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Oasys AdSec

Validation Examples

Contents

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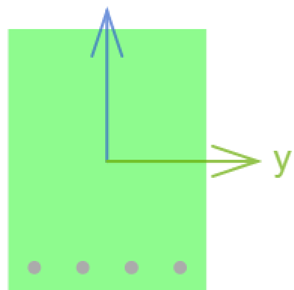
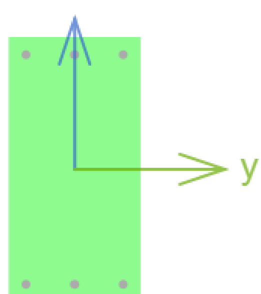
    (a) **Given:** a 400mm x 300mm rectangular concrete section with four bottom reinforcement bars

Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C45/55	*LINE*	4B20	-110,-160 110,-160
Profile	STD R 400 300			

    When: analysed for given axial load
    Then: the bending moment capacity (Myy) is within error margin of 1

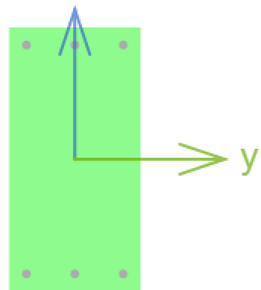
    (b) **Given:** a 600mm x 300mm rectangular concrete (C70/85) section with three reinforcement bars at top and bottom

Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C70/85	*LINE*	3B20	-110,260 110,260
Profile	STD R 600 300	*LINE*	3B20	-110,-260 110,-260

When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

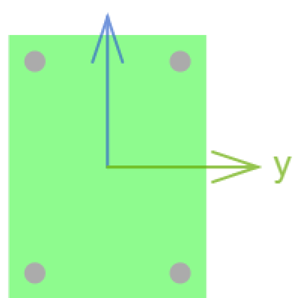
(c) **Given:** a 600mm x 300mm rectangular concrete (C30/37) section with three reinforcement bars at top and bottom



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	3B20	-110,260 110,260
Profile	STD R 600 300	*LINE*	3B20	-110,-260 110,-260

When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

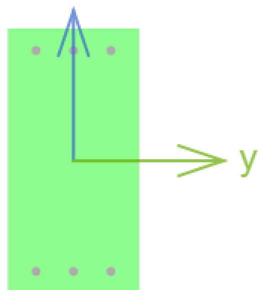
(d) **Given:** a 400mm x 300mm rectangular concrete section with two reinforcement bars at top and bottom



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C45/55	*LINE*	2B32	-110,160 110,160
Profile	STD R 400 300	*LINE*	2B32	-110,-160 110,-160

When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

(e) **Given:** a 600mm x 300mm rectangular concrete section with three reinforcement bars at top and bottom



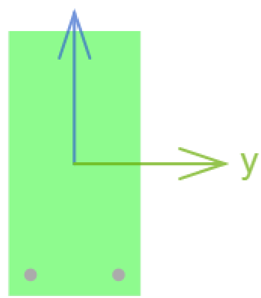
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	3B20	-85,250 85,250
Profile	STD R 600 300	*LINE*	3B20	-85,-250 85,-250

When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

2. **Scenario:** AdSec calculates bending moment capacity of a given section correctly to BS8110 97 (ULS)

   (a) **Given:** a 500mm x 250mm rectangular concrete section with two bottom reinforcement bars



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C25	*LINE*	2T24	-83,-210 83,-210
Profile	STD R 500 250			

When: concrete grade is set to C25
When: analysed for zero axial load
Then: the bending moment capacity (Myy) is within error margin of 1

When: concrete grade is set to C30
When: analysed for zero axial load
Then: the bending moment capacity (Myy) is within error margin of 1

When: concrete grade is set to C35
When: analysed for zero axial load
Then: the bending moment capacity (Myy) is within error margin of 1

When: concrete grade is set to C40
When: analysed for zero axial load
Then: the bending moment capacity (Myy) is within error margin of 1

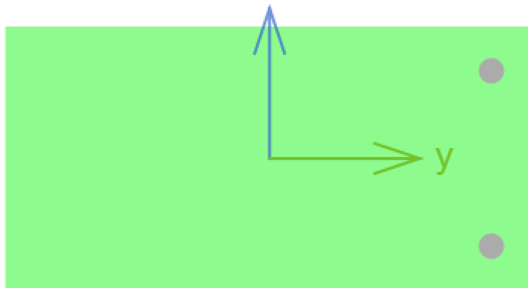
When: concrete grade is set to C45
When: analysed for zero axial load
Then: the bending moment capacity (Myy) is within error margin of 1

When: concrete grade is set to C50
When: analysed for zero axial load
Then: the bending moment capacity (Myy) is within error margin of 1

When: concrete grade is set to C55
When: analysed for zero axial load
Then: the bending moment capacity (Myy) is within error margin of 1

When: concrete grade is set to C60
When: analysed for zero axial load
Then: the bending moment capacity (Myy) is within error margin of 1

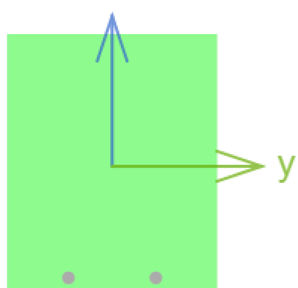
(b) **Given:** a 500mm x 250mm rectangular concrete section rotated at 90 degrees with two bottom reinforcement bars



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C25	*LINE*	2T24	-83,-210 83,-210
Profile	STD R 500 250 [R(90)]			

When: analysed for zero axial load
Then: the bending moment capacity (Mzz) is within error margin of 1

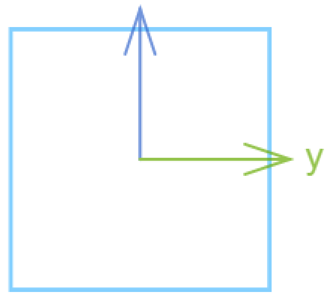
(c) **Given:** a 500mm x 400mm rectangular concrete section with two bottom reinforcement bars



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C25	*LINE*	2T24	-83,-210 83,-210
Profile	STD R 500 400			

When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

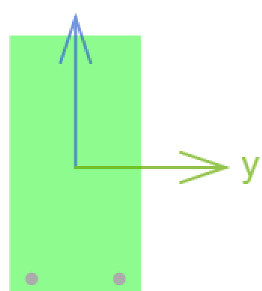
(d) **Given:** a 600mm x 600mm rectangular hollow steel section



Definition	
Material	Steel
Grade	S355
Profile	STD RHS 600 600 10 10

When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

(e) **Given:** a 500mm x 250mm rectangular concrete section with two bottom reinforcement bars



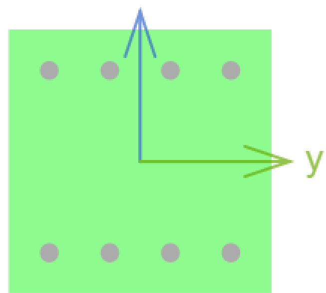
Definition	
Material	Concrete
Grade	C25 user defined
Profile	STD R 500 250

Reinforcement		
Type	*Description*	*Position(s)*
LINE	2T24	-83,-210 83,-210

When: analysed for an axial load of 0.0 kN
Then: the bending moment capacity (Myy) is within 1

3. **Scenario:** Adsec calculates bending moment capacity of a given section correctly to ACI318 02 (ULS)

   (a) **Given:** a 406mm x 406mm square concrete section with four reinforcement bars at top and bottom

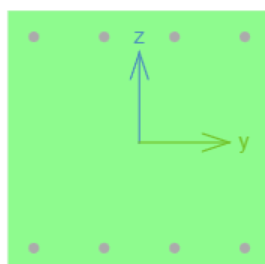


Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	5000 psi user defined	*LINE*	4"Grade 60"28.7	-140,140 140,140
Profile	STD R 406 406	*LINE*	4"Grade 60"28.7	-140,-140 140,-140

When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

4. **Scenario:** Adsec calculates the bending capacity correctly for the ACI318M-2019 code (ULS)

   (a) **Given:** A 1000mm x 1000mm square concrete section with four 40 mm 690MPa reinforcement bars at top and bottom

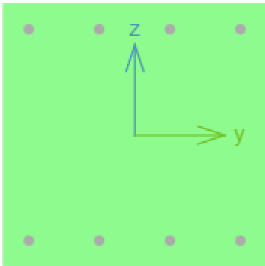


Definition		*Reinforcement*	
Material	Concrete	*Type*	*Description*
Grade	40 MPa	*BOTTOM*	4"Grade 690"40
Profile	STD R 1000 1000	*TOP*	4"Grade 690"40
Cover	80mm		

When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

5. **Scenario:** Adsec calculates the bending capacity correctly for the ACI318-2019 code (ULS)

   (a) **Given:** A 1000mm x 1000mm square concrete section with four 40 mm Grade 100 reinforcement bars at top and bottom



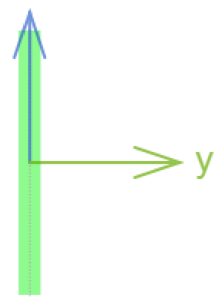
Definition		*Reinforcement*	
Material	Concrete	*Type*	*Description*
Grade	4000 psi	*BOTTOM*	4"Grade 100"40
Profile	STD R 1000 1000	*TOP*	4"Grade 100"40
Cover	80mm		

When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

1.2 Material Property Tests

1. **Scenario:** AdSec correctly uses 'Strain-hardening (Fig 3.8)' material model for steel reinforcements to EC2 GB 04 (ULS)

   (a) **Given:** a 3000mm x 250mm rectangular concrete section with reinforcement bars spaced at 40mm c/c along its depth at center



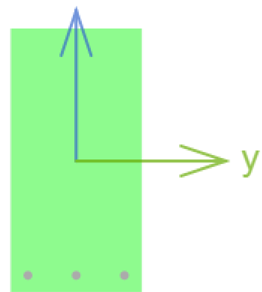
Definition	
Material	Concrete
Grade	C30/37
Profile	STD R 3000 250

Reinforcement		
Type	*Description*	*Position(s)*
LINE	75B16	0,-1500 0,1500

   When: the steel rebar ULS material model is set to 'Strain-hardening (Fig 3.8)'
   When: analysed for an axial load of -1000.0 kN (compression) and Myy of -7450.0 kNm (sagging)
   Then: the stress-strain results for steel rebars are within 1% of that expected from 'Strain-hardening (Fig 3.8)' material model

2. **Scenario:** AdSec correctly uses 'Explicit' material model for a given steel reinforcement to EC2 GB 04 (ULS)

   (a) **Given:** a 600mm x 300mm rectangular concrete section with three bottom reinforcment bars



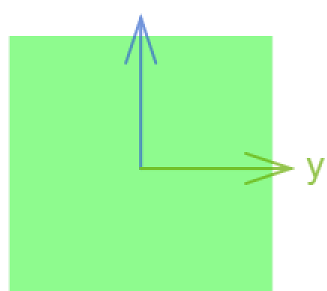
Definition	
Material	Concrete
Grade	C30/37
Profile	STD R 600 300

Reinforcement		
Type	*Description*	*Position(s)*
LINE	3B20	-110,-260 110,-260

When: the rebar ULS tension material model is set to 'Explicit' (explicitly defined 'Elastic-plastic (Fig 3.8)' model)
When: analysed for a Myy of -213.0 kNm (sagging)
Then: the load utilisation is within 1

3. **Scenario:** AdSec correctly uses 'Explicit' material model for a given concrete to EC2 GB 04 (ULS)

   (a) **Given:** a 1000mm x 1000mm rectangular concrete section with C35/45 material grade whose tensile stress-strain curve is explicitly defined



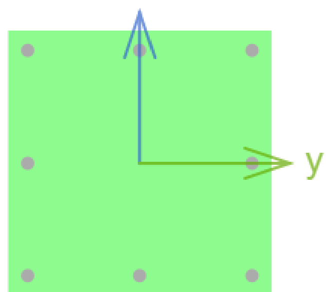
Definition	
Material	Concrete
Grade	C35/45
Profile	STD R 1000 1000

When: the concrete ULS tension material model is set to 'Explicit' ((0. 0, 0.0 MPa)(2.9e-5, 1.0 MPa)(2.5e-2, 1.0 MPa))

When: analysed for a Myy of -475.3 kNm (sagging)
Then: the load utilisation is within 1

4. **Scenario:** AdSec considers uses 'No-compression' material model for a given FRP reinforcement to BS8110 97 (ULS)

   (a) **Given:** a 400mm x 400mm rectangular concrete section with eight FRP reinforcement bars along its perimeter

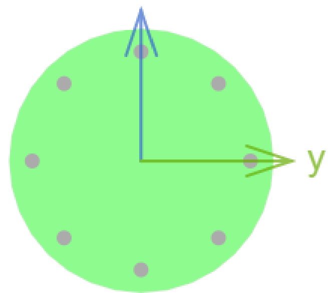


Definition		*Reinforcement*	
Material	Concrete	*Type*	*Description*
Grade	C35	*PERIMETER*	8"GFRP Aslan 100#3"20
Profile	STD R 400 400		
Cover	20mm		

When: the FRP rebar ULS material model is set to 'No-compression'
When: analysed for a Myy of -45.5 kNm (sagging)
Then: the stress in FRP rebars in compression equals zero

5. **Scenario:** AdSec correctly considers increased magnitude of concrete stress block for confined sections to ACI318 02 (ULS)

   (a) **Given:** a 508mm diameter circular concrete section with eight reinforcement bars along its perimeter

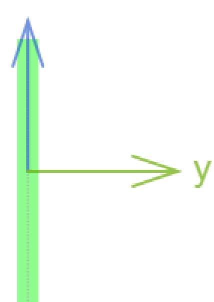


Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	5000 psi	*CIRCLE*	8"Grade 60"28.7	0,0 210
Profile	STD C 508			

When: the concrete grade is set to '5000 psi'
When: analysed for an axial load equal to its ultimate axial load capacity (compression) of -5130.0 kN
Then: the concrete stress is within 1% of the expected value of -29.3 MPa (0.85f'c)

6. **Scenario:** Adsec correctly uses 'No-compression' material model for a given FRP reinforcement to ACI318 02 (ULS)

   (a) **Given:** a 3000mm x 250mm rectangular concrete section with FRP reinforcement bars spaced at 40mm c/c along its depth at center



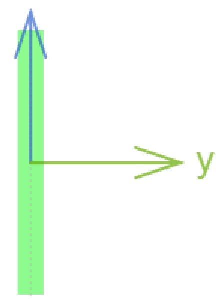
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	6500 psi	*LINE*	75"GFRP Aslan 100#2"16	0,-1475 0,1475
Profile	STD R 3000 250			

When: the FRP rebar ULS material model is set to 'No-compression'

When: analysed for an axial load of -200.0 kN (compression) and a Myy of -3300.0 kNm (sagging)
Then: the stress-strain results for FRP rebars are within 1% of that expected from 'No-compression' material model

7. **Scenario:** Adsec correctly uses 'Park' material model for a given steel reinforcement to ACI318 02 (ULS)

   (a) **Given:** a 5000mm x 500mm rectangular concrete section with reinforcement bars spaced at 110mm c/c along its depth at center

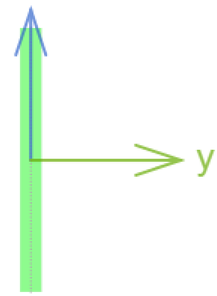


Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	10000 psi	*LINE*	45"Grade 60"22.2	0,-2480 0,2480
Profile	STD R 5000 500			

When: the steel rebar ULS material model is set to 'Park'
When: analysed for an axial load of 3500.0 kN (tension) and a Myy of - 7000.0 kNm (sagging)
Then: the stress-strain results for rebars are within 1% of that expected from 'Park' material model

8. **Scenario:** AdSec correctly uses 'Elastic-plastic' material model for steel reinforcements to AS3600 01 (ULS)

   (a) **Given:** a 3000mm x 250mm rectangular concrete section with reinforcement bars spaced at 40mm c/c along its depth at center



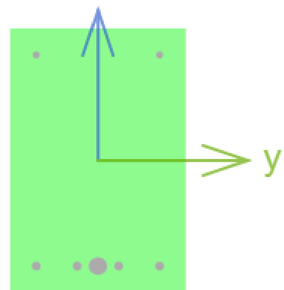
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	32 MPa	*LINE*	75Y16	0,-1475 0,1475
Profile	STD R 3000 250			

When: the steel rebar ULS material model is set to 'Elastic-plastic'
When: analysed for an axial load of -300.0 kN (compression) and a Myy of -5500.0 kNm (sagging)
Then: the stress-strain results for rebars are within 1% of that expected from 'Elastic-plastic' material model

1.3 Preload Tests

1. **Scenario:** AdSec correctly considers preload in section capacity calculations to BS8110 97 (ULS)

   (a) **Given:** a 600mm x 400mm rectangular concrete section with two top bars and five bottom bars



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C35	*LINE*	2T16	-140,240 140,240
Profile	STD R 600 400	*LINE*	4T20	-140,-240 140,-240
		POINT	T40	0,-240

When: bottom center bar is preloaded with 500.0 kN
When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

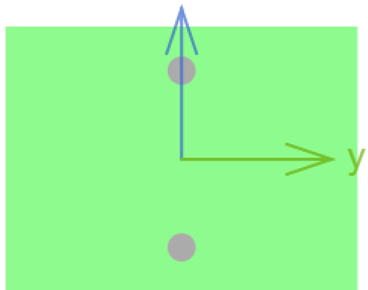
When: bottom center bar is preloaded with 550.0 kN
When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

When: no preload is applied
When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

When: bottom bars are preloaded with 120.0 kN and bottom center bar is preloaded with 500.0 kN
When: analysed for given axial load
Then: the bending moment capacity (Myy) is within error margin of 1

2. **Scenario:** AdSec correctly considers preload include-exclude option in section capacity calculations to BS8110 97 (ULS)

   (a) **Given:** A 300mm x 400mm rectangular concrete section with one rebar at top and bottom



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C35	*LINE*	2T32	0,100 0,-100
Profile	STD R 300 400			

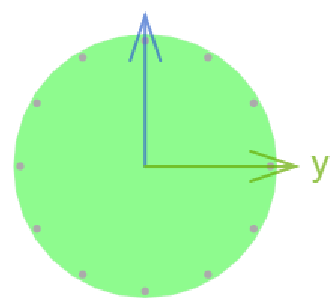
When: A force preload of 240.0 kN is applied to the bottom bar
When: Anchorage forces due to preload are excluded from the applied loads
Then: 1)The section bending moment capacity is within 1% of the expected value of -78.22.6 kNm (sagging) and zero axial load
2)Moment-curvature plot has a moment intercept of - 24.0 kNm (sagging) due to initial hogging preload moment in the section

When: A force preload of 240.0 kN is applied to the bottom bar
When: anchorage forces due to preload are included in the applied loads
Then: the section bending moment capacity is within 1

1.4 Material Safety Factor Tests

1. **Scenario:** AdSec correctly applies concrete material safety factor for 'Rectangular (Fig 3.5)' material model to EC2 GB 04 (ULS)

   (a) **Given:** a 500mm x 300mm rectangular concrete section with five bottom reinforcement bars

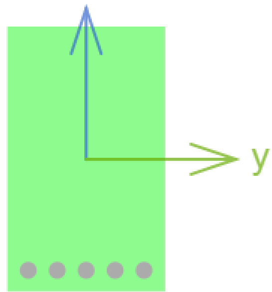


Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C12/15	*CIRCLE*	12B30	0,0 475
Profile	STD C 1000			

   When: the concrete ULS compression material model is set to 'Rectangular (Fig 3.5)'
   When: analysed for a Myy of -423.0 kNm (sagging)
   Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking concrete material safety factor into account

2. **Scenario:** AdSec correctly applies steel reinforcement material safety factor for 'Elastic-plastic (Fig 2.2)' material model to BS8110 97 (ULS)

   (a) **Given:** a 3000mm x 500mm rectangular concrete section with reinforcement bars spaced at 30mm c/c along its depth on both its sides



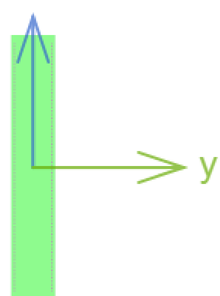
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	5A32	-110,-210 110,-210
Profile	STD R 500 300			

When: the steel rebar ULS material model is set to 'Elastic-plastic (Fig 2.2)'
When: analysed for an axial load of -5000.0 kN (compression) and a Myy of -13000.0 kNm (sagging)

Then: the stress-strain results for rebars are correctly calculated (within 1% error) taking rebar material safety factor into account

3. **Scenario:** AdSec correctly applies concrete material safety factor for 'Rectangular (Fig 6.1)' material model to BS8110 97 (ULS)

   (a) **Given:** a 500mm x 500mm rectangular concrete section having C40 material grade with rectangular material model



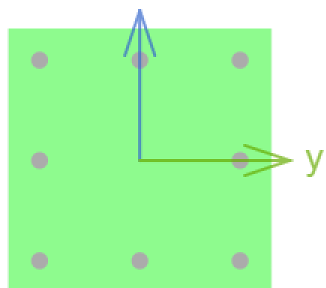
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C35	*LINE*	97T12	-210,-1400 -210,1400
Profile	STD R 3000 500	*LINE*	97T12	210,-1400 210,1400

When: the concrete ULS compression material model is set to 'Rectangular (Fig 6.1)'

When: analysed for a deformation of (-17.5e-2, -6.9e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking concrete material safety factor into account

4. **Scenario:** AdSec correctly applies steel reinforcement material safety factor for 'Elastic-plastic (Fig 2.2)' material model to BS8110 05 (ULS)

   (a) **Given:** a 3000mm x 250mm rectangular concrete section with reinforcement bars spaced at 40mm c/c along its depth at center

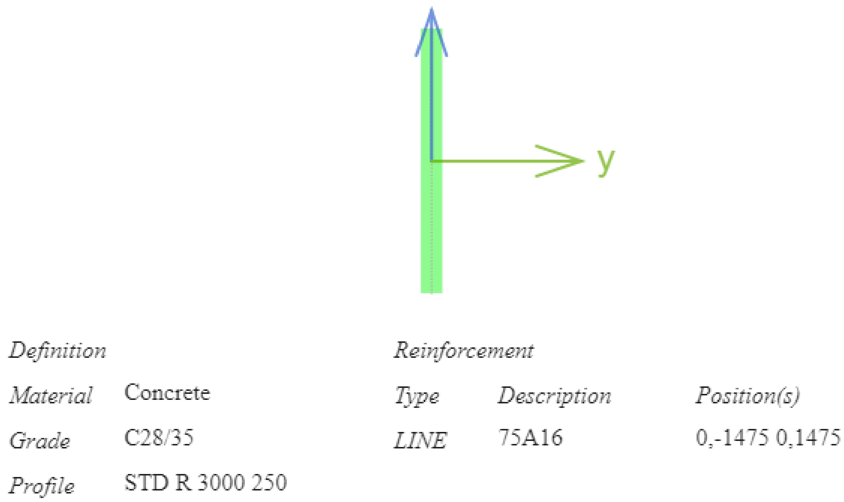


Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C40	*LINE*	3T32	-190,-190 190,-190
Profile	GEO P(MM)	*LINE*	3T32	-190,190 190,190
	M(250.|250.)	*LINE*	2T32	-190,0 190,0
	L(250.|-198.)			
	L(250.|-199.)			
	L(250.|-202.)			
	L(250.|-204.)			
	L(250.|-250.)			
	L(-250.|-250.)			
	L(-250.|250.)			

When: the steel rebar ULS material model is set to 'Elastic-plastic (Fig 2.2)'
When: analysed for an axial load of -300.0 kN (compression) and a Myy of -6900.0 kNm (sagging)
Then: the stress-strain results for rebars are correctly calculated (within 1% error) taking rebar material safety factor into account

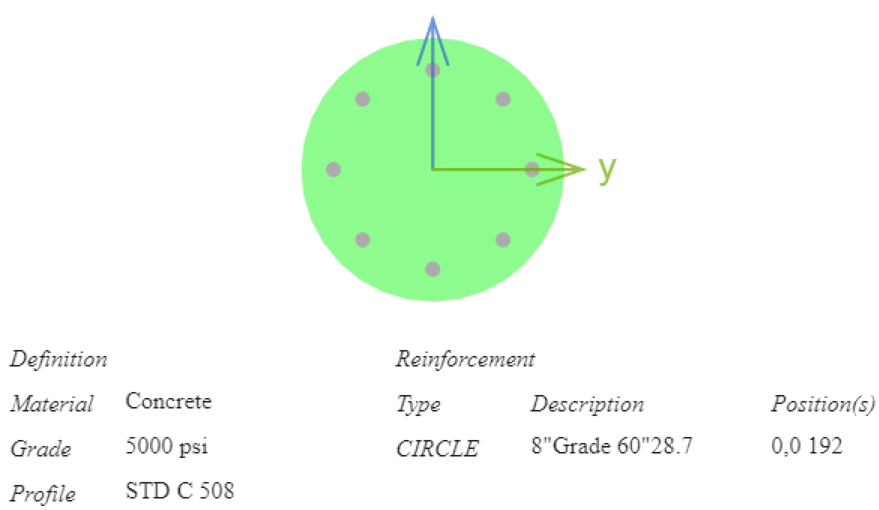
5. **Scenario:** Adsec correctly applies concrete material safety factor for 'Rectangular' material model to ACI318 02 (ULS)

   (a) **Given:** a 508mm diameter circular section with eight reinforcement bars



When: the concrete ULS compression material model is set to 'Rectangular'
When: analysed for an axial load of -1792.6 kN (compression) and a Myy of -324.0 kNm (sagging)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking concrete material safety factor into account

(b) **Given:** A 635mm x 305mm rectangular section with two bottom reinforcement bars



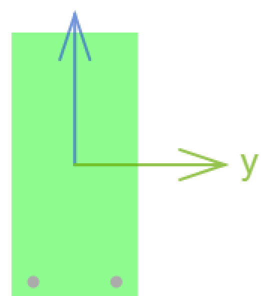
When: concrete grade is set to 4000 psi and ULS compression material model is set to 'Rectangular'

When: analysed for an axial load of -1632.0 kN (compression) and a Myy of -264.0 kNm (sagging)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking concrete

material safety factor into account

6. **Scenario:** Adsec correctly applies steel reinforcement material safety factor for 'Elastic-plastic' material model to ACI318 02 (ULS)

   (a) **Given:** a 3000mm x 250mm rectangular concrete section with reinforcement bars spaced at 40mm c/c along its depth at center

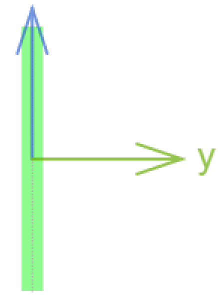


Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	4000 psi	*LINE*	2"Grade 60"28.7	100,-280 -100,-280
Profile	STD R 635 305			

When: the steel rebar ULS material model is set to 'Elastic-plastic'
When: analysed for an axial load of -300.0 kN (compression) and a Myy of 6890.0 kNm (hogging)
Then: the stress-strain results for rebars are correctly calculated (within 1% error) taking rebar material safety factor into account

7. **Scenario:** Adsec correctly applies strength reduction factor 'phi' for a given concrete section to ACI318 02 (ULS)

   (a) **Given:** a 508mm diameter circular concrete section with eight reinforcement bars along its perimeter

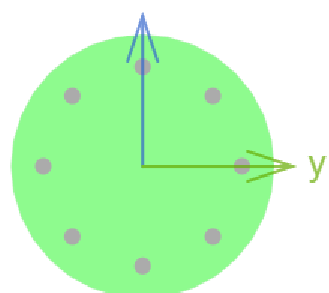


Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	5000 psi	*LINE*	75"Grade 60"16	0,-1500 0,1500
Profile	STD R 3000 250			

When: analysed for an axial load equal to its ultimate axial load capacity (compression) of -4244800.000000kN

Then: the load utilisation is within 1

(b) **Given:** a 406mm x 406mm rectangular concrete section with four reinforcement bars at top and bottom



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	4750 psi user defined	*CIRCLE*	8"Grade 60"32	0,0 192
Profile	STD C 508			

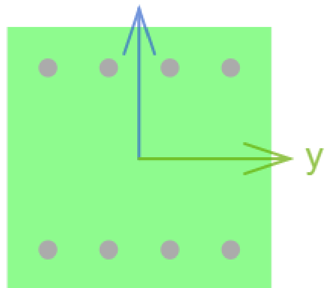
When: analysed for an axial load equal to its ultimate axial load capacity (compression) of -3425600.000000kN

Then: the load utilisation is within 1

8. **Scenario:** AdSec correctly applies concrete material safety factor for 'Rectangular' material model to

AS3600 01 (ULS)

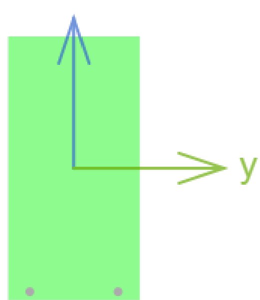
(a) **Given:** a 600mm x 300mm rectangular concrete section (20 MPa) with two bottom reinforcement bars



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	4750 psi user defined	*LINE*	4"Grade 60"28.7	-140,-140 140,-140
Profile	STD R 406 406	*LINE*	4"Grade 60"28.7	-140,140 140,140

When: the concrete ULS compression material model is set to 'Rectangular'
When: analysed for a Myy of -100.0 kNm (sagging)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking concrete material safety factor into account

(b) **Given:** a 600mm x 300mm rectangular concrete section (32 MPa) with two bottom reinforcement bars

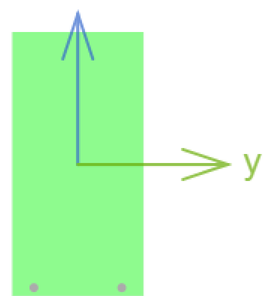


Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	20 MPa	*LINE*	2Y20	-101,-279 101,-279
Profile	STD R 600 300			

When: the concrete ULS compression material model is set to 'Rectangular'
When: analysed for a Myy of -100.0 kNm (sagging)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking concrete material safety factor into account

9. **Scenario:** AdSec correctly applies capacity reduction factor 'phi' for a given concrete section to AS3600 09 (ULS)

   (a) **Given:** a 600mm x 400mm rectangular concrete section with three bottom reinforcement bars



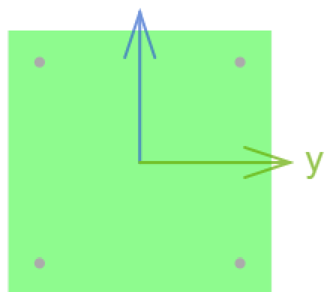
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	32 MPa	*LINE*	2Y20	-101,-279 101,-279
Profile	STD R 600 300			

When: analysed for a given load
Then: the load utilisation is within 1

1.5 Axial Capacity Tests

1. **Scenario:** AdSec calculates ultimate axial load capacity of a given section correctly to BS8110 97 (ULS)

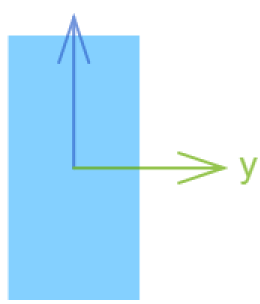
   (a) **Given:** a 500mm x 500mm rectangular concrete section with two reinforcement bars at top and bottom



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C35	*LINE*	2T20	-194,-194 194,-194
Profile	STD R 500 500	*LINE*	2T20	-194,194 194,194

   When: analysed for an axial load equal to its ultimate axial load capacity (compression) of -4439.0 kN
   Then: the load utilisation is within 1

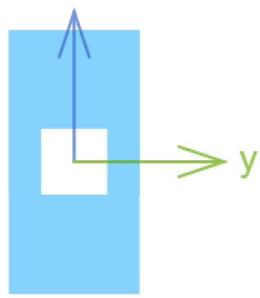
   (b) **Given:** a 800mm x 400mm rectangular steel section with S235 as its material grade



Definition	
Material	Steel
Grade	S235
Profile	STD R 800 400

When: analysed for an axial load equal to its ultimate axial load capacity (tension) of 75200.0 kN
Then: the load utilisation is within 1

(c) **Given:** a 800mm x 400mm rectangular S235 steel section with a 200mm square void created using perimeter section definition

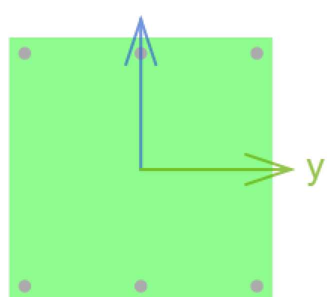


Definition	
Material	Steel
Grade	S235
Profile	GEO P M(-200|-400) L(-100|-100) L(-100|100) L(100|100) L(100|-100) L(-100|-100) L(-200|-400) L(200|-400) L(200|400) L(-200|400) L(-200|-400)

When: analysed for an axial load equal to its ultimate axial load capacity (tension) of 65800.0 kN
Then: the load utilisation is within 1

2. **Scenario:** AdSec calculates ultimate axial load capacity of a given section correctly to AS3600 01 (ULS)

(a) **Given:** a 500mm x 500mm rectangular concrete section with three reinforcement bars at top and bottom



Definition	
Material	Concrete
Grade	32 MPa
Profile	STD R 500 500

Reinforcement

Type	*Description*	*Position(s)*
LINE	3Y24	-218,218 218,218
LINE	3Y24	-218,-218 218,-218

When: analysed for an axial load equal to its ultimate axial load capacity (tension) of 868.0 kN
Then: the load utilisation is within 1

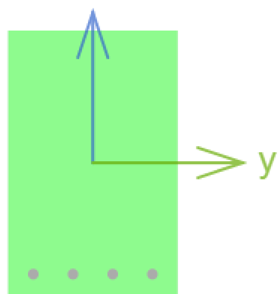
When: analysed for an axial load equal to its ultimate axial load capacity (compression) of -4687.0 kN
Then: the load utilisation is within 1

2 SLS Validation Examples

2.1 Crack Width Tests

1. **Scenario:** AdSec correctly calculates crack width 'wk' for a given concrete section to EC2 04 (SLS)

   (a) **Given:** a 620mm x 400mm rectangular concrete section with four bottom reinforcements



Definition	
Material	Concrete
Grade	C30/37
Profile	STD R 620 400

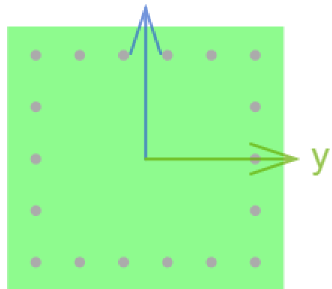
Reinforcement		
Type	*Description*	*Position(s)*
LINE	4B25	-140,-260 140,-260

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed with load term set to 'Short'
Then: 'Pp,eff', 'Sr,max', '(epsilon1 - epsilon2)' are correctly calculated and the crack width is within 0.002 mm margin from the expected value

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
Then: 'Pp,eff', 'Sr,max', '(epsilon1 - epsilon2)' are correctly calculated and the crack width is within 0.002 mm margin from the expected value

2. **Scenario:** AdSec correctly calculates crack width 'wk' for a 620mm x 650mm rectangular concrete section to EC2 04 (SLS)

   (a) **Given:** that the section has 18-25mm 500A reinforcements along its perimeter



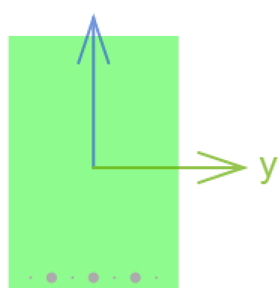
Definition	
Material	Concrete
Grade	C30/37
Profile	STD R 620 650
Cover	55mm

Reinforcement	
Type	*Description*
PERIMETER	18A25

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
Then: the crackwidth 'wk' is within 0.002 mm margin from the expected value of 0.114 mm

3. **Scenario:** AdSec correctly calculates crack width 'wk' for a 620mm x 400mm rectangular concrete section to EC2 04 (SLS)

   (a) **Given:** that the section has 3-25mm 500B reinforcements and 4-6mm YC1770C prestressed tendons at bottom



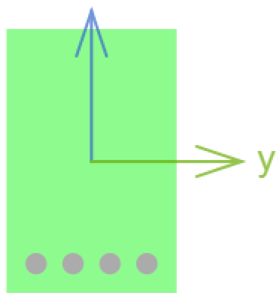
Definition	
Material	Concrete
Grade	C30/37
Profile	STD R 620 400

Reinforcement		
Type	*Description*	*Position(s)*
LINE	4"YC1770C"6	-147.5,-257.5 147.5,-257.5
LINE	3A25	-98.3,-257.5 98.3,-257.5

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'

When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 1.685 mm

(b) **Given:** that the section has 4-50mm 500A bottom reinforcement bars



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	4A50	-130,-240 130,-240
Profile	STD R 620 400			

When: National annex is set to UK
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -102.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.017 mm

When: National annex is set to UK
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -104.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.017 mm

When: National annex is set to UK
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.035 mm

When: National annex is set to UK
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -600.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.143 mm

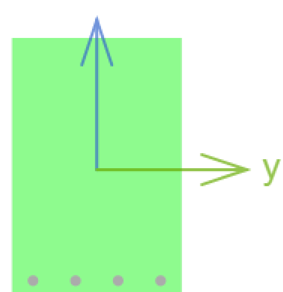
When: National annex is set to none
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -102.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.017 mm

When: National annex is set to none
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -104.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.017 mm

When: National annex is set to none
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.035 mm

When: National annex is set to none
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -600.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.143 mm

(c) **Given:** that the section has 4-25mm 500B bottom reinforcement bars



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	4B25	-147,-257 147,-257
Profile	STD R 620 400			

When: National annex is set to UK

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: the concrete and rebar elastic modulus is set to 20000.0 MPa and 250000.0 MPa respectively

When: analysed for a Myy of -93.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.057 mm

When: National annex is set to UK
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: the concrete and rebar elastic modulus is set to 20000.0 MPa and 250000.0 MPa respectively

When: analysed for a Myy of -94.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.057 mm

When: National annex is set to UK
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: the concrete and rebar elastic modulus is set to 20000.0 MPa and 250000.0 MPa respectively

When: analysed for a Myy of -300.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.244 mm

When: National annex is set to none
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: the concrete and rebar elastic modulus is set to 20000.0 MPa and 250000.0 MPa respectively

When: analysed for a Myy of -93.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.057 mm

When: National annex is set to none
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: the concrete and rebar elastic modulus is set to 20000.0 MPa and 250000.0 MPa respectively

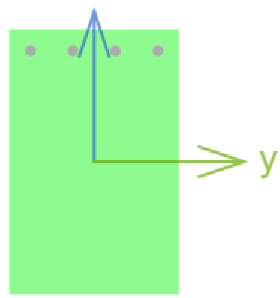
When: analysed for a Myy of -94.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.057 mm

When: National annex is set to none
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: the concrete and rebar elastic modulus is set to 20000.0 MPa and 250000.0 MPa respectively

When: analysed for a Myy of -300.0 kNm (sagging) with load term set to 'Short'

Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.244 mm

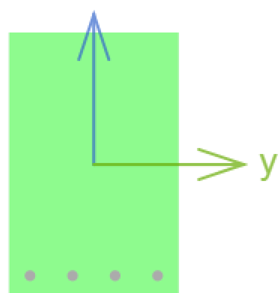
(d) **Given:** that the section has 4-25mm 500B top reinforcement bars



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	4B25	-147,257 147,257
Profile	STD R 620 400			

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of 200.0 kNm (hogging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.166 mm

(e) **Given:** that the section has 4-25mm 500A bottom reinforcement bars



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	4A25	-147,-257 147,-257
Profile	STD R 620 400			

When: the concrete SLS compression material model is set to 'Non-linear (Fig 3.2)' and SLS tension

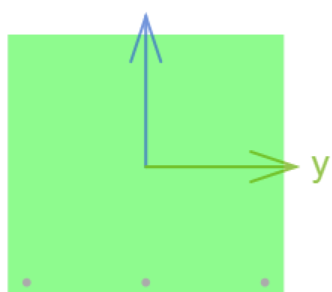
material model is set to 'Interpolated'
When: analysed for an axial load of 200.0 kN (tensile) and a Myy of -83. 3 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.03 mm margin from the expected value of 0.117 mm

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated (PD6687)(2.2)'
When: concrete grade is set to C50/60
When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.02 mm margin from the expected value of 0.148 mm

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated (PD6687)(2.2)'
When: concrete grade is set to C90/105
When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: the crack width is within 0.02 mm margin from the expected value of 0.143 mm

4. **Scenario:** AdSec correctly calculates EC2 crack width parameters for a given section to EC2 04 (SLS)

   (a) **Given:** a 620mm x 650mm rectangular concrete section with three bottom reinforcements with rebar spacing exceeding 5(c+phi/2)



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	3A20	-283,-268 283,-268
Profile	STD R 620 650			

When: the concrete SLS compression material model is set to 'Linear' for compression and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: 'x' is within 1.0 mm margin from the expected value of 92.6 mm

When: the concrete SLS compression material model is set to 'Linear' for compression and SLS tension material model is set to 'Interpolated'

When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: 'hceff' is within 1.0 mm margin from the expected value of 105.0 mm

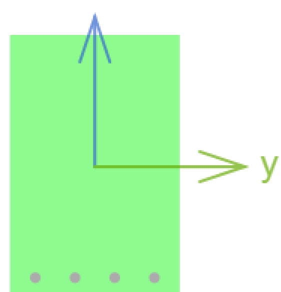
When: the concrete SLS compression material model is set to 'Linear' for compression and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: 'Pp,eff' is within 0.001 margin from the expected value of 0.014

When: the concrete SLS compression material model is set to 'Linear' for compression and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: 'Sr,max' is within 1.0 mm margin from the expected value of 685.6 mm

When: the concrete SLS compression material model is set to 'Linear' for compression and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: '(epsilon1 - epsilon2)' is within 1e-5 margin from the expected value of 12.6e-4

5. **Scenario:** AdSec correctly calculates 'hceff' for a given section to EC2 04 (SLS)

   (a) **Given:** a 620mm x 400mm rectangular concrete section with four bottom reinforcements

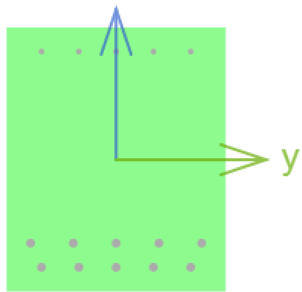


Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	4A25	-144,-257 144,-257
Profile	STD R 620 400			

When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: 'hceff' governed by (2.5*(h-d)) is within 3.0 mm margin from the expected value of 131.0 mm

6. **Scenario:** AdSec correctly calculates crack width 'wk' for a 1200mm x 1000mm rectangular concrete section to EC2 04 (SLS)

   (a) **Given:** that the section has 10-40mm 500A bottom reinforcement bars and 5- 25mm 500A top reinforcement bars



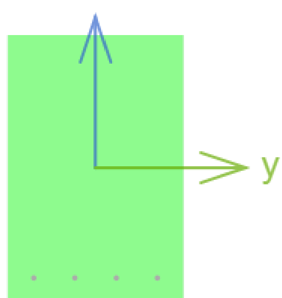
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	5A25	-335,492 335,492
Profile	STD R 1200 1000	*LINE*	5A40	-385,-375 385,-375
		LINE	5A40	-335,-490 335,-490

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -1507.0 kNm (sagging) with a creep coefficient of 1
Then: the interpolated deformation is (169.4e-6, -0.1e-2 /m, 0.0 /m)

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated'
When: analysed for a Myy of -1507.0 kNm (sagging) with a creep coefficient of 1
Then: the crackwidth 'wk' is within 0.02 mm margin from the expected value of 0.265 mm

7. **Scenario:** AdSec correctly calculates '(epsilon1 - epsilon2)' for a given section to EC2 04 (SLS)

   (a) **Given:** a 600mm x 400mm rectangular concrete section with four bottom reinforcement bars



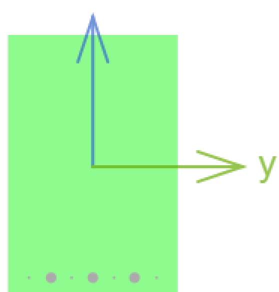
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	4A12	-144,-254 144,-254
Profile	STD R 600 400			

When: National annex is set to UK
When: '(epsilon1 - epsilon2)' according to equation 7.9 used in crack width calculation is less the limit '0.6*sigma/modulus'
When: analysed for a Myy of -100.0 kNm (sagging) with load term set to 'Short'
Then: '(epsilon1 - epsilon2)' is within 2e-5 margin from the expected value of 12.6e-4 (0.6*sigma/modulus)

When: National annex is set to none
When: '(epsilon1 - epsilon2)' according to equation 7.9 used in crack width calculation is less the limit '0.6*sigma/modulus'
When: analysed for a Myy of -100.0 kNm (sagging) with load term set to 'Short'
Then: '(epsilon1 - epsilon2)' is within 2e-5 margin from the expcetd value of 12.6e-4 (0.6*sigma/modulus)

8. **Scenario:** AdSec correctly calculates crack width 'wk' for a given section to BS EC2 PD 10 (SLS)

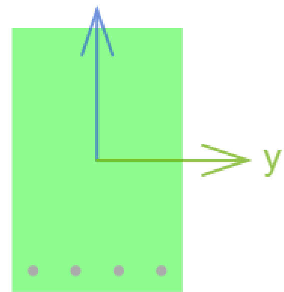
(a) **Given:** a 620mm x 400mm rectangular concrete section with three steel rebars and four prestressed tendons at bottomm



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	3B25	-98,-260 98,-260
Profile	STD R 620 400	*LINE*	4"YC1770C"6	-150,-260 150,-260

When: the concrete SLS comression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated (PD6687)(2.22)' for tension
When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.01 mm margin from the expected value of 0.169 mm

(b) **Given:** a 620mm x 400mm rectangular concrete section with four bottom reinforcements



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	4B25	-150,-260 150,-260
Profile	STD R 620 400			

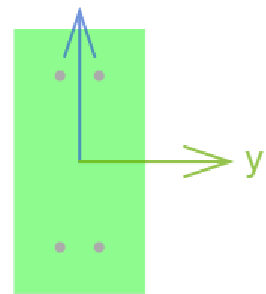
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated (PD6687)(2.22)'
When: analysed for a Myy of -200.0 kNm (sagging) with load term set to 'Short'
Then: the crack width 'wk' is within 0.002 mm margin from the expected value of 0.161 mm

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated (PD6687)(2.22)'
When: analysed for an axial load of 0.0 kN and a Myy of -82.0 kNm (sagging) with load term set to 'Short'
Then: the section is uncracked as the applied moment is below the cracking moment of -82.9 kNm (sagging)

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'Interpolated (PD6687)(2.22)'
When: analysed for an axial load of 200.0 kN (tension) and a Myy of -82. 0 kNm (sagging) with load term set to 'Short'
Then: the crack width is within 0.002 mm margin from the expected value of 0.108 mm

9. **Scenario:** AdSec correctly calculates Crack Width for a given section to BS5400

   (a) **Given:** a 500mm x 250mm standard Rectangular section with two bottom and two top reinforcement



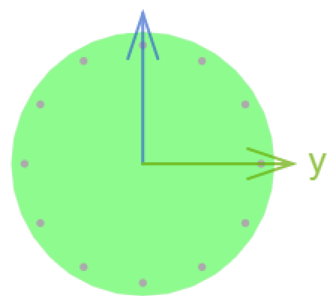
Definition		*Reinforcement*	
Material	Concrete	*Type*	*Description*
Grade	C35	*TOP*	2T20
Profile	STD R 500 250	*BOTTOM*	2T20
Cover	78mm		

When: the cover to the reinforcement is greater that Cnom
Then: the crack width is within 0.002mm and 0.02mm margin from the expected value of 0.016674mm and 0.1623mm respectively for the given load cases

2.2 Creep Factor Tests

1. **Scenario:** AdSec correctly considers creep coefficient in concrete SLS stress calculations to EC2 GB 04 (SLS)

   (a) **Given:** a 1000mm diameter circular concrete section with twelve reinforcement bars along its perimeter

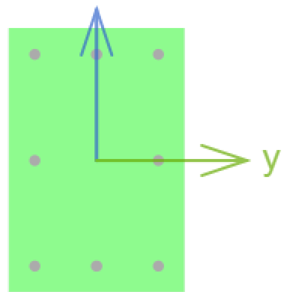


Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C45/55	*CIRCLE*	12B30	0,0 450
Profile	STD C 1000			

   When: the concrete SLS compression material model is set to 'Non-linear (Fig 3.2)' and SLS tension material model is set to 'No-tension'
   When: analysed for a deformation of (-1.6e-3, -0.3e-2 /m, 0.0 /m) with creep coefficients equal to 0, 1, 2 and 3
   Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking creep coefficient into account

2. **Scenario:** AdSec correctly calculates section stiffness 'EIyy' to EC2 GB 04 (SLS)

   (a) **Given:** a 600mm x 400mm rectangular concrete section with three reinforcements at top, bottom and one reinforcement on each side



Definition	
Material	Concrete
Grade	C40/50
Profile	STD R 600 400

Reinforcement		
Type	*Description*	*Position(s)*
LINE	3B25	-143,243 143,243
LINE	3B25	-143,-243 143,-243
LINE	2B25	-143,0 143,0

When: analysed for a creep coefficient of 2
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'No-tension'
Then: 1)analysed for an axial load of -1000.0 kN (compression) and a Myy of -100.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 117.4 MNsq.m
2)analysed for an axial load of -2000.0 kN (compression) and a Myy of -200.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 117.4 MNsq.m
3)analysed for an axial load of -3000.0 kN (compression) and a Myy of -300.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 117.4 MNsq.m

When: analysed with load term set to 'Short'
When: the concrete SLS compression material model is set to 'Bilinear (Fig 3.4)' and SLS tension material model is set to 'No-tension'
Then: analysed for an axial load of -1000.0 kN (compression) and a Myy of -100.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 171.5MNsq.m
2)analysed for an axial load of -2000.0 kN (compression) and a Myy of -200.0 kNm (sagging), the uncracked section stiffness EIyy is within 1.0 MNsq.m margin from the expected value of 171.5MNsq.m
3)analysed for an axial load of -3000.0 kN (compression) and a Myy of -300.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 171.5MNsq.m

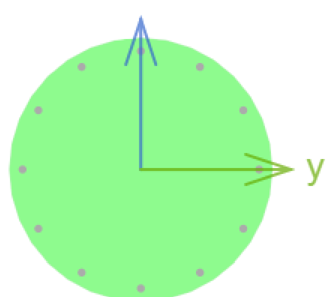
When: analysed with load term set to 'Short'
When: the concrete SLS compression material model is set to 'Non-linear (Fig 3.2)' and SLS tension

material model is set to 'No-tension'
Then: analysed for an axial load of -1000.0 kN (compression) and a Myy of -100.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 287.0MNsq.m
2)analysed for an axial load of -2000.0 kN (compression) and a Myy of -200.0 kNm (sagging), the uncracked section stiffness EIyy is within 1.0 MNsq.m margin from the expected value of 276.0MNsq.m
3)analysed for an axial load of -3000.0 kN (compression) and a Myy of -300.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 265.0MNsq.m

When: analysed with load term set to 'Short'
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'No-tension'
Then: analysed for an axial load of -1000.0 kN (compression) and a Myy of -100.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 282.6MNsq.m
2)analysed for an axial load of -2000.0 kN (compression) and a Myy of -200.0 kNm (sagging), the uncracked section stiffness EIyy is within 1.0 MNsq.m margin from the expected value of 282.6MNsq.m
3)analysed for an axial load of -3000.0 kN (compression) and a Myy of -300.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 282.6MNsq.m

3. **Scenario:** AdSec correctly considers creep coefficient in concrete SLS stress calculations to EC2 04 (SLS)

   (a) **Given:** a 1000mm diameter circular concrete section with twelve reinforcement bars along its perimeter



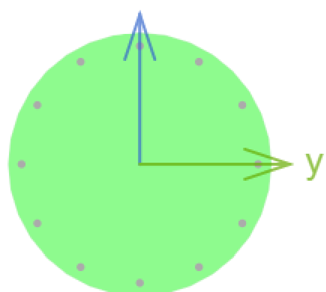
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C45/55	*CIRCLE*	12B30	0,0 450
Profile	STD C 1000			

When: the concrete SLS compression material model is set to 'Parabola rectangle (Fig 3.3)' and SLS tension material model is set to 'No- tension'
When: analysed for a deformation of (-1.6e-3, -0.3e-2 /m, 0.0 /m) with creep coefficients equal to 0, 1, 2 and 3
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking creep coefficient into account

When: the concrete SLS compression material model is set to 'Bilinear (Fig 3.4)' and SLS tension material model is set to 'No-tension'
When: analysed for a deformation of (-1.4e-3, -2.8e-3 /m, 0.0 /m) with creep coefficients equal to 0, 1, 2 and 3
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking creep coefficient into account

4. **Scenario:** AdSec correctly considers creep coefficient in concrete SLS stress calculations to BS8110 97 (SLS)

   (a) **Given:** a 1000mm diameter circular concrete section with twelve reinforcement bars along its perimeter



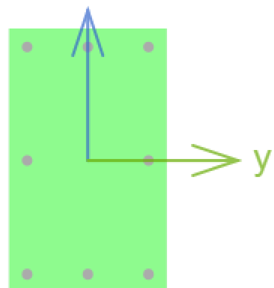
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C120 user defined	*CIRCLE*	12T30	0,0 450
Profile	STD C 1000			

When: the concrete SLS compression material model is set to 'Non-linear (BS8110-2 Fig 2.1)' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.4e-3, -2.4e-3 /m, 0.0 /m) with creep coefficients equal to 0, 1, 2 and 3
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking creep coefficient into account

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'

When: analysed for a deformation of (-1.4e-3, -2.4e-3 /m, 0.0 /m) with creep coefficients equal to 0, 1, 2 and 3
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking creep coefficient into account

(b) **Given:** a 500mm x 300mm rectangular concrete section with eight reinforcement bars along its perimeter

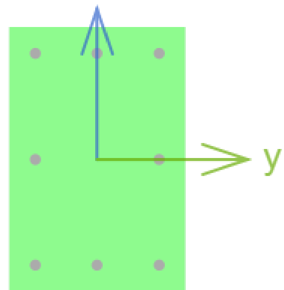


Definition		*Reinforcement*	
Material	Concrete	*Type*	*Description*
Grade	C30	*PERIMETER*	8T20
Profile	STD R 500 300		
Cover	25mm		

When: the concrete SLS material model is set to 'Explicit' (compression - (0.0, 0.0)(-3.5e-3, -30.0 MPa); tension - (0.0, 0.0)(3.5e-3, 30. 0 MPa))
When: analysed for a Myy of -100.0 kNm (sagging) with creep coefficients equal to 0, 1, 2 and 3
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking creep coefficient into account

5. **Scenario:** AdSec correctly calculates section stiffness 'EIyy' to BS8110 97 (SLS)

(a) **Given:** a 600mm x 400mm rectangular concrete section with three reinforcements at top, bottom and one reinforcement on each side



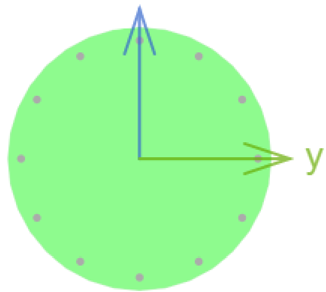
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C40	*LINE*	3T25	-143,-243 143,-243
Profile	STD R 600 400	*LINE*	3T25	-143,243 143,243
		LINE	2T25	-143,0 143,0

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'No-tension'
When: analysed with a creep coefficient of 2
Then: 1)analysed for an axial load of -1000.0 kN (compression) and a Myy of -100.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 100.5 MNsq.m
2)analysed for an axial load of -2000.0 kN (compression) and a Myy of -200.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 100.5 MNsq.m
3)analysed for an axial load of -3000.0 kN (compression) and a Myy of -300.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 100.5 MNsq.m

When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'No-tension'
When: analysed with load term set to 'Short'
Then: 1)analysed for an axial load of -1000.0 kN (compression) and a Myy of -100.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 231.0 MNsq.m.
2)analysed for an axial load of -2000.0 kN (compression) and a Myy of -200.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 231.0 MNsq.m.
3)analysed for an axial load of -3000.0 kN (compression) and a Myy of -300.0 kNm (sagging), the uncracked section stiffness 'EIyy' is within 1.0 MNsq.m margin from the expected value of 231.0 MNsq.m

6. **Scenario:** AdSec correctly uses 'Explicit' material model for a given concrete to BS8110 97 (SLS)

   (a) **Given:** a 1000mm diameter circular concrete section with twelve reinforcement bars along its perimeter

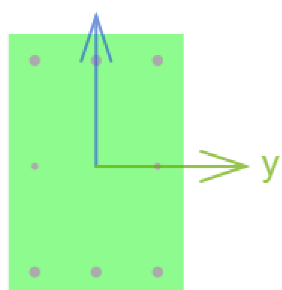


Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C50	*CIRCLE*	12T30	0,0 450
Profile	STD C 1000			

When: the concrete SLS compression material model is set to 'Explicit' and SLS tension material model is set to 'No-tension'
When: analysed for a deformation of (-1.4e-3, -2.4e-3 /m, 0.0 /m) with creep coefficients equal to 0, 1, 2 and 3
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Explicit' SLS compression curve and creep coefficient into account

7. **Scenario:** AdSec considers creep coefficient in concrete SLS stress calculations for BS8110 05 (SLS)

   (a) **Given:** a 600mm x 400mm rectangular concrete section with three reinforcements at top, bottom and one bar on sides



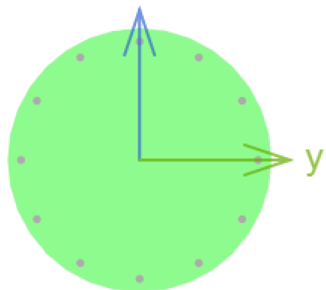
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	3B25	-141,244 141,244
Profile	STD R 600 400	*LINE*	3B25	-141,-244 141,-244
		LINE	2B16	-141,0 141,0

When: the concrete SLS compression material model is set to 'Explicit' and SLS tension material model is set to 'No-tension'
When: analysed for a Myy of -100.0 kNm (sagging) with creep coefficients equal to 0, 1 and 2
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking creep coefficient into account

2.3 Material Stress Tests

1. **Scenario:** AdSec correctly uses 'Non-linear (Fig 3.2)' material model for a given concrete to EC2 GB 04 (SLS)

   (a) **Given:** a 1000mm diameter circular concrete section with twelve reinforcement bars along its perimeter



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C12/15	*CIRCLE*	12B30	0,0 450
Profile	STD C 1000			

When: the concrete grade is set to C12/15 and concrete SLS compression material model is set to 'Non-linear (Fig 3.2)'
When: analysed for a deformation of (-1.6e-3, -0.3e-2 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (Fig 3.2)' SLS compression material model into account

When: the concrete grade is set to C16/20 and concrete SLS compression material model is set to 'Non-linear (Fig 3.2)'
When: analysed for a deformation of (-1.6e-3, -0.3e-2 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (Fig 3.2)' SLS compression material model into account

When: the concrete grade is set to C20/25 and concrete SLS compression material model is set to 'Non-linear (Fig 3.2)'
When: analysed for a deformation of (-1.6e-3, -0.3e-2 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (Fig 3.2)' SLS compression material model into account

When: the concrete grade is set to C25/30 and concrete SLS compression material model is set to 'Non-linear (Fig 3.2)'
When: analysed for a deformation of (-1.6e-3, -0.3e-2 /m, 0.0 /m)

Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (Fig 3.2)' SLS compression material model into account

When: the concrete grade is set to C35/45 and concrete SLS compression material model is set to 'Non-linear (Fig 3.2)'
When: analysed for a deformation of (-1.6e-3, -0.3e-2 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (Fig 3.2)' SLS compression material model into account

When: the concrete grade is set to C40/50 and concrete SLS compression material model is set to 'Non-linear (Fig 3.2)'
When: analysed for a deformation of (-1.6e-3, -0.3e-2 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (Fig 3.2)' SLS compression material model into account

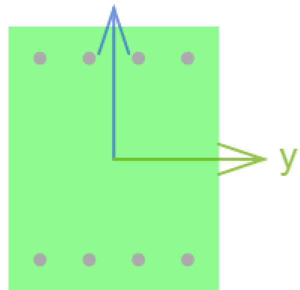
When: the concrete grade is set to C45/55 and concrete SLS compression material model is set to 'Non-linear (Fig 3.2)'
When: analysed for a deformation of (-1.6e-3, -0.3e-2 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (Fig 3.2)' SLS compression material model into account

When: the concrete grade is set to C50/60 and concrete SLS compression material model is set to 'Non-linear (Fig 3.2)'
When: analysed for a deformation of (-1.6e-3, -0.3e-2 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (Fig 3.2)' SLS compression material model into account

When: the concrete grade is set to C55/67 and concrete SLS compression material model is set to 'Non-linear (Fig 3.2)'
When: analysed for a deformation of (-1.6e-3, -0.3e-2 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (Fig 3.2)' SLS compression material model into account

2. **Scenario:** AdSec correctly calculates cracking moment for a given section to EC2 GB 04 (SLS)

   (a) **Given:** a 500mm x 400mm rectangular concrete section with four reinforcement bars at top and bottom



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	4B25	-136,-189 136,-189
Profile	STD R 500 400	*LINE*	4B25	-136,189 136,189

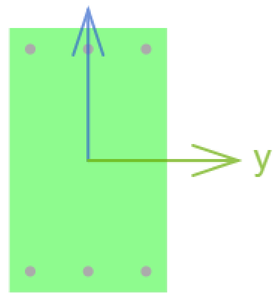
When: concrete SLS model is set to FIB model code for compression and linear for tension
Then: 1)Section is cracked for Myy equal to Mcrsection.
2) Section is uncracked for Myy equal to 1kN.m lesser than Mcr

When: the concrete SLS compression material model is set to 'Non-linear (Fig 3.2)' and SLS tension material model is set to 'No-tension'
Then: 1)The section is cracked for an axial load of -1000.0 kN (compression) and a Myy equal to its cracking moment of -87.8 kNm (sagging).
2)Section is uncracked for an axial load of -1000.0 kN (compression) and a Myy of -86.8 kNm (sagging).

When: the concrete SLS compression material model is set to 'Non-linear (Fig 3.2)' and SLS tension material model is set to 'No-tension'
Then: 1)The section is cracked for an axial load of -2000.0 kN (compression) and a Myy equal to its cracking moment of -172.1 kNm (sagging).
2)Section is uncracked for an axial load of -2000.0 kN (compression) and a Myy of -171.1 kNm (sagging).

3. **Scenario:** AdSec correctly analyses a given section subjected to a Myy below and above its cracking moment to EC2 GB 04 (SLS)

   (a) **Given:** a 500mm x 300mm rectangular concrete section with three reinforcement bars at top and bottom

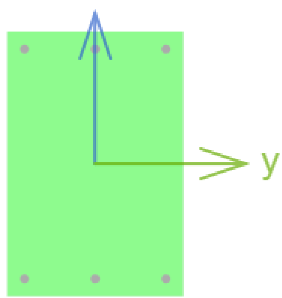


Definition		Reinforcement		
Material	Concrete	Type	Description	Position(s)
Grade	C35/45	LINE	3B20	-110,-210 110,-210
Profile	STD R 500 300	LINE	3B20	-110,210 110,210

When: analysed for a given load (cracking moment = -46.0 kNm (sagging))
Then: 1)the maximum tensile strain in concrete is less than the cracking strain of 94.2e-6
2)zeta is within 0.001 margin and interpolated axial strain 'epsilon x' is within 0.3e-4 margin from the expected value

4. **Scenario:** AdSec correctly uses 'Explicit' material model for a given concrete to EC2 GB 04 (SLS)

   (a) **Given:** a 600mm x 400mm rectangular concrete section with three reinforcement bars at top and bottom



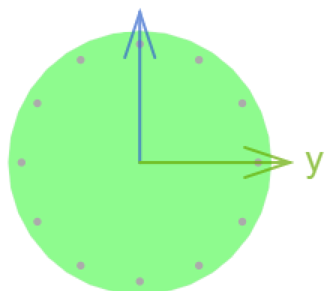
Definition		Reinforcement		
Material	Concrete	Type	Description	Position(s)
Grade	C40/50	LINE	3B20	-155,-255 155,-255
Profile	STD R 600 400	LINE	3B20	-155,255 155,255

When: the concrete SLS compression material model is set to 'Explicit' and SLS tension material model is set to 'No-tension'

When: analysed for a deformation input
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Explicit' SLS compression curve into account

5. **Scenario:** AdSec correctly uses 'Non-linear (BS8110-2 Fig 2.1)' material model for a given concrete to BS8110 97 (SLS)

   (a) **Given:** a 1000mm diameter circular concrete section with twelve reinforcement bars along its perimeter



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C25	*CIRCLE*	12T30	0,0 450
Profile	STD C 1000			

When: the concrete grade is set to C25 and concrete SLS compression material model is set to 'Non-linear (BS8110-2 Fig 2.1)' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.6e-3, -2.6e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (BS8110-2 Fig 2.1)' SLS compression material model into account

When: the concrete grade is set to C30 and concrete SLS compression material model is set to 'Non-linear (BS8110-2 Fig 2.1)' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.6e-3, -2.6e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (BS8110-2 Fig 2.1)' SLS compression material model into account

When: the concrete grade is set to C35 and concrete SLS compression material model is set to 'Non-linear (BS8110-2 Fig 2.1)' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.6e-3, -2.6e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (BS8110-2 Fig 2.1)' SLS compression material model into account

When: the concrete grade is set to C40 and concrete SLS compression material model is set

to 'Non-linear (BS8110-2 Fig 2.1)' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.6e-3, -2.6e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (BS8110-2 Fig 2.1)' SLS compression material model into account

When: the concrete grade is set to C45 and concrete SLS compression material model is set to 'Non-linear (BS8110-2 Fig 2.1)' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.6e-3, -2.6e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (BS8110-2 Fig 2.1)' SLS compression material model into account

When: the concrete grade is set to C50 and concrete SLS compression material model is set to 'Non-linear (BS8110-2 Fig 2.1)' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.6e-3, -2.6e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (BS8110-2 Fig 2.1)' SLS compression material model into account

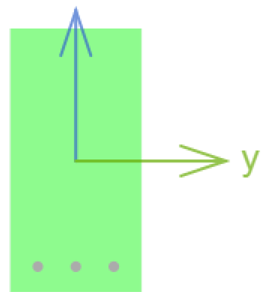
When: the concrete grade is set to C55 and concrete SLS compression material model is set to 'Non-linear (BS8110-2 Fig 2.1)' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.6e-3, -2.6e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (BS8110-2 Fig 2.1)' SLS compression material model into account

When: the concrete grade is set to C60 and concrete SLS compression material model is set to 'Non-linear (BS8110-2 Fig 2.1)' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.6e-3, -2.6e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (BS8110-2 Fig 2.1)' SLS compression material model into account

When: the concrete grade is set to C70 and concrete SLS compression material model is set to 'Non-linear (BS8110-2 Fig 2.1)' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.6e-3, -2.6e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Non-linear (BS8110-2 Fig 2.1)' SLS compression material model into account

6. **Scenario:** AdSec correctly uses 'BS8110 Part 2 (Fig 3.1)' SLS tension material model for a given concrete to BS8110 97 (SLS)

   (a) **Given:** a 500mm x 250mm rectangular concrete section with three bottom reinforcements



Definition

Material	Concrete
Grade	C35
Profile	STD R 500 250

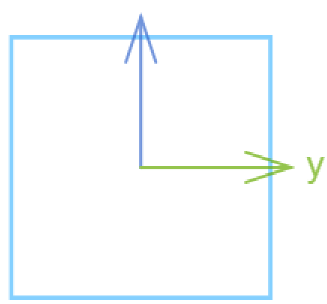
Reinforcement

Type	*Description*	*Position(s)*
LINE	3T20	-72,-199 72,-199

When: the concrete SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'BS8110 Part 2 (Fig 3.1)' SLS tension material model into account

7. **Scenario:** AdSec correctly analyses steel only sections for SLS to BS8110 97 (SLS)

   (a) **Given:** a 600mm hollow square steel section



Definition

Material	Steel
Grade	S355
Profile	STD RHS 600 600 10 10

When: analysed for a Myy of -500.0 kN.m (sagging)(elastic)
Then: the stress at extreme compression fibers is -109.5 MPa (within 1 % error) and at extreme tension fibers is 109.5 MPa (within 1% error)

When: analysed for a Myy of -500.0 kN.m (sagging)(elastic)
Then: the stiffness 'EIyy' is within 1.0 MN.sqm margin from the expected value of 280.6 MN.sqm

When: analysed for a Myy of -1300.0 kN.m (sagging)(elastic)
Then: the stress at extreme compression fibers is -284.7 MPa (within 1% error) and at extreme tension fibers is 284.7 MPa (within 1% error)

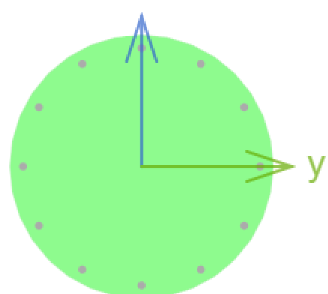
When: analysed for a Myy of -1300.0 kN.m (sagging)(elastic)
Then: the stiffness 'EIyy' is within 1.0 MN.sqm margin from the expected value of 280.6 MN.sqm

When: analysed for a Myy of -1800.0 kN.m (sagging)(plastic)
Then: the stress at extreme compression fibers is -355.0 MPa (within 1% error) and at extreme tension fibers is 355.0 MPa (within 1% error)

When: analysed for a Myy of -1800.0 kN.m (sagging)(plastic)
Then: the stiffness 'EIyy' is lesser than 280.6 MN.sqm

8. **Scenario:** AdSec correctly uses 'Linear' material model for a given concrete to BS8110 and BS5400 (SLS)

   (a) **Given:** a 1000mm diameter circular concrete section with twelve reinforcement bars along its perimeter



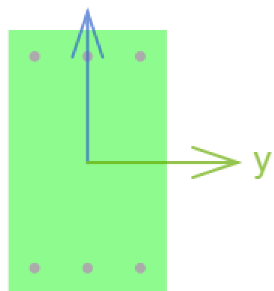
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C60	*CIRCLE*	12T30	0,0 450
Profile	STD C 1000			

When: design code is set to BS8110
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.4e-3, -2.8e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Linear' SLS compression material model into account

When: design code is set to BS5400
When: the concrete SLS compression material model is set to 'Linear' and SLS tension material model is set to 'BS8110 Part 2 (Fig 3.1)'
When: analysed for a deformation of (-1.4e-3, -2.8e-3 /m, 0.0 /m)
Then: the stress-strain results for concrete are correctly calculated (within 1% error) taking 'Linear' SLS compression material model into account

9. **Scenario:** AdSec correctly uses distribution coefficient to model tension stiffening for a given concrete section to ACI318 02 (SLS)

    (a) **Given:** a 500mm x 300mm rectangular section with three reinforcements at top and bottom



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	6500 psi	*LINE*	3"Grade 60"20	-100,-200 100,-200
Profile	STD R 500 300	*LINE*	3"Grade 60"20	-100,200 100,200

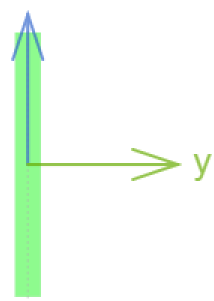
When: analysed for given load
Then: the interpolated deformation is within error margin of 1

3 Miscellaneous Validation Examples

3.1 Miscellaneous Tests

1. **Scenario:** Adsec correctly uses 'Park' material model for a given steel reinforcement to ACI318 02 (MISC)

   (a) **Given:** a 5000mm x 500mm rectangular concrete section with reinforcement bars spaced at 110mm c/c along its depth at center

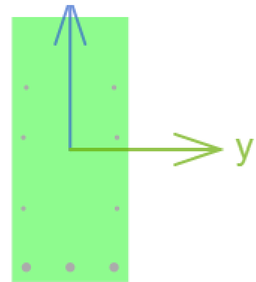
   

Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	3500 psi	*LINE*	45"Grade 60"22.2	0,-2480 0,2480
Profile	STD R 5000 500			

   When: the rebar ULS material model is set to 'Park'
   When: analysed for an axial load of 0.0 kN and a Myy equal to its bending moment capacity of -13800.0 kNm (sagging)
   Then: the stress-strain results for rebar are correctly calculated (within 1% error) taking 'Park' material model into account

2. **Scenario:** AdSec correctly calculates crack width 'w' for a given section to BS5400 (MISC)

   (a) **Given:** a 900mm x 400mm rectangular concrete section with two rebars at top, three rebars at bottom and two rebars at sides



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C35	*LINE*	2T16	-150,210 150,210
Profile	STD R 900 400	*LINE*	2T16	-160,40 160,40
		LINE	2T16	-160,-200 160,-200
		LINE	3T32	-150,-400 150,-400

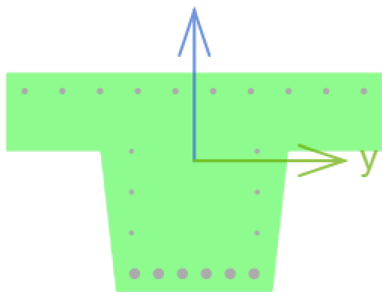
When: 'Mq/Mg Ratio' is set to 0.9
When: analysed for a Myy of -123.0 kNm (sagging) with load term set to 'Short'
Then: the crack width is within 0.002 mm margin from the expected value of 0.032 mm

When: 'Mq/Mg Ratio' is set to 1.0
When: analysed for a Myy of -123.0 kNm (sagging) with load term set to 'Short'
Then: the crack width is within 0.002 mm margin from the expected value of 0.061 mm

When: 'Mq/Mg Ratio' is set to 1.1
When: analysed for a Myy of -123.0 kNm (sagging) with load term set to 'Short'
Then: the crack width is within 0.002 mm margin from the expected value of 0.061 mm

3. **Scenario:** AdSec correctly performs intermediate analysis for a given section to BS5400 (MISC)

   (a) **Given:** a tapered T concrete section with ten rebars at top, six rebars at bottom and three rebars at sides



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C50	*LINE*	10T20	-540,220 540,220
Profile	STD TT 700 1200 600 500 250	*LINE*	6T35	-190,-360 190,-360
		LINE	3T16	-200,-230 -200,30
		LINE	3T16	200,-230 200,30

When: the load term is set to 'Intermediate' and Mq/Mg set to 0.0
When: analysed for a Myy of -1000.0 kNm (sagging) with a creep coefficient of 1
Then: the stress-strain results for concrete are correctly calculated (within 1% error) using E intermediate equal to 17000.0 MPa

When: the load term is set to 'Intermediate' and Mq/Mg set to 0.3
When: analysed for a Myy of -1000.0 kNm (sagging) with a creep coefficient of 1
Then: the stress-strain results for concrete are correctly calculated (within 1% error) using E intermediate equal to 20923.0 MPa

When: the load term is set to 'Intermediate' and Mq/Mg set to 0.8
When: analysed for a Myy of -1000.0 kNm (sagging) with a creep coefficient of 1
Then: the stress-strain results for concrete are correctly calculated (within 1% error) using E intermediate equal to 24555.5 MPa

When: the load term is set to 'Intermediate' and Mq/Mg set to 1.0
When: analysed for a Myy of -1000.0 kNm (sagging) with a creep coefficient of 1
Then: the stress-strain results for concrete are correctly calculated (within 1% error) using E intermediate equal to 25500.0 MPa

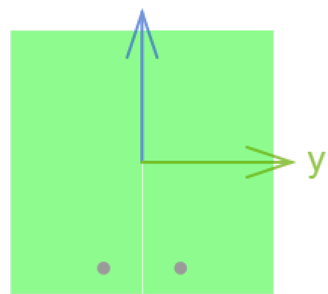
When: the load term is set to 'Intermediate' and Mq/Mg set to 2.0
When: analysed for a Myy of -1000.0 kNm (sagging) with a creep coefficient of 1
Then: the stress-strain results for concrete are correctly calculated (within 1% error) using E intermediate equal to 28333.3 MPa

When: the load term is set to 'Intermediate' and Mq/Mg set to 10.0
When: analysed for a Myy of -1000.0 kNm (sagging) with a creep coefficient of 1
Then: the stress-strain results for concrete are correctly calculated (within 1% error) using E

intermediate equal to 32454.5 MPa

4. **Scenario:** AdSec correctly calculates ULS results for a multi-component section to BS8110 97 (MISC)

   (a) **Given:** a 500mm x 500mm rectangular concrete section defined using two similar 500mm x 250mm components each with two bottom rebars



Component 1

Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	2	*LINE*	2T24	-73,-200 73,-200
Profile	STD R 500 250			

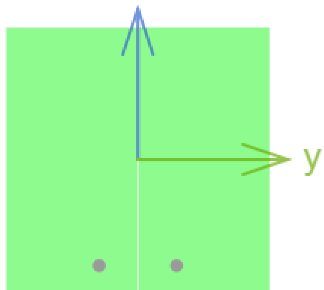
Component 2

Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	2	*LINE*	2T24	-73,-200 73,-200
Profile	STD R 500 250 [T(250.000|0.0)]			

When: analysed for an axial load of 0.0 kN and a Myy equal to its bending moment capacity of -318.7 kNm (sagging)
Then: the load utilisation is within 1

5. **Scenario:** AdSec correctly calculates ULS results for a multi-component section to EC2 GB 04 (MISC)

   (a) **Given:** a 500mm x 500mm rectangular concrete section defined using two similar 500mm x 250mm components each with two bottom rebars



Component 1

Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	2B24	-73,-200 73,-200
Profile	STD R 500 250			

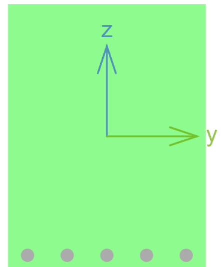
Component 2

Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C30/37	*LINE*	2B24	-73,-200 73,-200
Profile	STD R 500 250 [T(250.000|0.0)]			

When: analysed for an axial load of 0.0 kN and a Myy equal to its bending moment capacity of -319.1 kNm (sagging)
Then: the load utilisation is within 1

6. **Scenario:** The response load is calculated correctly for the given strain for FE415 using M50 for IRC-112-2011 (MISC)

   (a) **Given:** A section and a set of deformation values



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	M50	*LINE*	5"FE415"20	-120,-180 120,-180
Profile	STD R 400. 300.			

When: We provide a deformation ex: -0.100%, kyy: -1.245%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: -1129.71kN, myy: -196.94kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.200%, kyy: -2.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 129.15kN, myy: -176.23kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.200%, kyy: -1.500%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 387.51kN, myy: -136.13kNm, mzz: 0.00kNm

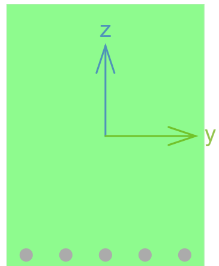
When: We provide a deformation ex: 0.200%, kyy: -2.500%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: -47.31kN, myy: -198.74kNm, mzz: 0.00kNm

When: We provide a deformation ex: 2.000%, kyy: 0.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 610.99kN, myy: -109.98kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.000%, kyy: 1.245%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: -1513.78kN, myy: 215.44kNm, mzz: 0.00kNm

7. **Scenario:** The response load is calculated correctly for the given strain for FE500D and M70 using IRC-112-2011 (MISC)

   (a) **Given:** A section and a set of deformation values



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	M70	*LINE*	5"FE500D"20	-120,-180 120,-180
Profile	STD R 400 300.			

When: We provide a deformation ex: -0.100%, kyy: -0.800%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: -1949.97kN, myy: -187.41kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.200%, kyy: -2.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 132.91kN, myy: -214.69kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.200%, kyy: -1.500%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 471.98kN, myy: -161.45kNm, mzz: 0.00kNm

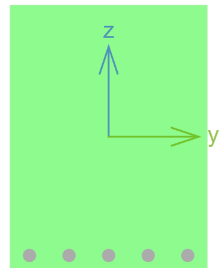
When: We provide a deformation ex: 0.200%, kyy: -2.500%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: -129.50kN, myy: -249.62kNm, mzz: 0.00kNm

When: We provide a deformation ex: 4.000%, kyy: 0.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 736.59kN, myy: -132.59kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.000%, kyy: 1.245%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: -1892.51kN, myy: 271.55kNm, mzz: 0.00kNm

8. **Scenario:** The response load is calculated correctly for the given strain for FEMS1 and M30 using IRC-112-2011 (MISC)

   (a) **Given:** A section and a set of deformation values



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	M30	*LINE*	5"FEMS1"20	-120,-180 120,-180
Profile	STD R 400. 300.			

When: We provide a deformation ex: -0.100%, kyy: -0.800%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: -833.34kN, myy: -94.80kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.200%, kyy: -2.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 103.80kN, myy: -110.47kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.200%, kyy: -1.500%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 251.42kN, myy: -85.08kNm, mzz: 0.00kNm

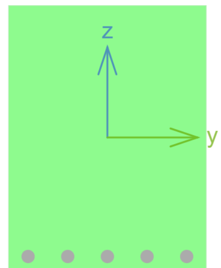
When: We provide a deformation ex: 0.200%, kyy: -2.500%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 5.32kN, myy: -125.31kNm, mzz: 0. 00kNm

When: We provide a deformation ex: 2.000%, kyy: 0.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 511.32kN, myy: -92.04kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.000%, kyy: 1.245%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: -906.95kN, myy: 129.03kNm, mzz: 0.00kNm

9. **Scenario:** The response load is calculated correctly for the given strain for FE550 and M80 using IRC-112-2011 (MISC)

    (a) **Given:** A section and a set of deformation values



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	M80	*LINE*	5"FE550"20	-120,-180 120,-180
Profile	STD R 400. 300.			

When: We provide a deformation ex: 0.120%, kyy: -0.700%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 731.61kN, myy: -138.88kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.218%, kyy: -2.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 270.62kN, myy: -218.29kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.200%, kyy: -1.500%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 543.25kN, myy: -173.61kNm, mzz: 0.00kNm

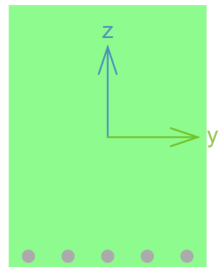
When: We provide a deformation ex: 0.200%, kyy: -2.250%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 11.89kN, myy: -255.79kNm, mzz: 0.00kNm

When: We provide a deformation ex: 2.000%, kyy: 0.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 785.96kN, myy: -141.47kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.000%, kyy: 1.245%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: -1987.32kN, myy: 287.07kNm, mzz: 0.00kNm

10. **Scenario:** The response load is calculated correctly for the given strain for FE500S and M55 using IRC-112-2020 (MISC)

    (a) **Given:** A section and a set of deformation values



Definition	
Material	Concrete
Grade	M55
Profile	STD R 400. 300.

Reinforcement		
Type	*Description*	*Position(s)*
LINE	5"FE500S"20	-120,-180 120,-180

When: We provide a deformation ex: 0.100%, kyy: -0.700%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 604.18kN, myy: -137.10kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.200%, kyy: -2.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 198.79kN, myy: -204.06kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.200%, kyy: -1.500%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 483.42kN, myy: -160.03kNm, mzz: 0.00kNm

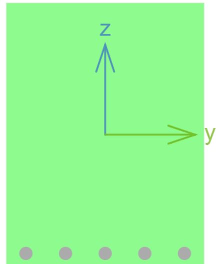
When: We provide a deformation ex: 0.200%, kyy: -2.250%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 90.59kN, myy: -218.42kNm, mzz: 0.00kNm

When: We provide a deformation ex: 3.000%, kyy: 0.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 743.64kN, myy: -133.85kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.000%, kyy: 1.245%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: -1723.53kN, myy: 247.49kNm, mzz: 0.00kNm

11. **Scenario:** The response load is calculated correctly for the given strain for FE415S and M25 using IRC 112-2020 (MISC)

    (a) **Given:** A section and a set of deformation values



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	M25	*LINE*	5"FE415S"20	-120,-180 120,-180
Profile	STD R 400. 300.			

When: We provide a deformation ex: 0.120%, kyy: -0.700%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 558.49kN, myy: -103.95kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.218%, kyy: -2.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 380.30kN, myy: -135.45kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.200%, kyy: -1.500%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 478.74kN, myy: -119.36kNm, mzz: 0.00kNm

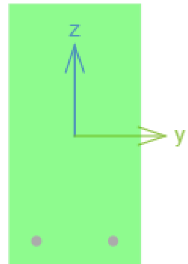
When: We provide a deformation ex: 0.200%, kyy: -2.250%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 301.28kN, myy: -146.10kNm, mzz: 0.00kNm

When: We provide a deformation ex: 2.000%, kyy: 0.000%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: 599.52kN, myy: -107.91kNm, mzz: 0.00kNm

When: We provide a deformation ex: 0.000%, kyy: 1.245%/m, kzz: 0.000 %/m
Then: We expect response load to be fx: -1040.42kN, myy: 158.76kNm, mzz: 0.00kNm

12. **Scenario:** The BS8110-1997 load response is calculated for the rectangular section are correct

    (a) **Given:** An app instance set to BS 8110-1997



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C35	*POINT*	T20	-72,-199 72,-199
Profile	STD R 500 250			

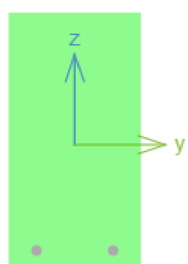
When: We create a 500x250 C35 concrete section with 2T20 bottom bars [Ref: craval1 (BS8110-1997).ads]

Then: The deformations are as expected for given loads

When: We change the SLS tension curve to no-tension [Ref: craval2 (BS8110-1997).ads]
Then: The deformations are as expected for given loads

13. **Scenario:** The BS5400 load response is calculated for the rectangular section are correct for load case

    (a) **Given:** An app instance set to BS 5400



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C35	*POINT*	T20	-72,-199 72,-199
Profile	STD R 500 250			

When: We create a 500x250 C35 concrete section with 2T20 bottom bars [Ref: craval1 (BS 5400).ads]

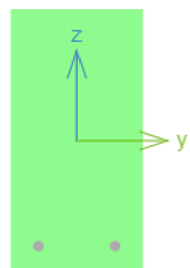
Then: The deformations are as expected for given loads

When: We create a 500x250 C35 concrete section with 2T20 bottom bars [Ref: craval1 (BS 5400).ads]

When: We change the SLS tension curve to no-tension [Ref: craval2 (BS 5400).ads]
Then: The deformations are as expected for given loads

14. **Scenario:** The HKSDM-2002 load response is calculated for the rectangular section are correct for load case

    (a) **Given:** An app instance set to HKSDM-2002



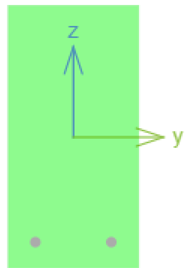
Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	C35	*POINT*	T20	-72,-199 72,-199
Profile	STD R 500 250			

When: We create a 500x250 C35 concrete section with 2T20 bottom bars [Ref: craval1 (HK SDM-2002).ads]
Then: The loads expected for given deformations

When: We create a 500x250 C35 concrete section with 2T20 bottom bars [Ref: craval1 (HK SDM-2002).ads]
When: We change the SLS tension curve to no-tension [Ref: craval2 (HK SDM-2002).ads]
Then: The loads expected for given deformations

15. **Scenario:** The IRS bridge-1997 load response is calculated for the rectangular section are correct for load case

    (a) **Given:** An app instance set to IRS bridge-1997



Definition		*Reinforcement*		
Material	Concrete	*Type*	*Description*	*Position(s)*
Grade	M35	*POINT*	"500"20	-72,-199 72,-199
Profile	STD R 500 250			

When: We create a 500x250 M35 concrete section with 2 Fe500 20 bottom bars [Ref: craval1 (IRS bridge-1997).ads]
Then: The loads expected for given deformations

When: We create a 500x250 M35 concrete section with 2 Fe500 20 bottom bars [Ref: craval1 (IRS bridge-1997).ads]
When: We change the SLS tension curve to no-tension [Ref: craval2 (IRS bridge-1997).ads]
Then: The loads expected for given deformations