB)	N / A	N / A	
	Pile Cap	[ULS] ALL:ENV #1A	[SLS] COMBO1A:DL+SDL+HA(CB) #2A	N / A	N / A	
	Pile	[ULS] ALL:ENV	[NOM] ALL:ENV #2B	N / A	N / A	

#1A Results → Forces → Beam Diagrams → check vertical bending moments and vertical shear forces with
- Load Cases / Combinations → CBall: [ULS] ALL:ENV
- Components → Part → Total
- Components → My | Fz
- Type of Display → Solid Fill
- Type of Display → select Contour | Legend

#2A Results → Forces → Beam Diagrams → check vertical bending moments and vertical shear forces with
- Load Cases / Combinations → CBall: [SLS] COMBO1A:DL+SDL+HA(CB)
- Components → Part → Total
- Components → My
- Type of Display → Solid Fill
- Type of Display → select Contour | Legend

#2B Results → Reaction → Reaction Forces/Moments → check reactions with
- Load Cases / Combinations → CBall: [NOM] ALL:ENV
- Components → FXYZ | MXYZ
- Type of Display → select Values | Legend

#3A Results → Stresses → Beam Stresses Diagram → check axial precompression and combined stresses with
- Load Cases / Combinations → CBall: [SLS] COMBO1A:DL+SDL+HA(CB)
- Components → Part → Total
- Components → Sax | Combined [1|2|3|4]
- Fill Type → Solid
- Type of Display → select Contour | Legend

#4A Results → Stresses → Beam Stresses Diagram → check axial precompression and combined stresses with
- Load Cases / Combinations → CBall: [SLS] ALL:ENV
- Components → Part → Total
- Components → Sax | Combined [1|2|3|4]
- Fill Type → Solid
- Type of Display → select Contour | Legend

FEM Design Verification Checklist for MidasCivil 2019 (Summary)

ITEM	CONTENT	√
10.0	**AUTOMATED DESIGN OF ELEVATED HIGHWAY WITH MULTIPLE PIERS**	
10.1	**General**	
10.11	Company template file	☐
10.2	**Model Units**	
10.21	Set model units to kN and m	☐
10.31	**Geometry Modelling in AutoCAD and Import in MidasCivil**	
10.31	File → Import → AutoCAD dxf → select dxf file → select relevant layers → OK to generate nodes and elements • MIDAS-BG-M2 | MIDAS-BG-M3 | MIDAS-BG-M4 | MIDAS-BG-M5 • MIDAS-LINK-SLAB-200x2400 • MIDAS-PARAPET • MIDAS-CH-M1 | MIDAS-CH-M2 | MIDAS-CH-M3 | MIDAS-CH-M4 | MIDAS-CH-M5 • MIDAS-PIER-1600x3600 • MIDAS-DECK-200x2400 • MIDAS-DIAPHRAGM-800x1800 Note the following in the beam girder naming convention above • U12 | section shape • 1 | 2 | 3 | refers to general applicable span ranges • A | B | C | refers to varying beam lengths and/or prestress strand designs within the general applicable span ranges	☐
10.32	Structure → Check/Duplicate Elements to delete overlapping duplicate elements	☐
10.33	TM → Group → select cross head and pier elements by groups MIDAS-CH-M1 | MIDAS-CH-M2 | MIDAS-CH-M3 | MIDAS-CH-M4 | MIDAS-CH-M5 | MIDAS-PIER-1600x3600 Node/Element → Translate Elements → offset cross head and pier elements with • Mode → Move • Equal Distance → {dx, dy, dz} = {0, 0, -1.8 m say to clear the deck thickness and model offset to corbel bearing level}	☐
10.34	Right-Click → Select → Window → select top of pier nodes at cross head Node/Element → Extrude Elements → extrude pier elements with • Extrude Type → Node to Line Element • Element Type → Beam • Material → MAT-C50 • Section → SECT-PIER-1600x3600 • Generation Type → Translate • Translation → Equal Distance → {dx, dy, dz} = {0, 0, -4.2 m cross head depth + 1.5 m cross head user vertical offset + pier free standing height say}	☐
10.4	**Section Assignment**	
10.41	TM → Group → select corresponding elements by group TM → Works → Properties → D&D section to assign onto elements: - • C-SECT-BG-U12-200x2400 onto MIDAS-BG-M2 | MIDAS-BG-M3 | MIDAS-BG-M4 | MIDAS-BG-M5 • SECT-LINK-SLAB-200x2400 onto MIDAS-LINK-SLAB-200x2400 • SECT-NULL-SLAB onto MIDAS-PARAPET • SECT-CH-M1 | SECT-CH-M2 | SECT-CH-M3 | SECT-CH-M4 | SECT-CH-M5 onto MIDAS-CH-M1 | MIDAS-CH-M2 | MIDAS-CH-M3 | MIDAS-CH-M4 | MIDAS-CH-M5 • SECT-PIER-1600x3600 onto MIDAS-PIER-1600x3600 • SECT-DECK-200x2400 onto MIDAS-DECK-200x2400 • SECT-DIAPHRAGM-800x1800 onto MIDAS-DIAPHRAGM-800x1800	☐
10.5	**Group Definition and Assignment**	
10.51	TM → Group → select corresponding elements by group TM → Group → D&D group to assign onto elements: - • GROUP-BG-M2 | GROUP-BG-M3 | GROUP-BG-M4 | GROUP-BG-M5 onto MIDAS-BG-M2 | MIDAS-BG-M3 | MIDAS-BG-M4 | MIDAS-BG-M5 • GROUP-LINK-SLAB onto MIDAS-LINK-SLAB-200x2400 • GROUP-CH-M1 | GROUP-CH-M2 | GROUP-CH-M3 | GROUP-CH-M4 | GROUP-CH-M5 onto MIDAS-CH-M1 | MIDAS-CH-M2 | MIDAS-CH-M3 | MIDAS-CH-M4 | MIDAS-CH-M5 • GROUP-SUBSTR onto MIDAS-PIER-1600x3600 • GROUP-DECK onto MIDAS-PARAPET | MIDAS-DECK-200x2400 • GROUP-DIAPHRAGM onto MIDAS-DIAPHRAGM-800x1800	☐
10.52	Right-Click → Select → Window → select corresponding nodes TM → Group → D&D group to assign onto nodes: - • GROUP-NODES-ABUTMENT onto abutment bearing nodes • GROUP-NODES-BEARING onto cross head bearing nodes	☐

FEM Design Verification Checklist for MidasCivil 2019 (Summary)

ITEM	CONTENT	√
10.53	TM → Works → Properties → Section → select corresponding elements by section TM → Group → D&D group to assign onto elements: - • GROUP-TRANSVERSE-ELEMENTS onto SECT-DECK-200x2400 and SECT-DIAPHRAGM-800x1800	☐
10.6	**Material Assignment**	
10.61	TM → Group → select corresponding elements by group TM → Works → Properties → Material → D&D materials to assign onto elements: - • MAT-C60 onto GROUP-BG-M2 | GROUP-BG-M3 | GROUP-BG-M4 | GROUP-BG-M5 • MAT-C50 onto GROUP-CH-M1 | GROUP-CH-M2 | GROUP-CH-M3 | GROUP-CH-M4 | GROUP-CH-M5 • MAT-C40 onto GROUP-LINK-SLAB | GROUP-SUBSTR | GROUP-DIAPHRAGM • MAT-C40-PSEUDO onto GROUP-DECK	☐
10.7	**Boundary Conditions**	
10.71	Right-Click → Select → Window → select girder to cross head bearing nodes Boundary → Elastic Link → define girder to cross head bearing nodes elastic link | GROUP-SUPPORT-BEARING | Type → General | SDx = 5,000 kN/m say | SDy = 5,000 kN/m say | SDz = 2,000,000 kN/m say | SRx = 10 kNm/[rad] | SRy = 0 kNm/[rad] | SRz = 10 kNm/[rad]	☐
10.72	Right-Click → Select → Window → select cross head bearing nodes to cross head Boundary → Elastic Link → define cross head bearing nodes to cross head elastic links | GROUP-SUPPORT-BEARING | Type → Rigid	☐
10.73	TM → Group → select abutment bearing nodes by group GROUP-NODES-ABUTMENT Boundary → Point Spring → define abutment spring supports | GROUP-SUPPORT-ABUTMENT | SDx = 5,000 kN/m say | SDy = 5,000 kN/m say | SDz = 2,000,000 kN/m say	☐
10.8	**Loading Definitions**	
10.81	Load → Static Loads → Self Weight → define self-weight load | LC-SELF-WEIGHT | GROUP-LOAD-SELF-WEIGHT | X = 0 | Y = 0 | Z = -1	☐
10.82	TM → Group → select beam girder and link slab elements by groups GROUP-BG-M2 | GROUP-BG-M3 | GROUP-BG-M4 | GROUP-BG-M5 Load → Static Loads → Element → define wet concrete load | LC-WET-CONCRETE | GROUP-LOAD-WET-CONCRETE | w = width x 200mm x 25kN/m^3 say = width x 5.0kN/m^2 say = -12.0 kN/m say	☐
10.83	TM → Group → select beam girder and link slab elements by groups GROUP-BG-M2 | GROUP-BG-M3 | GROUP-BG-M4 | GROUP-BG-M5 and GROUP-LINK-SLAB Load → Static Loads → Element → define surfacing load | LC-SURFACING | GROUP-LOAD-SURFACING | w = width x 75mm x 22kN/m^3 say = width x 1.65kN/m^2 say = -4.0 kN/m say	☐
10.84	TM → Works → Properties → Section → select parapet elements by section SECT-NULL-SLAB Load → Static Loads → Element → define parapet load | LC-PARAPET | GROUP-LOAD-PARAPET | w = -10 kN/m say	☐
10.85	Load → Temp./Prestress → Tendon Profile → Add → define tendon profile | Tendon Name = C1-ZL | C1-ZR | C2-ZL | C2-ZR | C3-ZL | C3-ZR | C4-ZL | C4-ZR | C5-ZL | C5-ZR | Tendon Property → TENDON-12S15.2 | TENDON-19S15.2 | TENDON-27S15.2 Load → Temp/Prestress → Tendon Prestress → define tendon prestress load | LC-TENDON | Load Group Name → GROUP-LOAD-TENDON-CH-M2 | GROUP-LOAD-TENDON-CH-M3 | GROUP-LOAD-TENDON-CH-M4 | GROUP-LOAD-TENDON-CH-M5 | GROUP-LOAD-TENDON-CH-STAGE3 | Select Tendon for Loading = C1-ZL | C1-ZR | C2-ZL | C2-ZR | C3-ZL | C3-ZR | C4-ZL | C4-ZR | C5-ZL | C5-ZR | Stress Value → select Force → Begin = 75% x 12 | 19 | 27 strands x 260.7 kN say Tables → Structure Tables → Static Loads → Tendon Prestress Loads → check definition of PT loads	☐
10.86	TM → Works → Properties → Section → select beam girder, link slab, cross head, pier and diaphragm beam elements by sections C-SECT-BG-U12-200x2400, SECT-LINK-SLAB-200x2400, SECT-CH-M1 | SECT-CH-M2 | SECT-CH-M3 | SECT-CH-M4 | SECT-CH-M5, SECT-PIER-1600x3600 and SECT-DIAPHRAGM-800x1800 Load → Temp./Prestress → Element Temp → define temperature load | LC-TEMP(+) | Temperature → Initial = 70 °F [21 °C] | Temperature → Final = 100 °F [38 °C] Load → Temp./Prestress → Element Temp → define temperature load | LC-TEMP(-) | Temperature → Initial = 100 °F [38 °C] | Temperature → Final = 70 °F [21 °C]	☐
10.87	TM → Group → select cross head elements by groups GROUP-CH-M1 | GROUP-CH-M2 | GROUP-CH-M3 | GROUP-CH-M4 | GROUP-CH-M5 Load → Static Loads → Element → define HA braking load | LC-HA-BRAKING | Load Type → Uniform Loads | Direction → Global X | w = 750 kN / bridge width say = 25 kN/m say Load → Static Loads → Element → define HB braking load | LC-HB-BRAKING | Load Type → Uniform Loads | Direction → Global X | w = 450 kN / bridge width say = 15 kN/m say Load → Static Loads → Element → define HA skidding load | LC-HA-SKIDDING | Load Type → Uniform Loads | Direction → Global X | w = 300 kN / bridge width say = 10 kN/m say	☐
10.88	TM → Works → Properties → Section → select pier elements by section SECT-PIER-1600x3600	☐

FEM Design Verification Checklist for MidasCivil 2019 (Summary)

ITEM	CONTENT	√
	Load → Static Loads → Element → define collision load | LC-COLLISION | Load Type → Concentrated Forces | Direction → Global X | Value → Absolute | x1 = 1.5 m | P1 = 1000 kN | x1 = 3.0 m | P1 = 500 kN Load → Static Loads → Element → define collision load | LC-COLLISION | Load Type → Concentrated Forces | Direction → Global Y | Value → Absolute | x1 = 1.5 m | P1 = 500 kN | x1 = 3.0 m | P1 = 250 kN	
10.89	TM → Group → select cross head elements by groups GROUP-CH-M1 | GROUP-CH-M2 | GROUP-CH-M3 | GROUP-CH-M4 | GROUP-CH-M5 Load → Static Loads → Element → define transverse wind load | LC-WIND-TRANS | Load Type → Uniform Loads | Direction → Global Y | w = bridge span x girder height / bridge width x 1.0 kPa say = 1.6 kN/m say Load → Static Loads → Element → define longitudinal wind load | LC-WIND-LONG | Load Type → Uniform Loads | Direction → Global X | w = girder height x 1.0 kPa say = 1.6 kN/m say Load → Static Loads → Element → define upward wind load | LC-WIND-VERT(+) | Load Type → Uniform Loads | Direction → Global Z | w = bridge span x 1.0 kPa say = 30 kN/m say Load → Static Loads → Element → define downward wind load | LC-WIND-VERT(-) | Load Type → Uniform Loads | Direction → Global Z | w = bridge span x -1.0 kPa say = -30 kN/m say	☐
10.810	Load → Moving Load → Moving Load Code → BS → Traffic Line Lanes → Add → define Design Traffic Line Lane with • Lane Name → NL1 | NL2 | NL3 | NL4 | NL5 | NL6 | NL7 | NL8 | NL9 | NL10 • Lane Width = Carriageway Width / No. of Notional Lanes say Note No. of Notional Lanes = ROUNDUP {Carriageway Width / 3.65m} • Eccentricity = - < distance to centre of notional lane from edge of deck > • Wheel Spacing = 1.0 m say • Vehicular Load Distribution → Cross Beam • Cross Beam Group → GROUP-TRANSVERSE-ELEMENTS • Moving Direction → Both • Selection by → 2 Points → < left-click edge of deck to define longitudinal extent of loading >	☐
10.811	Load → Moving Load → Moving Load Cases → Add → define moving load cases with • Load Case Name = HA | HA+HB30-NL1 | HA+HB30-NL2 | HA+HB30-NL3 | HA+HB30-NL4 | HA+HB30-NL5 | HA+HB30-NL6 | HA+HB30-NL7 | HA+HB30-NL8 • Select Load Model → Standard Load (BD 37/01, BS 5400) • Auto Live Load Combination → deselect • Sub-Load Cases → Loading Effects → select Combined → Add HA | HB30 loading to notional lanes Load → Moving Load → Moving Load Cases → Add → define moving load cases with • Load Case Name = HA | HA+HB45-NL1 | HA+HB45-NL2 | HA+HB45-NL3 | HA+HB45-NL4 | HA+HB45-NL5 | HA+HB45-NL6 | HA+HB45-NL7 | HA+HB45-NL8 • Select Load Model → Standard Load (BD 37/01, BS 5400) • Auto Live Load Combination → deselect • Sub-Load Cases → Loading Effects → select Combined → Add HA | HB45 loading to notional lanes	☐
10.812	Results → Load Combination → redefine additional NOM load envelopes with • [NOM] HA:ENV → Type : Envelope → ○ LC-HA(MV) :1.0 • [NOM] HA+HB30:ENV → Type : Envelope → ○ LC-HA+HB30-NL1(MV) :1.0 ○ LC-HA+HB30-NL2(MV) :1.0 ○ LC-HA+HB30-NL3(MV) :1.0 ○ LC-HA+HB30-NL4(MV) :1.0 ○ LC-HA+HB30-NL5(MV) :1.0 ○ LC-HA+HB30-NL6(MV) :1.0 ○ LC-HA+HB30-NL7(MV) :1.0 ○ LC-HA+HB30-NL8(MV) :1.0 • [NOM] HA+HB45:ENV → Type : Envelope → ○ LC-HA+HB45-NL1(MV) :1.0 ○ LC-HA+HB45-NL2(MV) :1.0 ○ LC-HA+HB45-NL3(MV) :1.0 ○ LC-HA+HB45-NL4(MV) :1.0 ○ LC-HA+HB45-NL5(MV) :1.0 ○ LC-HA+HB45-NL6(MV) :1.0 ○ LC-HA+HB45-NL7(MV) :1.0 ○ LC-HA+HB45-NL8(MV) :1.0	☐
10.9	**Additional Creep Material and Construction Stage Definitions**	
10.91	Properties → Change Property → select all elements → automatically calculate the notional size of all frame members with • Element Dependent Material → Notional Size of Member • Code → CEB-FIP(1990)	

FEM Design Verification Checklist for MidasCivil 2019 (Summary)

<table>
<tr><th>ITEM</th><th>CONTENT</th><th>√</th></tr>
<tr><td>10.92</td><td>Load → Construction Stage → Composite Section for C.S. → Add → define Composite Section for Construction Stage with
• Active Stage → CS-M2-TBG | CS-M3-TBG | CS-M4-TBG | CS-M5-TBG
• Section → C-SECT-BG-U12-200x2400
• Composite Type → Normal
• Define Construction Sequence with
○ Part 1 → Material Type → Element | Comp. Stage : Active Stage | Age : 10
○ Part 2 → Material Type → Material | Material → MAT-C40 | Comp. Stage : CS-DECK-TDB | Age : 10
Load → Construction Stage → Composite Section for C.S. → Update all H | Update Long Term</td><td>☐</td></tr>
<tr><td>10.10</td><td>Beam Girder Effects Validity Checks</td><td></td></tr>
<tr><td>10.101</td><td>
<table>
<tr><th>No.</th><th>Item</th><th>MidasCivil</th><th>Validation Spreadsheet</th><th>Value</th></tr>
<tr><td></td><td>Construction Stage(s)
Stage</td><td>Construction Stage (s):
CS-M2-TBG
CS-M3-TBG
CS-M4-TBG
CS-M5-TBG
CS-DECK-TDB
CS-PRT-TPRT
CS-SURF-TSURF</td><td>Construction Stage(s):
CS-M2-TBG
CS-M3-TBG
CS-M4-TBG
CS-M5-TBG
CS-DECK-TDB
CS-PRT-TPRT
CS-SURF-TSURF</td><td>[kNm] | [MPa]</td></tr>
<tr><td rowspan="2">1</td><td>Load Case / Combination</td><td>CS: Dead Load</td><td>BG (each) E/E sagging moment, $M_{[BG]}$</td><td></td></tr>
<tr><td>Effects Check</td><td>Results → Forces → Beam Diagrams → Components → My → Apply</td><td>BG (each) E/E sagging moment, $M_{[BG]}$</td><td></td></tr>
<tr><td rowspan="2">2</td><td>Load Case / Combination</td><td>CS: Tendon Primary</td><td>BG (each) PT sagging moment - $\Sigma P_{BG,ST}.e_{s,[BG]}$</td><td></td></tr>
<tr><td>Effects Check</td><td>Results → Forces → Beam Diagrams → Components → My → Apply</td><td>BG (each) PT sagging moment - $\Sigma P_{BG,ST}.e_{s,[BG]}$</td><td></td></tr>
<tr><td rowspan="2">3</td><td>Load Case / Combination</td><td>CS: Summation</td><td>BG (each) PT precomp. $\sigma_a = -\Sigma P_{BG,ST}/A_{BG}$</td><td></td></tr>
<tr><td>Effects Check</td><td>Results → Stresses → Beam Stresses Diagram → Components → Sax → Apply</td><td>BG (each) PT precomp. $\sigma_a = -\Sigma P_{BG,ST}/A_{BG}$</td><td></td></tr>
<tr><td rowspan="2">4</td><td>Load Case / Combination</td><td>CS: Summation</td><td>BG (each) E/E + PT top combined $\sigma_{c,t} = \sigma_t + \sigma_a$</td><td></td></tr>
<tr><td>Effects Check</td><td>Results → Stresses → Beam Stresses Diagram → Components → Combined [1|2] → Apply</td><td>BG (each) E/E + PT top combined $\sigma_{c,t} = \sigma_t + \sigma_a$</td><td></td></tr>
<tr><td rowspan="2">5</td><td>Load Case / Combination</td><td>CS: Summation</td><td>BG (each) E/E + PT bot. combined $\sigma_{c,b} = \sigma_b + \sigma_a$</td><td></td></tr>
<tr><td>Effects Check</td><td>Results → Stresses → Beam Stresses Diagram → Components → Combined [3|4] → Apply</td><td>BG (each) E/E + PT bot. combined $\sigma_{c,b} = \sigma_b + \sigma_a$</td><td></td></tr>
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</td></tr>
<tr><td>10.102</td><td>
<table>
<tr><th>No.</th><th>Item</th><th>MidasCivil</th><th>Validation Spreadsheet</th><th>Value</th></tr>
<tr><td></td><td>In-Service Stage(s)
Stage</td><td>In-Service Stage(s):
[SLS] COMBO1A:DL+SDL+HA(CB)
[SLS] COMBO1B:DL+SDL+HA+HB30(CB)</td><td>In-Service Stage(s):
[SLS] DL + SDL + HA
[SLS] DL + SDL + HA + HB30</td><td>[kNm] | [MPa]</td></tr>
<tr><td rowspan="2">1</td><td>Load Case / Combination</td><td>CBall:
[SLS] COMBO1A:DL+SDL+HA(CB)
[SLS] COMBO1B:DL+SDL+HA+HB30(CB)</td><td>BG (each) E/E + PT sagging moment, $M_{[BG]}-\Sigma P_{BG,LT}.e_{s,[BG]}$</td><td></td></tr>
<tr><td>Effects Check</td><td>Results → Forces → Beam Diagrams → Components → My → Apply</td><td>BG (each) E/E + PT sagging moment, $M_{[BG]}-\Sigma P_{BG,LT}.e_{s,[BG]}$</td><td></td></tr>
<tr><td rowspan="2">2</td><td>Load Case / Combination</td><td>CBall:
[SLS] COMBO1A:DL+SDL+HA(CB)
[SLS] COMBO1B:DL+SDL+HA+HB30(CB)</td><td>BG (each) PT precomp. $\sigma_a = -\Sigma P_{BG,LT}/A_{BG}$</td><td></td></tr>
<tr><td>Effects Check</td><td>Results → Stresses → Beam Stresses Diagram → Components → Sax → Apply</td><td>BG (each) PT precomp. $\sigma_a = -\Sigma P_{BG,LT}/A_{BG}$</td><td></td></tr>
<tr><td>3</td><td>Load Case / Combination</td><td>CBall:
[SLS] COMBO1A:DL+SDL+HA(CB)</td><td>BG (each) E/E + PT top combined $\sigma_{c,t} = \sigma_t + \sigma_a$</td><td></td></tr>
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</table>

FEM Design Verification Checklist for MidasCivil 2019 (Summary)

ITEM	CONTENT					√
			[SLS] COMBO1B:DL+SDL+HA+HB30(CB)			
		Effects Check	Results → Stresses → Beam Stresses Diagram → Components → Combined [1|2] → Apply	BG (each) E/E + PT top combined $\sigma_{c,t} = \sigma_t + \sigma_a$		
	4	Load Case / Combination	CBall: [SLS] COMBO1A:DL+SDL+HA(CB) [SLS] COMBO1B:DL+SDL+HA+HB30(CB)	BG (each) E/E + PT bot. combined $\sigma_{c,b} = \sigma_b + \sigma_a$		
		Effects Check	Results → Stresses → Beam Stresses Diagram → Components → Combined [3|4] → Apply	BG (each) E/E + PT bot. combined $\sigma_{c,b} = \sigma_b + \sigma_a$		
10.11	**Cross Head Effects Validity Checks**					
10.111	**No.**	**Item**	**MidasCivil**	**Validation Spreadsheet**	**Value**	☐
		Construction Stage(s)				
		Stage	Construction Stage(s): CS-M2 | CS-M2-TBG CS-M3 | CS-M3-TBG CS-M4 | CS-M4-TBG CS-M5-TBG CS-DECK-T | CS-DECK-TDB CS-PRT-T | CS-PRT-TPRT CS-SURF-T | CS-SURF-TSURF	Construction Stage(s): CS-M2 | CS-M2-TBG CS-M3 | CS-M3-TBG CS-M4 | CS-M4-TBG CS-M5-TBG CS-DECK-T | CS-DECK-TDB CS-PRT-T | CS-PRT-TPRT CS-SURF-T | CS-SURF-TSURF	[kNm] | [MPa]	
	1	Load Case / Combination	CS: Dead Load	Cross head E/E hogging moment, $-M_{[CH]}$		
		Effects Check	Results → Forces → Beam Diagrams → Components → My → Apply	Cross head E/E hogging moment, $-M_{[CH]}$		
	2	Load Case / Combination	CS: Tendon Primary	Cross head PT hogging moment $\Sigma P_{CH,ST}.e_{T,[CH]}$		
		Effects Check	Results → Forces → Beam Diagrams → Components → My → Apply	Cross head PT hogging moment $\Sigma P_{CH,ST}.e_{T,[CH]}$		
	3	Load Case / Combination	CS: Summation	Cross head PT precomp. $\sigma_a = -\Sigma P_{CH,ST}/A_{CH}$		
		Effects Check	Results → Stresses → Beam Stresses Diagram → Components → Sax → Apply	Cross head PT precomp. $\sigma_a = -\Sigma P_{CH,ST}/A_{CH}$		
	4	Load Case / Combination	CS: Summation	Cross head E/E + PT top combined $\sigma_{c,t} = \sigma_t + \sigma_a$		
		Effects Check	Results → Stresses → Beam Stresses Diagram → Components → Combined [1|2] → Apply	Cross head E/E + PT top combined $\sigma_{c,t} = \sigma_t + \sigma_a$		
	5	Load Case / Combination	CS: Summation	Cross head E/E + PT bot. combined $\sigma_{c,b} = \sigma_b + \sigma_a$		
		Effects Check	Results → Stresses → Beam Stresses Diagram → Components → Combined [3|4] → Apply	Cross head E/E + PT bot. combined $\sigma_{c,b} = \sigma_b + \sigma_a$		
10.112	**No.**	**Item**	**MidasCivil**	**Validation Spreadsheet**	**Value**	☐
		In-Service Stage(s)				
		Stage	In-Service Stage(s): [SLS] COMBO1A:DL+SDL+HA(CB) [SLS] COMBO1B:DL+SDL+HA+HB30(CB)	In-Service Stage(s): [SLS] DL + SDL + HA [SLS] DL + SDL + HA + HB30	[kNm] | [MPa]	
	1	Load Case / Combination	CBall: [SLS] COMBO1A:DL+SDL+HA(CB) [SLS] COMBO1B:DL+SDL+HA+HB30(CB)	Cross head E/E + PT hogging moment, $-M_{[CH]}+\Sigma P_{CH,LT}.e_{T,[CH]}$		
		Effects Check	Results → Forces → Beam Diagrams → Components → My → Apply	Cross head E/E + PT hogging moment, $-M_{[CH]}+\Sigma P_{CH,LT}.e_{T,[CH]}$		
	2	Load Case / Combination	CBall: [SLS] COMBO1A:DL+SDL+HA(CB) [SLS] COMBO1B:DL+SDL+HA+HB30(CB)	Cross head PT precomp. $\sigma_a = -\Sigma P_{CH,LT}/A_{CH}$		
		Effects Check	Results → Stresses → Beam Stresses Diagram → Components → Sax → Apply	Cross head PT precomp. $\sigma_a = -\Sigma P_{CH,LT}/A_{CH}$		

FEM Design Verification Checklist for MidasCivil 2019 (Summary)

ITEM	CONTENT					√
	3	Load Case / Combination	CBall: [SLS] COMBO1A:DL+SDL+HA(CB) [SLS] COMBO1B:DL+SDL+HA+HB30(CB)	Cross head E/E + PT top combined $\sigma_{c,t} = \sigma_t + \sigma_a$		
		Effects Check	Results → Stresses → Beam Stresses Diagram → Components → Combined [1|2] → Apply	Cross head E/E + PT top combined $\sigma_{c,t} = \sigma_t + \sigma_a$		
	4	Load Case / Combination	CBall: [SLS] COMBO1A:DL+SDL+HA(CB) [SLS] COMBO1B:DL+SDL+HA+HB30(CB)	Cross head E/E + PT bot. combined $\sigma_{c,b} = \sigma_b + \sigma_a$		
		Effects Check	Results → Stresses → Beam Stresses Diagram → Components → Combined [3|4] → Apply	Cross head E/E + PT bot. combined $\sigma_{c,b} = \sigma_b + \sigma_a$		