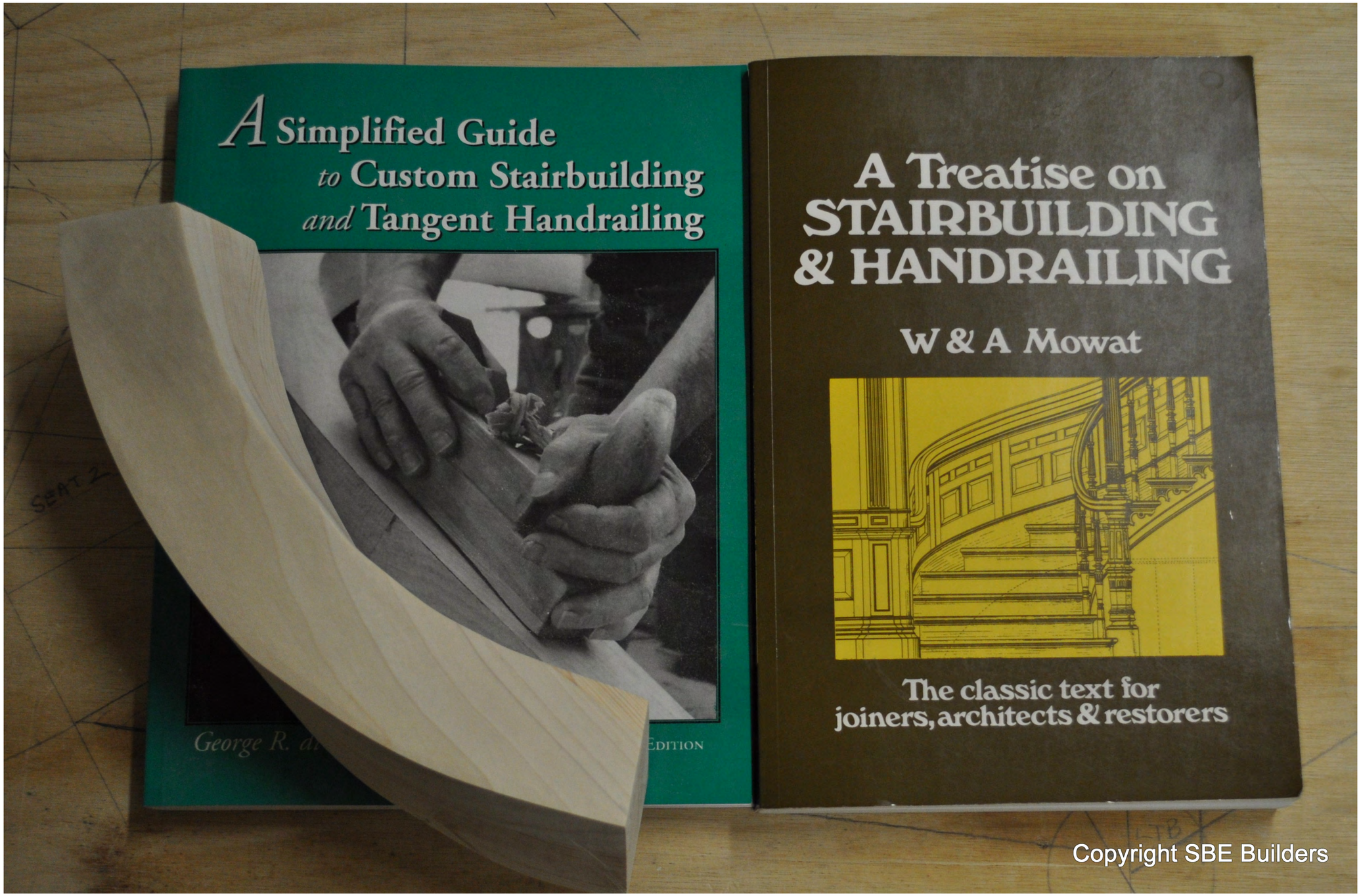


Tangent handrailing wreath developed from both books. A Treatise on StairBuilding & Handrailing is theoretically geometrical correct, but you need A Simplified Guide to Custom StairBuilding and Tangent Handrailing to understand W & A Mowat.

BOOKS PUBLISHED TREATING ON STAIR-BUILDING.

THE following as a complete list and dates, as far as ascertained, of publications in the English language that either treats partially or wholly of stair-building and hand-railing:

DATE.

1693. Moxon, "Mechanical Exercises."

1725. Halfpenny, "Art of Sound Building."

1735. Francis Price, "British Carpenter."

1738. Batty Langley, "Builder's Complete Assistant."

1750. Abraham Swan, "Architect."

1792. Peter Nicholson, "Carpenter's Guide."

1813. Peter Nicholson, New "Carpenter's Guide."

1826. M. A. Nicholson, "Carpenter, Joiner, and Builder's Companion."

1864. Joshua Jeays, "Orthogonal System of Hand-railing."

1873. Newland's "Carpenter and Joiner's Assistant."

The above are all English publications.
The following are all-or have been-published the United States :

DATE.

1844. R. G. Hatfield, "The American House-carpenter."

1845· Simon De Graff, "The Modern Geometrical Stair-builder's Gui

1849. Cupper's "Hand-railing."

1856. Robert Riddell's " Hand-railing."

1858. Perry's " Hand-railing."

1859. Esterbrook & Monckton's "American Stair-builder."

1872. Monckton's "National Stair-builder."

1873. Wm. Forbes's" The Sectorian System of Hand-railing."

1875. Gould's "Hand-railing."

1886. Frank 0. Cresswell's Hand-railing and Staircasing."

1888. Monckton's "Stair-building in its Various Forms, and One-plane Method of Drawing Face moulds and Unfolding the Centre Line of Wreaths."

1889. John V. H. Secor, "Nonpareil System of Hand-land-railing.

All drawings on this page are from
Stair Builders' Guide
By Morris Williams
1914

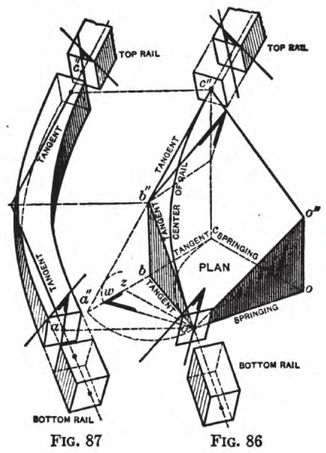


FIG. 87 FIG. 86

Books on understanding the tangent handrail system.
Treatise On Stairbuilding and Handrailing
1900
W & A Mowat

A Simplified Guide to Custom Stairbuilding and Tangent Handrailing
1994
George R. Di Christina

Stair builders' guide: a treatise on the construction of straight flight, platform, cylindrical and eliptical [!] stairs, explaining the theory and practice so the average building mechanic may understand it, with examples of work ranging from the simplest to the most complex forms
1914
Morris Williams
http://books.google.com/books?id=435OAAAAYAAJ&ots=gaoLPNPPmJ&dq=Stair%20builders'%20guide%20by%20Morris%20Williams&pg=PP1#v=onepage&q&f=false <http://books.google.com/books?id=435OAAAAYAAJ&ots=gaoLPNPPmJ&dq=Stair%20builders'%20guide%20by%20Morris%20Williams&pg=PP1>

Building age, Volume 40
Morris Williams
http://books.google.com/books?id=_ko_AAAAYAAJ&lpg=RA6-PA526&ots=vxAtasg85K&dq=peter%20nicholson%20tangent%20handrailing&pg=RA6-PA526#v=onepage&q=peter%20nicholson%20tangent%20handrailing&f=false <http://books.google.com/books?id=_ko_AAAAYAAJ&lpg=RA6-PA526&ots=vxAtasg85K&dq=peter%20nicholson%20tangent%20handrailing&pg=RA6-PA526>

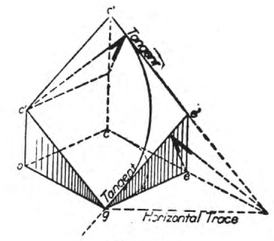


FIG. 89

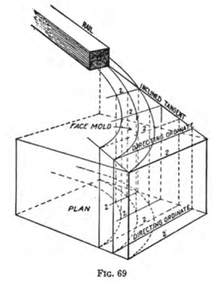


FIG. 69

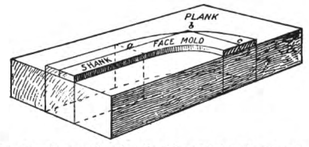
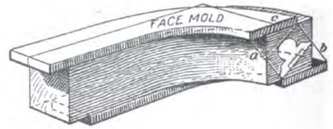


FIG. 75.—How to Cut Out the Material for the Wreath From the Plank.



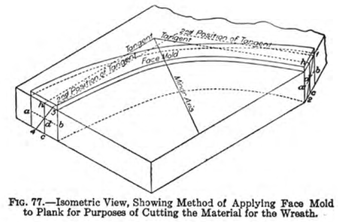
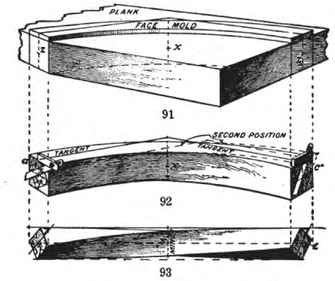


FIG. 77.—Isometric View, Showing Method of Applying Face Mold to Plank for Purposes of Cutting the Material for the Wreath.

FIG. 78.—Diagram Illustrating Method of Applying Face Mold to Trace the Outlines of the Wreath Preparatory to Squaring its Verticle Sides.



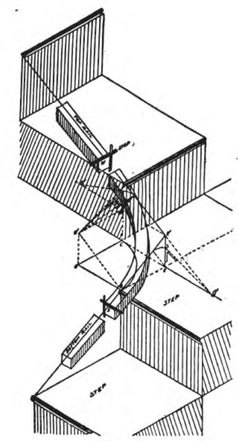


FIG. 90

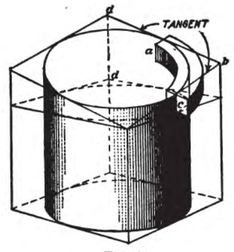
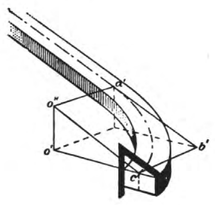
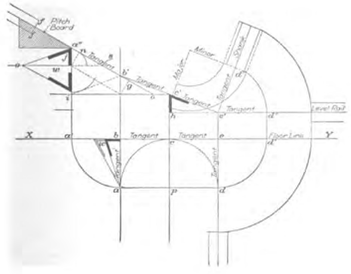
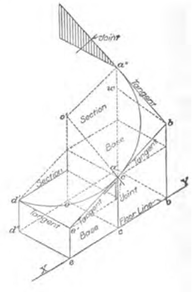


FIG. 48







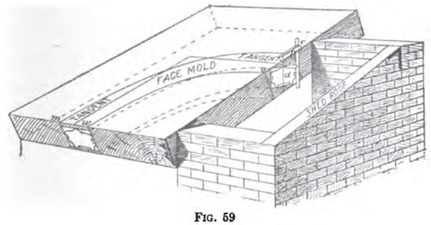
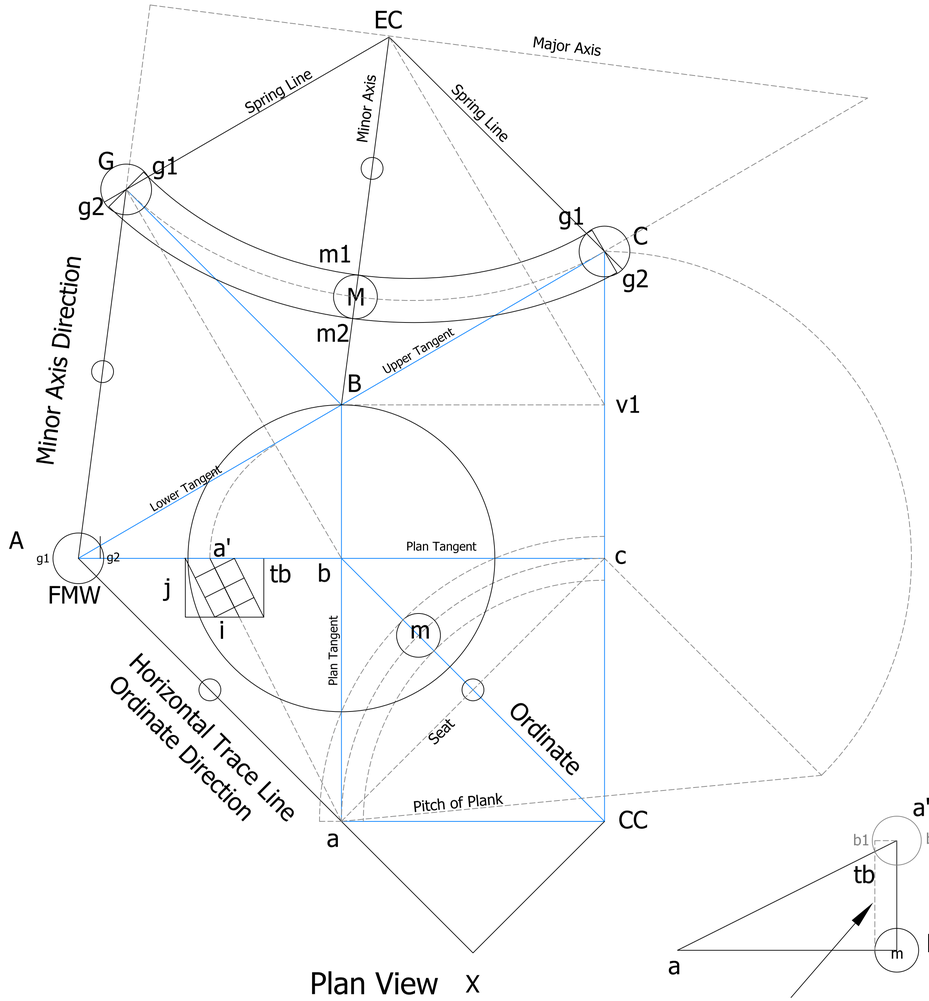


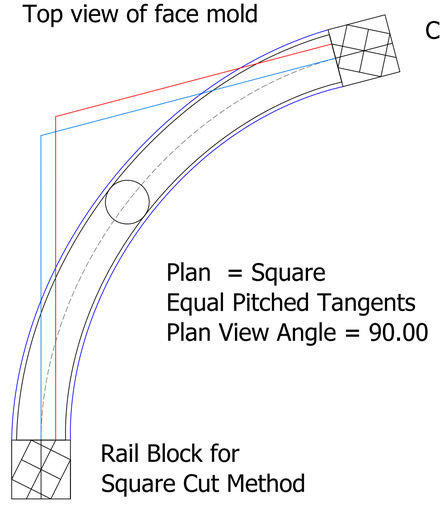
FIG. 59

Plate 1

Quarter-Circle Plan with Equally Pitched Tangents



Top view of face mold

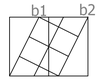


Plan = Square
Equal Pitched Tangents
Plan View Angle = 90.00

Rail Block for
Square Cut Method

Tangents in Orginal Position

Tangents shifted into Second Position



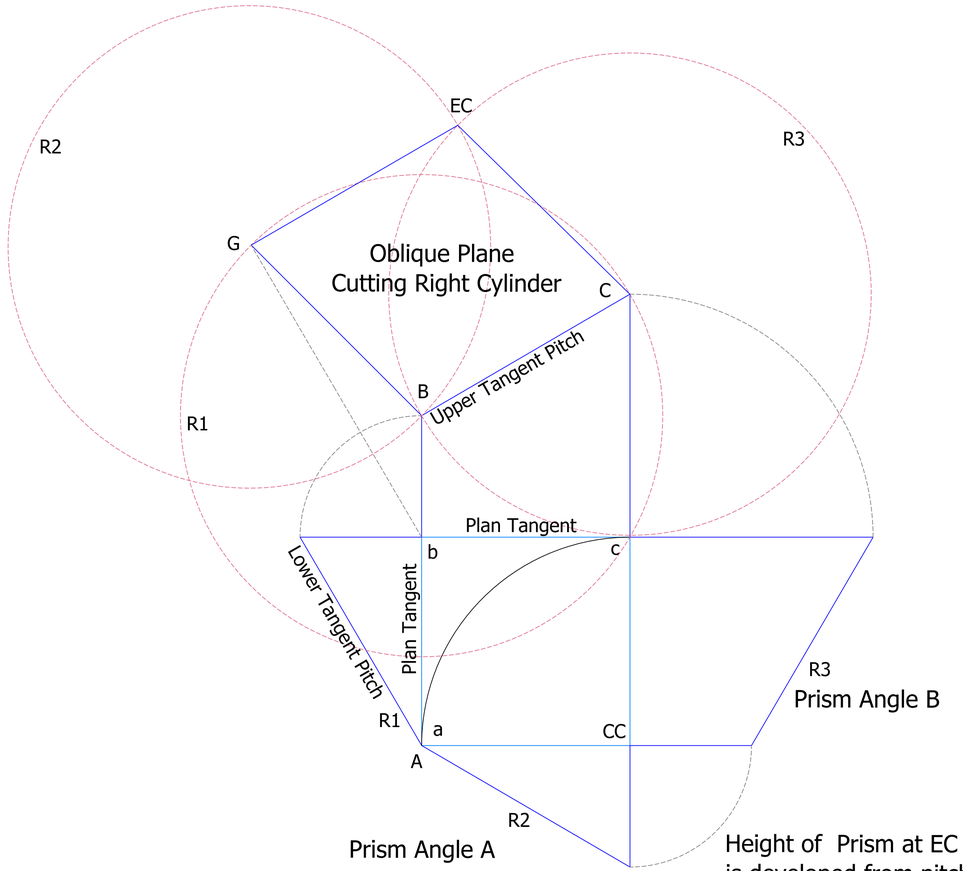
Rail Block for
Oblique Cut Method

Rail Block for
Square Cut Method

Plate 1.1

Quarter-Circle Plan with Equally Pitched Tangents

Net of Prism



Height of Prism at EC Spring Lines is developed from pitch of plank

Isometric View of Prism

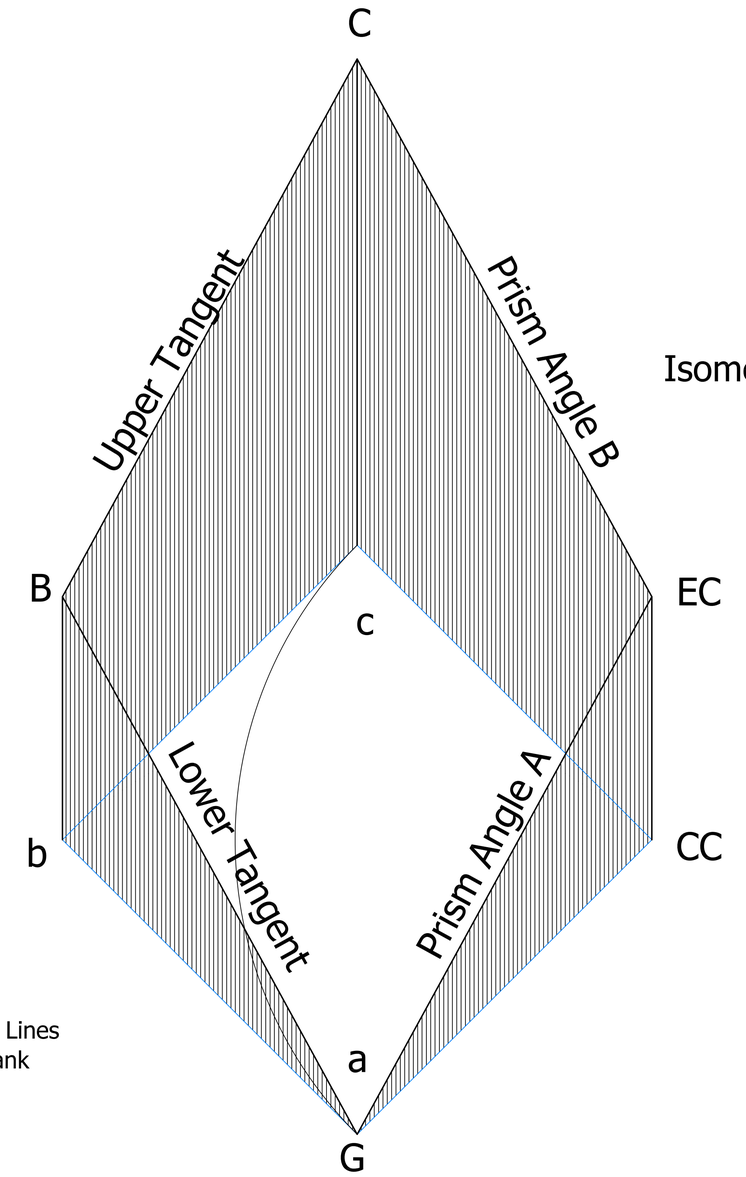
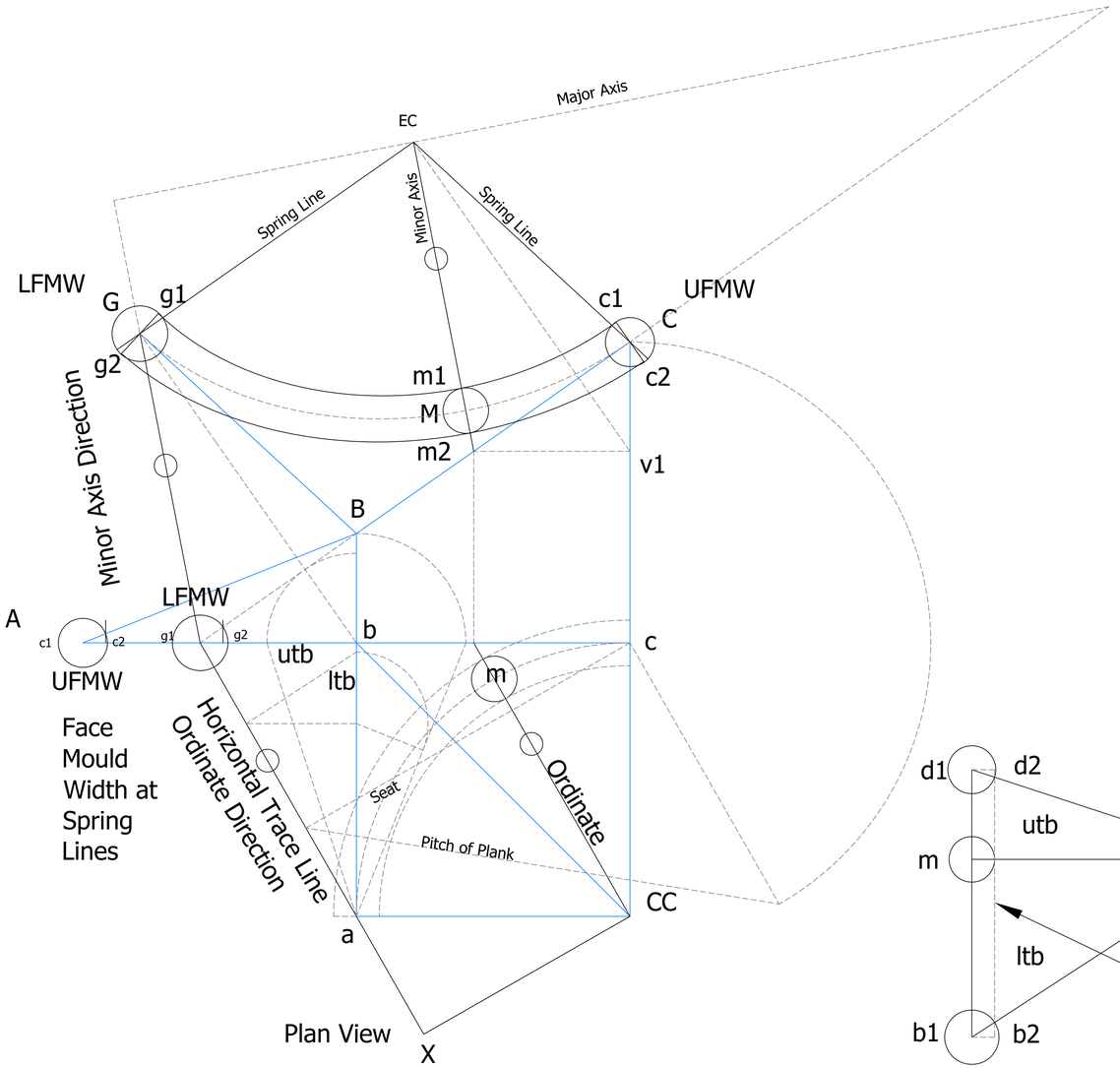
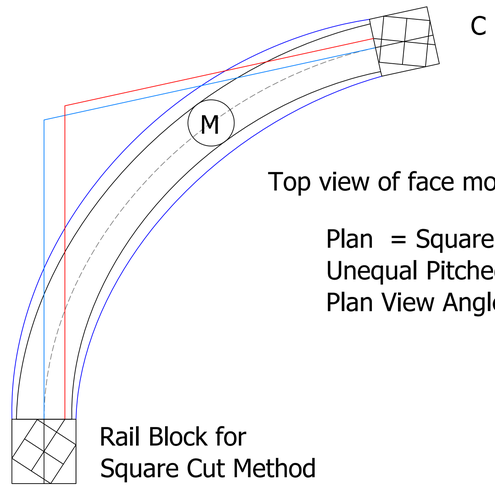


Plate 2

Quarter-Circle Plan with Short Lower Pitched Tangent





Top view of face mold

Plan = Square
Unequal Pitched Tangents
Plan View Angle = 90.00

Tangents in Orginal Position

Tangents shifted into Second Position

Rail Block for
Oblique Cut Method

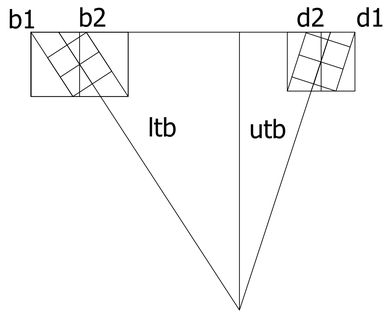
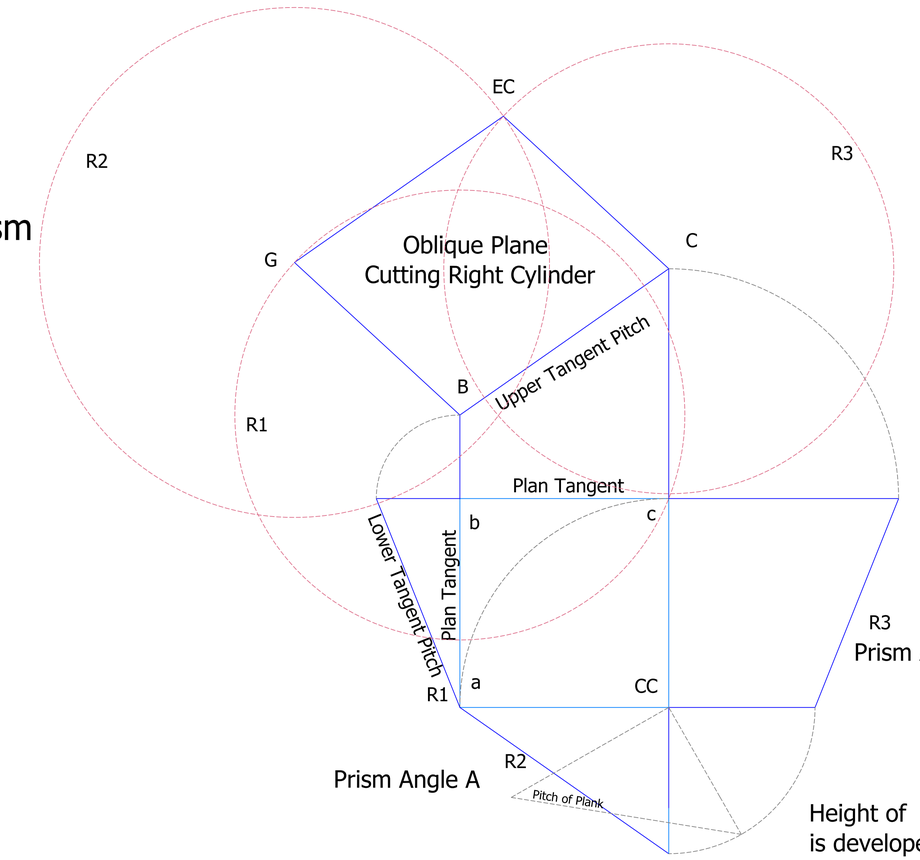


Plate 2.1

Quarter-Circle Plan with Short Lower Pitched Tangent

Net of Prism



Height of Prism at EC Spring Lines is developed from pitch of plank

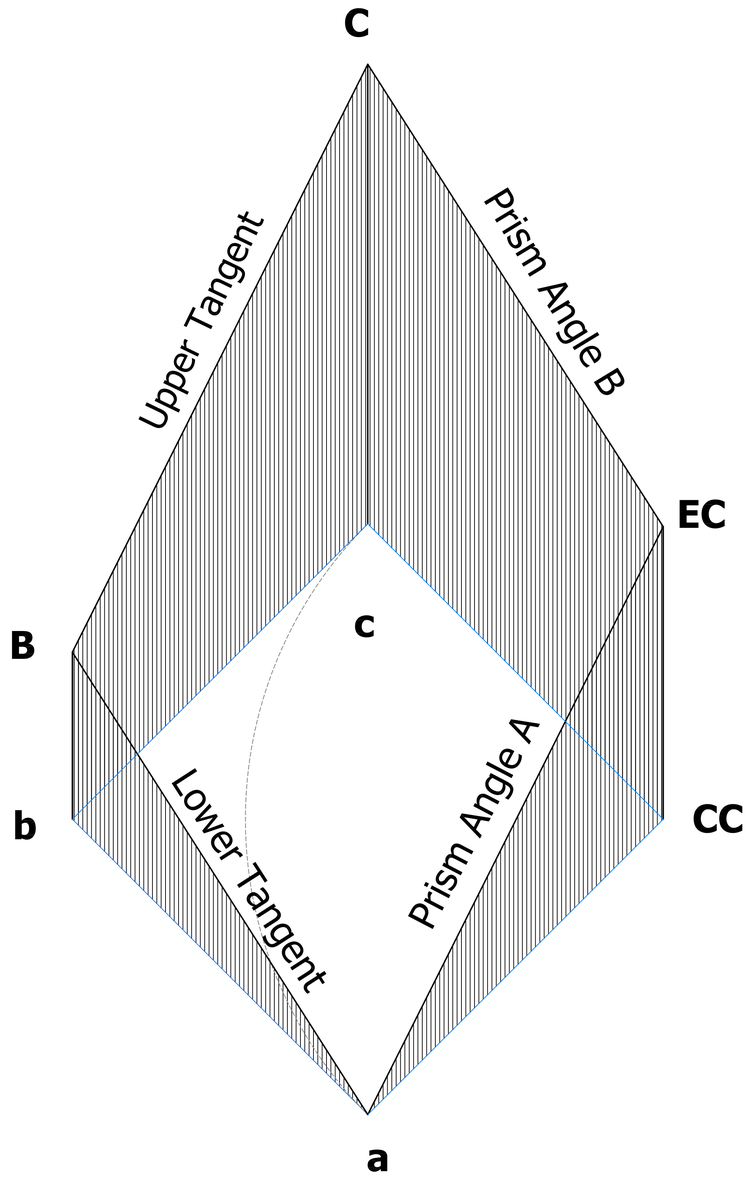
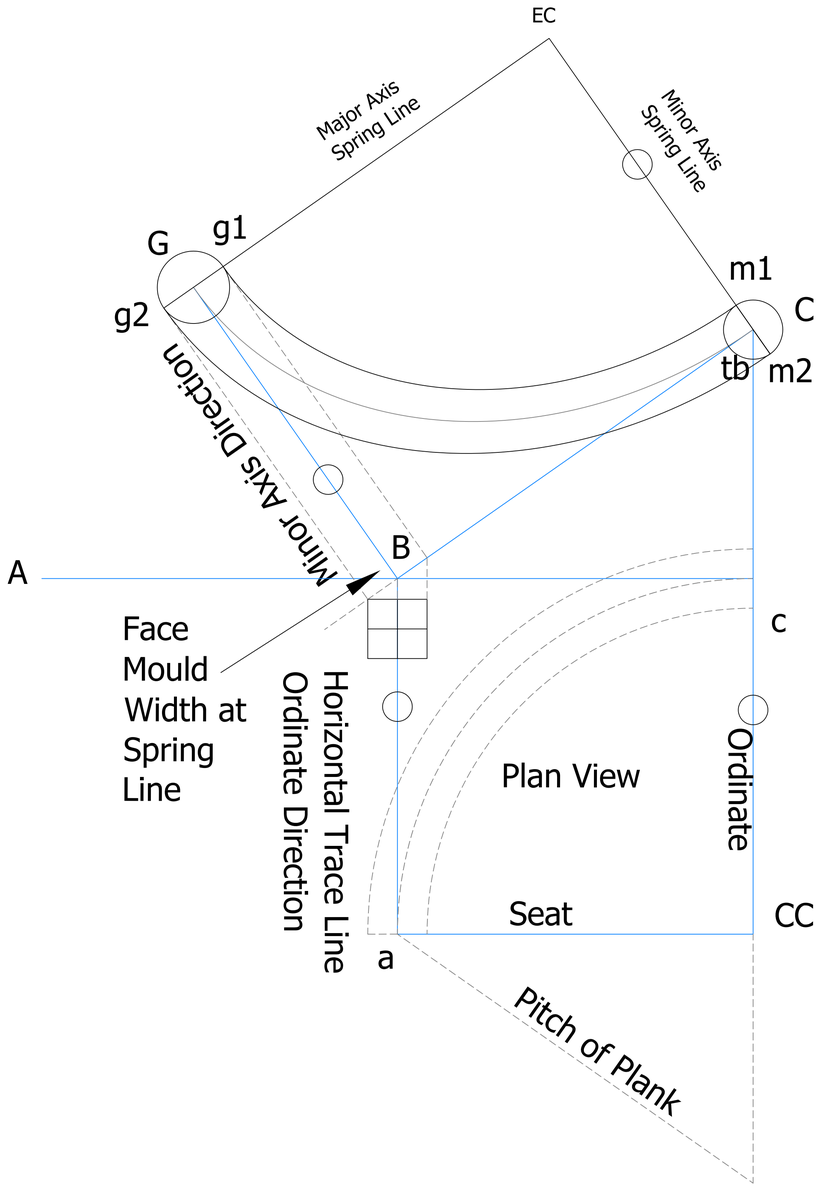
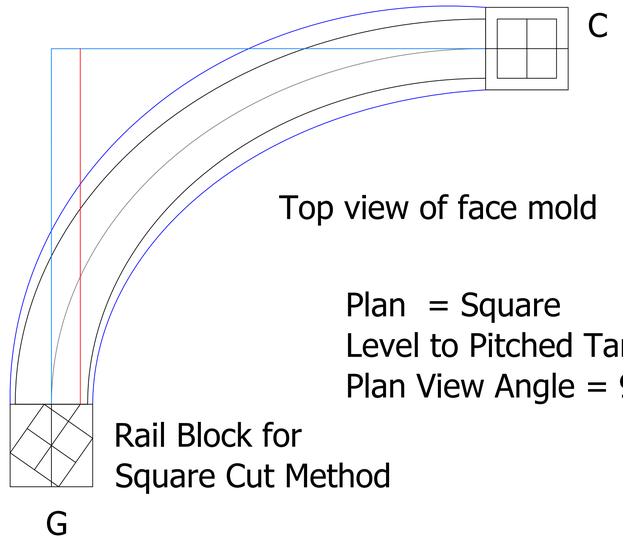


Plate 3

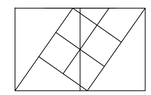
Quarter-Circle Plan The Upper Tangent is Pitched, the Lower Tangent is Level





Tangents in Orginal Position

Tangents shifted into Second Position

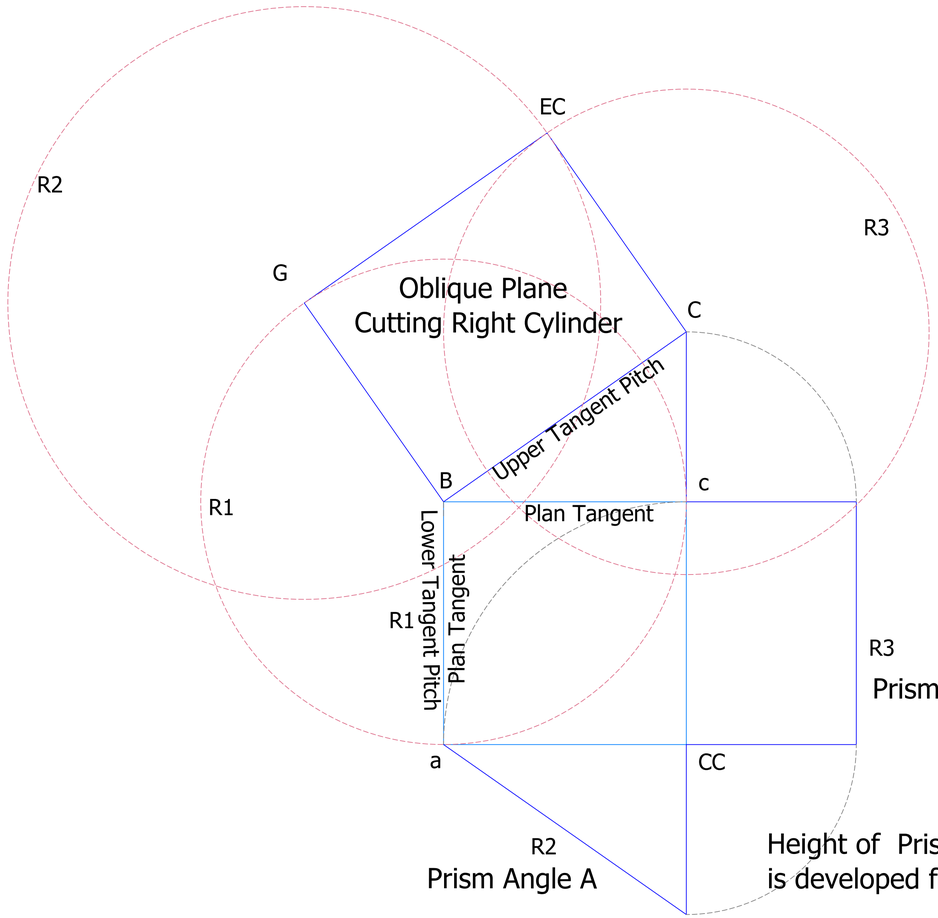


Rail Block for
Oblique Cut Method

Plate 3.1

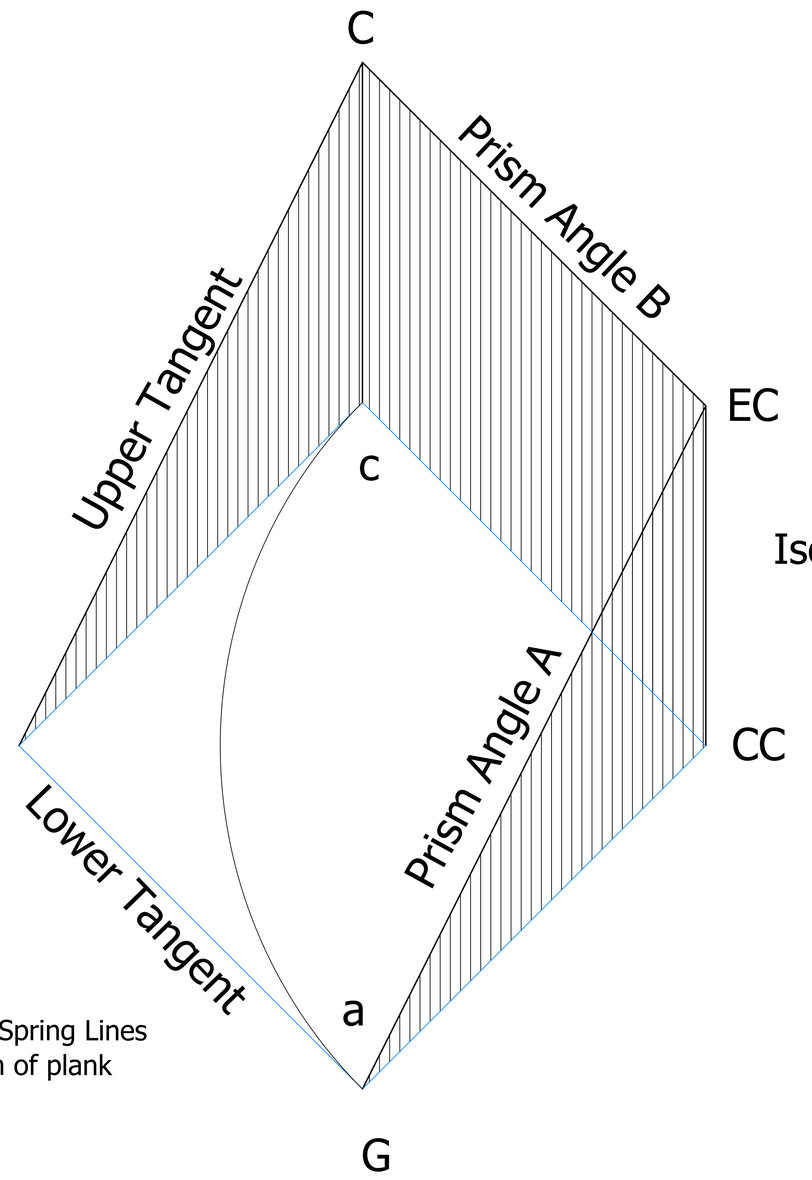
Quarter-Circle Plan The Upper Tangent is Pitched, the Lower Tangent is Level

Net of Prism



Height of Prism at EC Spring Lines is developed from pitch of plank

Isometric View of Prism



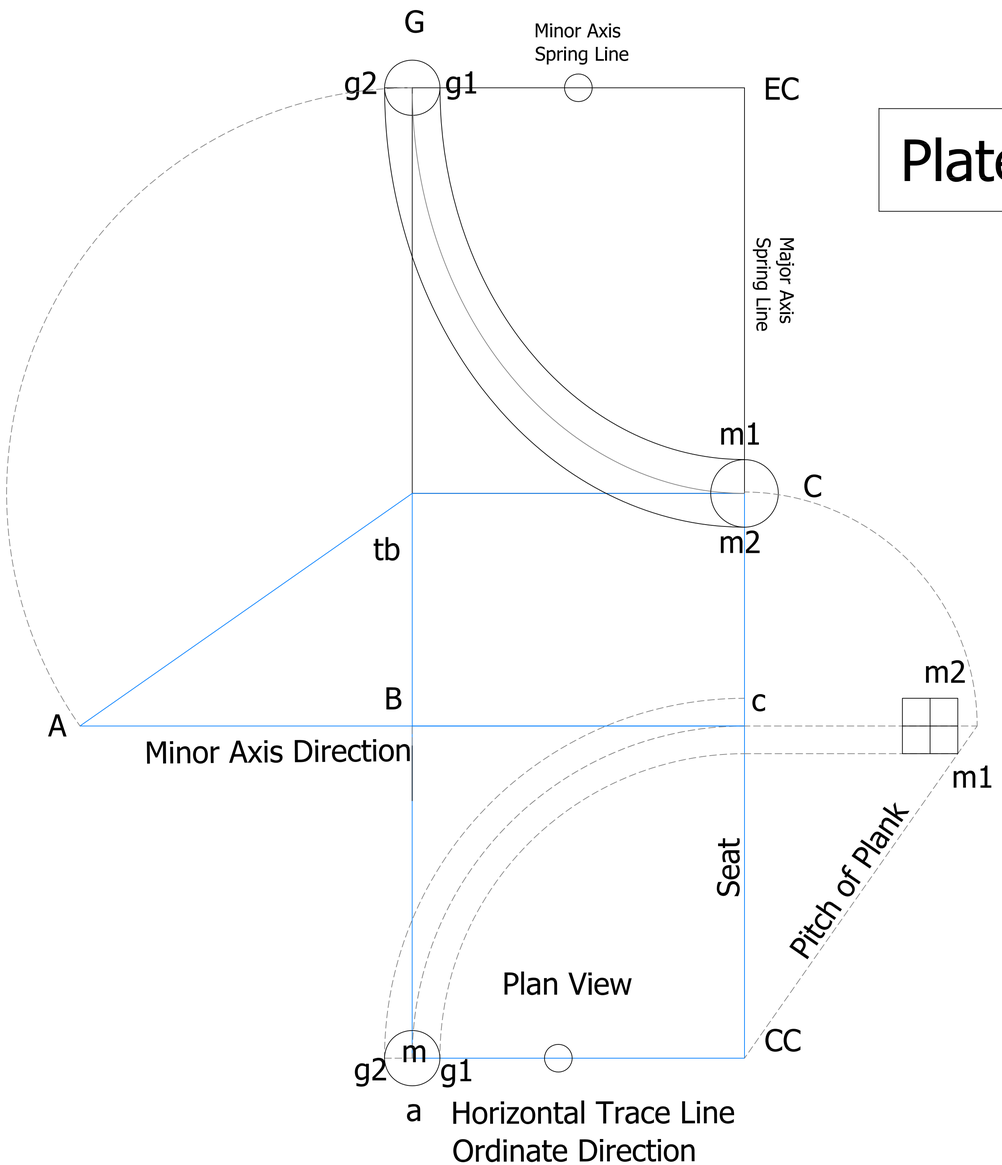
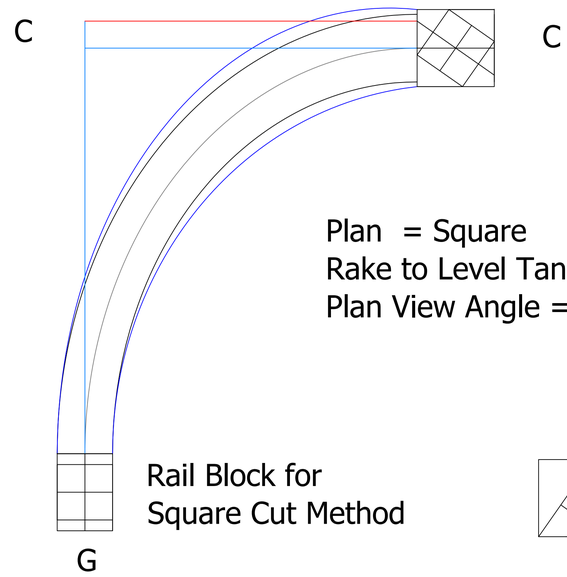


Plate 4

Quarter-Circle Plan The Upper Tangent is Level, the Lower Tangent is Pitched



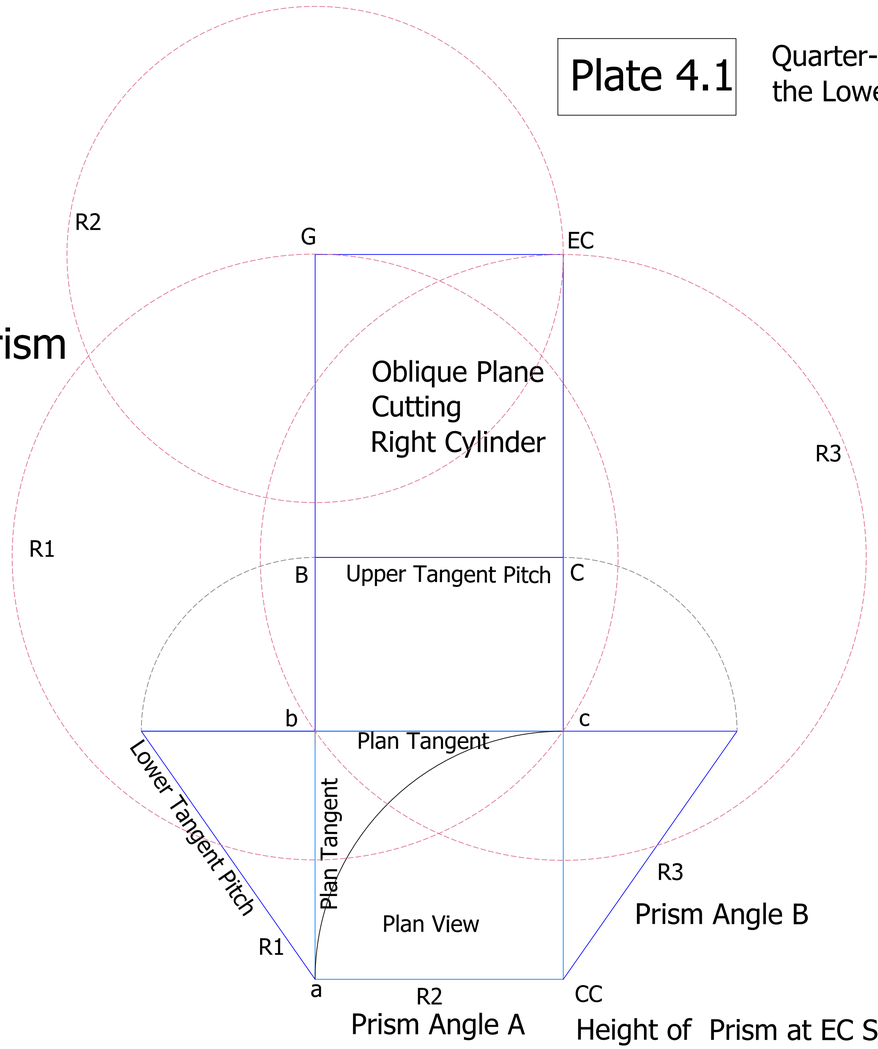
Tangents in Orginal Position

Tangents shifted into Second Position

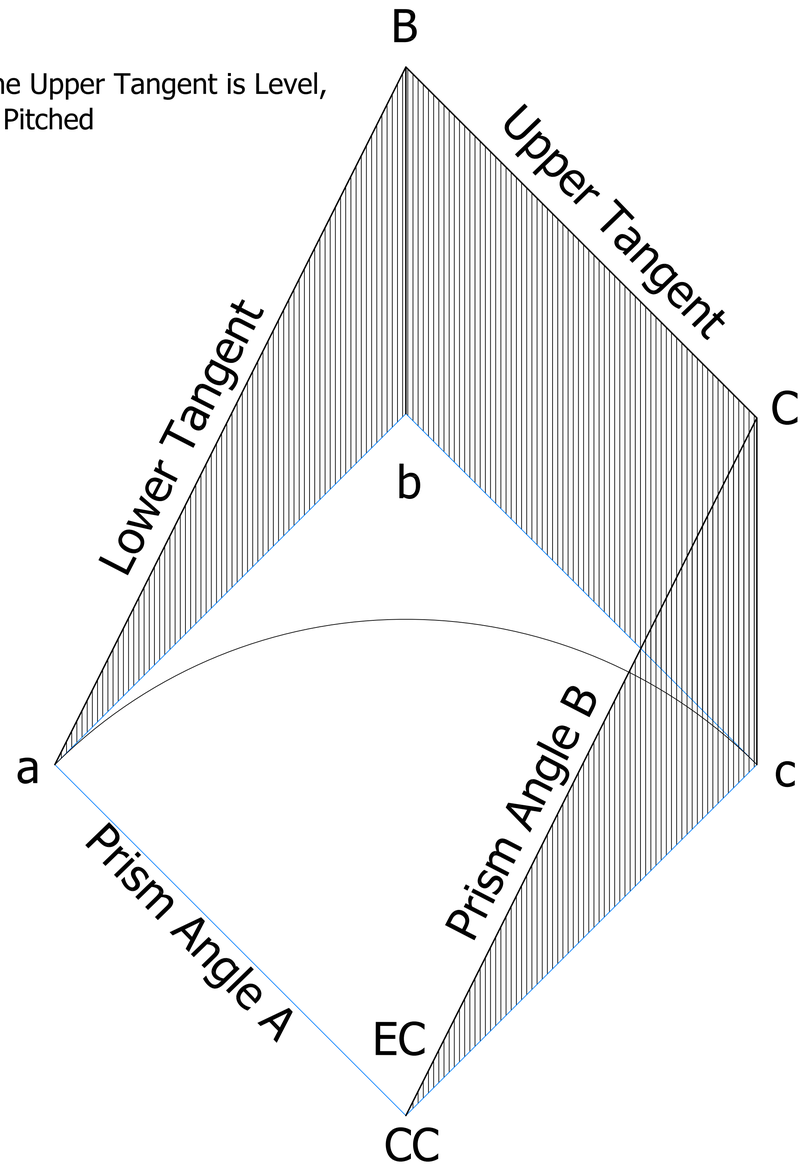
Plate 4.1

Quarter-Circle Plan The Upper Tangent is Level, the Lower Tangent is Pitched

Net of Prism

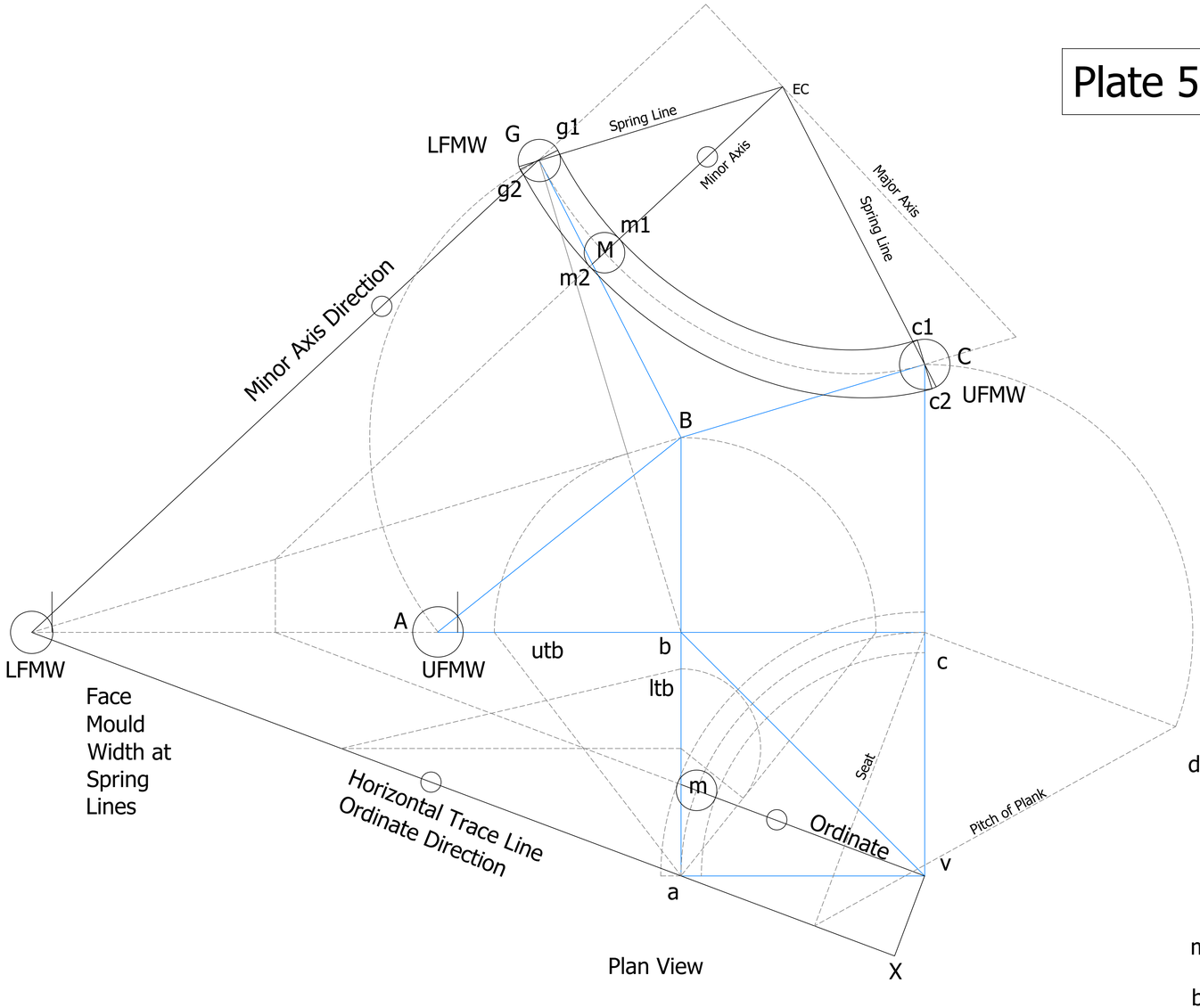


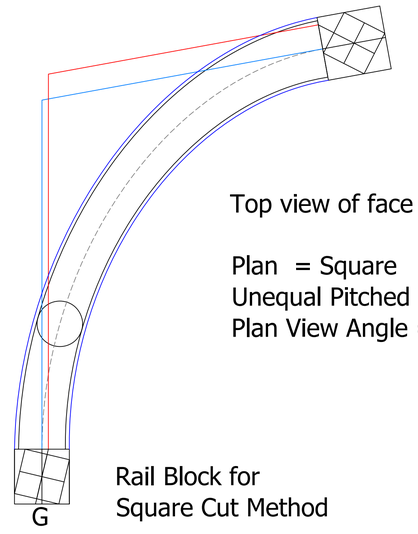
Height of Prism at EC Spring Lines is developed from pitch of plank



Isometric View of Prism

Plate 5 Quarter-Circle Plan with Short Upper Pitched Tangent





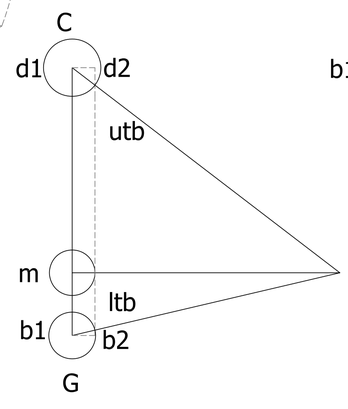
Top view of face mold

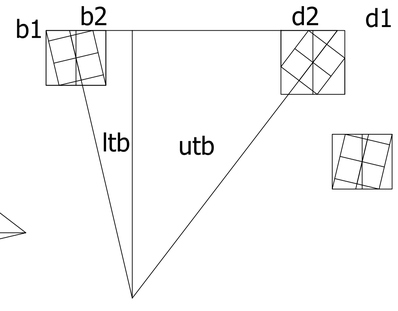
Plan = Square
Unequal Pitched Tangents
Plan View Angle = 90.00

Rail Block for
Square Cut Method

Tangents in Orginal Position

Tangents shifted into Second Position



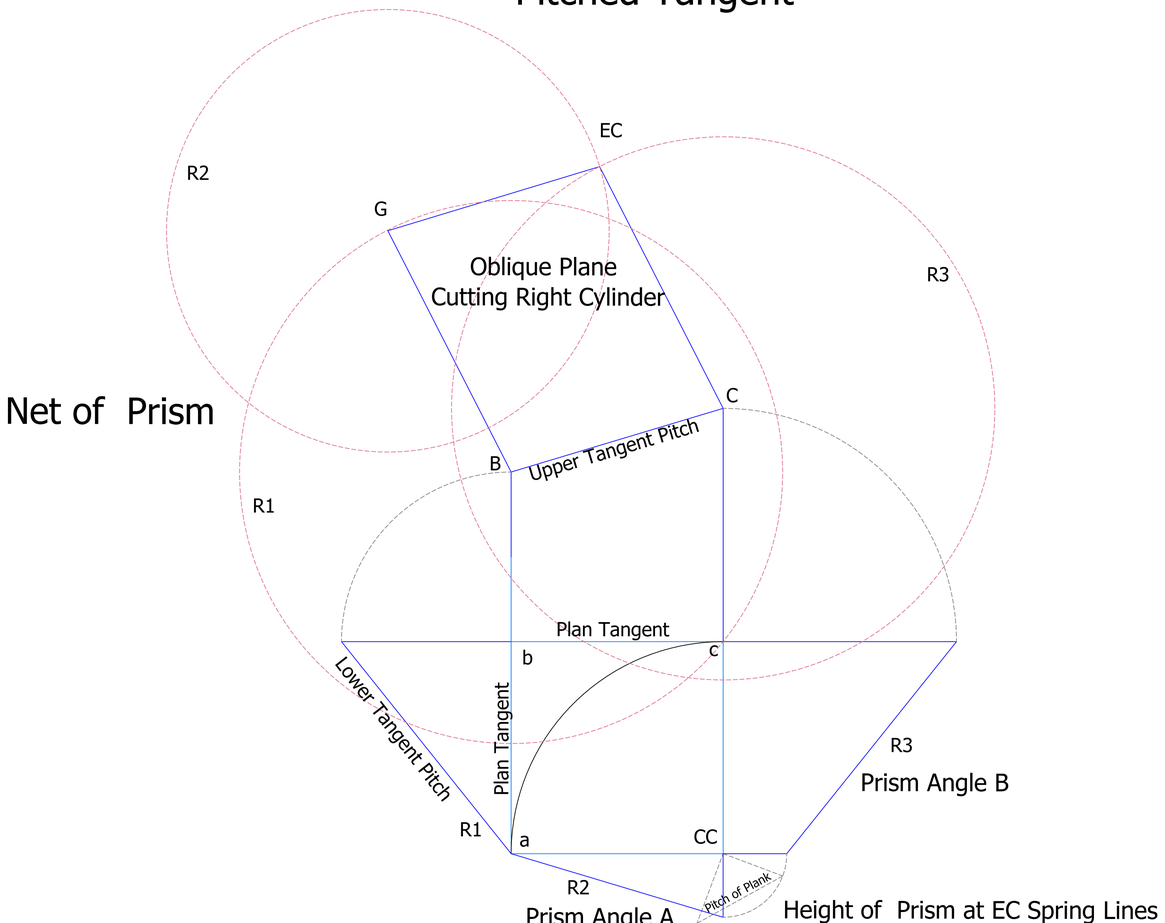


Rail Block for
Oblique Cut Method

Plate 5.1

Quarter-Circle Plan with Short Upper Pitched Tangent

Net of Prism



Height of Prism at EC Spring Lines is developed from pitch of plank

Isometric View of Prism

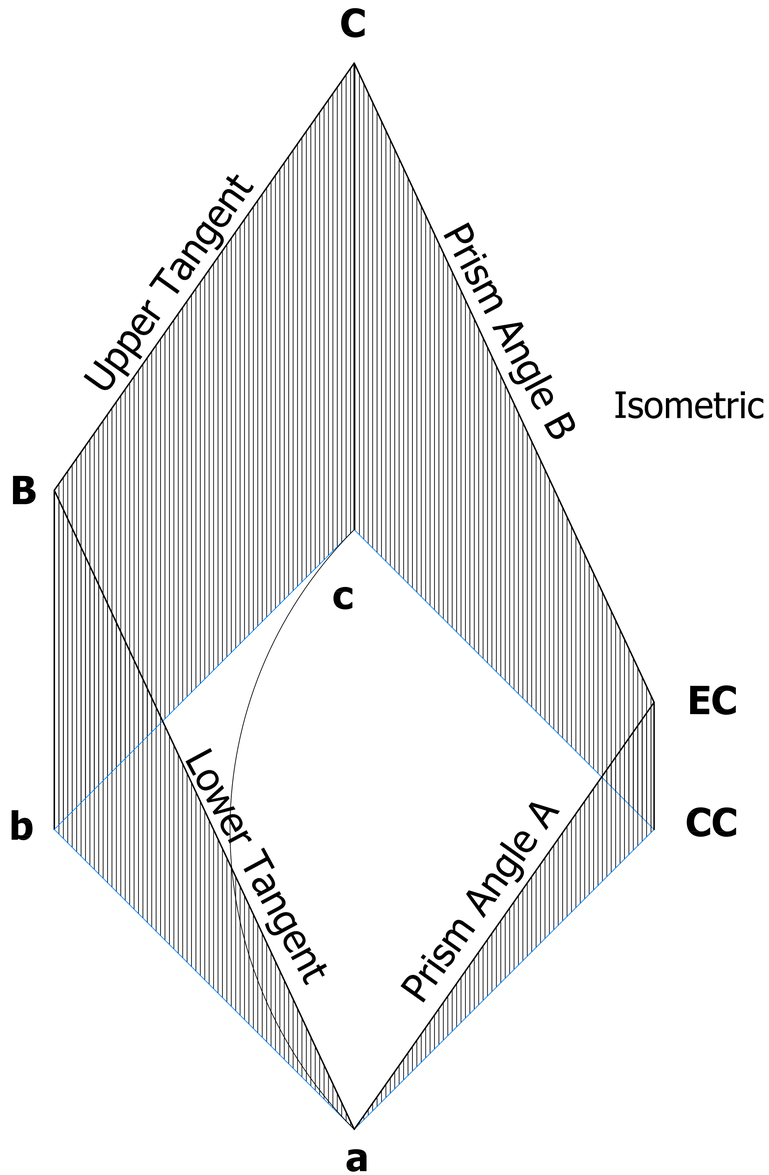
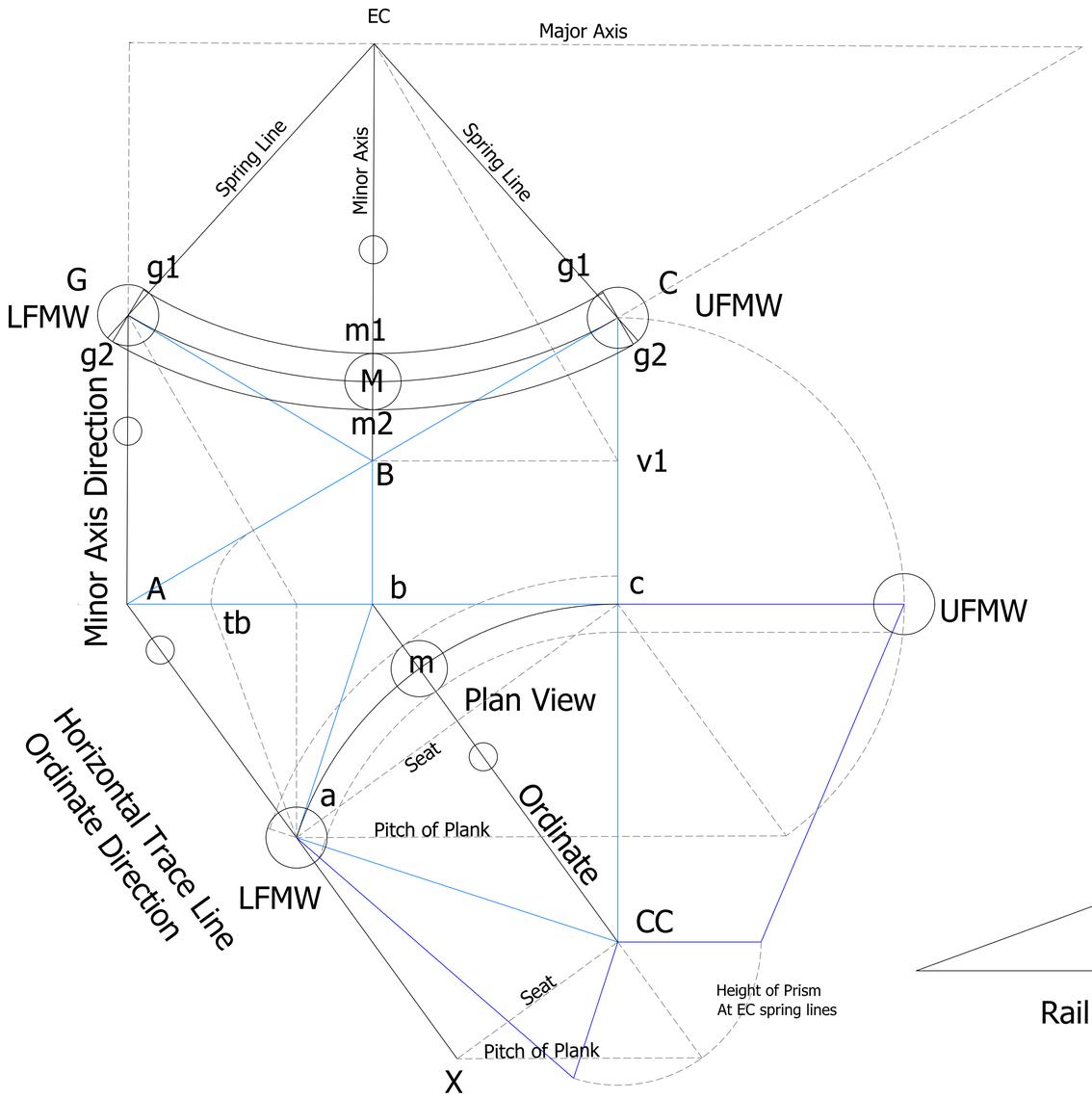
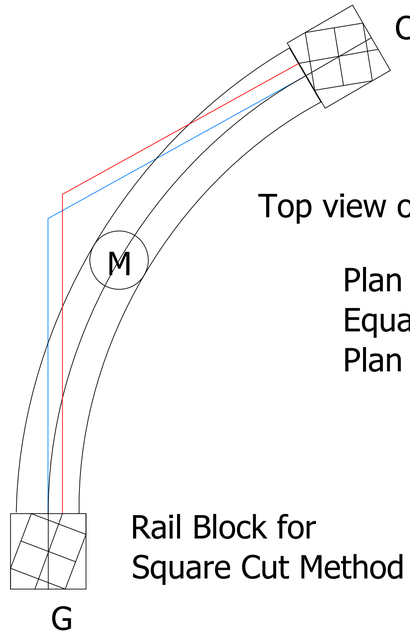


Plate 6

Obtuse Plan with Equally Pitched Tangents





Top view of face mold

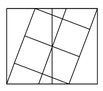
Plan = Obtuse
Equal Pitched Tangents
Plan View Angle = 108.00

Rail Block for
Square Cut Method

Rail
Block
Width

Tangents in Orginal Position

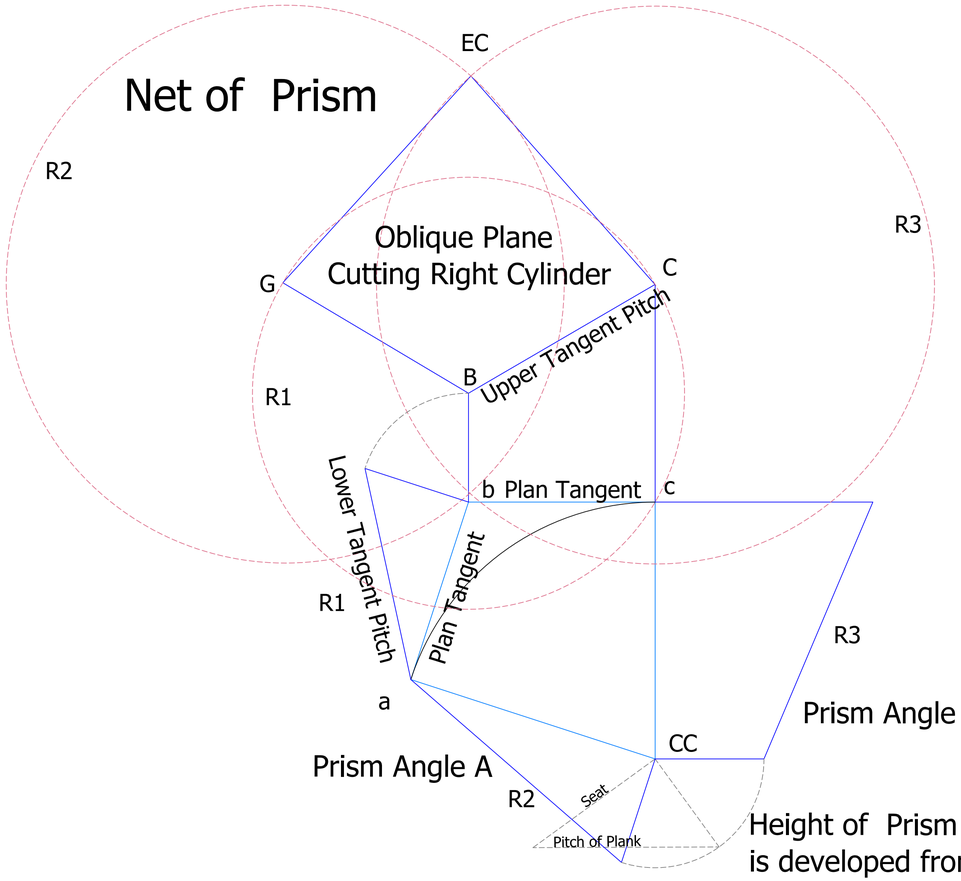
Tangents shifted into Second Position



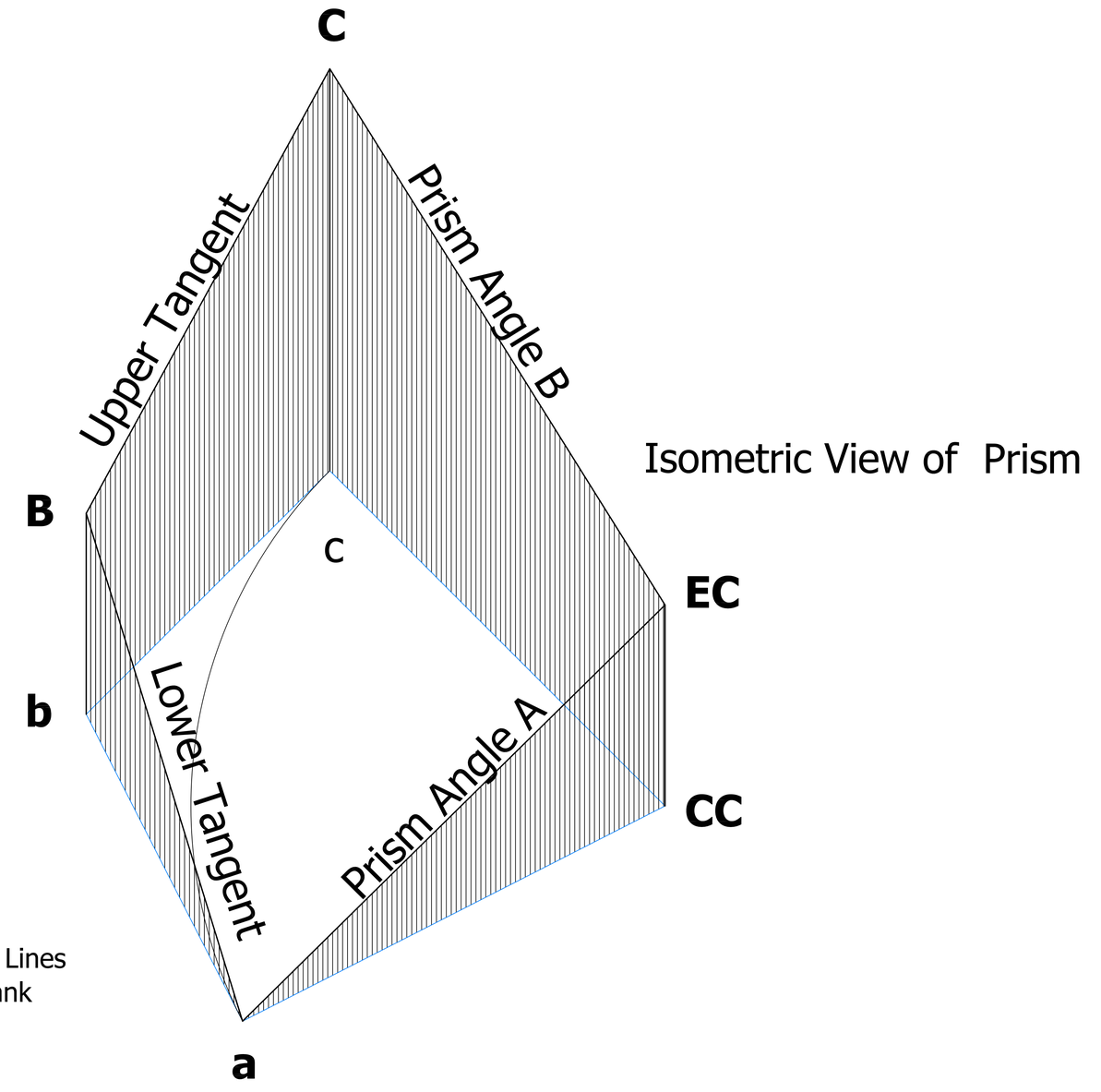
Rail Block for
Oblique Cut Method

Plate 6.1

Obtuse Plan with Equally Pitched Tangents
Locating ellipse center point and drawing
the oblique plane



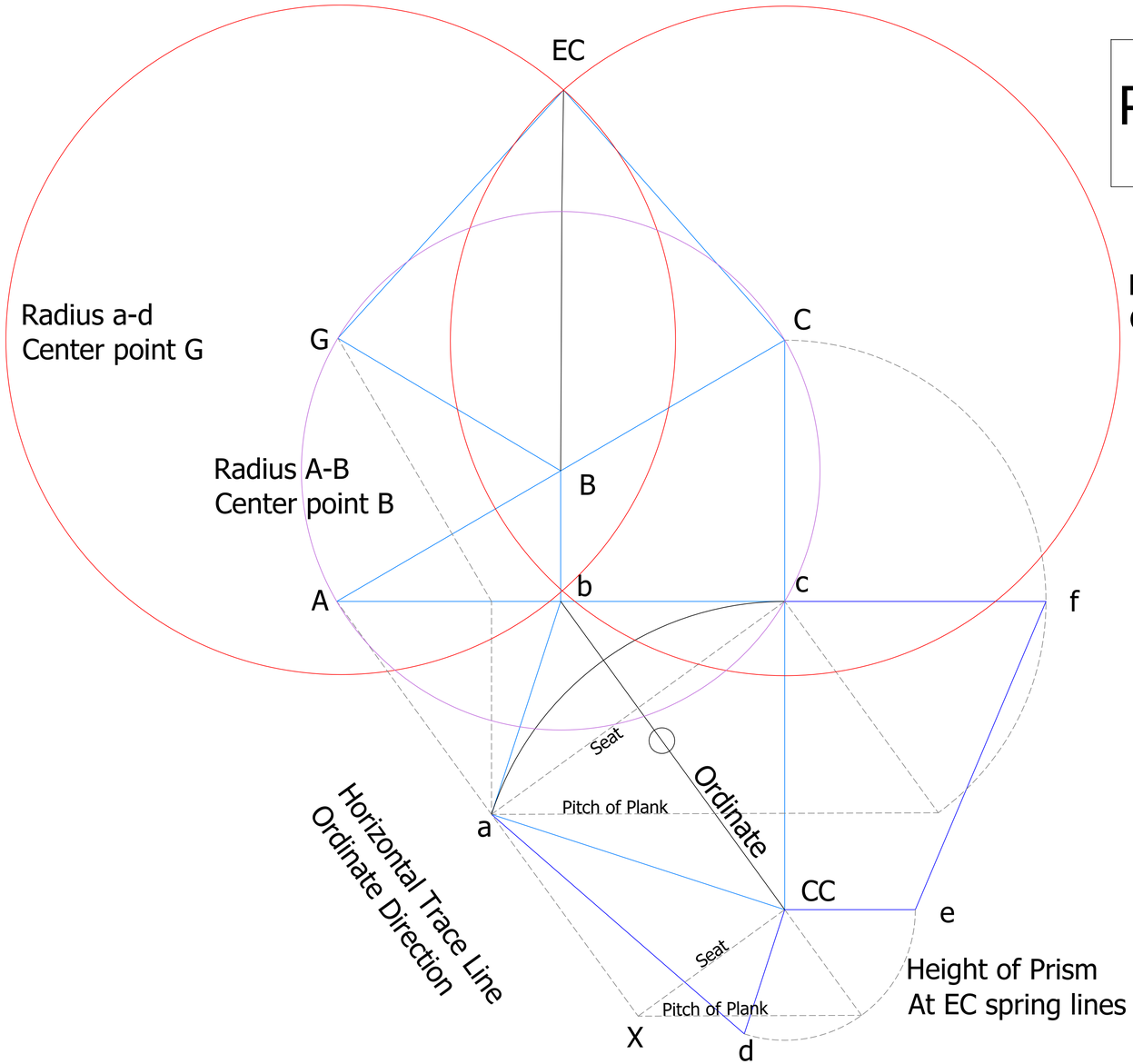
Height of Prism at EC Spring Lines
is developed from pitch of plank



Isometric View of Prism

Plate 6.1

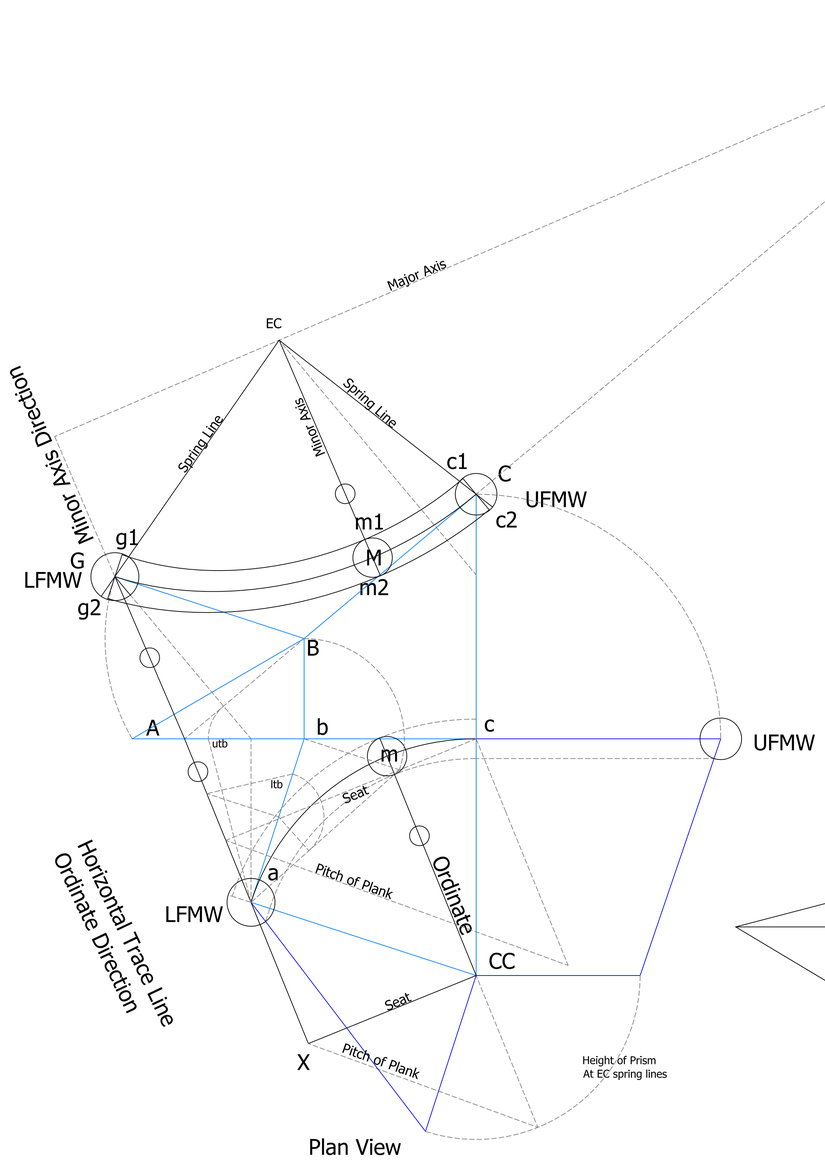
Obtuse Plan with Equally Pitched Tangents
Locating ellipse center point and drawing the oblique plane



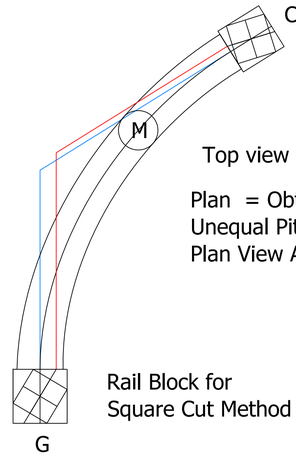
Plan = Obtuse
Equal Pitched Tangents
Plan View Angle = 108.00

Plate 7

Obtuse Plan with Short Lower Pitched Tangent



Plan View



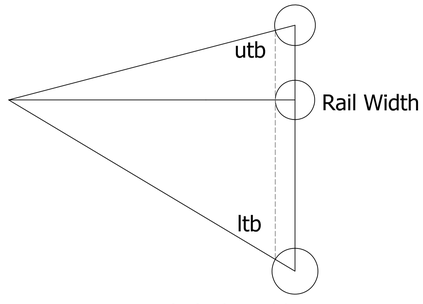
Top view of face mold

Plan = Obtuse
Unequal Pitched Tangents
Plan View Angle = 108.00

Rail Block for
Square Cut Method

Rail Block for
Oblique Cut Method

Rail Block Width at Upper Twist Bevel



Rail Block Width at Lower Twist Bevel

Tangents in Orginal Position

Tangents shifted into Second Position

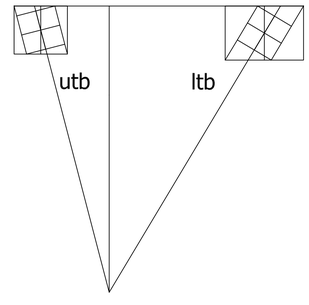
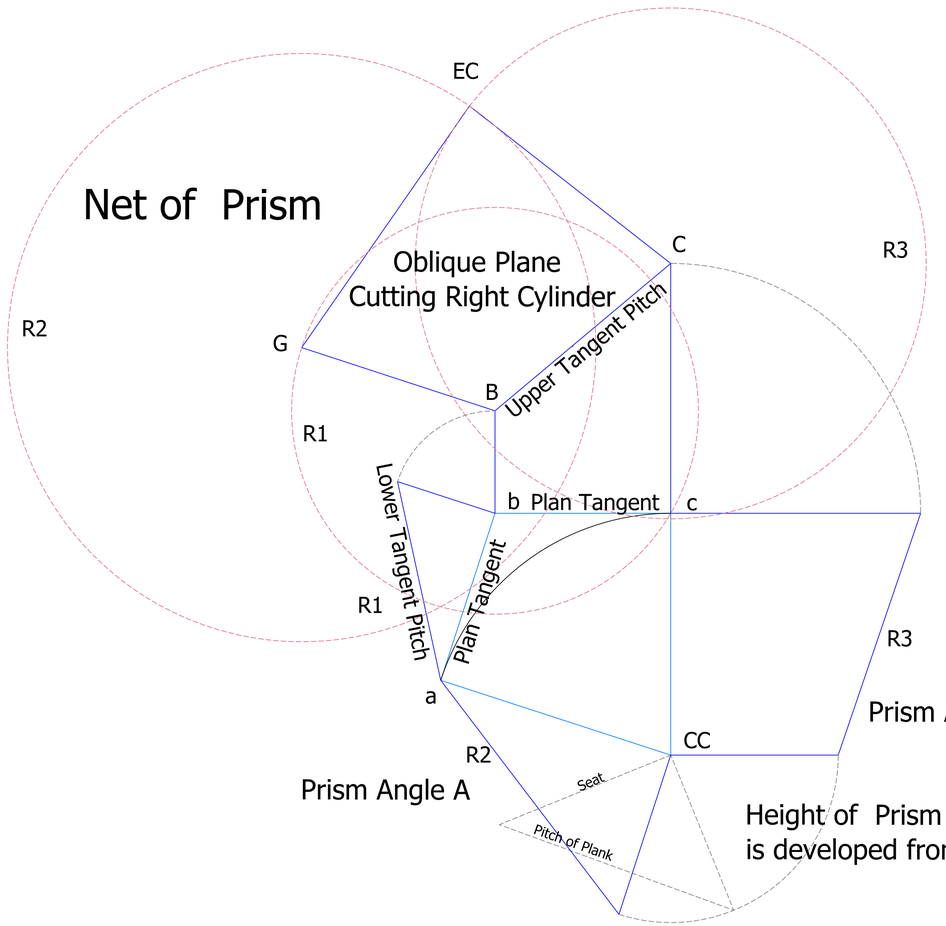
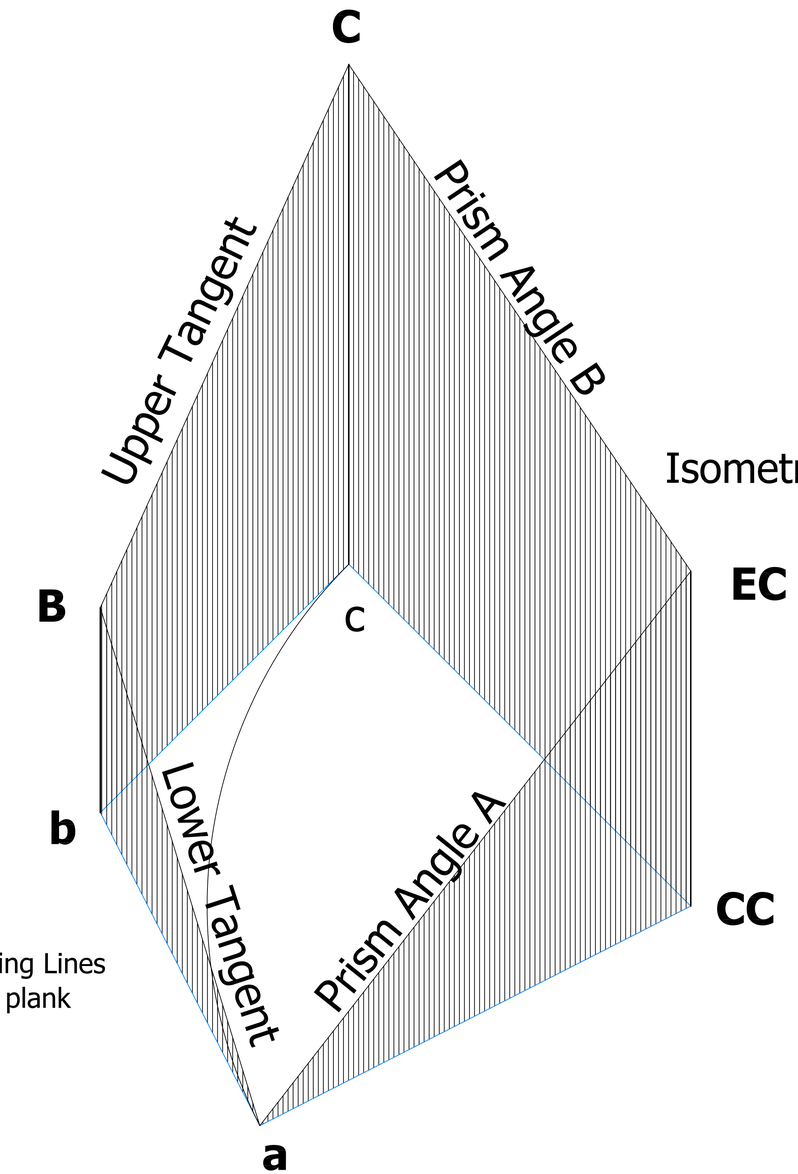


Plate 7.1

Obtuse Plan with Short Lower Pitched Tangent
Locating ellipse center point and drawing
the oblique plane



Height of Prism at EC Spring Lines
is developed from pitch of plank



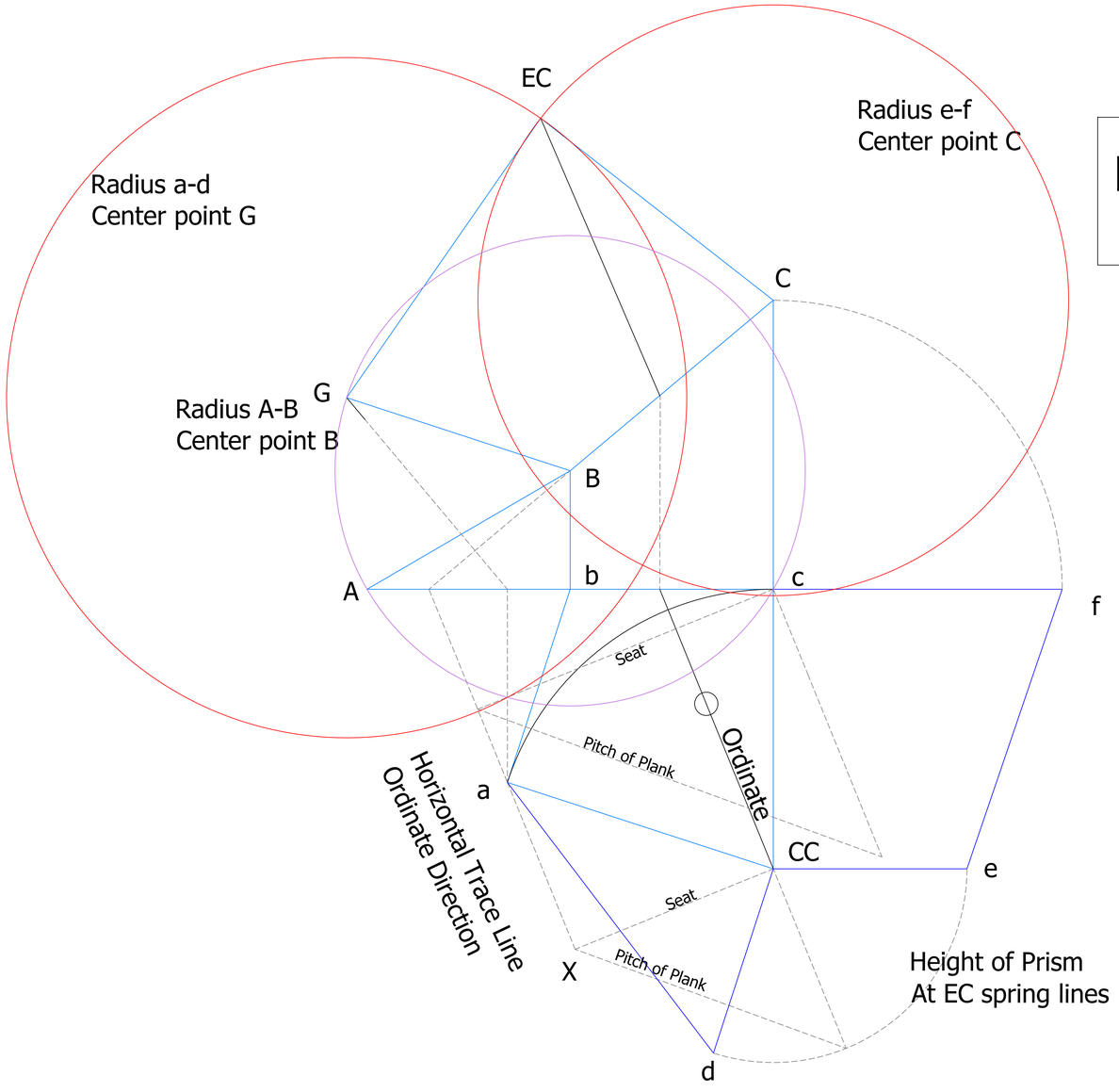


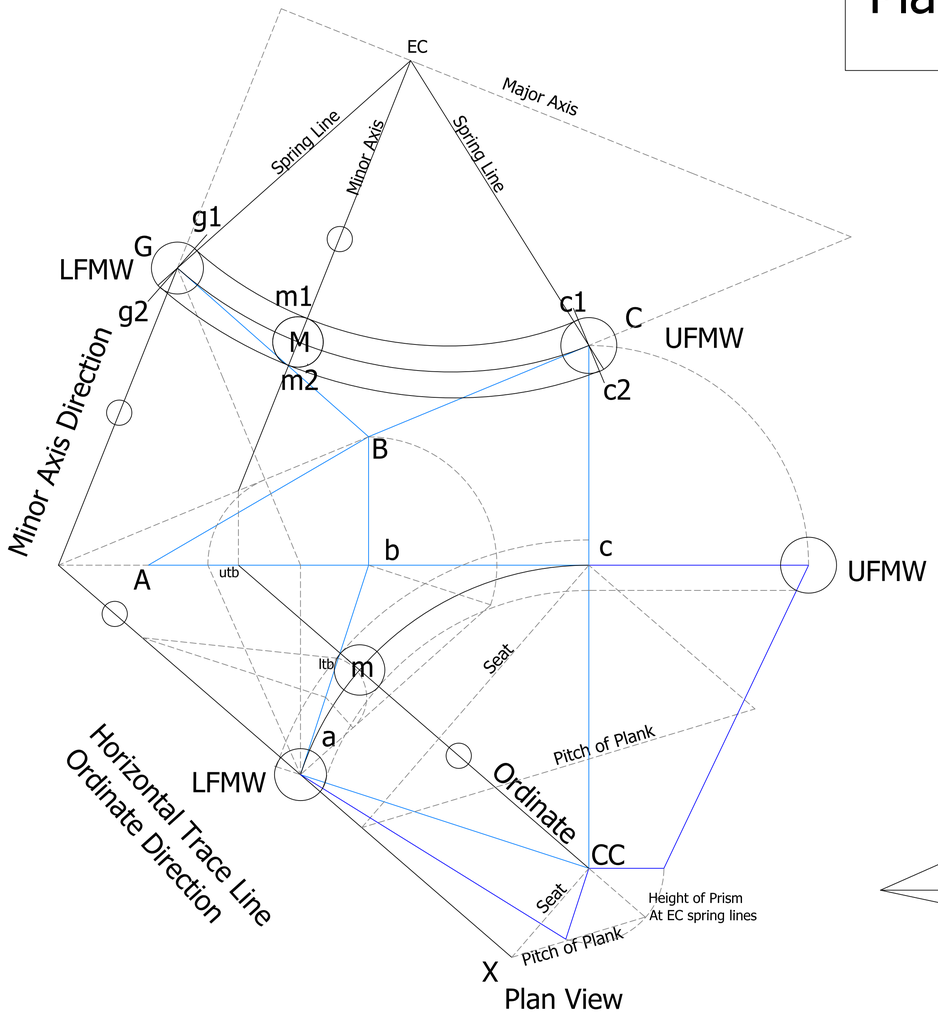
Plate 7.1

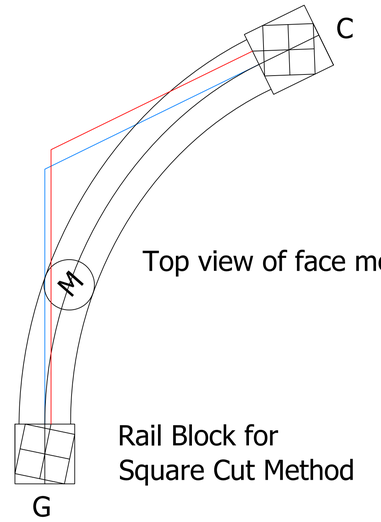
Obtuse Plan with Short Lower Pitched Tangent
Locating ellipse center point and drawing
the oblique plane

Plan = Obtuse
Unequal Pitched Tangents
Plan View Angle = 108.00

Plate 8

Obtuse Plan with Short Upper Pitched Tangent

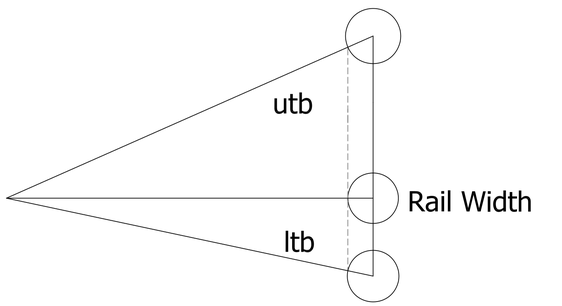




Top view of face mold

Rail Block for
Square Cut Method

Rail Block Width at Upper Twist Bevel



Rail Block Width at Lower Twist Bevel

Plan = Obtuse
Unequal Pitched Tangents
Plan View Angle = 108.00

Tangents in Orginal Position

Tangents shifted into Second Position

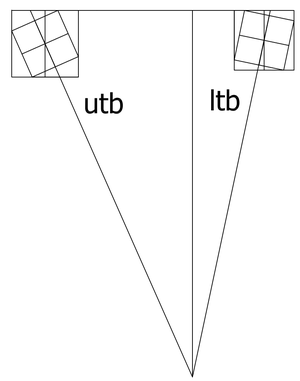
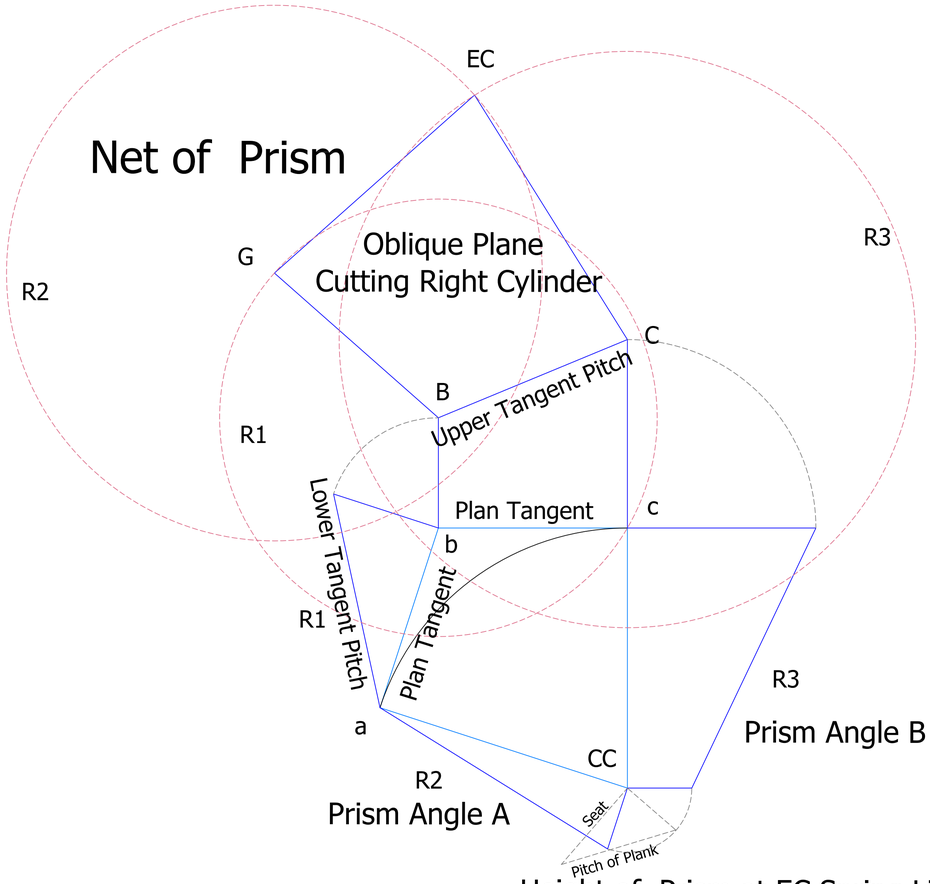
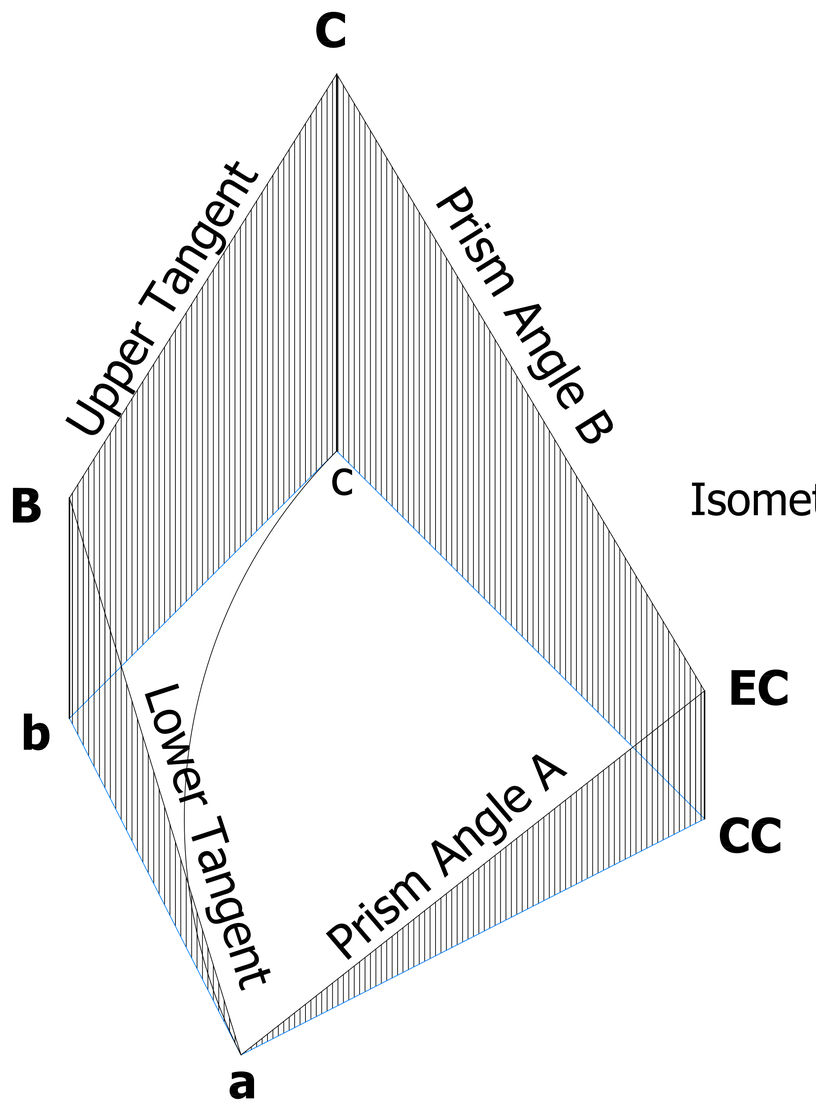


Plate 8.1

Obtuse Plan with Short Upper Pitched Tangent



Height of Prism at EC Spring Lines is developed from pitch of plank

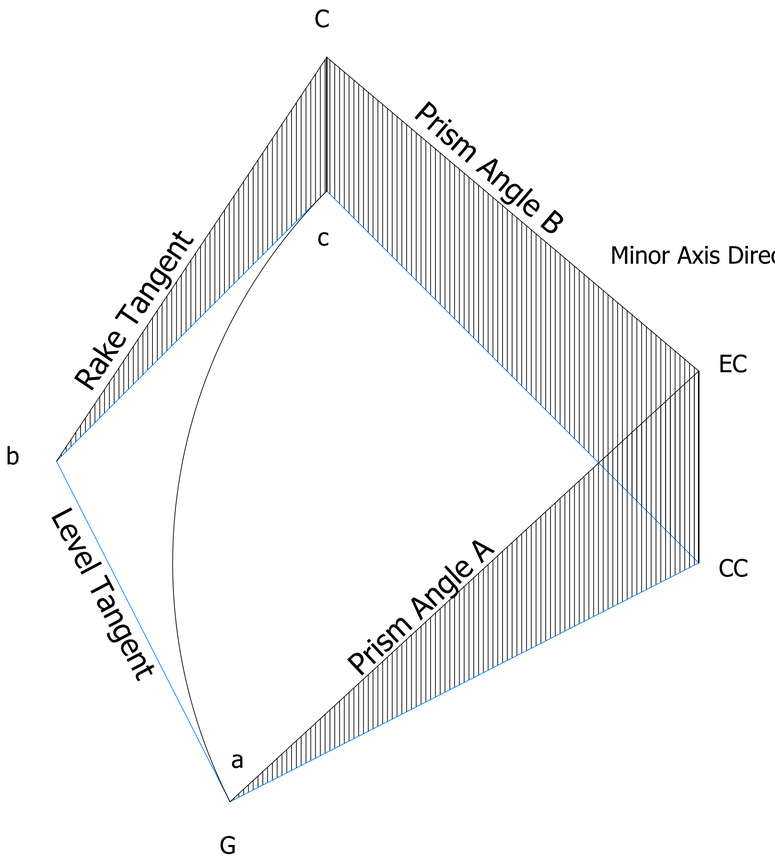


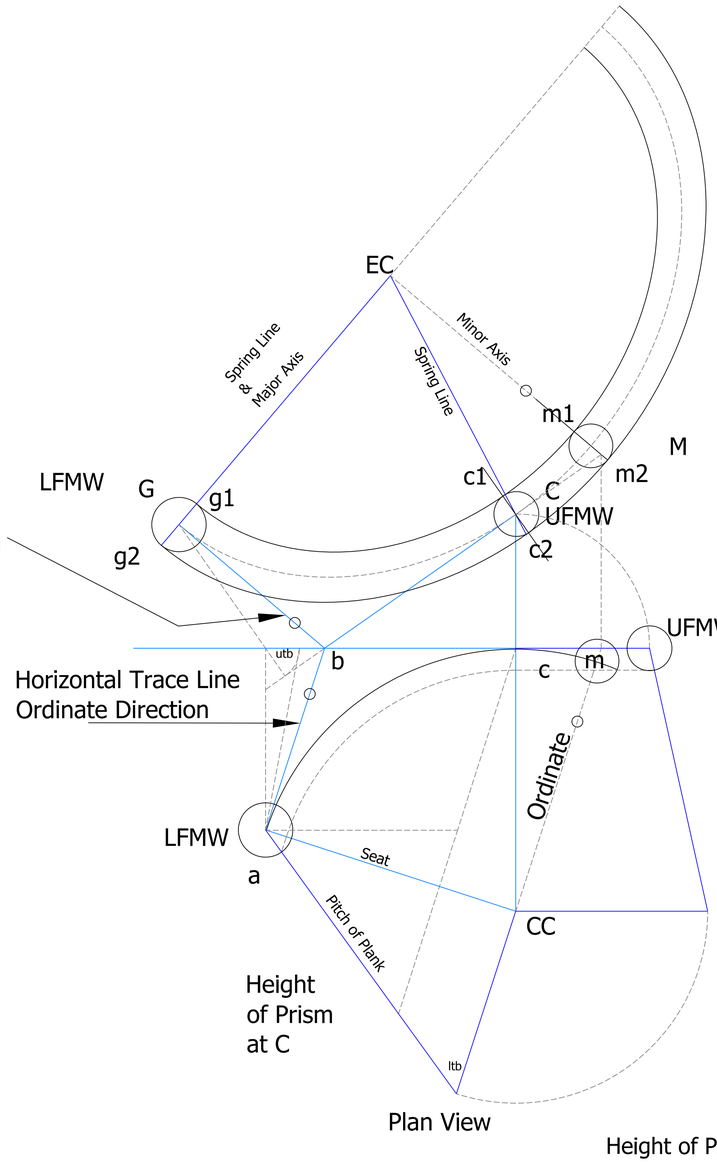
Isometric View of Prism

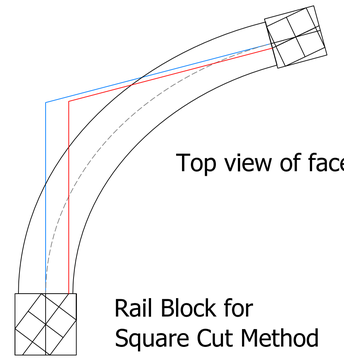
Plate 9

Obtuse Plan, The Upper Tangent is Pitched
The lower Tangent is Level

Isometric View of Prism





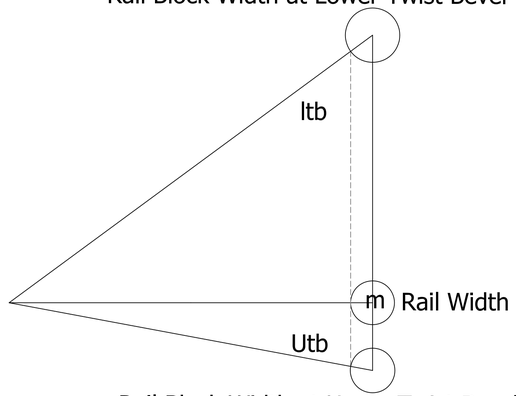


Plan = Obtuse
LowerTangent Pitch = 0.00°
Upper Tangent = 35.00°
Plan View Angle = 108.00

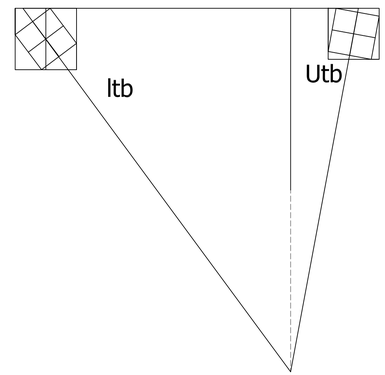
Tangents in Orginal Position

Tangents shifted into Second Position

Rail Block Width at Lower Twist Bevel



Rail Block Width at Upper Twist Bevel



Height of Prism
At EC spring lines

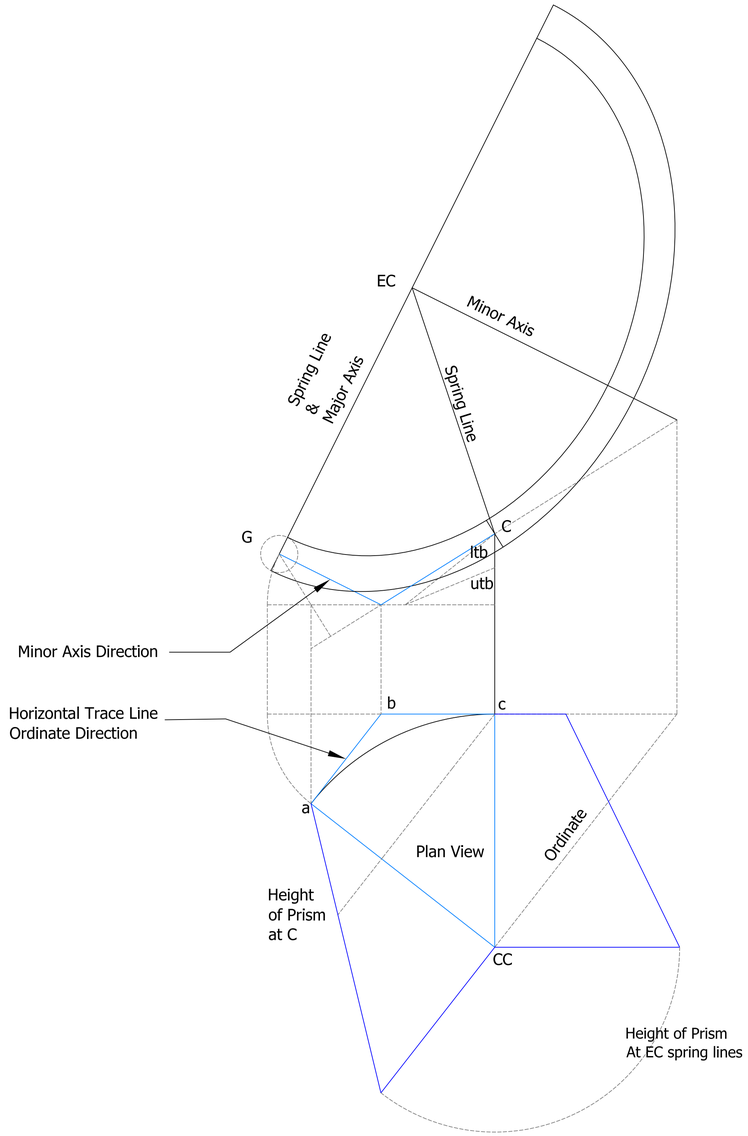


Plate 9.1

Obtuse Plan, The Upper Tangent is Pitched
The lower Tangent is Level

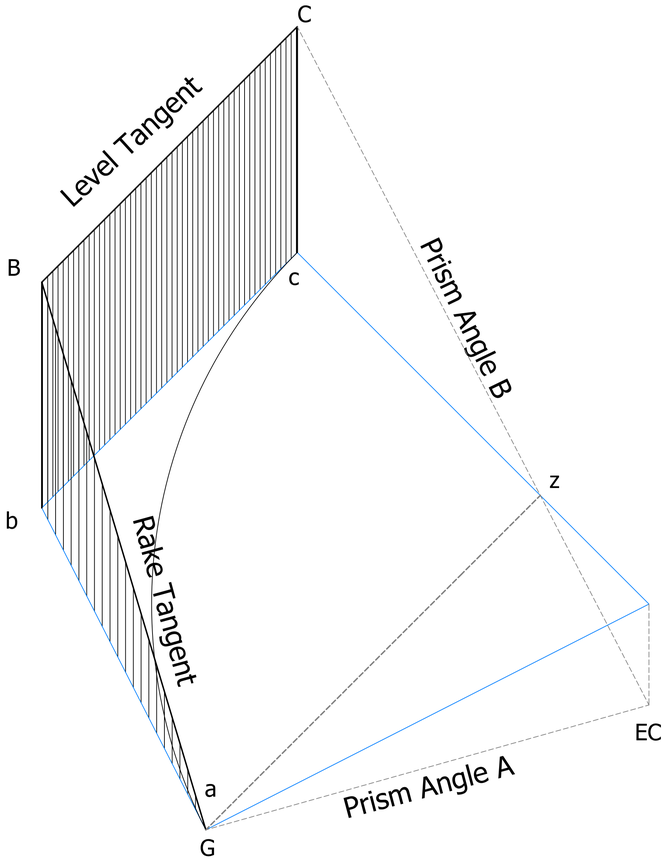
Based on the book
The Stair Builders Guide by Morris Williams 1914
Manner Of Laying Out tHe Face Mould
Fig 181.

Plan = Obtuse
LowerTangent Pitch = 0.00°
Upper Tangent = 32.00°
Plan View Angle = 128.00

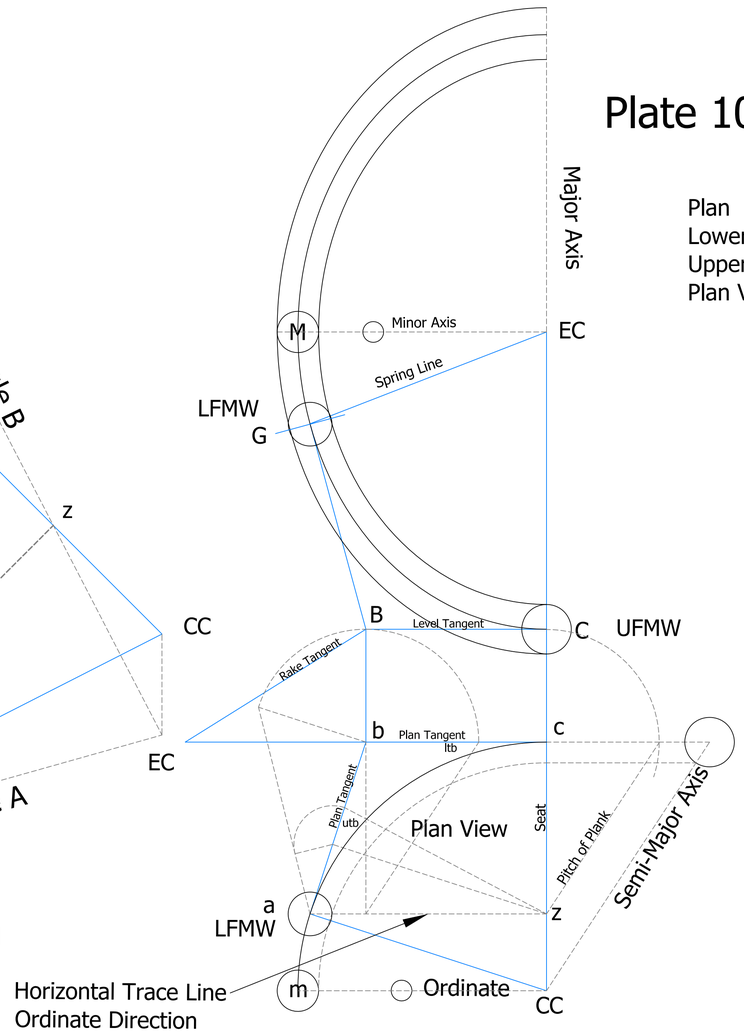
Plate 10

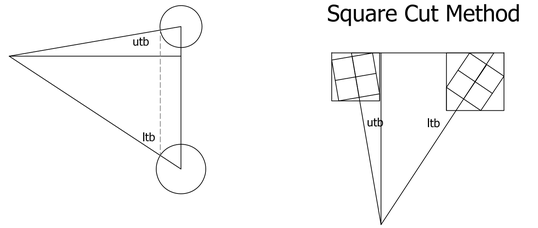
Obtuse Plan, The Lower Tangent is Pitched
The Upper Tangent is Level

Plan = Obtuse
LowerTangent Pitch = 32.00°
Upper Tangent = 0.00°
Plan View Angle = 108.00

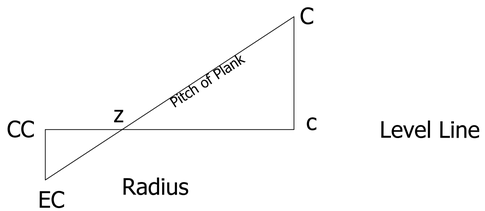


Isometric View of Prism





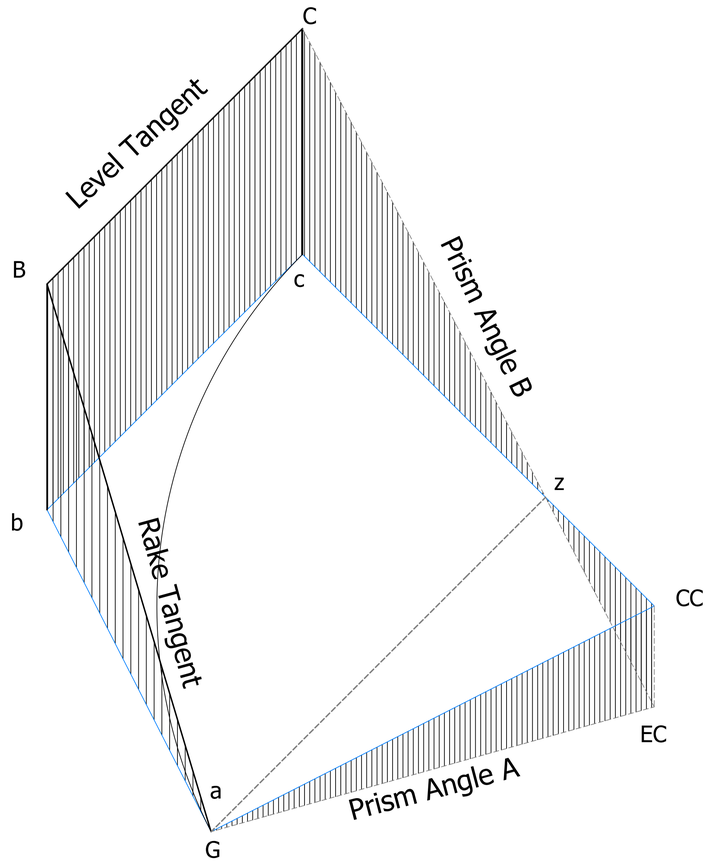
Height
of Prism
at C



Level Line

Rail Blocks for
Square Cut Method

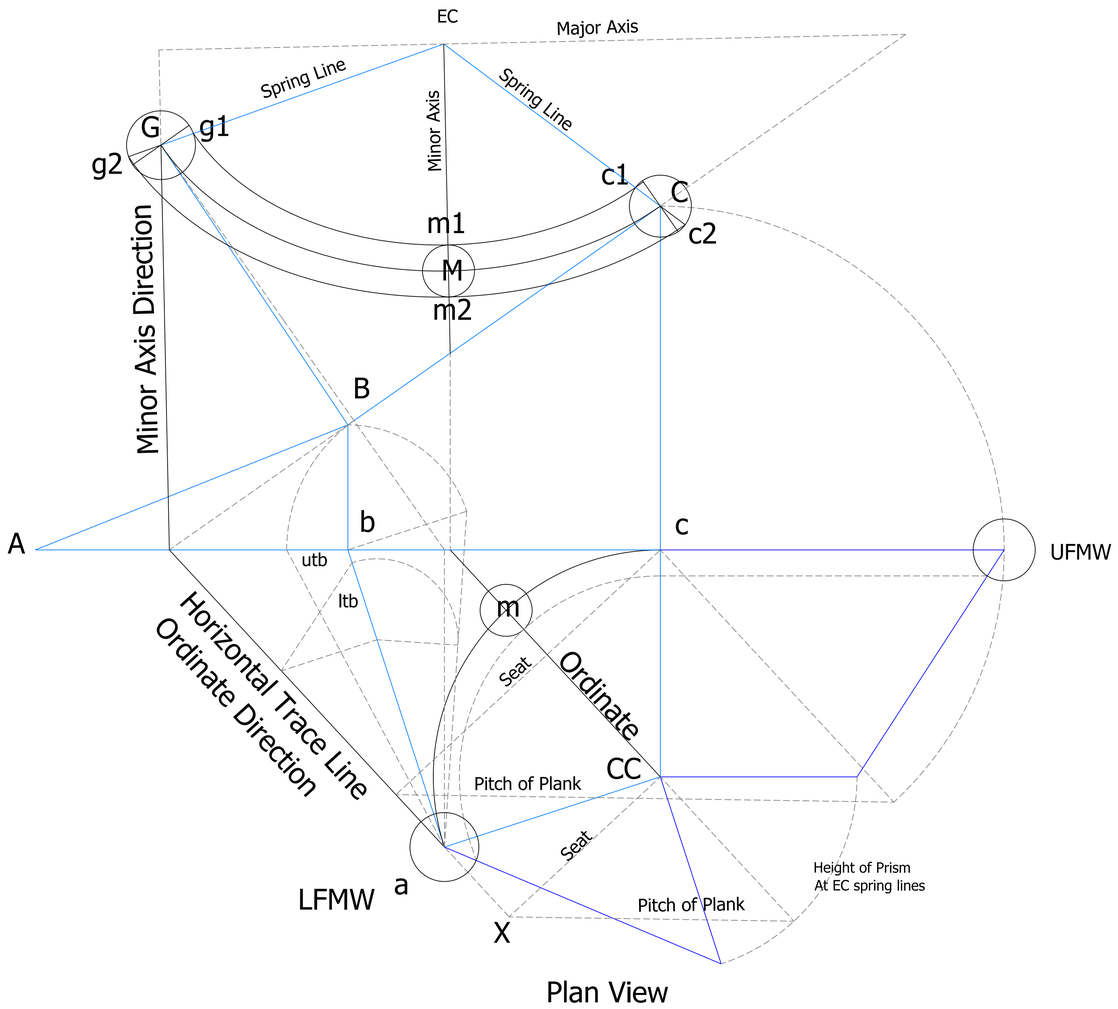
Height of Prism
At EC spring lines is below the plan view



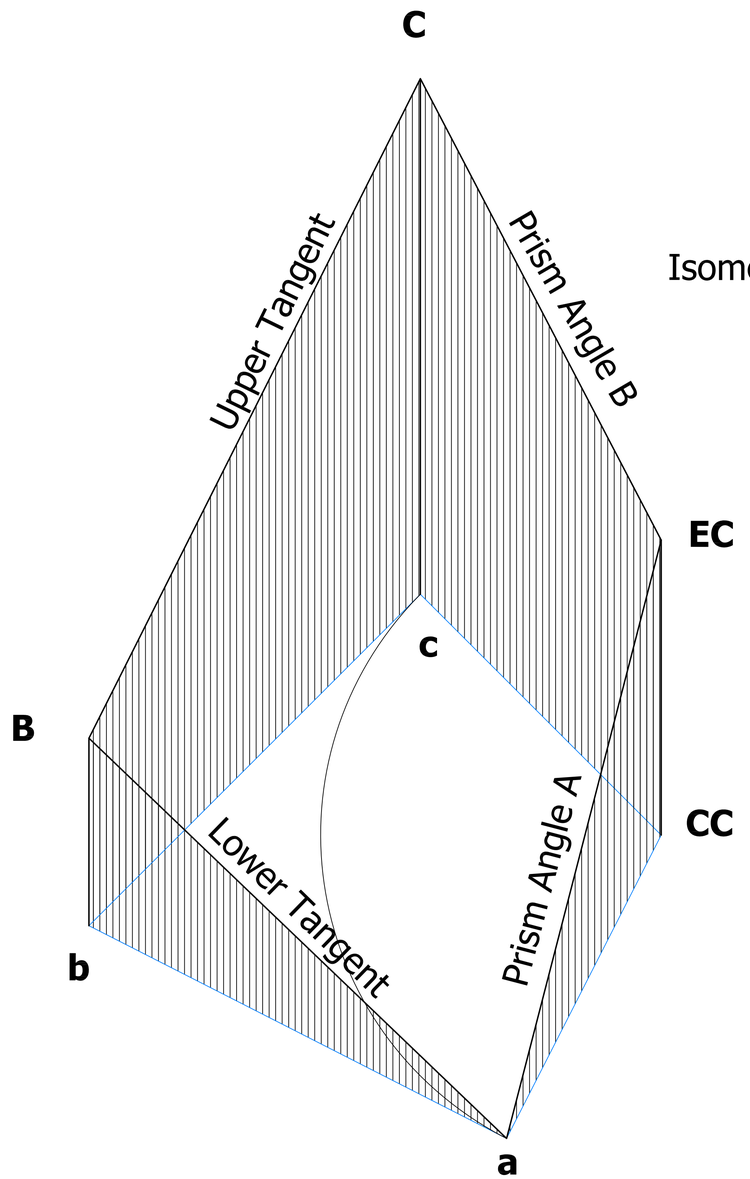
Isometric View of Prism

Plate 11

Acute Plan with Unequally Pitched Tangents



Plan View



Isometric View of Prism

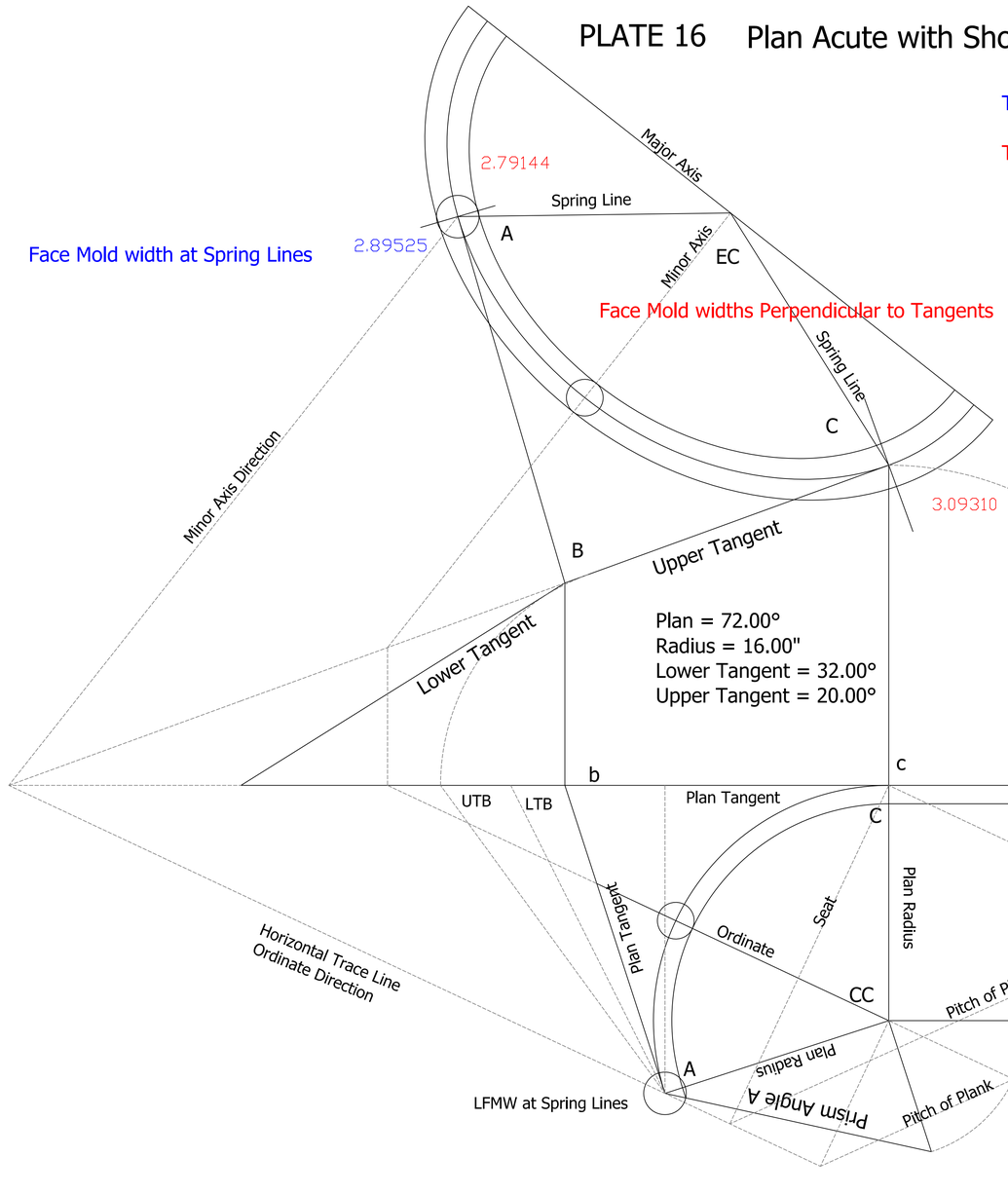
PLATE 16 Plan Acute with Short Upper Tangent Pitched

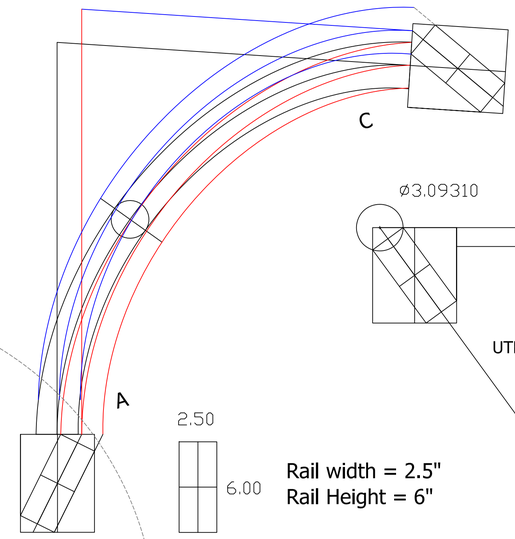
Face Mold width at Spring Lines

Tangent Shift for Face Mold at Upper Tangent

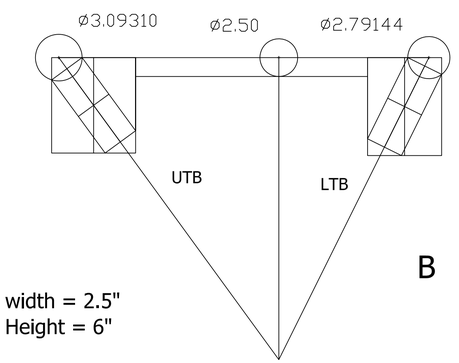
Tangent Shift for Face Mold at Lower Tangent

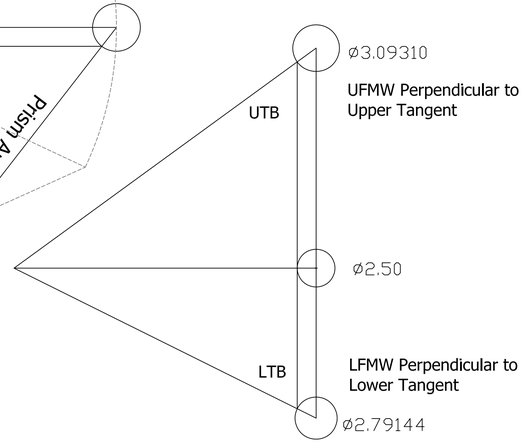
Face Mold widths Perpendicular to Tangents

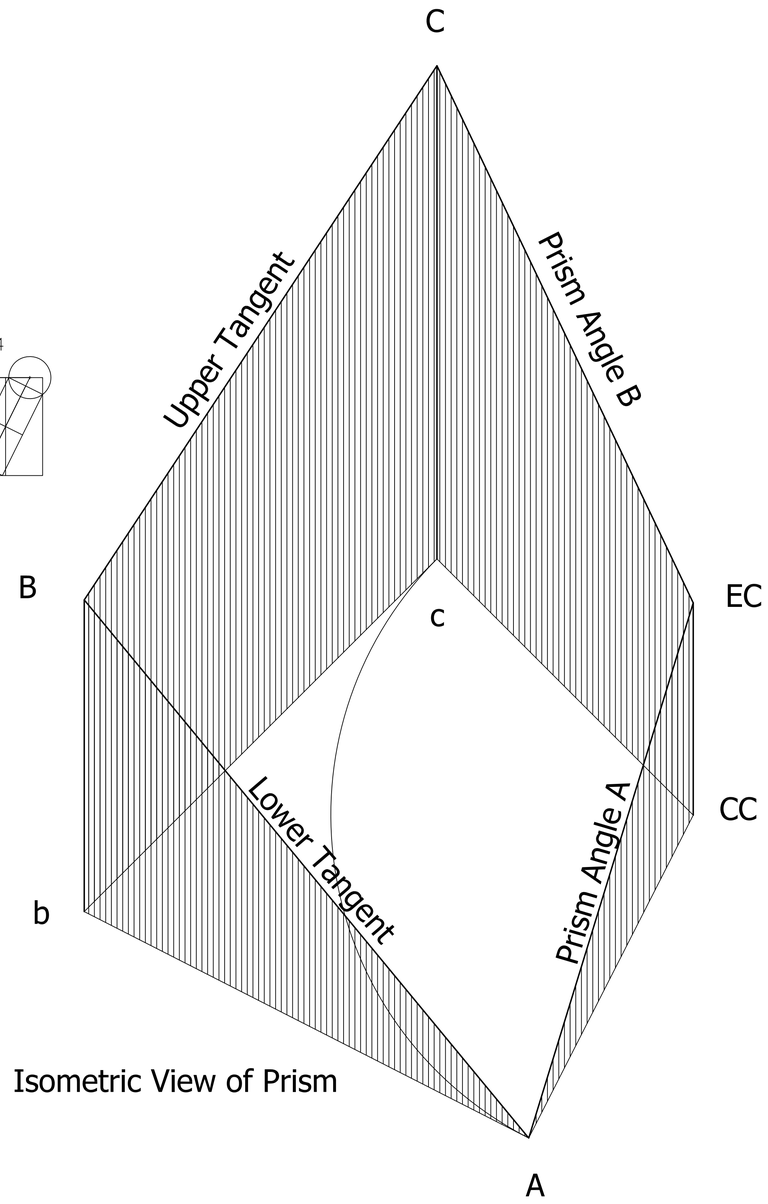




Rail width = 2.5"
Rail Height = 6"



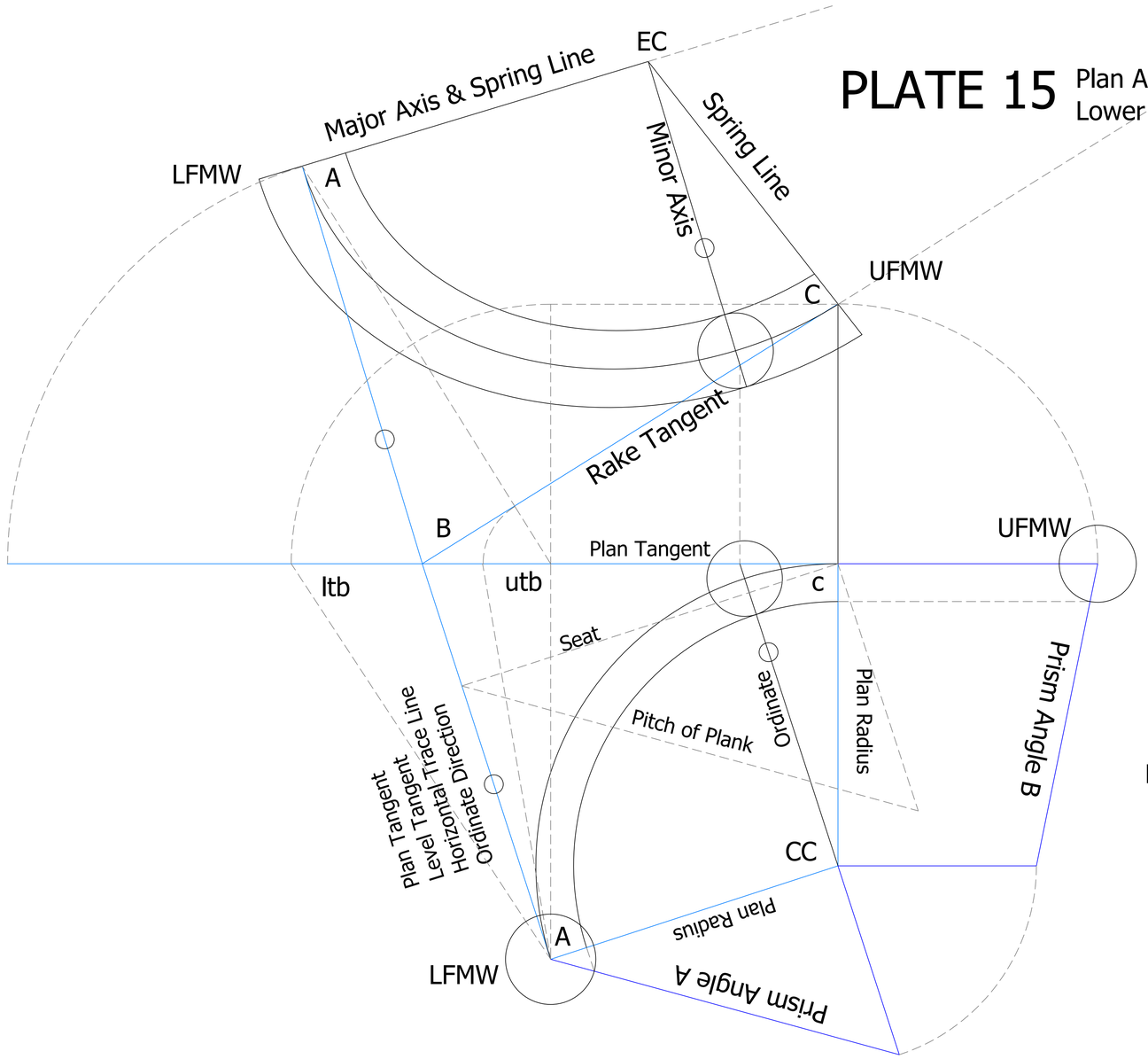


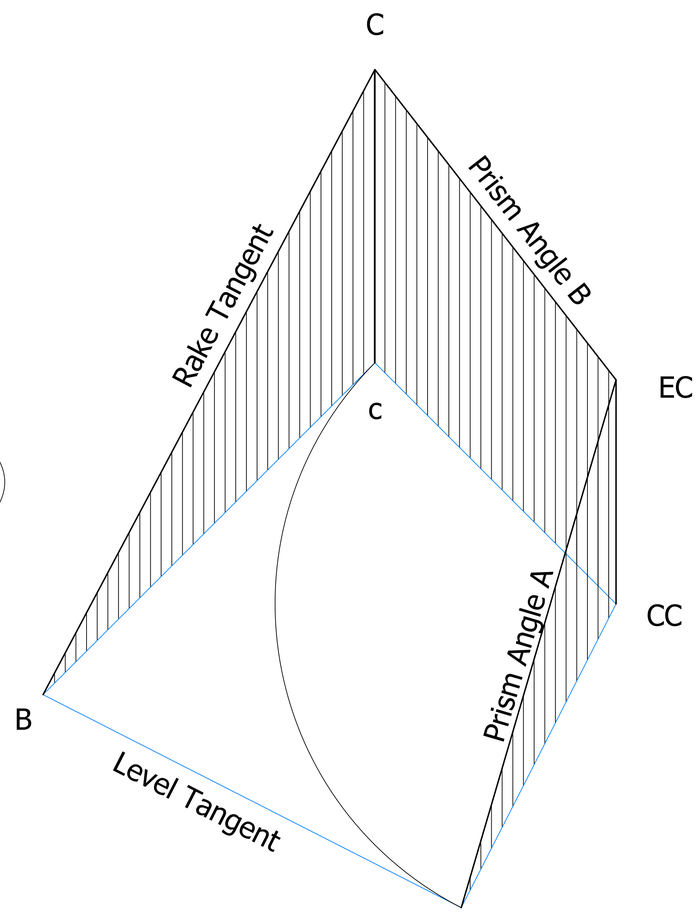


Isometric View of Prism

PLATE 15

Plan Acute with Upper Tangent Pitched
Lower Tangent Level





Isometric View of Prism

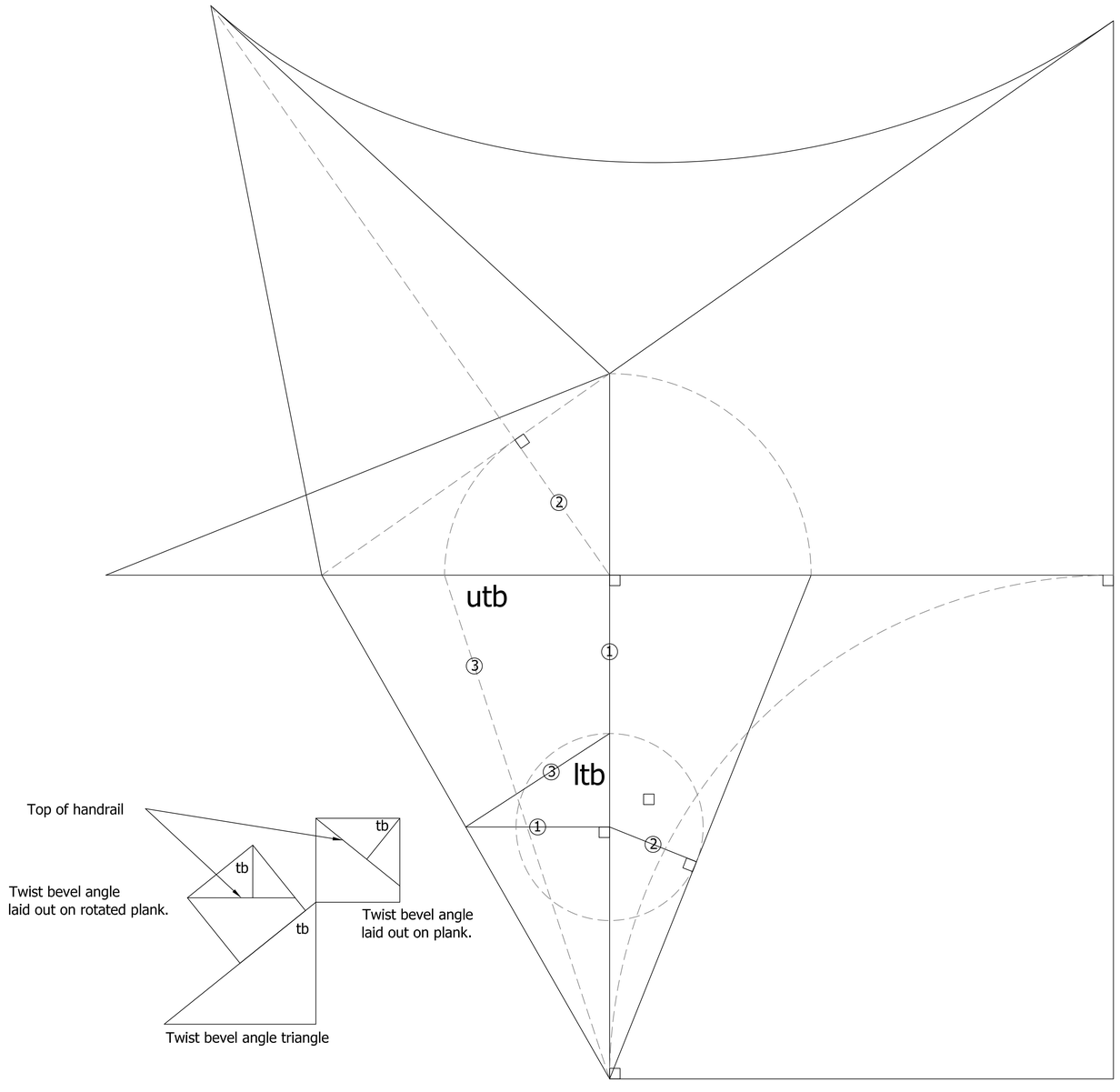


Plate 16

Quater Circle Square Plan with Short Lower Pitched Tangent

Plan View Section Plane Vertex Information
Plan = Square
Unequal Pitched Tangents
Plan View Angle = 90.00

Tangent Angles
Upper Tangent Angle = 35.00000
Lower Tangent Angle = 21.80141
Upper Twist Bevel Angle = 71.85806
Lower Twist Bevel Angle = 56.97104

The Upper and Lower Twist Bevel Angles
are the Dihedral Angles between two Planes.

Line 1 is perpendicular to hip run
Line 2 is perpendicular to hip rafter
Line 3 triangle height = line 2 length

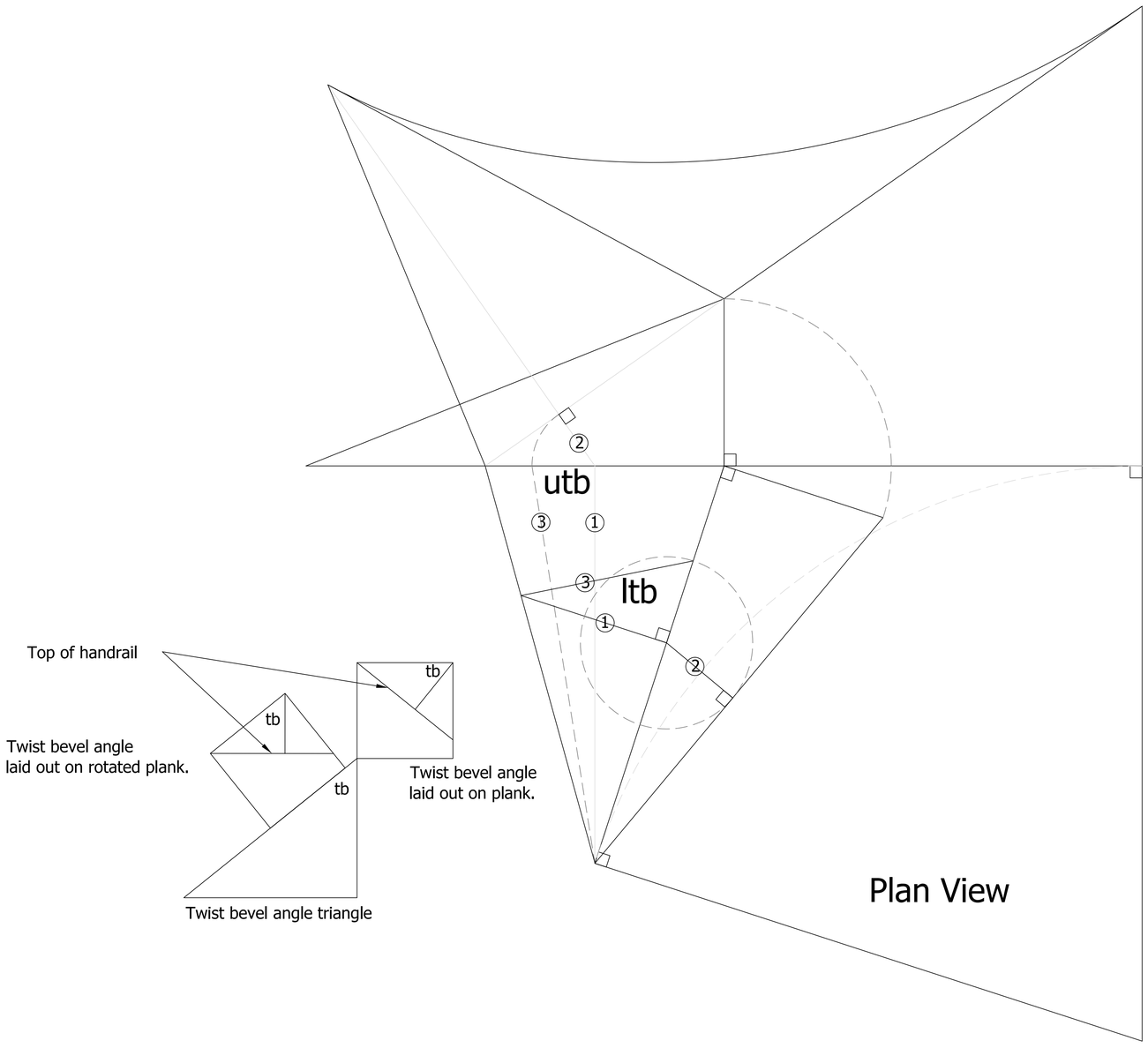


Plate 17

Obtuse Plan with Short Lower Pitched Tangent

Plan View Section Plane Vertex Information
Plan = Obtuse
Unequal Pitched tangents
Plan View Angle = 108.00000

Tangent Angles
Upper Tangent Angle = 35.00000
Lower Tangent Angle = 21.80141
Upper Twist Bevel Angle = 81.01273
Lower Twist Bevel Angle = 60.62435

The Upper and Lower Twist Bevel Angles
are the Dihedral Angles between two Planes.

Line 1 is perpendicular to hip run
Line 2 is perpendicular to hip rafter
Line 3 triangle height = line 2 length

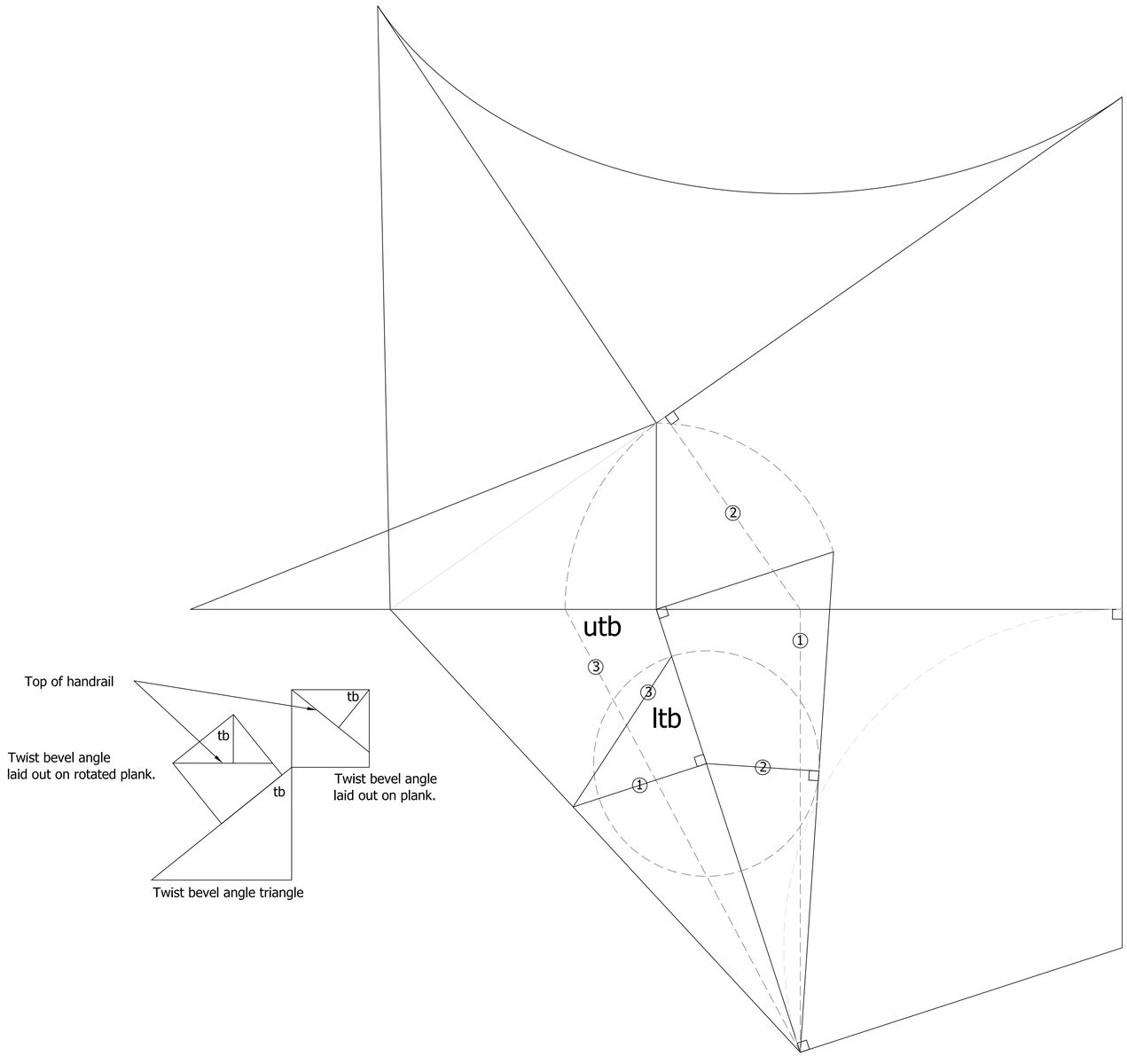


Plate 18

Acute Plan with Short Lower Pitched Tangent

Plan View Section Plane Vertex Information
Plan = Acute
Unequal Pitched Tangents
Plan View Angle = 72.00

Tangent Angles
Upper Tangent Angle = 35.00000
Lower Tangent Angle = 21.80141
Upper Twist Bevel Angle = 62.03665
Lower Twist Bevel Angle = 51.19183

The Upper and Lower Twist Bevel Angles
are the Dihedral Angles between two Planes.

Line 1 is perpendicular to hip run
Line 2 is perpendicular to hip rafter
Line 3 triangle height = line 2 length

Plate 19.1

Tangent Handrail folding template for oblique plane angles.

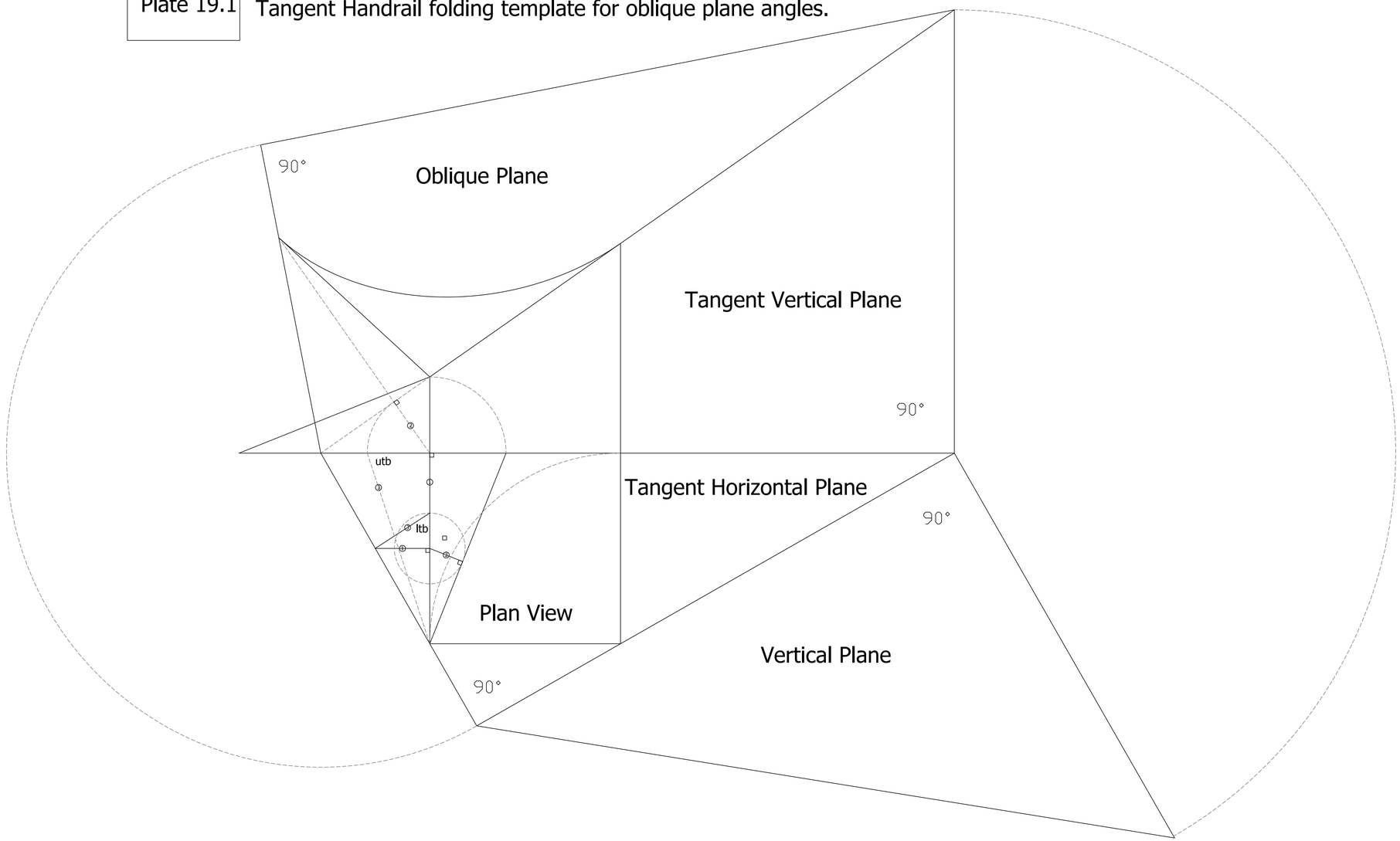


Plate 19.2

Minor Axis Offset

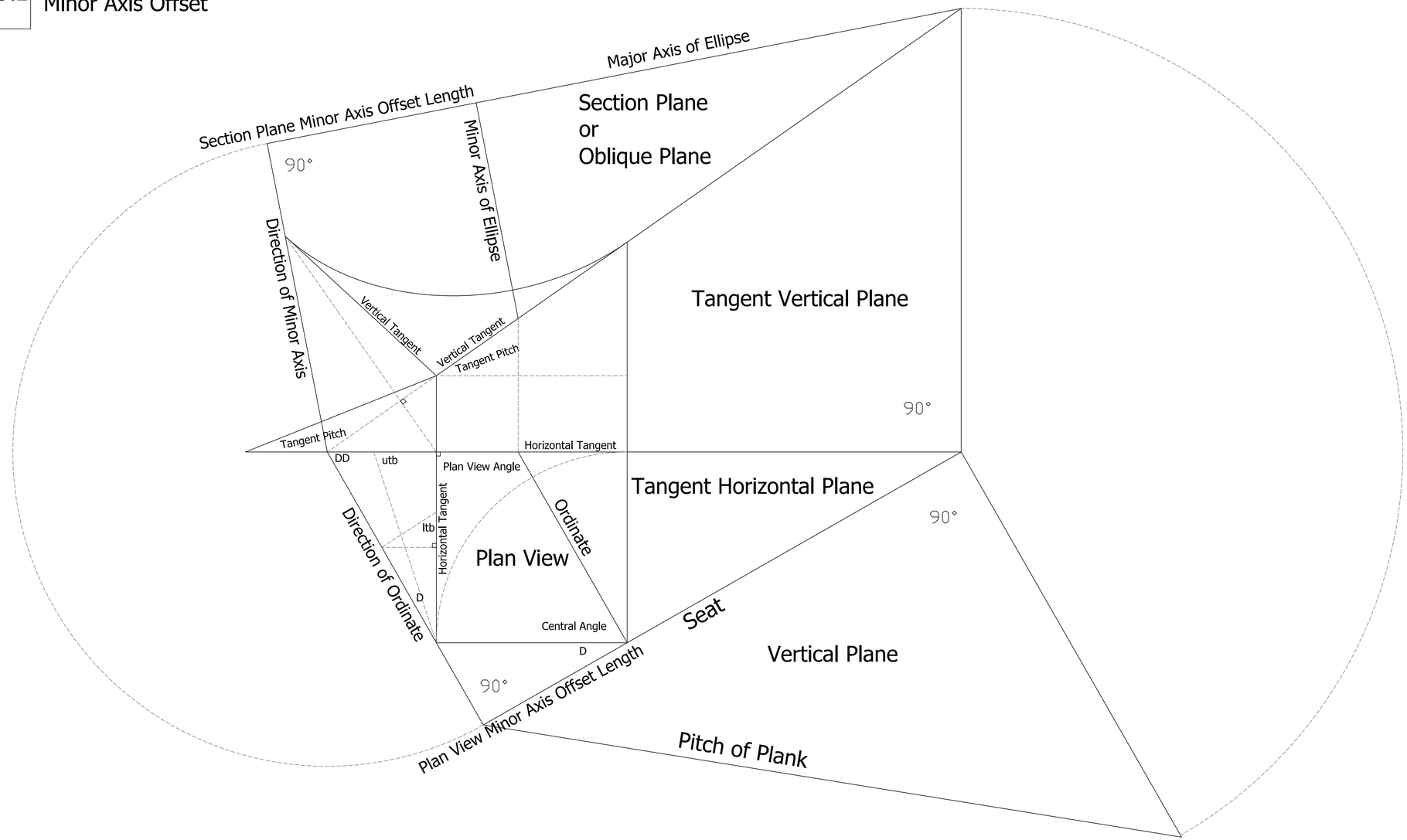
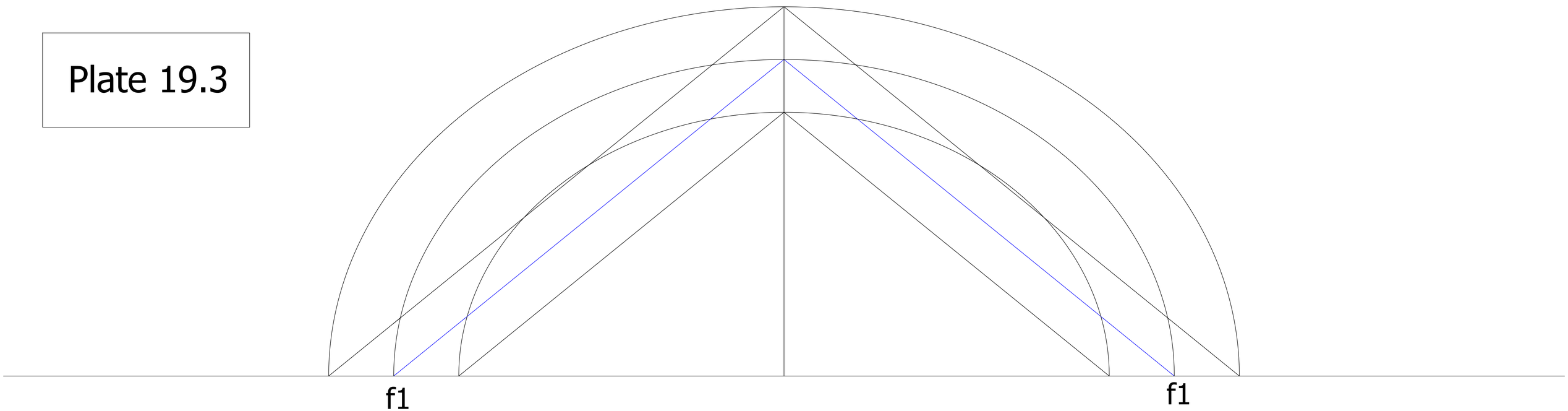


Plate 19.3

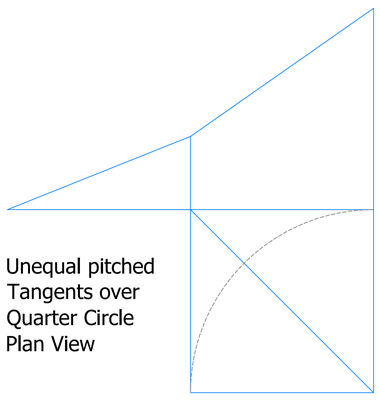


Face Mould Ellipse semi major axis lines are parallel

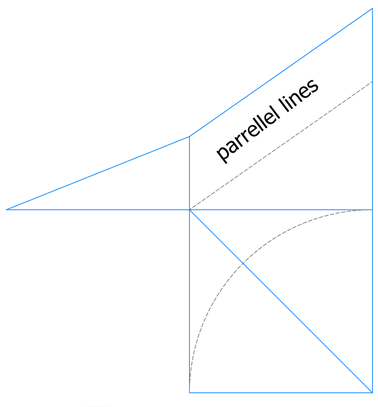
Draw face mould semi major axis lines for center of face mould (blue),
then draw semi major axis lines that are parallel to the semi major axis lines of the center of the face mould for the inner and outer curves of the face mould.

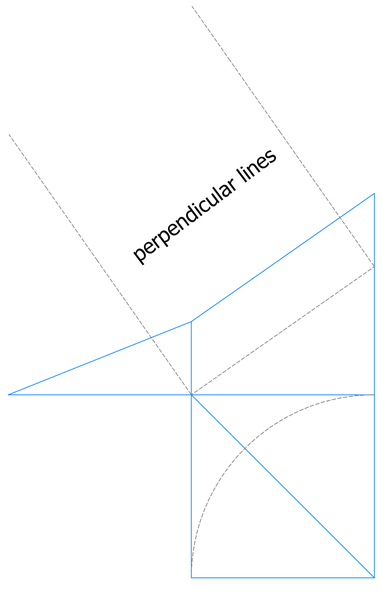
Plate 19.4

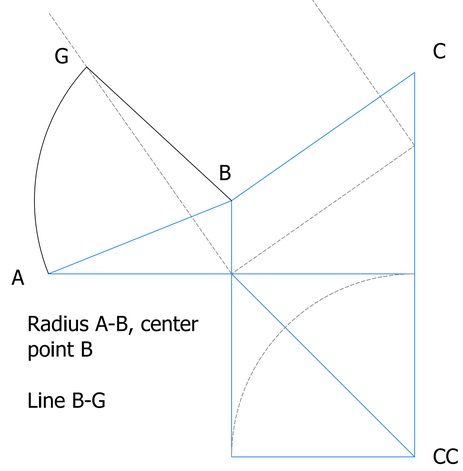
Tangent Handrail drawing for oblique section plane and center of ellipse for quarter circle plans.



Unequal pitched Tangents over Quarter Circle Plan View

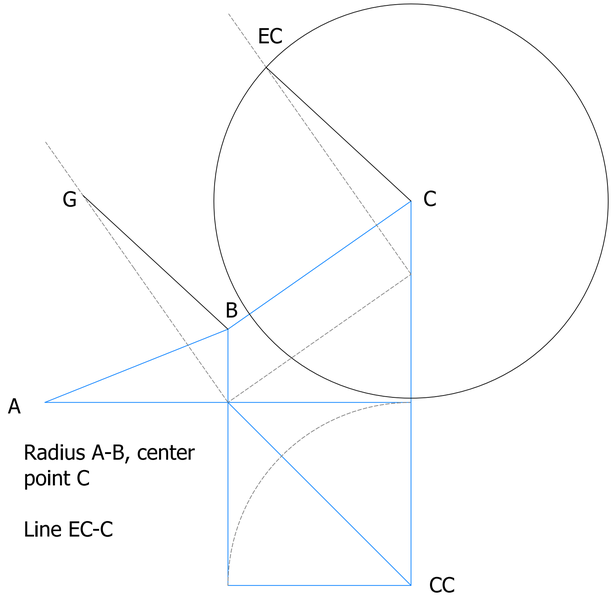






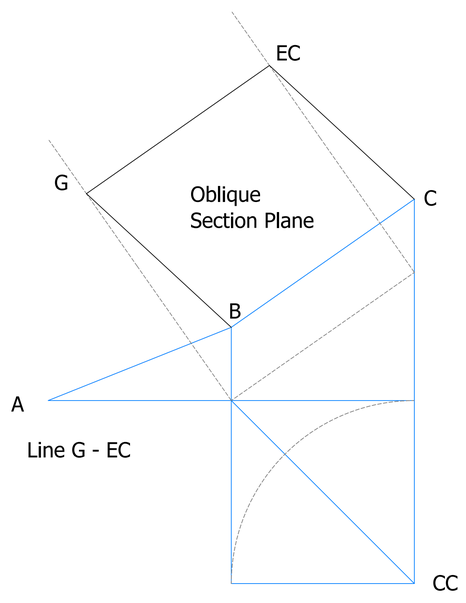
Radius A-B, center point B

Line B-G

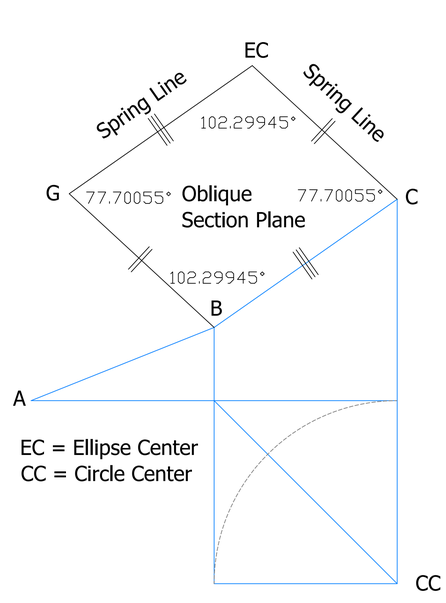


Radius A-B, center point C

Line EC-C



Line G - EC



EC = Ellipse Center
CC = Circle Center

Net of prism for tangent handrailing for
Quarter Circle with Unequal Pitched Tangents

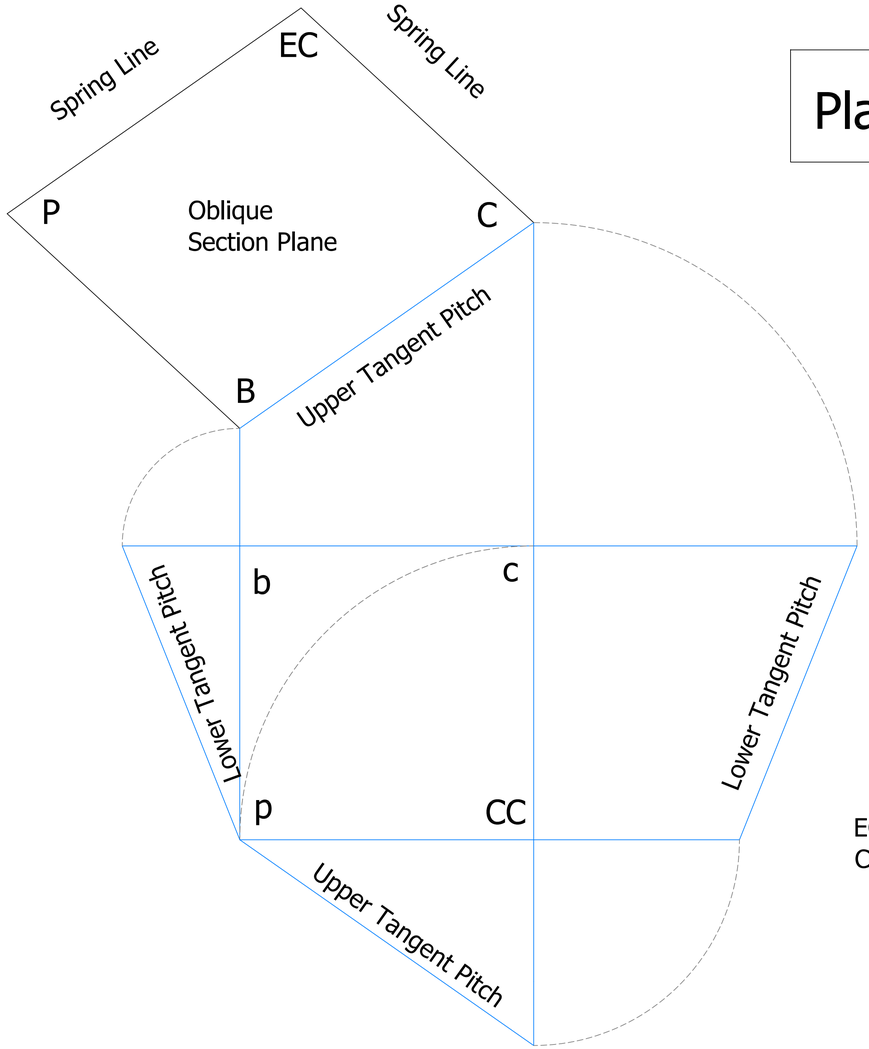
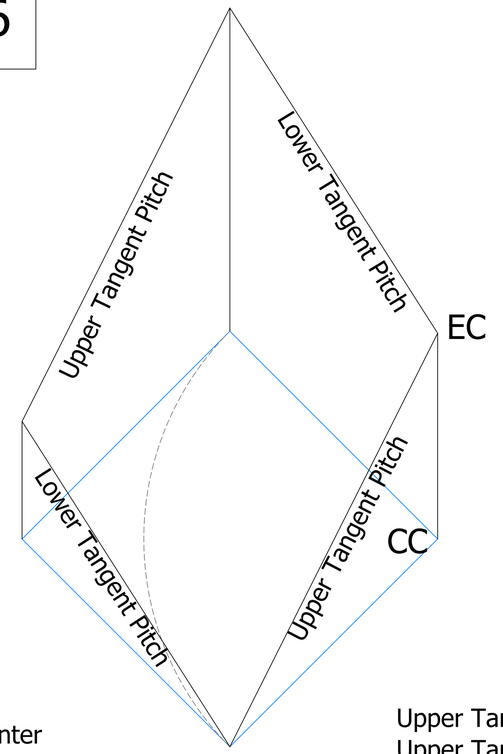


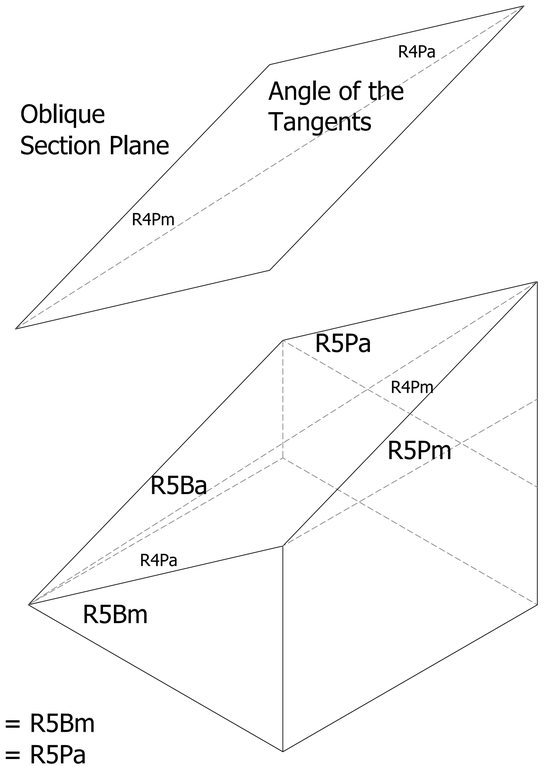
Plate 19.6

Isometric drawing of prism for tangent handrailing for
Quarter Circle with Unequal Pitched Tangents

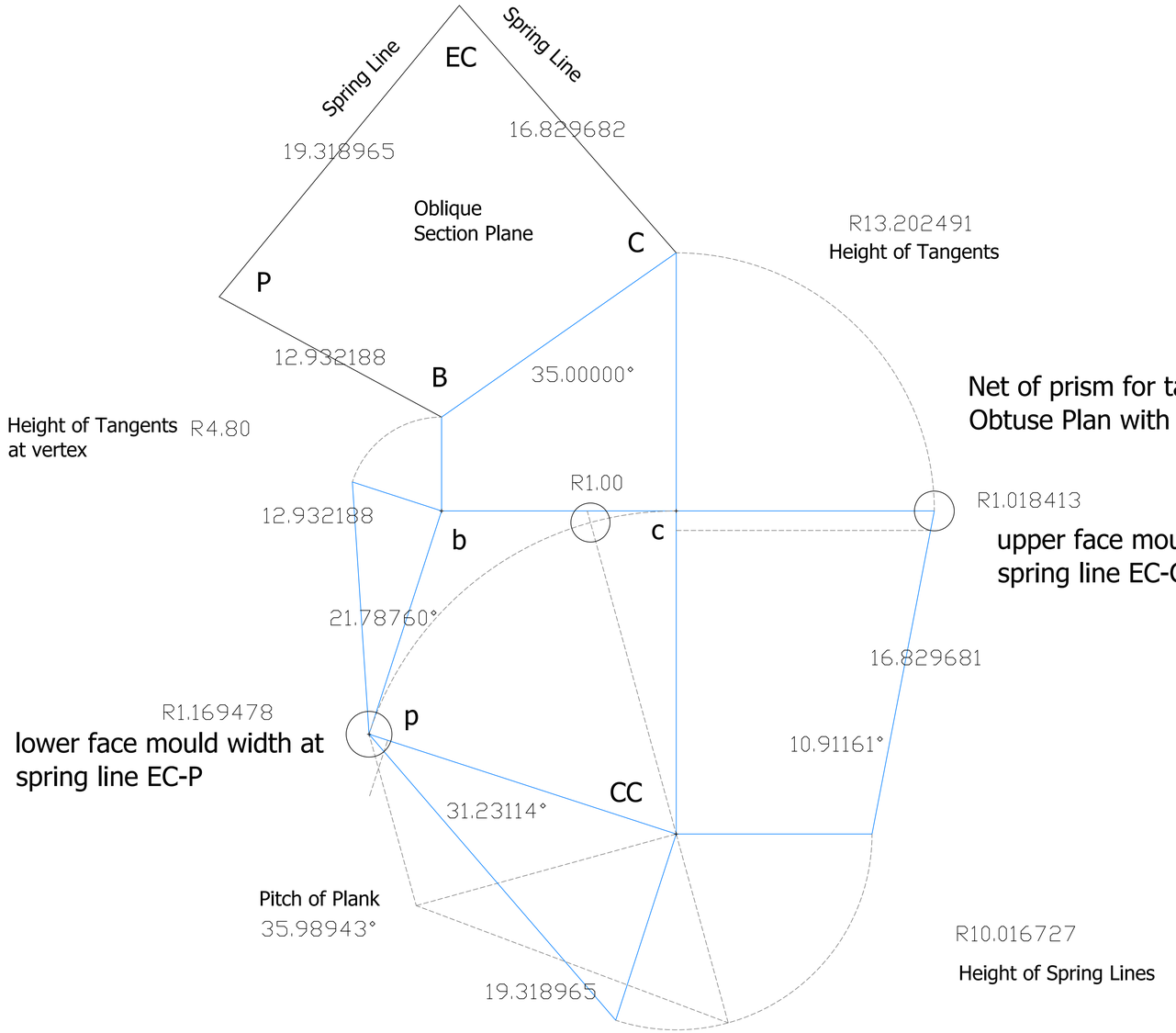


EC = Ellipse Center
CC = Circle Center

Isometric drawing of prism for tangent handrailing for
Quarter Circle with Unequal Pitched Tangents
showing the relationship to roof framing geometry and trigonometry
for Hip Rafter Diamond Post



Upper Tangent Pitch = R5Bm
Upper Tangent Pitch = R5Pa
Lower Tangent Pitch = R5Ba
Lower Tangent Pitch = R5Pm
Angle of the Tangents = 180° - R4Pm - R4Pa



Net of prism for tangent handrailing for
Obtuse Plan with Unequal Pitched Tangents

upper face mould width at
spring line EC-C

Net of prism for tangent handrailing for Acute Plan with Unequal Pitched Tangents

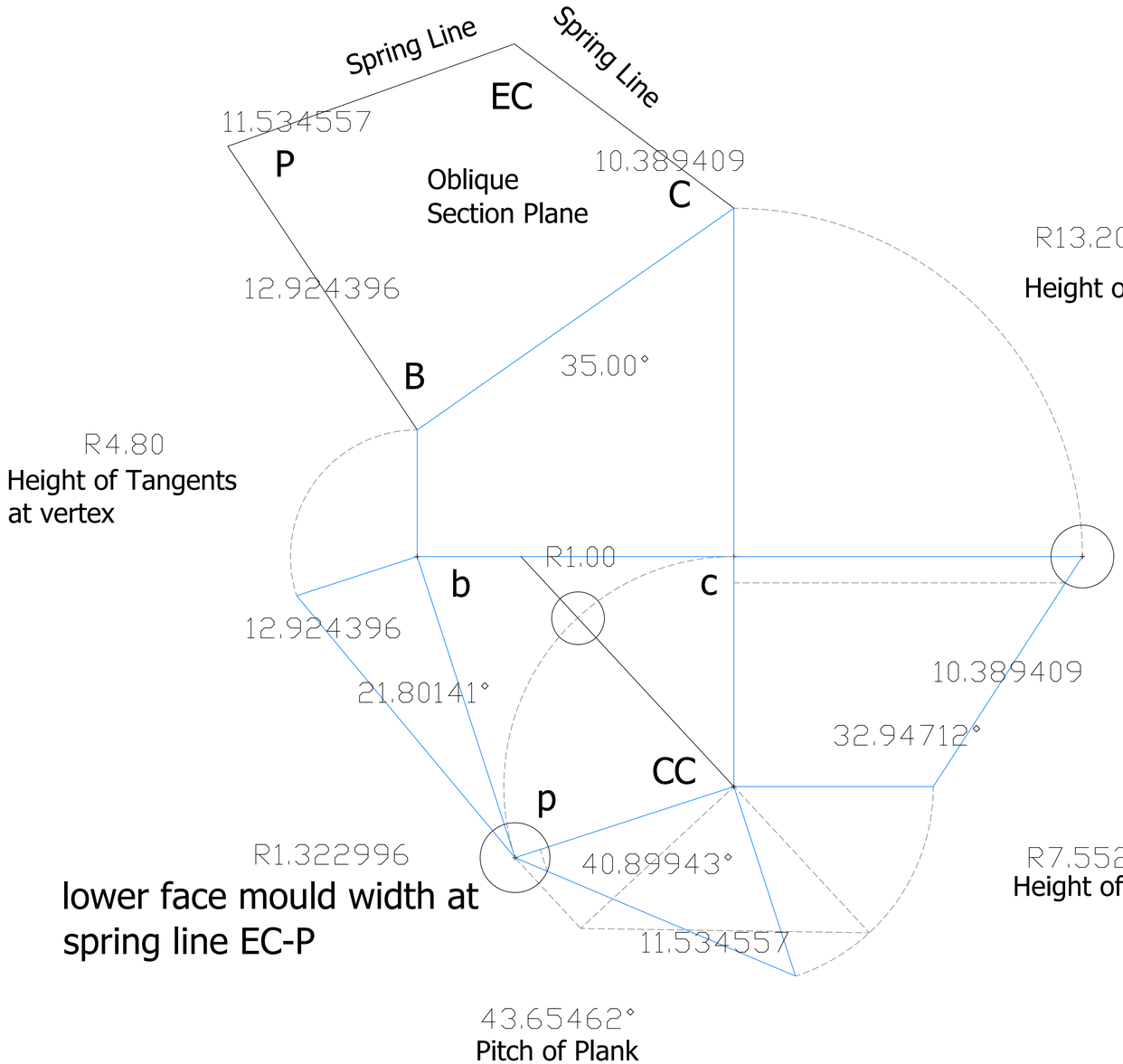
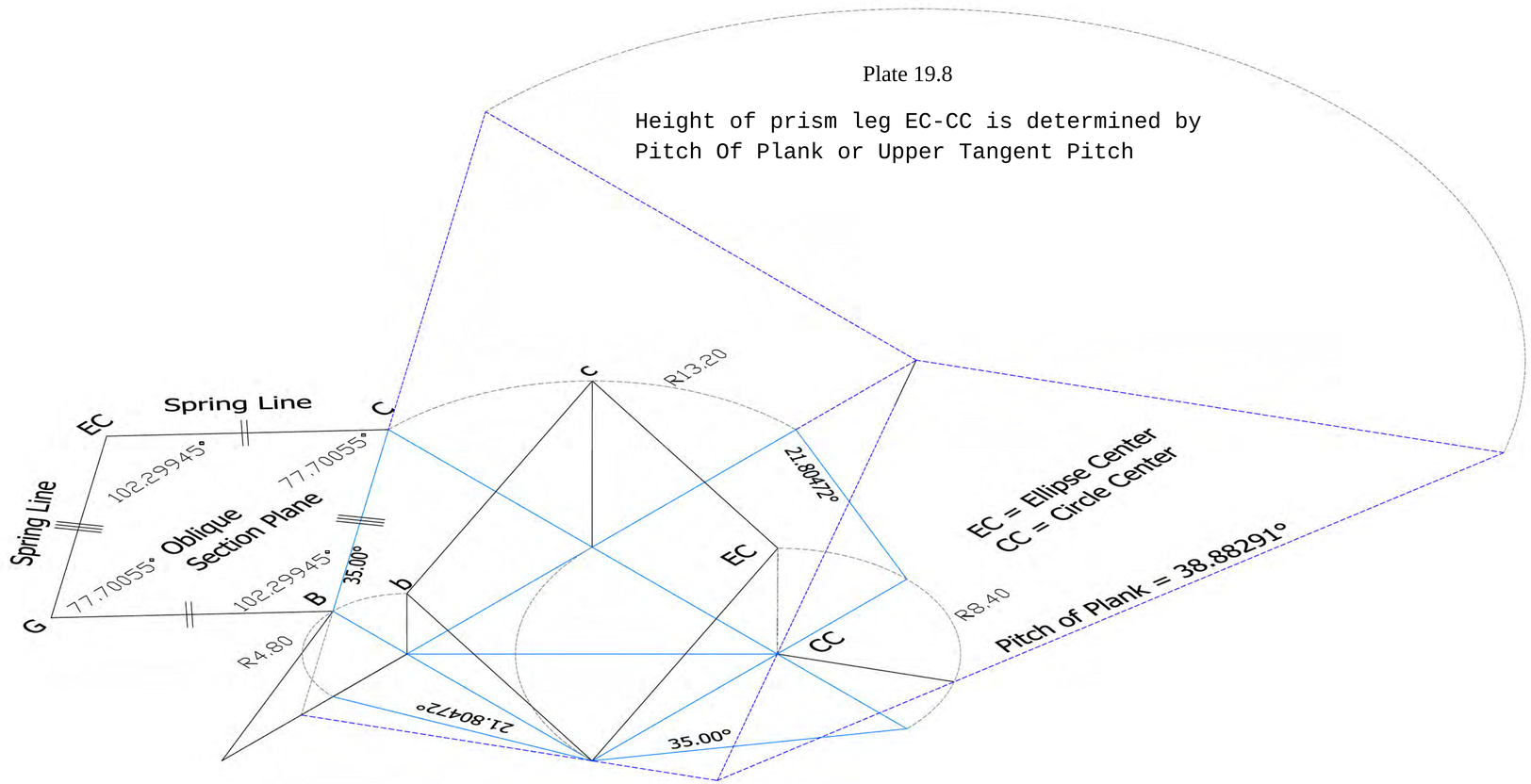


Plate 19.8

Height of prism leg EC-CC is determined by
Pitch Of Plank or Upper Tangent Pitch

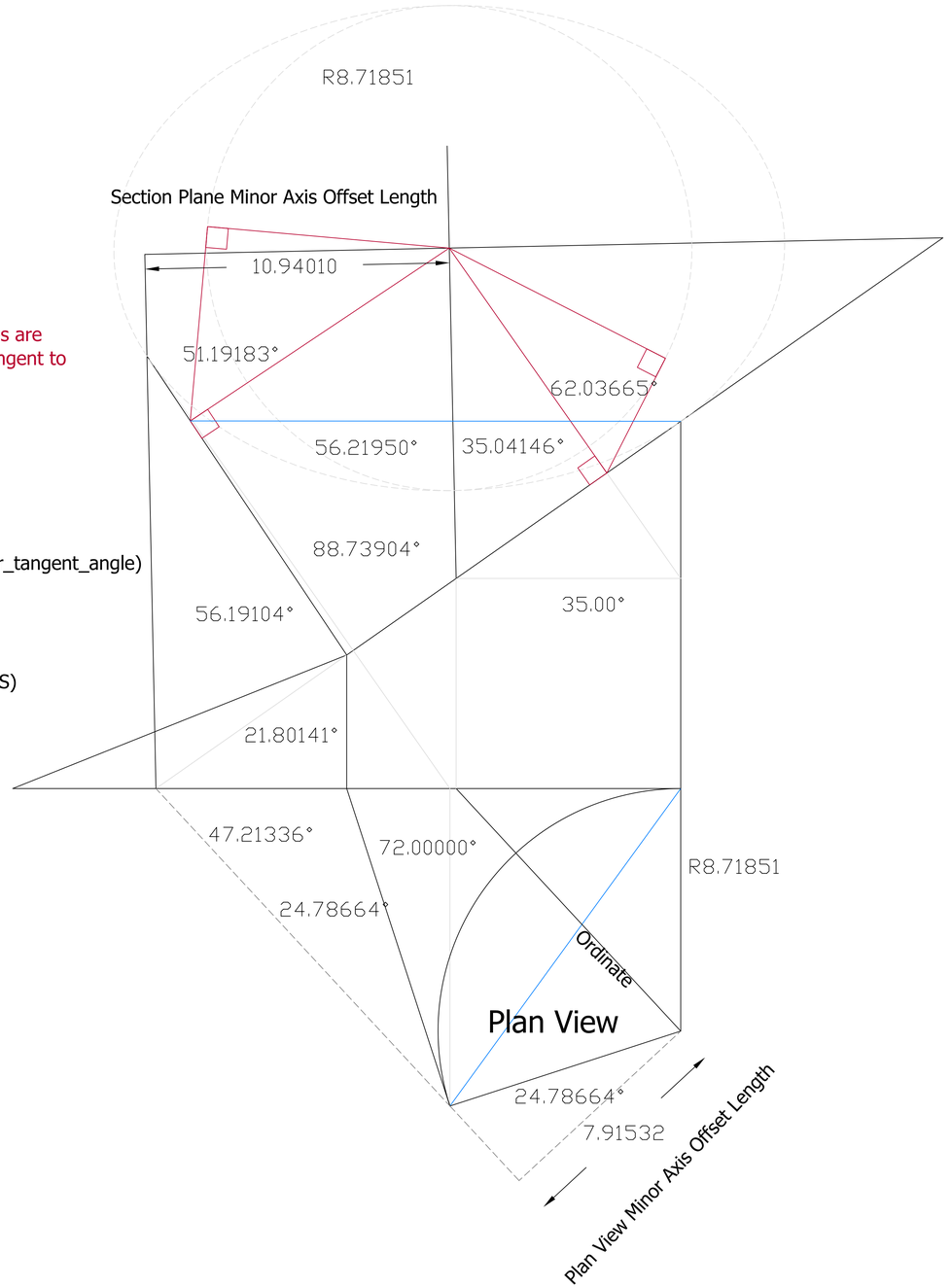


SBE Builders

Plate 20

Acute Plan with Short Lower Pitched Tangent

Upper & Lower Twist Bevel Angles are perpendicular to tangents and tangent to right cylinder on section plane



slant_angle = upper_tangent_angle

(Angle_D,Angle_DD) = get_plan_angles(plan_view_angle,upper_tangent_angle,lower_tangent_angle)
SS = arctan(tan(slant_angle) ÷ sin(Angle_DD))
S = atan(tan(slant_angle) ÷ sin(Angle_D))

Plan View Minor Axis Offset Length = radius * cos(Angle_D)
Section Plane Minor Axis Offset Length = Plan View Minor Axis Offset Length ÷ cos(SS)
major_axis = radius ÷ cos(SS)
utb = 90° - arctan(sin(upper_tangent_angle) ÷ tan(Angle_DD))
ltb = 90° - arctan(sin(lower_tangent_angle) ÷ tan(Angle_D))

R1 = arctan(tan(upper_tangent_angle) ÷ sin(Angle_DD))
R4Bm = arctan(cos(R1) ÷ tan(Angle_DD))
R4Ba = arctan(cos(R1) ÷ tan(Angle_D))
Angle of the Tangents = 180 - R4Bm - R4Ba

Plan View Section Plane Vertex Information
Plan View Angle = 72.0000000000
Plan View Radius = 8.7185100000

Tangent Angles
Upper Tangent Angle = 35.0000000000
Lower Tangent Angle = 21.8014100000
Upper Twist Bevel Angle = 62.0366474261
Lower Twist Bevel Angle = 51.1918289162

Ellipse Angles
Plan Angle DD = 47.2133581426
Plan Angle D = 24.7866418574
Minor Axis = 8.7185100000
Major Axis = 12.0502272720
Plan View Minor Axis Offset Length = 7.9153194146
Section Plane Minor Axis Offset Length = 10.9401030539
R1 = 43.65462
R4Bm = 33.80896
R4Ba = 57.45200
Angle of the Tangents = 180 - 33.80896 - 57.45200 = 88.73904

Tetrahedron Angles

D Angle = 47.2133581426
A Angle = 43.6546170252
C Angle = 35.0000000000
E Angle = 33.8089621505
B Angle = 27.9633525739

90-D Angle = 42.7866418574
90-A Angle = 46.3453829748
90-C Angle = 55.0000000000
90-E Angle = 56.1910378495
90-B Angle = 62.0366474261

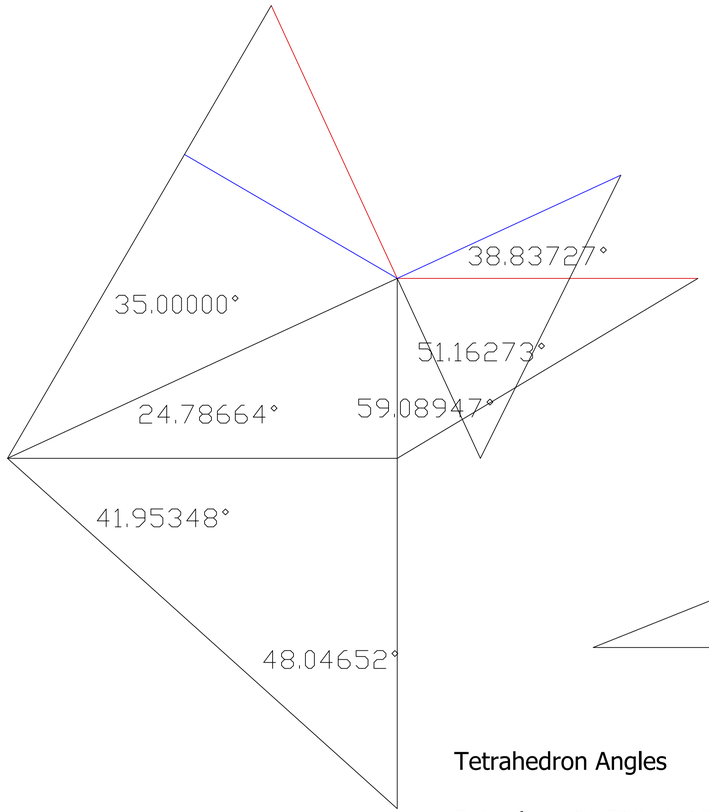
Tetrahedron Angles

D Angle = 24.7866418574
A Angle = 59.0894662316
C Angle = 35.0000000000
E Angle = 48.0465198522
B Angle = 51.1627258173

90-D Angle = 65.2133581426
90-A Angle = 30.9105337684
90-C Angle = 55.0000000000
90-E Angle = 41.9534801478
90-B Angle = 38.8372741827

Plate 21

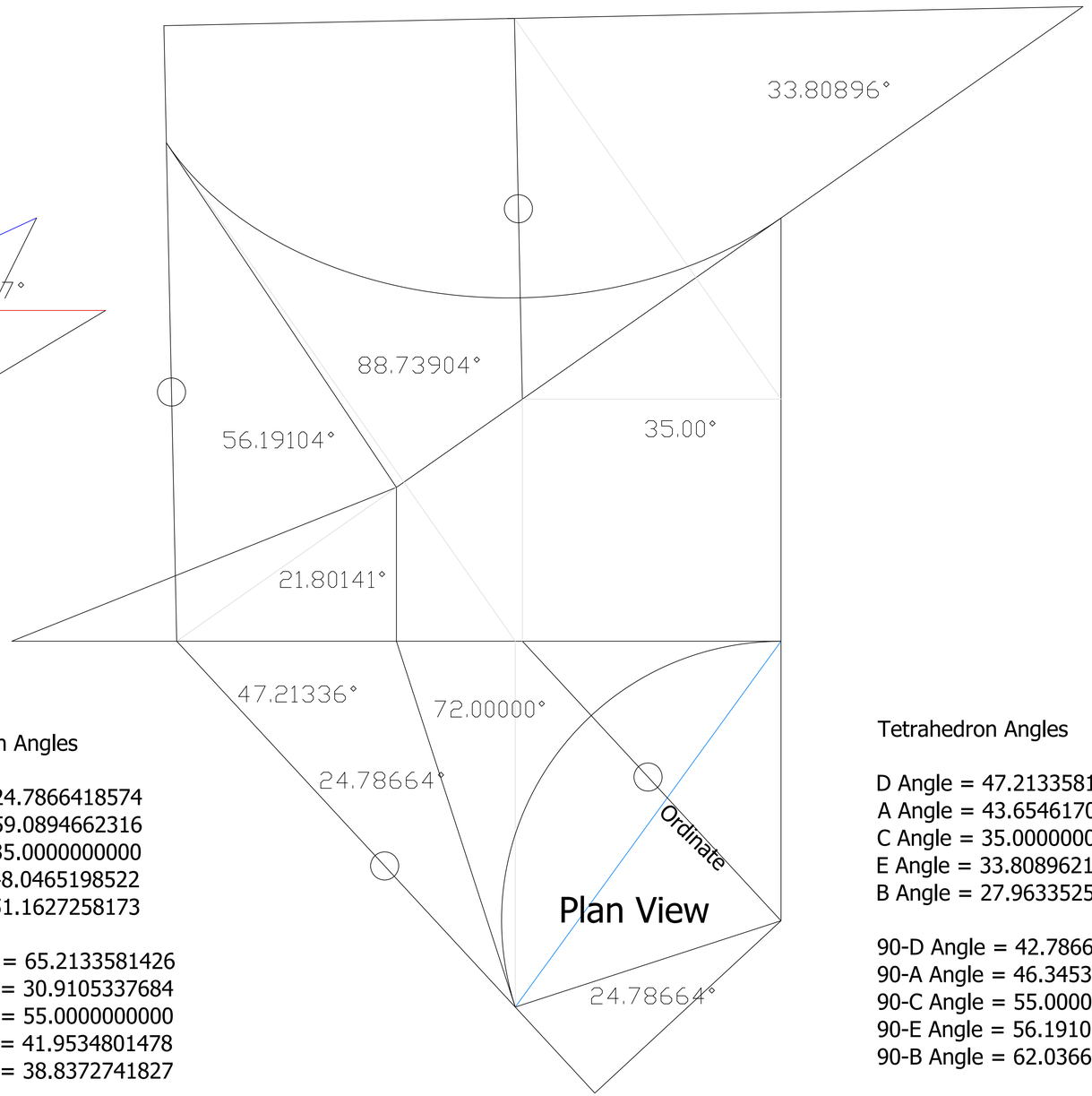
Acute Plan with Short Lower Pitched Tangent



Tetrahedron Angles

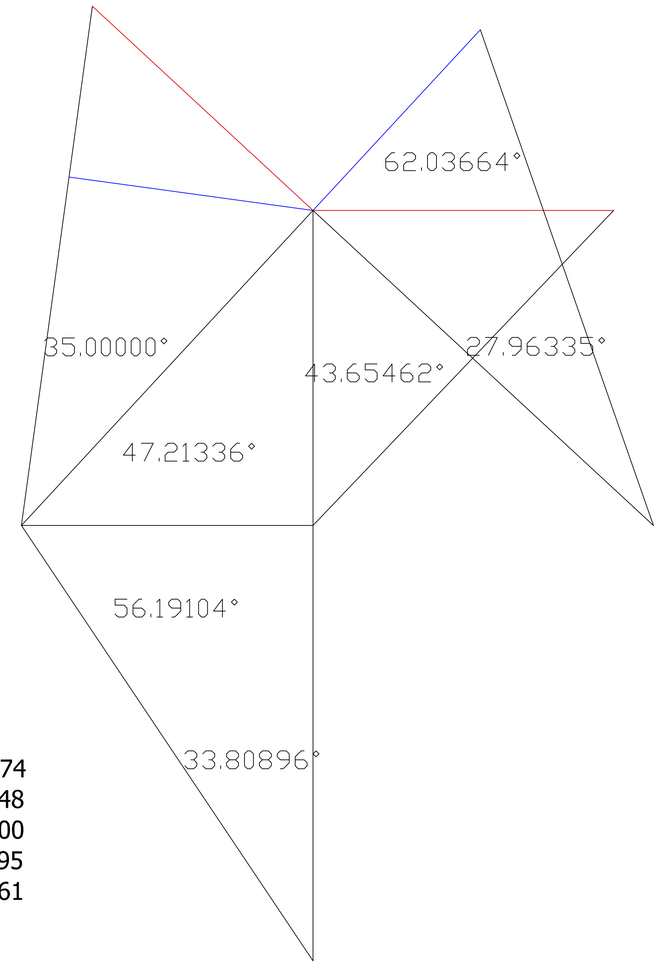
D Angle = 24.7866418574
A Angle = 59.0894662316
C Angle = 35.0000000000
E Angle = 48.0465198522
B Angle = 51.1627258173

90-D Angle = 65.2133581426
90-A Angle = 30.9105337684
90-C Angle = 55.0000000000
90-E Angle = 41.9534801478
90-B Angle = 38.8372741827



Plan View Section Plane Vertex Information
Plan = Acute
Unequal Pitched Tangents
Plan View Angle = 72.00

Tangent Angles
Upper Tangent Angle = 35.00
Lower Tangent Angle = 21.80141
Upper Twist Bevel Angle = 62.0366474261
Lower Twist Bevel Angle = 51.1918289162



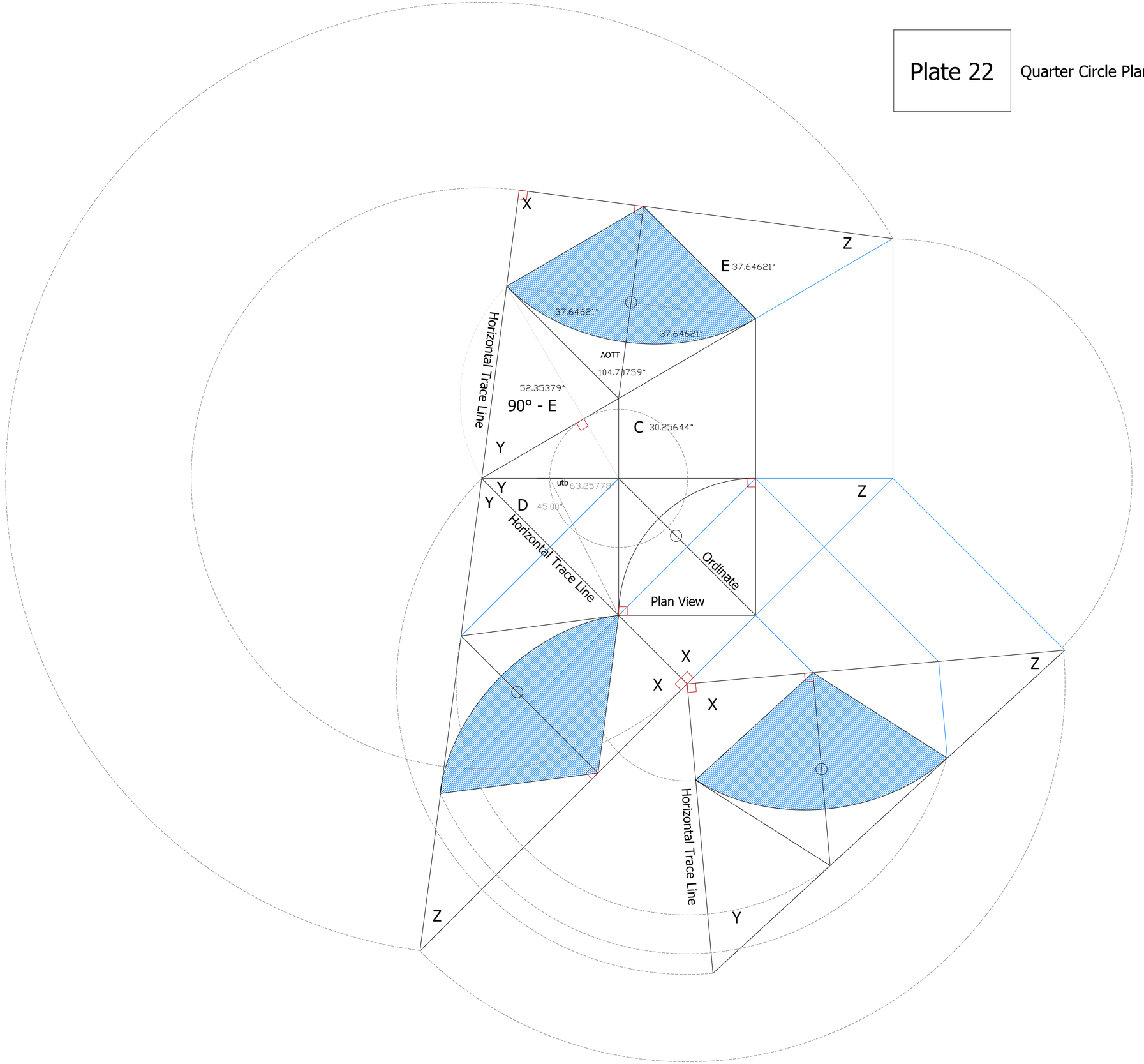
Tetrahedron Angles

D Angle = 47.2133581426
A Angle = 43.6546170252
C Angle = 35.0000000000
E Angle = 33.8089621505
B Angle = 27.9633525739

90-D Angle = 42.7866418574
90-A Angle = 46.3453829748
90-C Angle = 55.0000000000
90-E Angle = 56.1910378495
90-B Angle = 62.0366474261

Plate 22

Quarter Circle Plan with Equally Pitched Tangents



Plan View Section Plane Vertex Information
Plan = Square
Equal Pitched Tangents
Plan View Angle = 90.00000
Plan View Radius = 12.00000

Tangent Angles
Upper Tangent Angle = 30.25644
Lower Tangent Angle = 30.25644
Upper Twist Bevel Angle = 63.25779
Lower Twist Bevel Angle = 63.25779

Dihedral Angle at Upper Tangent Angle = 63.25779

R1 = 39.52120
R4Bm = 37.64621
R4Ba = 37.64621
Angle of the Tangents = 180° - 37.64621° - 37.64621 = 104.70759°

Ellipse Angles
Plan Angle DD = 45.00000
Plan Angle D = 45.00000
Minor Axis = 12.00000
Major Axis = 15.55635
Plan View Minor Axis Offset Length = 8.48528
Section Plane Minor Axis Offset Length = 11.00000

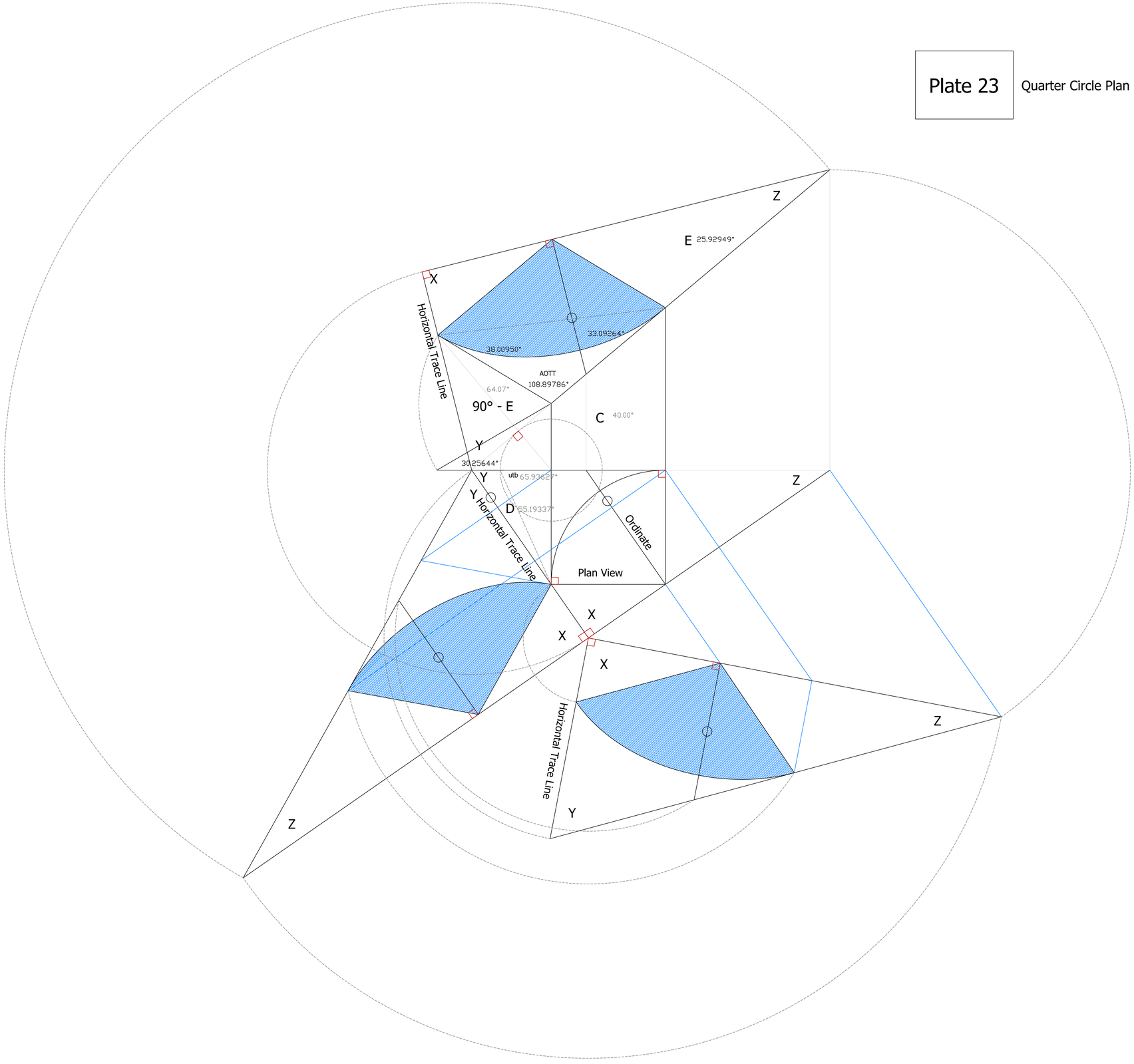
Tetrahedron Angles

D Angle = 45.00000
A Angle = 39.52120
C Angle = 30.25644
E Angle = 37.64621
B Angle = 26.74221

90-D Angle = 45.00000
90-A Angle = 50.47880
90-C Angle = 59.74356
90-E Angle = 52.35379
90-B Angle = 63.25779

Plate 23

Quarter Circle Plan with Shorter Pitched Tangent



Plan View Section Plane Vertex Information
Plan = Square
Unequal Pitched Tangents
Plan View Angle = 90.00000
Plan View Radius = 12.00000

Tangent Angles
Upper Tangent Angle = 40.00000
Lower Tangent Angle = 30.25644
Upper Twist Bevel Angle = 65.92208
Lower Twist Bevel Angle = 54.06553

Dihedral Angle at Upper Tangent Angle = 65.92208

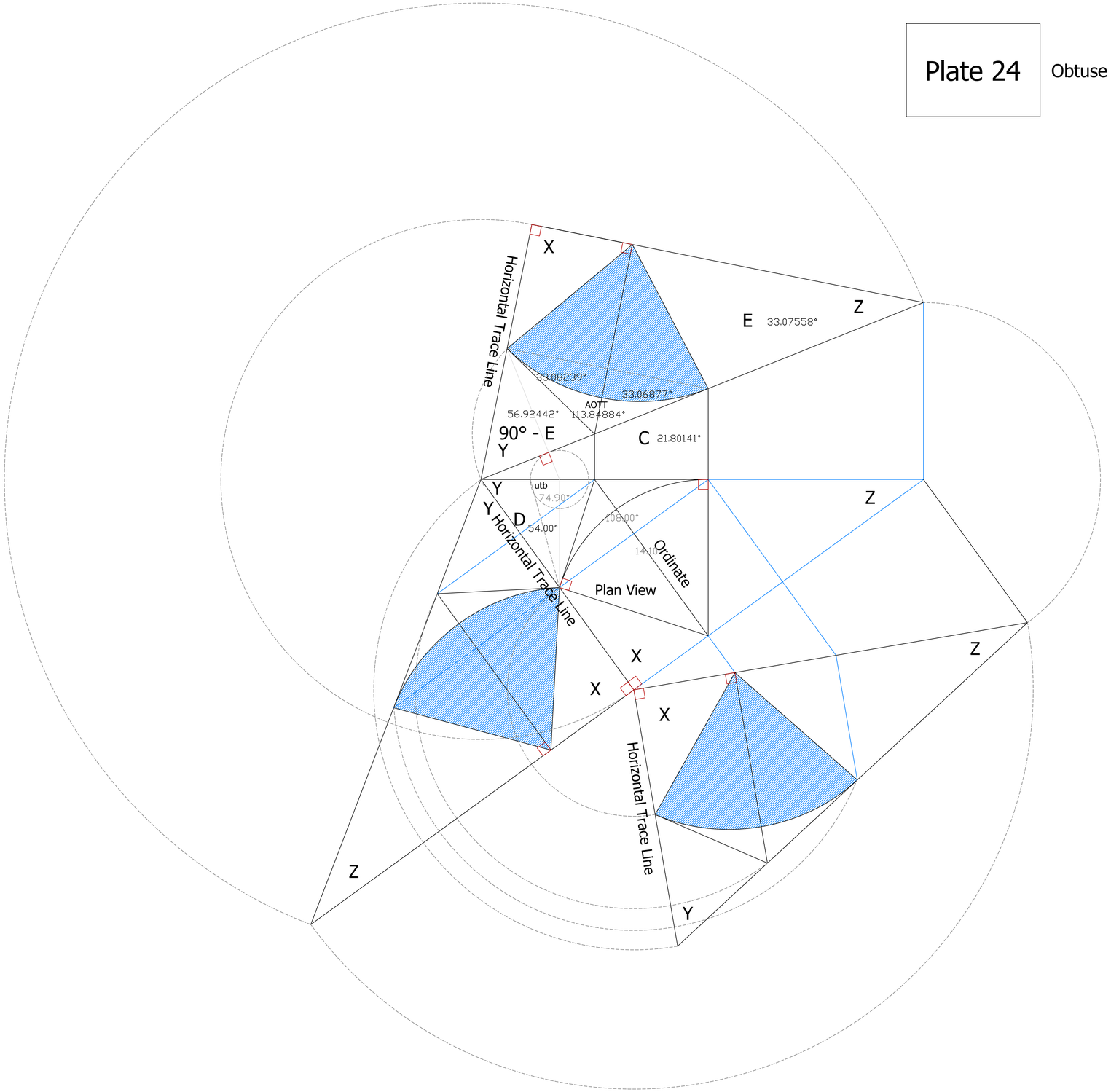
R1 = 45.62175
R4Bm = 25.92949
R4Ba = 45.17265
Angle of the Tangents = 180° - 25.92949° - 45.17265 = 108.89786°

Ellipse Angles
Plan Angle DD = 55.19337
Plan Angle D = 34.80663
Minor Axis = 12.00000
Major Axis = 17.15776
Plan View Minor Axis Offset Length = 9.85300
Section Plane Minor Axis Offset Length = 14.08795

Tetrahedron Angles	Tetrahedron Angles
D Angle = 55.19337	D Angle = 34.80663
A Angle = 45.62175	A Angle = 55.77399
C Angle = 40.00000	C Angle = 40.00000
E Angle = 25.92949	E Angle = 38.97537
B Angle = 24.07792	B Angle = 42.75715
90-D Angle = 34.80663	90-D Angle = 55.19337
90-A Angle = 44.37825	90-A Angle = 34.22601
90-C Angle = 50.00000	90-C Angle = 50.00000
90-E Angle = 64.07051	90-E Angle = 51.02463
90-B Angle = 65.92208	90-B Angle = 47.24285

Plate 24

Obtuse Plan with Equally Pitched Tangents



Plan View Section Plane Vertex Information
Plan = Obtuse
Equal Pitched Tangents
Plan View Angle = 108.00000
Plan View Radius = 8.71851

Tangent Angles
Upper Tangent Angle = 21.80141
Lower Tangent Angle = 21.80141
Upper Twist Bevel Angle = 74.89944
Lower Twist Bevel Angle = 74.89944

Dihedral Angle at Upper Tangent Angle = 74.89944

R1 = 26.30904
R4Bm = 33.07558
R4Ba = 33.07558
Angle of the Tangents = 180° - 33.07558° - 33.07558 = 113.84884°

Ellipse Angles
Plan Angle DD = 54.00000
Plan Angle D = 54.00000
Minor Axis = 8.71851
Major Axis = 9.72596
Plan View Minor Axis Offset Length = 5.12461
Section Plane Minor Axis Offset Length = 5.71678

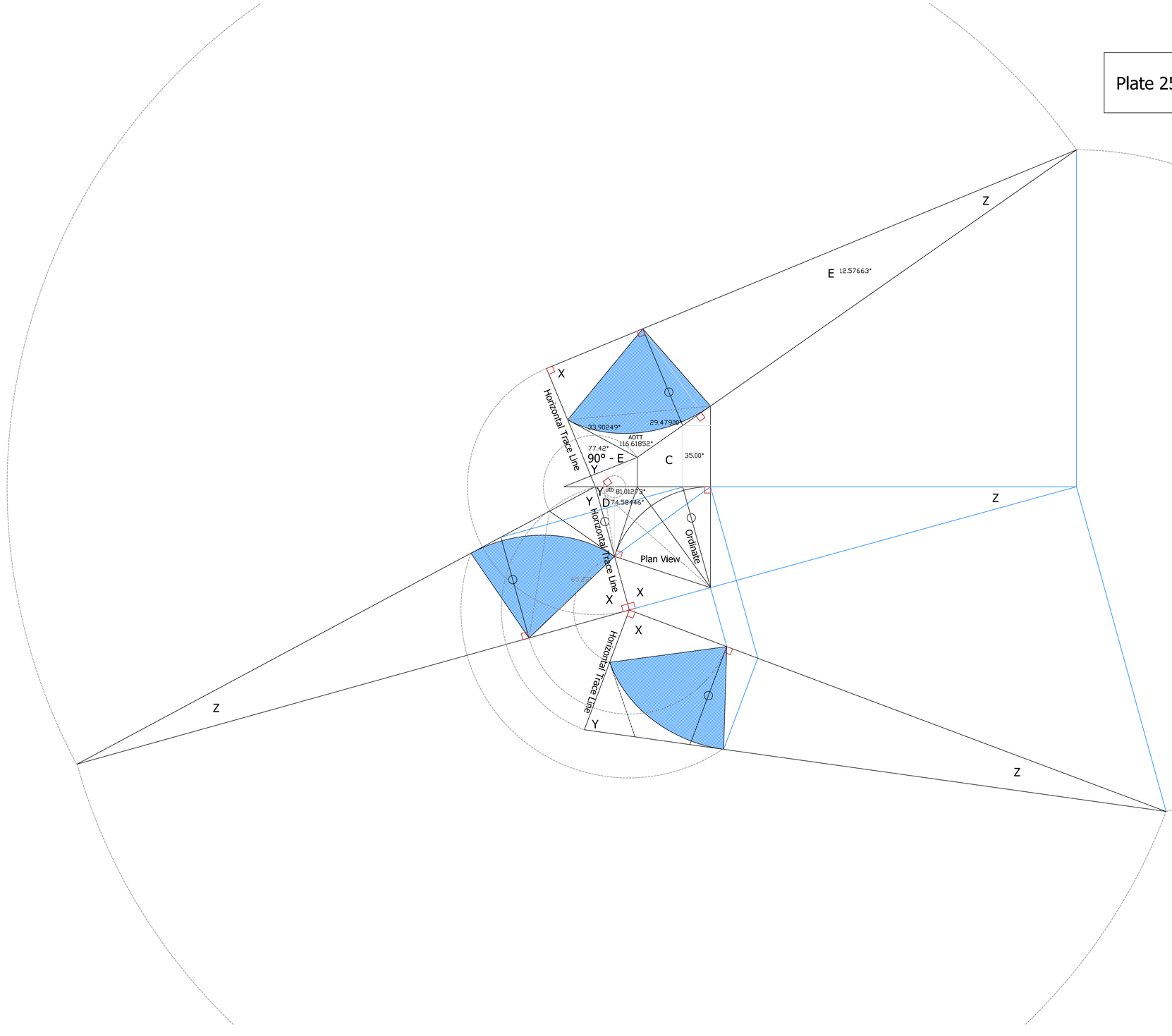
Tetrahedron Angles

D Angle = 54.00000
A Angle = 26.30904
C Angle = 21.80141
E Angle = 33.07558
B Angle = 15.10056

90-D Angle = 36.00000
90-A Angle = 63.69096
90-C Angle = 68.19859
90-E Angle = 56.92442
90-B Angle = 74.89944

Plate 25

Obtuse Plan with Shorter Pitched Tangent



Plan View Section Plane Vertex Information
Plan = Obtuse
Unequal Pitched tangents
Plan View Angle = 108.00000
Plan View Radius = 8.71851

Tangent Angles
Upper Tangent Angle = 35.00000
Lower Tangent Angle = 21.80141
Upper Twist Bevel Angle = 81.01273
Lower Twist Bevel Angle = 60.62435

Dihedral Angle at Upper Tangent Angle = 81.01273

R1 = 35.99236
R4Bm = 12.57663
R4Ba = 50.80486
Angle of the Tangents = 180° - 12.57663° - 50.80486 = 116.61852°

Ellipse Angles
Plan Angle DD = 74.58446
Plan Angle D = 33.41554
Minor Axis = 8.71851
Major Axis = 10.77563
Plan View Minor Axis Offset Length = 7.27733
Section Plane Minor Axis Offset Length = 8.99440

Tetrahedron Angles

D Angle = 74.58446
A Angle = 35.99236
C Angle = 35.00000
E Angle = 12.57663
B Angle = 8.98727

90-D Angle = 15.41554
90-A Angle = 54.00764
90-C Angle = 55.00000
90-E Angle = 77.42337
90-B Angle = 81.01273

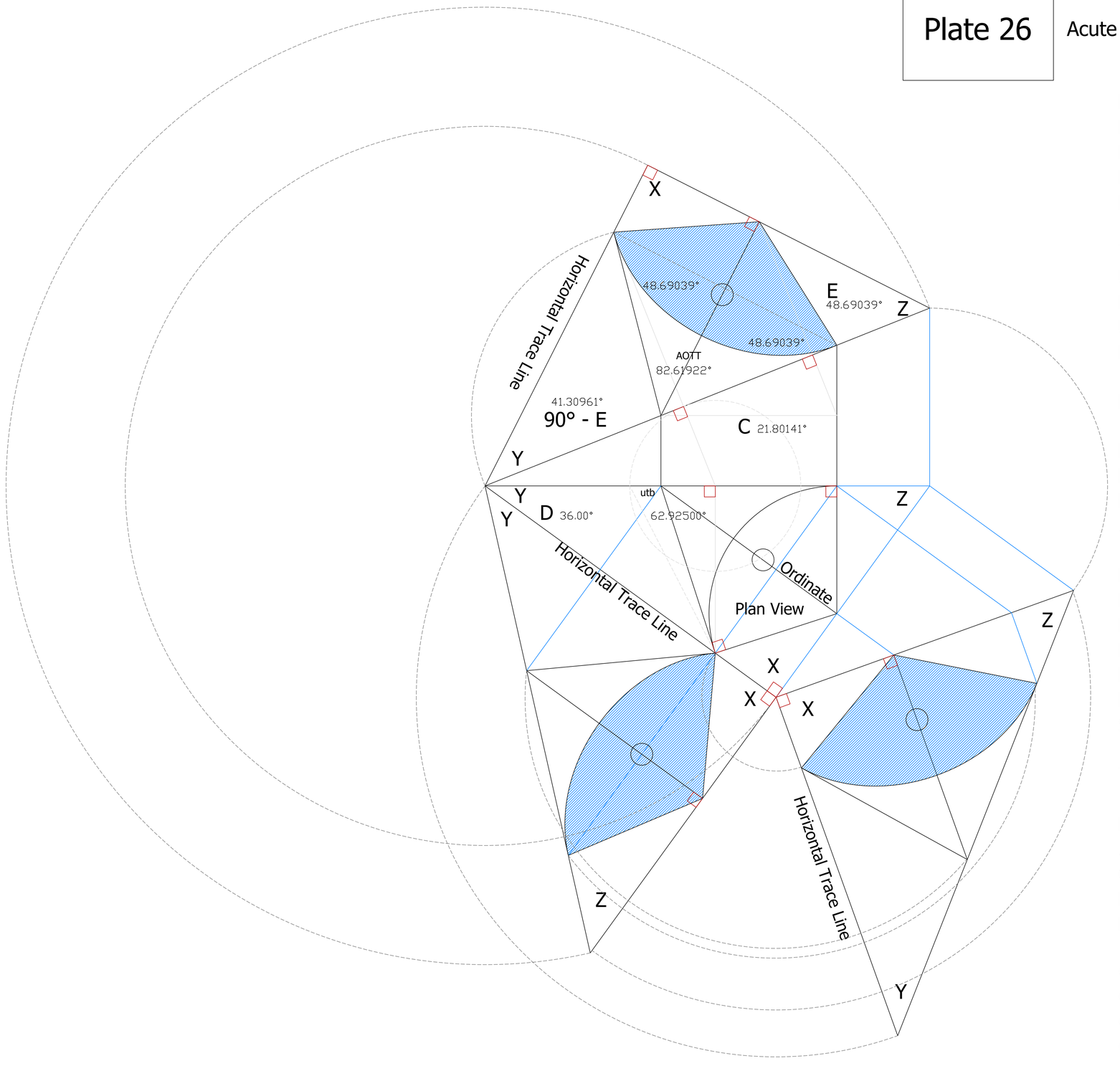
Tetrahedron Angles

D Angle = 33.41554
A Angle = 51.81525
C Angle = 35.00000
E Angle = 43.13699
B Angle = 41.00242

90-D Angle = 56.58446
90-A Angle = 38.18475
90-C Angle = 55.00000
90-E Angle = 46.86301
90-B Angle = 48.99758

Plate 26

Acute Plan with Equally Pitched Tangents



Plan View Section Plane Vertex Information
Plan = Acute
Equal Pitched Tangents
Plan View Angle = 72.00000
Plan View Radius = 8.71851

Tangent Angles
Upper Tangent Angle = 21.80141
Lower Tangent Angle = 21.80141
Upper Twist Bevel Angle = 62.92500
Lower Twist Bevel Angle = 62.92500

Dihedral Angle at Upper Tangent Angle = 62.92500

R1 = 34.23610
R4Bm = 48.69039
R4Ba = 48.69039
Angle of the Tangents = 180° - 48.69039° - 48.69039° = 82

Ellipse Angles
Plan Angle DD = 36.00000
Plan Angle D = 36.00000
Minor Axis = 8.71851
Major Axis = 10.54582
Plan View Minor Axis Offset Length = 7.05342
Section Plane Minor Axis Offset Length = 8.53175

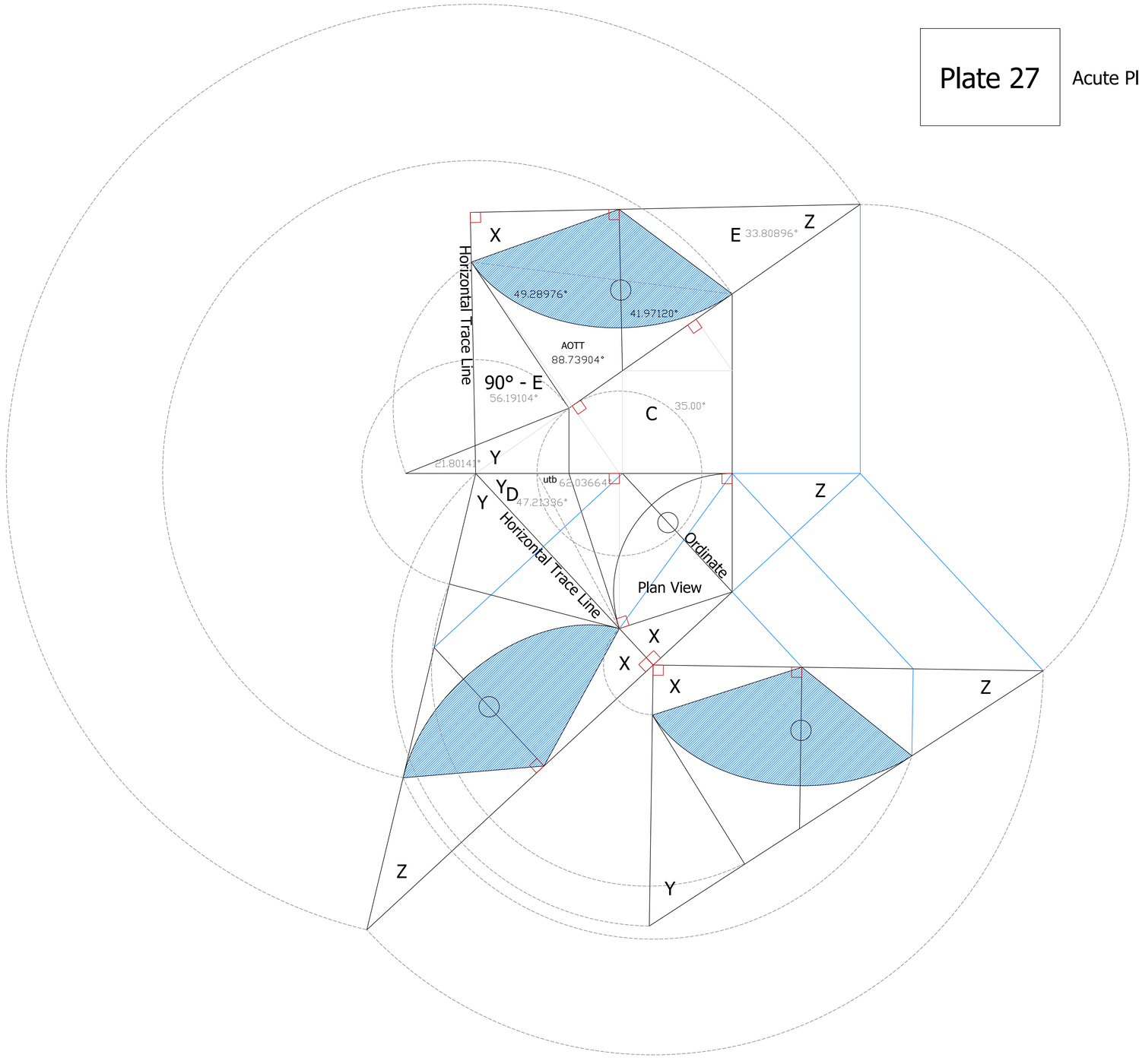
Tetrahedron Angles

D Angle = 36.00000
A Angle = 34.23610
C Angle = 21.80141
E Angle = 48.69039
B Angle = 27.07500

90-D Angle = 54.00000
90-A Angle = 55.76390
90-C Angle = 68.19859
90-E Angle = 41.30961

Plate 27

Acute Plan with Shorter Pitched Tangent



Plan View Section Plane Vertex Information
Plan = Acute
Unequal Pitched Tangents
Plan View Angle = 72.00000
Plan View Radius = 8.71851

Tangent Angles
Upper Tangent Angle = 35.00000
Lower Tangent Angle = 21.80141
Upper Twist Bevel Angle = 62.03665
Lower Twist Bevel Angle = 51.19183

Dihedral Angle at Upper Tangent Angle = 62.03665

R1 = 43.65462
R4Bm = 33.80896
R4Ba = 57.45200
Angle of the Tangents = 180° - 33.80896° - 57.45200 = 88.73904°

Ellipse Angles
Plan Angle DD = 47.21336
Plan Angle D = 24.78664
Minor Axis = 8.71851
Major Axis = 12.05023
Plan View Minor Axis Offset Length = 7.91532
Section Plane Minor Axis Offset Length = 10.94010

Tetrahedron Angles

D Angle = 47.21336
A Angle = 43.65462
C Angle = 35.00000
E Angle = 33.80896
B Angle = 27.96335

90-D Angle = 42.78664
90-A Angle = 46.34538
90-C Angle = 55.00000
90-E Angle = 56.19104
90-B Angle = 62.03665

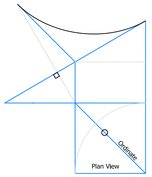
Tetrahedron Angles

D Angle = 24.78664
A Angle = 59.08947
C Angle = 35.00000
E Angle = 48.04652
B Angle = 51.16273

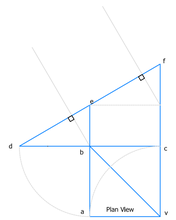
90-D Angle = 65.21336
90-A Angle = 30.91053
90-C Angle = 55.00000
90-E Angle = 41.95348
90-B Angle = 38.83727

Plate 28

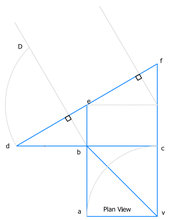
Tangent Handrailing step by step instructions for drawing the face mold pattern for a square plan and equal pitched vertical plane tangents.



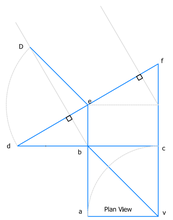
Plan View = Square
Equal Pitched Tangents



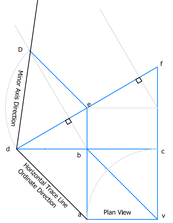
Step 1
a-b = d-b
Draw perpendiculars to upper tangent angle d-e-f



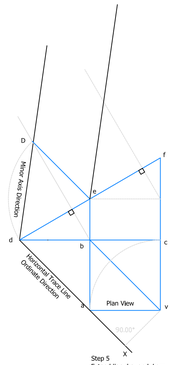
Step 2
Draw arc or circle equal to radius e-d from center point e



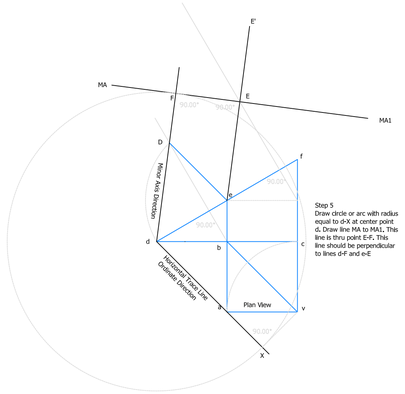
Step 3
Draw line from e to D for the angle of the tangents



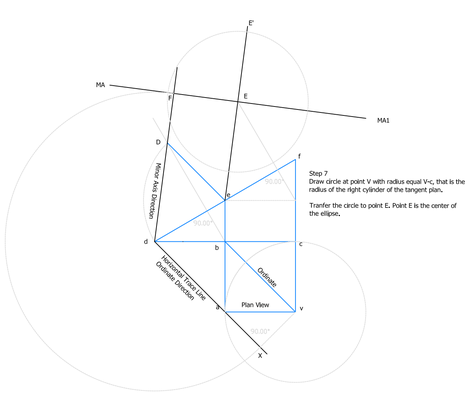
Step 4
Draw line from a to d for the Ordinate Direction
Draw line from d thru D for the Direction on the Minor Axis on the Oblique Section Plane



Step 5
Extend line d-a and draw line from V to X, perpendicluar to line d-a. Tranfer the line d-D, the dirrection of the minor axis of the ellipse to point e.

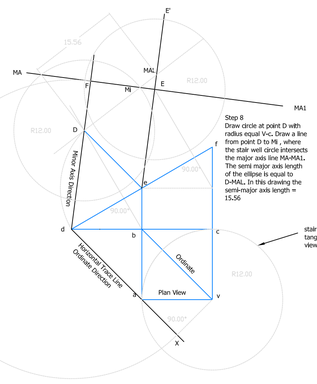


Step 5
Draw circle or arc with radius equal to d-X at center point d. Draw line MA to MA1. This line is thru point E-F. This line should be perpendicular to lines d-F and e-E



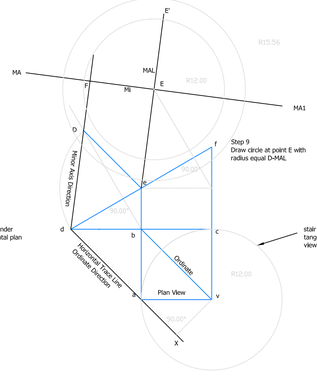
Step 7
Draw circle at point V with radius equal V-c_1 that is the radius of the right cylinder of the tangent plan.

Tranfer the circle to point E. Point E is the center of the ellipse.



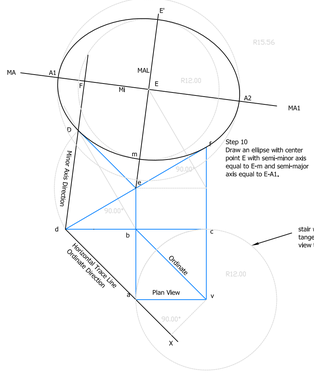
Step 8
Draw circle at point D with radius equal V-c_1. Draw a line from point D to M , where the stair well circle intersects the major axis line MA-MA1. The semi major axis length of the ellipse is equal to D-MAL. In this drawing the semi-major axis length = 15.56

stair well right cylinder tangent to horizontal plan view tangents.



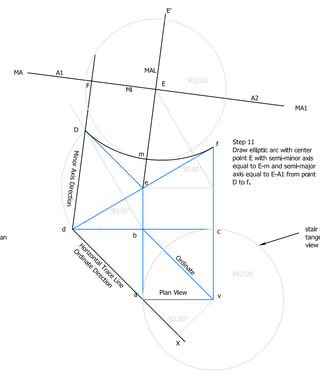
Step 9
Draw circle at point E with radius equal D-MAL

stair well right cylinder tangent to horizontal plan view tangents.



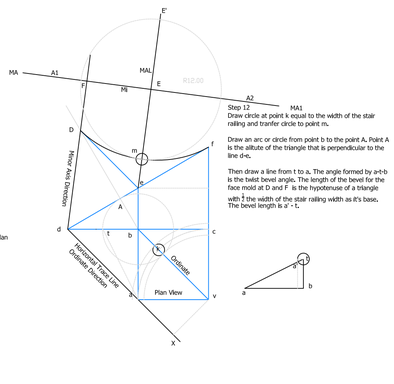
Step 10
Draw an ellipse with center point E with semi-minor axis equal to E-m and semi-major axis equal to E-A1.

stair well right cylinder tangent to horizontal plan view tangents.



Step 11
Draw elliptic arc with center point E with semi-minor axis equal to E-m and semi-major axis equal to E-A1 from point D to f.

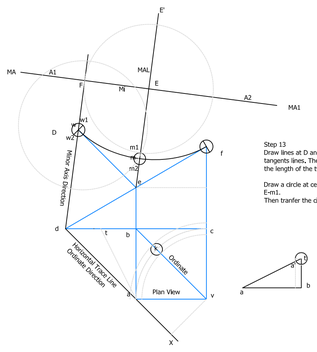
stair well right cylinder tangent to horizontal plan view tangents.



Step 12
Draw circle at point k equal to the width of the stair railing and tranfer circle to point m.

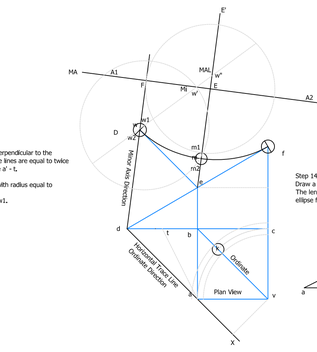
Draw an arc or circle from point b to the point A. Point A is the altitute of the triangle that is perpendicular to the line d-e.

Then draw a line from t to a. The angle formed by a-t-b is the twist bevel angle. The length of the bevel for the face mold at D and F is the hypotenuse of a triangle with $\frac{1}{2}$ the width of the stair railing width as it's base. The bevel length is a' - t.

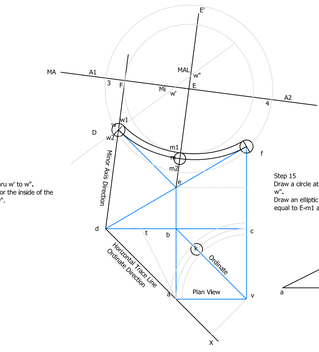


Step 13
Draw lines at D and f that are perpendicular to the tangents lines. The length of the lines are equal to twice the length of the twist bevel line a' - t.

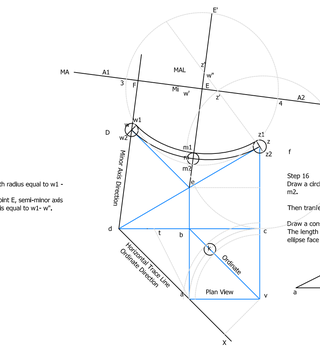
Draw a circle at center point E with radius equal to E-m1.
Then tranfer the circle to point w1.



Step 14
Draw a construction line from w1 thru w' to w".
The length of the semi-major axis for the inside of the ellipse face mold template is w1 - w".



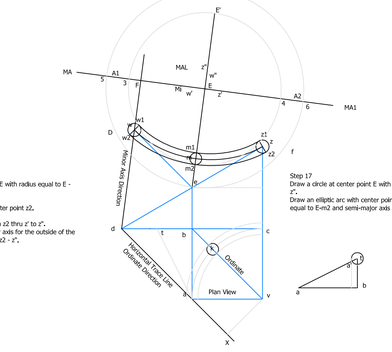
Step 15
Draw a circle at center point E with radius equal to w1 - w".
Draw an elliptic arc with center point E, semi-minor axis equal to E-m1 and semi-major axis equal to w1- w".



Step 16
Draw a circle at center point E with radius equal to E - m2.

Then tranfer the circle to center point z2.

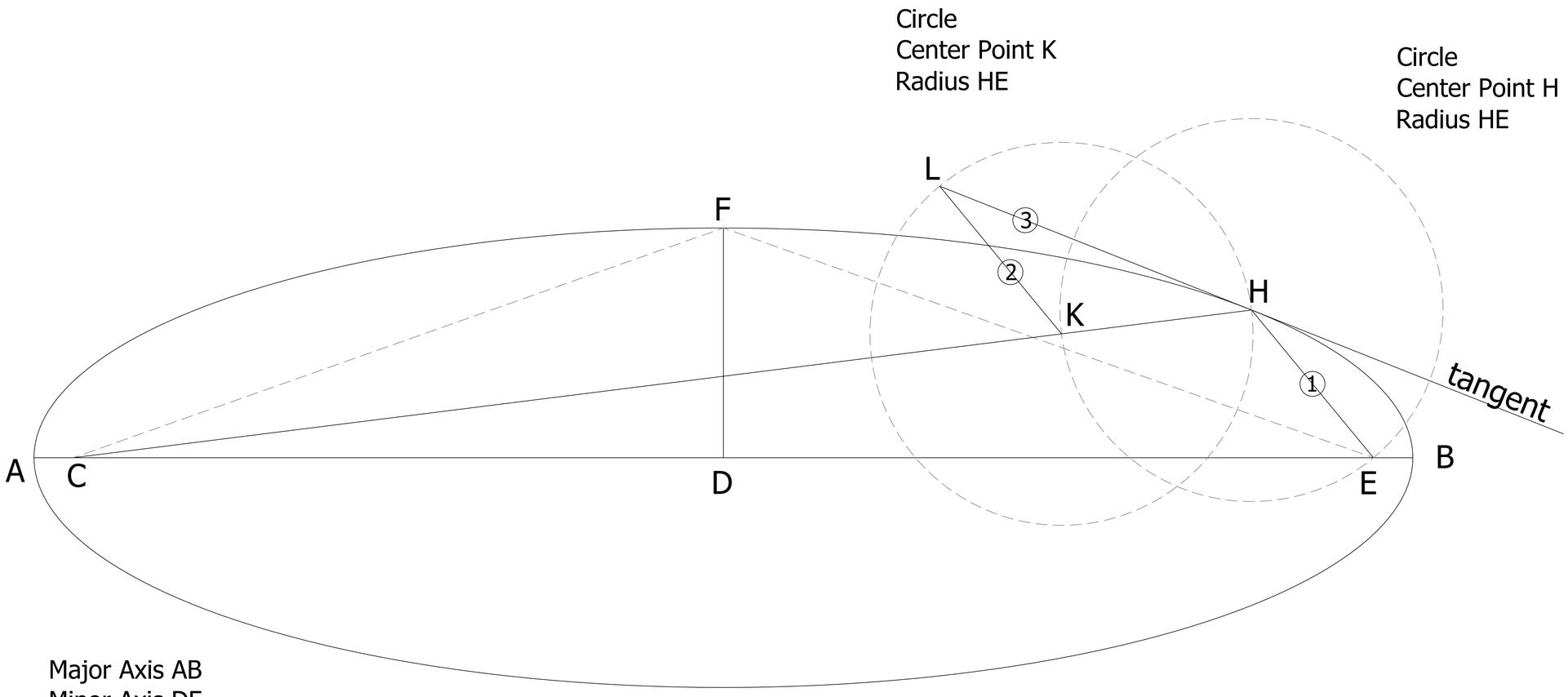
Draw a construction line from z2 thru z' to z".
The length of the semi-major axis for the outside of the ellipse face mold template is z2 - z".



Step 17
Draw a circle at center point E with radius equal to z2 - z".
Draw an elliptic arc with center point E, semi-minor axis equal to E-m2 and semi-major axis equal to z2- z".

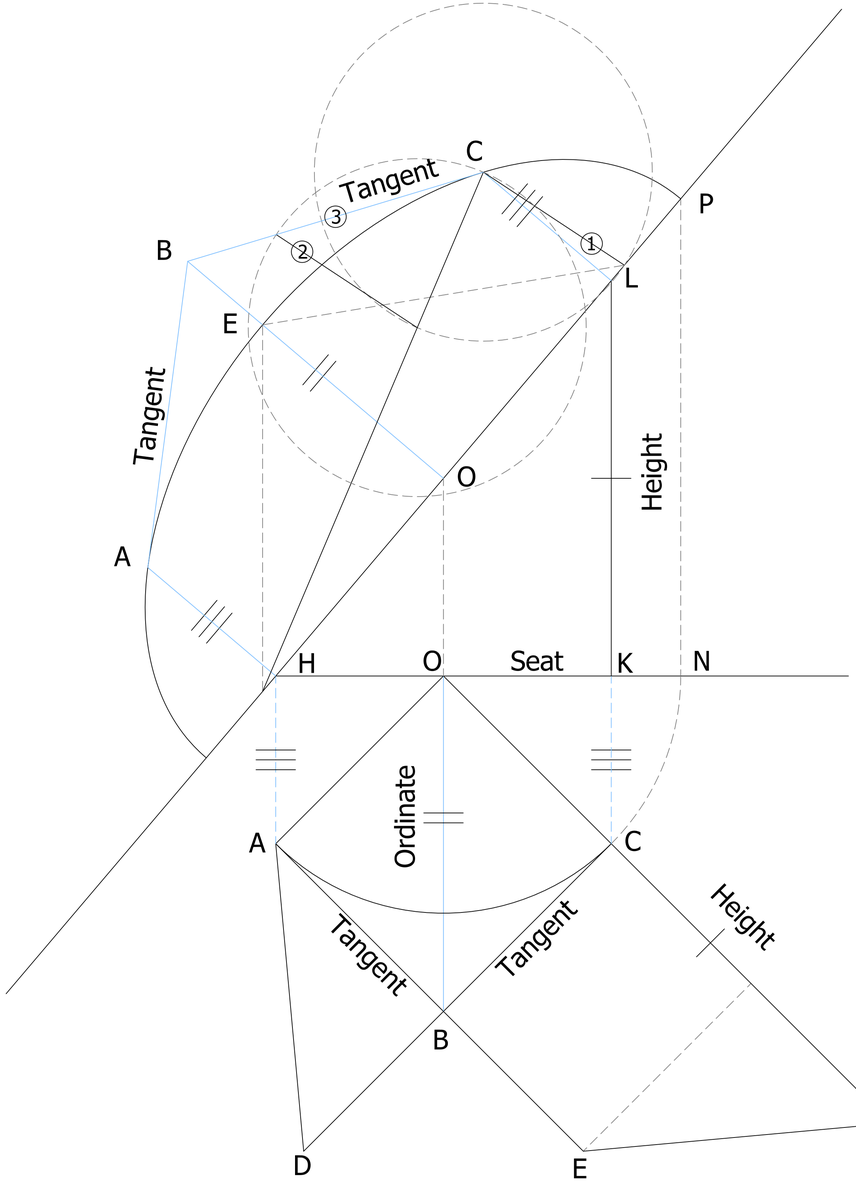
Plate 29

Tangent to an Ellipse
from New Elements of Hand-Railing
by Robert Riddell 1871



Major Axis AB
Minor Axis DF
CF = AD = DB
EF = AD = DB
Ellipse Foci C & E

Lines 1 and 2 are parallel and equal in length
Line 3 is tangent to the ellipse at point H



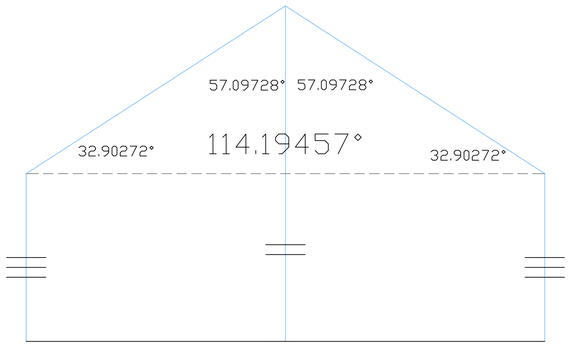


Plate 30

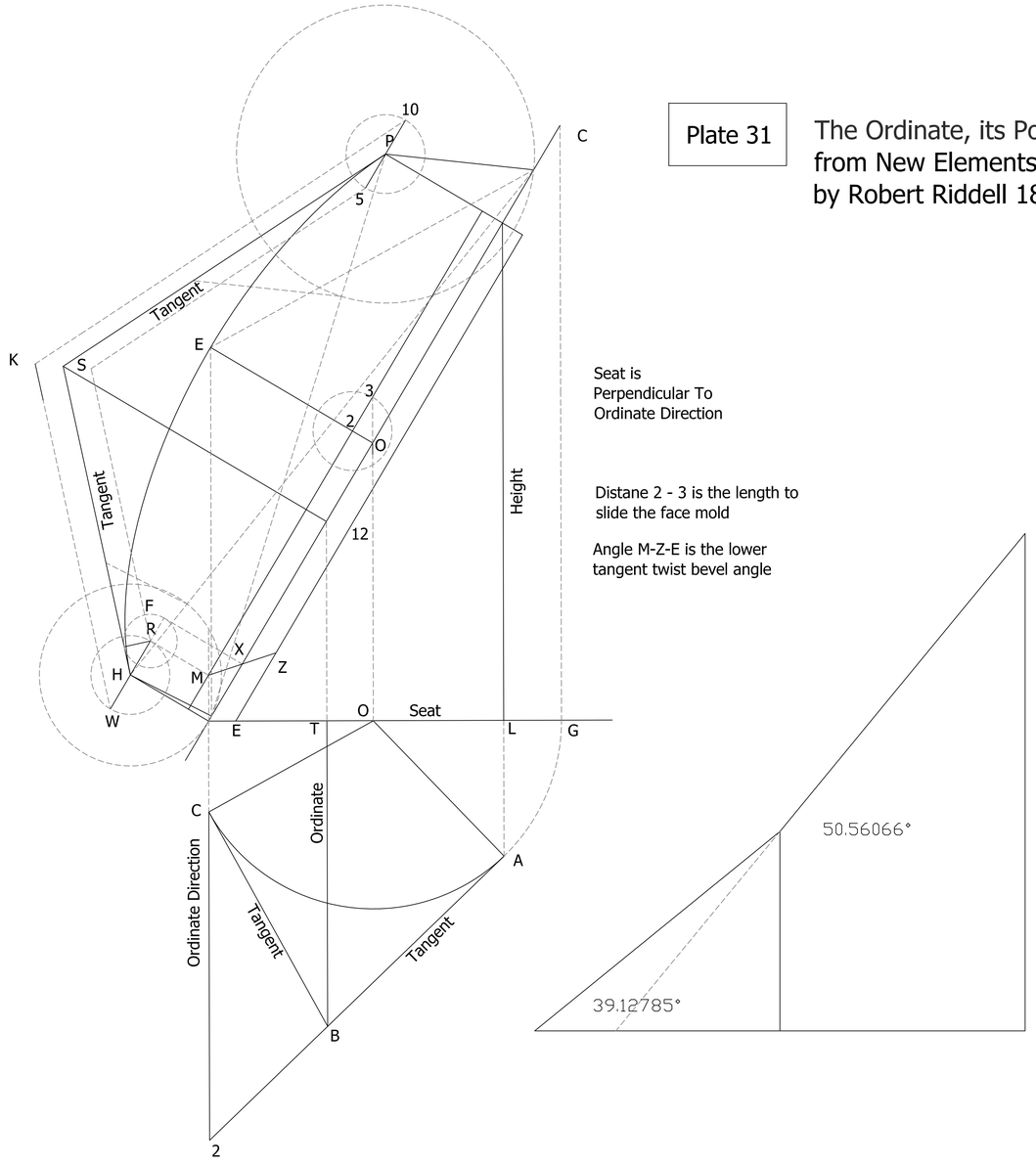
Tangent, Bevel and Elliptic Curve from New Elements of Hand-Railing by Robert Riddell 1871

Tangent Angles
Upper Tangent Angle = 39.80557
Lower Tangent Angle = 39.80557
Upper Twist Bevel Angle = 57.37326
Lower Twist Bevel Angle = 57.37326

Dihedral Angle at Upper Tangent Angle = 57.37326

R1 = 49.68446
R4Bm = 32.90273
R4Ba = 32.90273
Angle of the Tangents = 180° - 32.90273° - 32.90273 = 114.19454°

Ellipse Angles
Plan Angle DD = 45.00000
Plan Angle D = 45.00000
Minor Axis = 6.00000
Major Axis = 9.27362
Plan View Minor Axis Offset Length = 4.24264
Section Plane Minor Axis Offset Length = 6.55744
Major Axis inside rail width = 7.72802
Major Axis outside rail width = 10.81922



Seat is
Perpendicular To
Ordinate Direction

Distane 2 - 3 is the length to
slide the face mold

Angle M-Z-E is the lower
tangent twist bevel angle

Plate 31

The Ordinate, its Power and value in the Construction of Wreaths
from New Elements of Hand-Railing
by Robert Riddell 1871

Plan View Section Plane Vertex Information
Plan View Angle = 75.00000
Plan View Radius = 8.04494

Tangent Angles
Upper Tangent Angle = 50.56066
Lower Tangent Angle = 39.12785
Upper Twist Bevel Angle = 53.42673
Lower Twist Bevel Angle = 41.12187

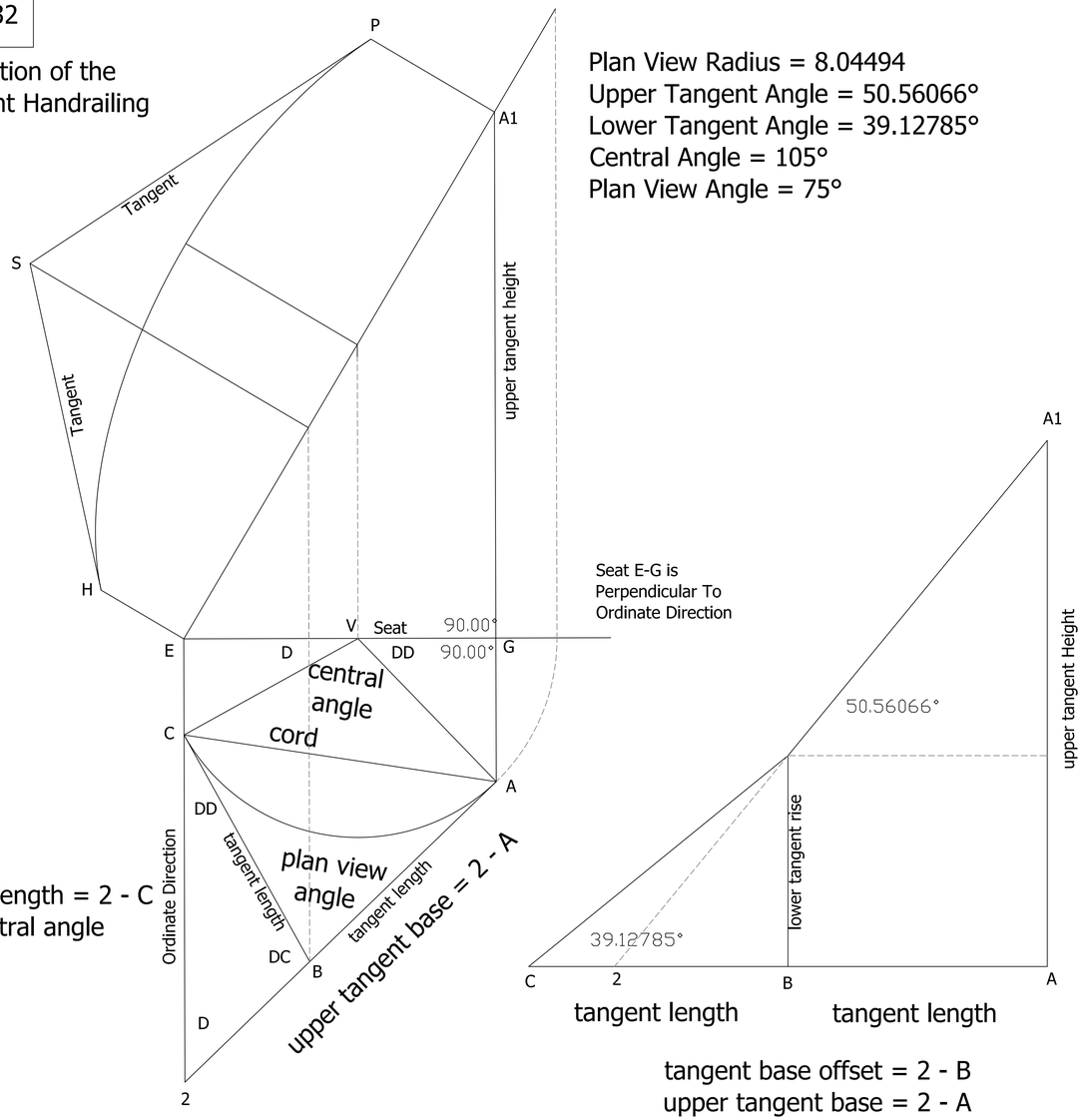
Dihedral Angle at Upper Tangent Angle = 53.42673

R1 = 59.32450
R4Pm = 26.11051
R4Pa = 42.80063
Angle of the Tangents = 180° - 26.11051° - 42.80063 = 111.08886°

Ellipse Angles
Plan Angle DD = 46.14845
Plan Angle D = 28.85155
Minor Axis = 8.04494
Major Axis = 15.76897

Plate 32

Elucidation of the Tangent Handrailing Angles



Plan View Radius = 8.04494
Upper Tangent Angle = 50.56066°
Lower Tangent Angle = 39.12785°
Central Angle = 105°
Plan View Angle = 75°

ordinate length = 2 - C
DC = central angle

tangent base offset = 2 - B
upper tangent base = 2 - A

cord = 2 * Radius * sin(central angle ÷ 2) = 12.76496
tangent length = (Radius * sin(central angle ÷ 2)) ÷ cos(central angle ÷ 2) = 10.48436
lower tangent rise = tangent length * tan(lower tangent angle)
lower tangent rise = 10.48436 * tan(39.12785) = 8.52888
tangent base offset = lower tangent rise ÷ tan(upper tangent angle)
tangent base offset = 8.52888 ÷ tan(50.56066) = 7.015515
upper tangent base = tangent length + tangent base offset
upper tangent base = 10.48436 + 7.015515 = 17.49988
upper tangent height = upper tangent base ÷ tan(upper tangent angle)
upper tangent height = 17.49988 * tan(50.56066) = 21.2749033461

ordinate length = $\sqrt{}$ (($cord^2$ +$upper\ tangent\ base^2$) - (2 * cord * upper tangent base * cos(central angle ÷ 2))
ordinate length = $\sqrt{}$ ((469.1900038160) - (2 * 12.76496 * 17.49988 * cos(52.5))
ordinate length = $\sqrt{}$ ((469.1900038160) - (271.9766701837) = 14.0432664873

angle D = arccos(($upper\ tangent\ base^2$ + $ordinate\ length^2$ - $cord^2$) ÷ (2 * upper tangent base * ordinate length))
angle D = arccos((17.49988^2 + 14.0432664873^2 - 12.76496^2) ÷ (2 * 17.49988 * 14.0432664873))
angle D = arccos((340.515206998) ÷ (491.511223015)) = 46.148445275

angle DD = 180° - central angle - angle D
angle DD = 180° - 105 - 46.148445275 = 28.851554725

seat = (Radius * cos(angle DD)) + (Radius * cos(angle D))
seat = (8.04494 * cos(28.851554725)) + (8.04494 * cos(46.148445275)) = 12.6195363496

pitch of plank = arctan(upper tangent height ÷ seat)
pitch of plank = arctan(21.2749033461 ÷ 12.6195363496) = 59.3250488281

semi-major axis = Radius ÷ cos(pitch of plank)
semi-major axis = 8.04494 ÷ cos(59.3250488281) = 15.7692298976