BASIC SURFACES FOR ENGINEERING

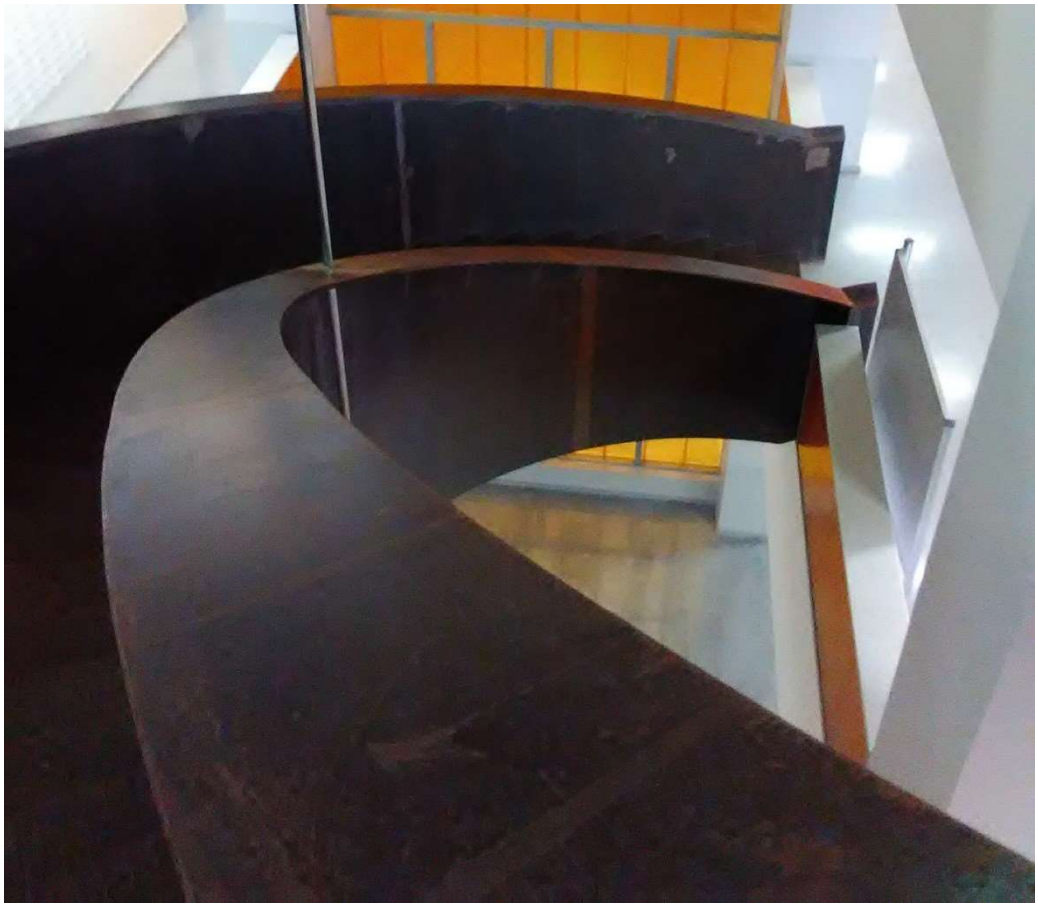

Figure 00. Main stairs of Engineering School of Bilbao II. Picture made by the authors, 2018.

4. Surface development

Content

4. SURFACE DEVELOPMENT

At the end of this topic, it is expected that the students will be able to:

- Identify developable surfaces.
- Calculate the development of the developable surfaces studied in class
- Calculate the transformation of those same surfaces.
- Select the most appropriate graphic method for each case.
- To develop skills to carry out graphic operations to resolve geometric problems where surfaces are involved.

For an adequate follow-up of this topic it is necessary to have achieved the learning results of the previous topics:

- Surfaces: Representation.
- Dihedral System: Turns.
- Flat section layout.

A surface is developable when it can be extended over a plane without distortion or breakage.
Prismatic, cylindrical, pyramidal and conical surfaces are all developable. The spherical surface is a non-developable surface.

The generatrices of a surface are in real magnitude in development.

The straight section is of great importance in the development of prismatic and cylindrical surfaces, since its transformation is a straight line because all the generatrixes form the same angle (90º) with the line of the section. *See section* 3.4.3.

Figure 4.1. Straight cylinder development example.
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http://estaticos03.elmundo.es/elmundo/imagenes/2012/06/07/paisvasco/1339086618_0.jpg

4.1 DEVELOPMENTS

4.1.1 Pyramid

Straight pyramid:

When the pyramid is straight, the development of the lateral surface consists of as many triangles, equal to each other, as the sides have the guideline. See figures 4.2 and 4.3.

Generally, triangles are isosceles, unless the length of the lateral edges and the side of the generatrix coincide, in which case the development consists of 3 equilateral triangles and the surface is called a tetrahedron.

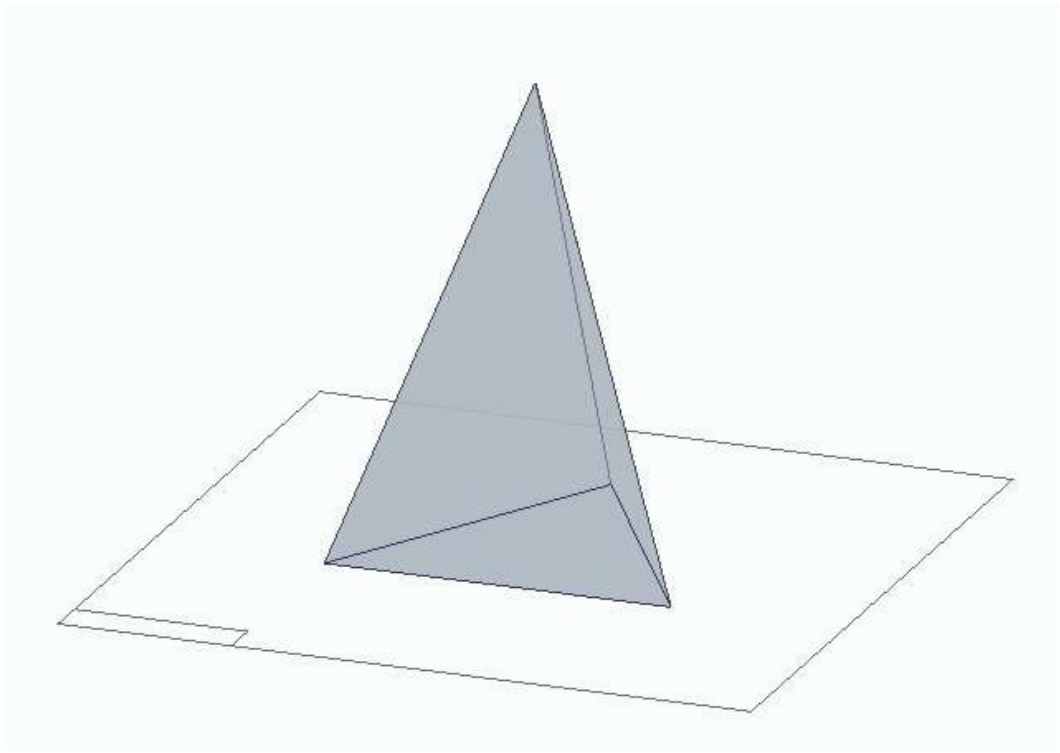


Figure 4.2. Straight pyramid (Image made with Solid Edge)

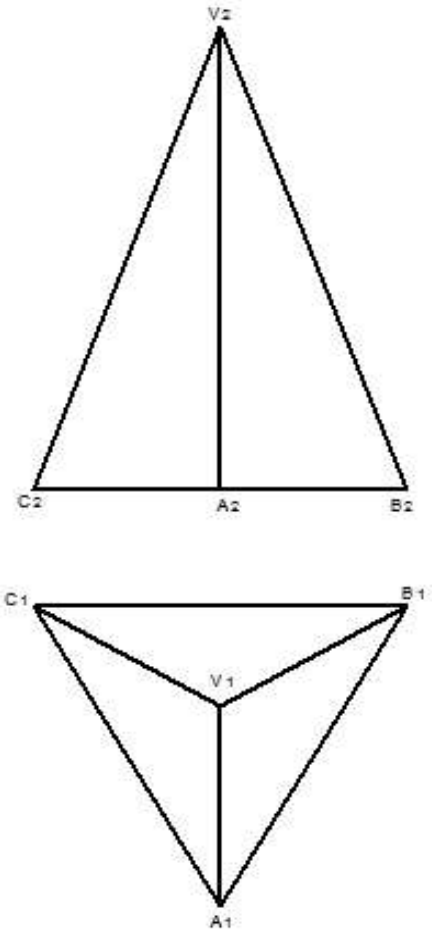


Figure 4.3. Projections of a straight pyramid (Image made with Solid Edge)

To find the surfaces of the three triangles, the dimensions of their edges are found by rotating them. In this case, as it is a straight pyramid with a regular base, the three triangles are equal. See figure 4.4.

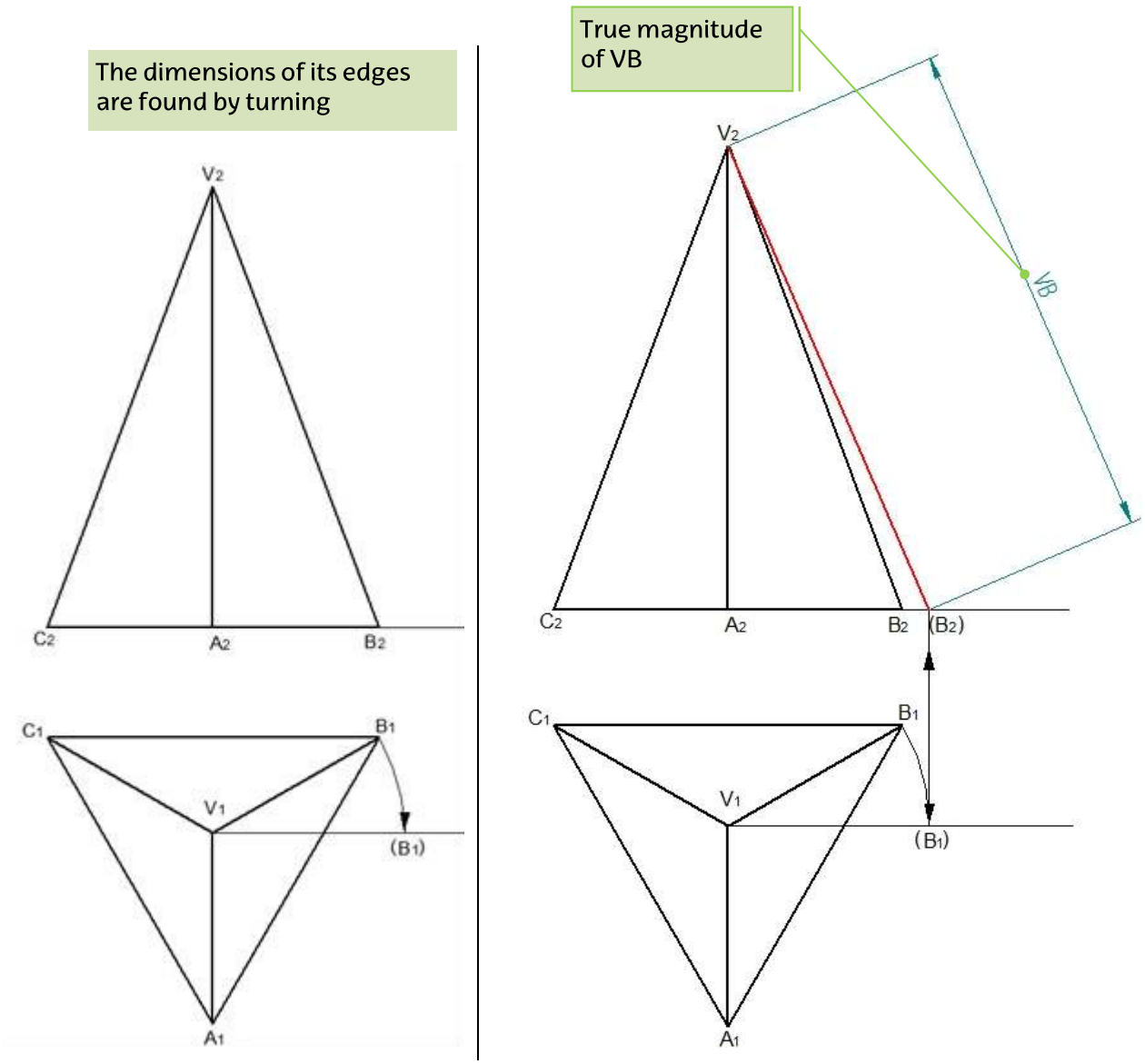


Figure 4.4. Projections of a straight pyramid (Image made with Solid Edge)

To carry out the development we place VB and take the real magnitudes of VC and BC with the compass to find point C. See figure 4.5.

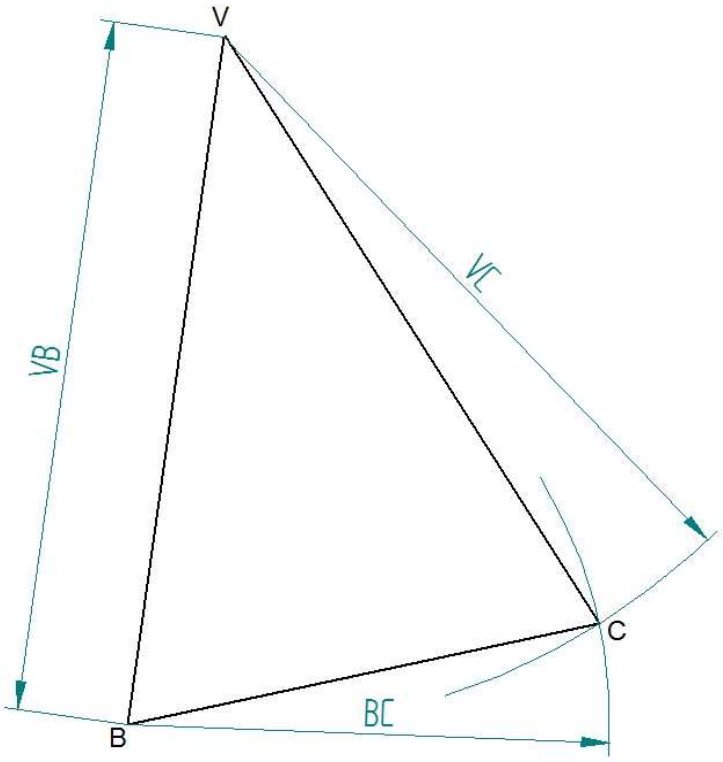


Figure 4.5. Method for drawing the development of a straight pyramid (Image made with Solid Edge)

The same is done to get point A and finish the development. See figure 4.6.

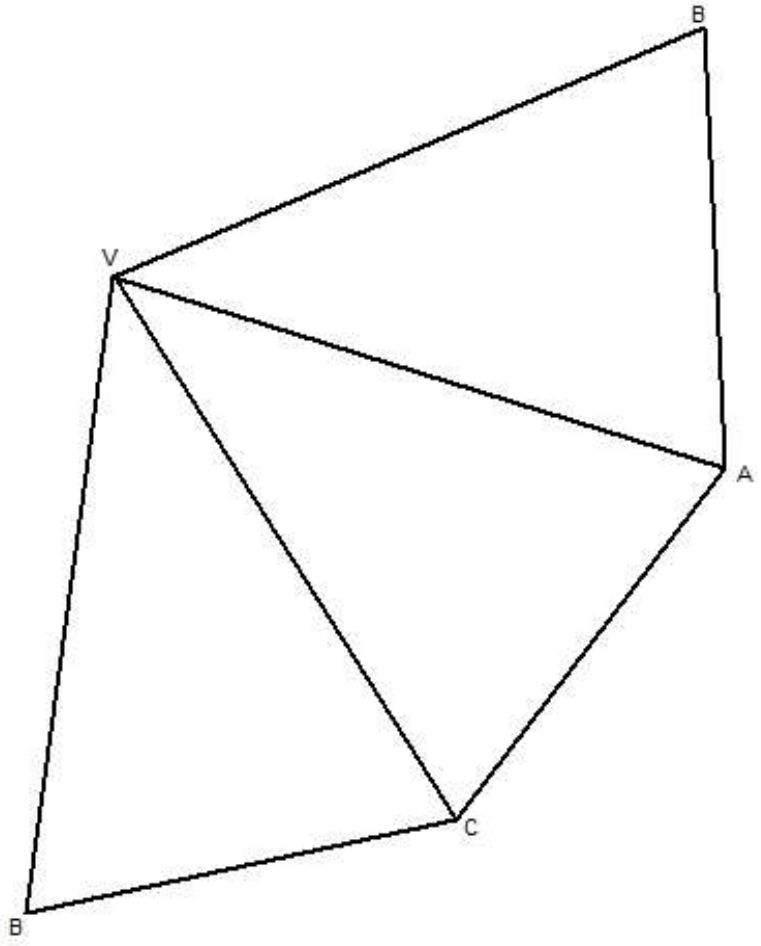


Figure 4.6. Method for drawing the development of a straight pyramid (Image made with Solid Edge)

Oblique pyramid:

See section DEVELOPMENT AND TRANSFORMATION EXERCISES OF THE SECTIONS.

4.1.2 Cone

Straight cone:

When the cone is straight of revolution, the development of the lateral surface is a circular sector, of radius the value of the generator and the length of the arc equal to that of the directional circumference. Therefore, the value of the angle at the vertex of the circular sector is:

$$^{o} = 360^{o} \cdot r / g$$

See section DEVELOPMENT AND TRANSFORMATION EXERCISES OF THE SECTIONS.

When the cone is straight but not revolutionary, the general method of finding the development of the lateral surface is to replace it with an inscribed pyramid. The development obtained is approximate and the curve of the guideline in the development is drawn with some imprecision. The accuracy is improved by knowing that the directrix curve is tangent to the longer and shorter generatrices. Generally, the opening generator in the development is the shortest one.

Oblique cone:

If the cone is not of revolution, but has a circular guideline, the surface has a plane of symmetry that is formed by the shorter and longer generatrices. Then, for greater simplicity of the development, the plane of symmetry of the conical surface must also be the plane of symmetry of the inscribed pyramidal surface. Generally, the opening generatrix in the development is the shortest, so the longest generator is the axis of symmetry of the development. See figure 4.7 and 4.8.

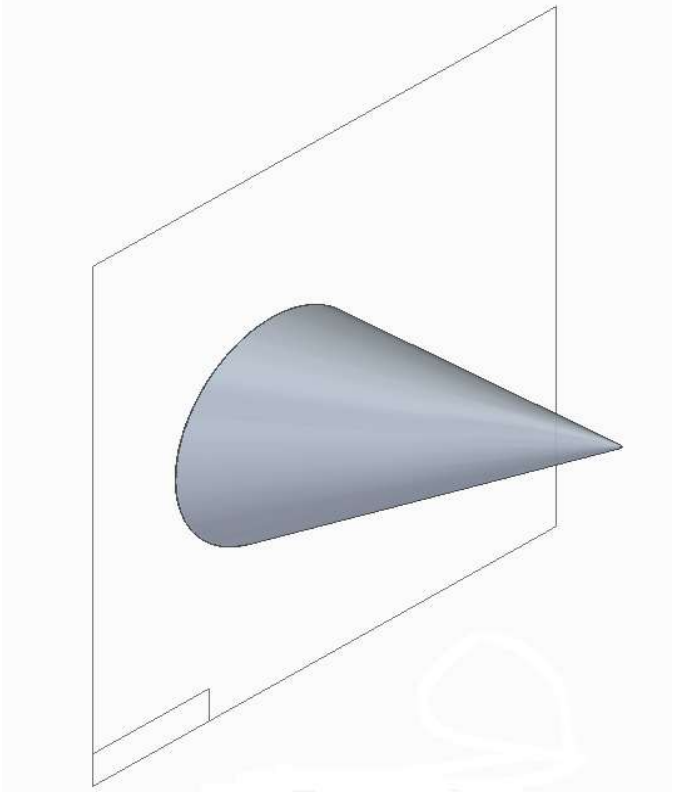


Figure 4.7. Oblique cone (Image made with Solid Edge)

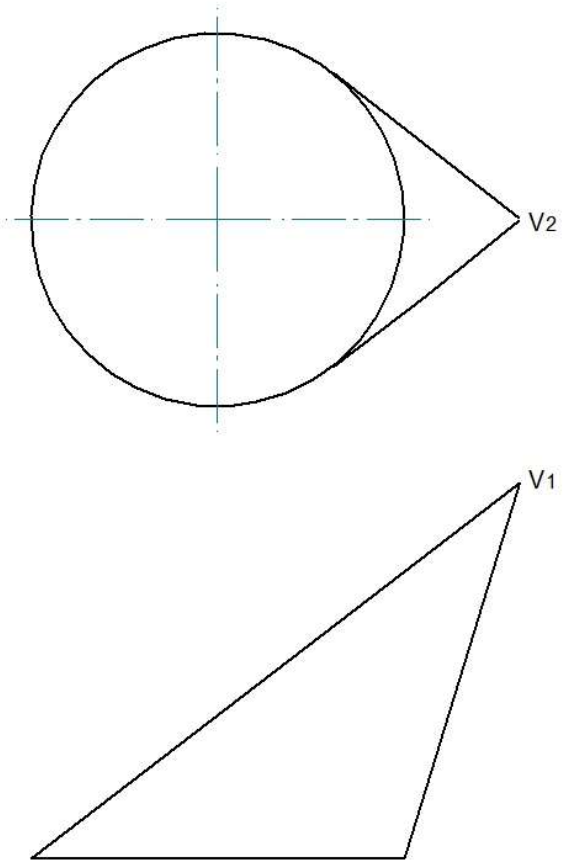


Figure 4.8. Projections of an oblique cone (Image made with Solid Edge)

The generatrices to find the development will be of different lengths so it is necessary to divide the base in a minimum of 12 equal parts and then find the true magnitudes of the 12 generatrices with which the development will be built. See figure 4.9.

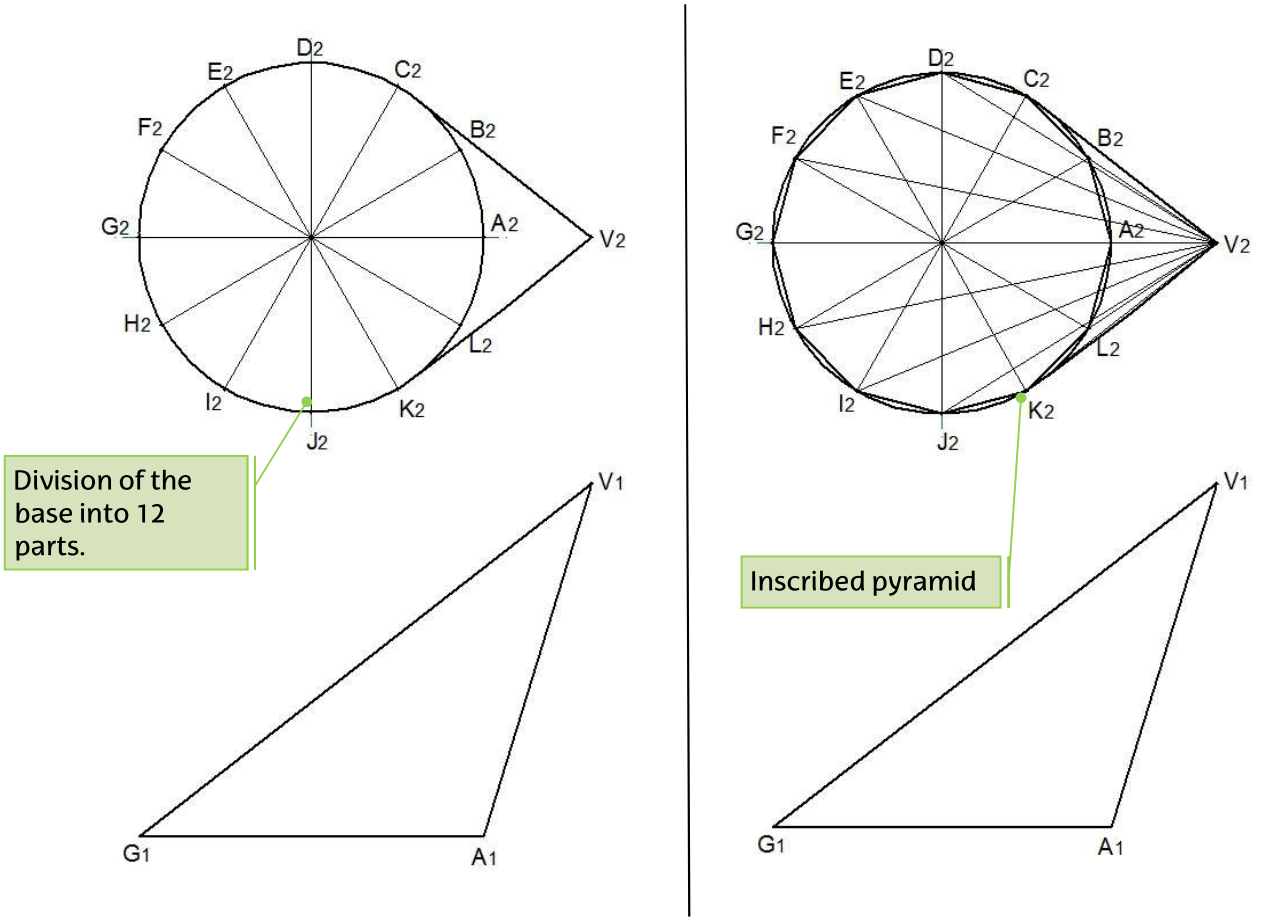


Figure 4.9. Method for tracing the development of an oblique cone (Image made with Solid Edge)

The true magnitudes are obtained by spinning. See figures 4.10 and 4.11.

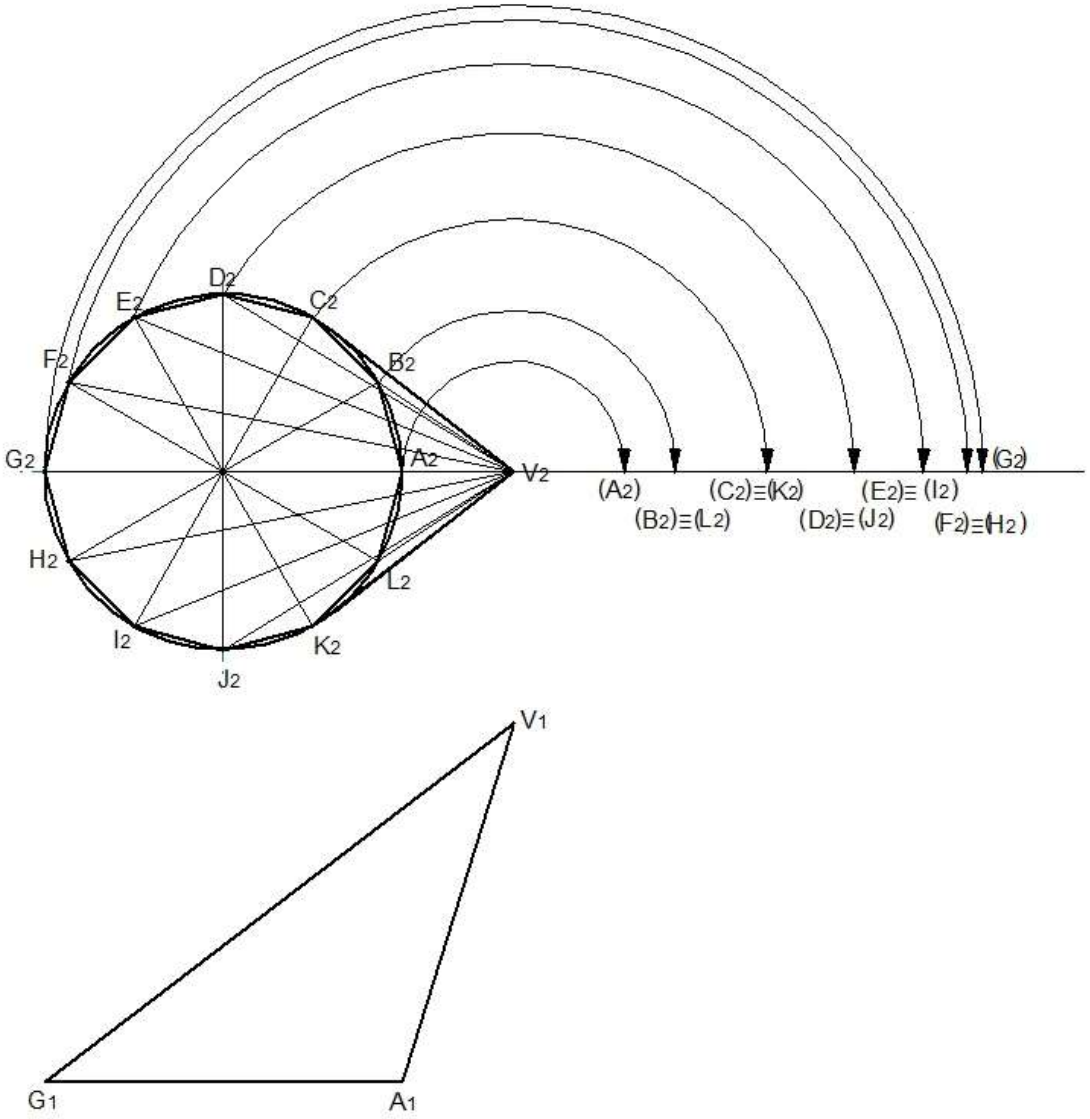


Figure 4.10. Method for tracing the development of an oblique cone (Image made with Solid Edge)

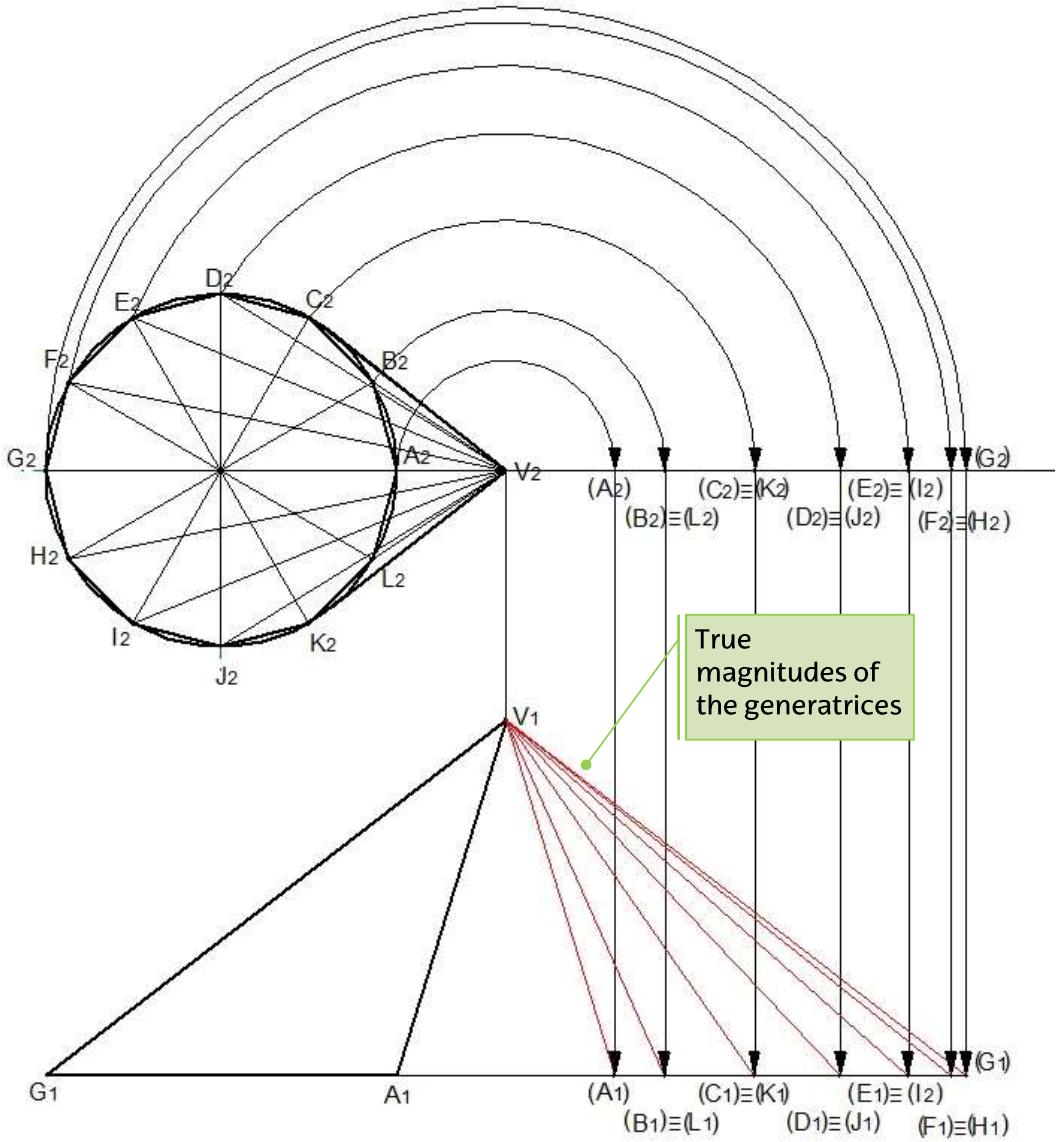


Figure 4.11. Method for tracing the development of an oblique cone (Image made with Solid Edge)

The first VA element is placed and the distances are carried out with a compass successively: AB and VB to find point B, BC and VC to find point C and at the end join the points. See figure 4.12.

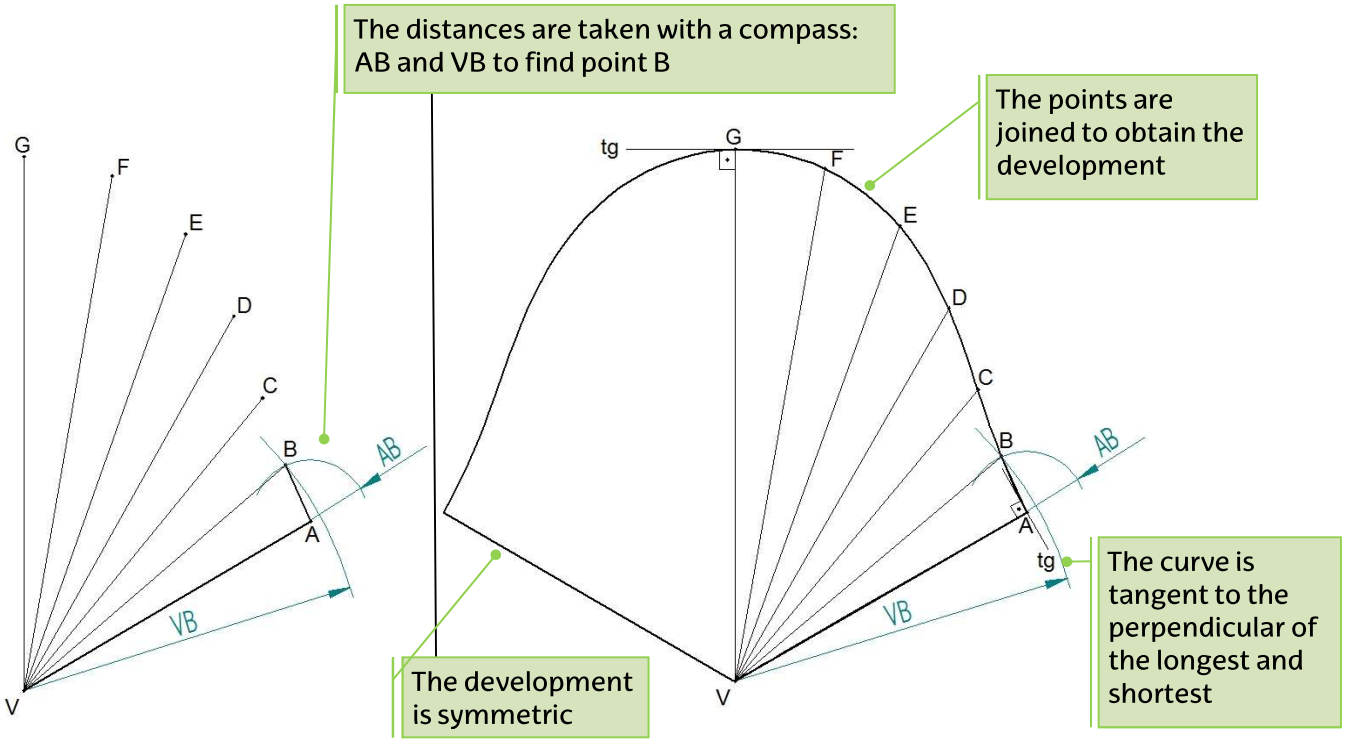


Figure 4.12. Method for tracing the development of an oblique cone (Image made with Solid Edge)

4.1.3 Prism

Straight prism:

When the prism is straight, the development of the side surface consists of as many rectangles as the sides have the guideline. The complete development of the lateral surface is a rectangle of sides the length of the lateral edges and the perimeter of the guideline. The lateral edges and the guideline are perpendicular to the development because the guideline is a straight section of the prismatic surface.

See section DEVELOPMENT AND TRANSFORMATION EXERCISES OF THE SECTIONS.

Oblique prism:

When the prism is oblique, the development of the lateral surface consists of as many parallelograms as the sides have the guideline. See figures 4.13 and 4.14. The general method for finding the development of the lateral surface is to make a straight section. See figure 4.15. This section is a straight line in the development, to which the lateral edges are perpendicular. The development is traced by taking the distances of the corresponding lateral edges to each side of the straight section. See figure 4.16.

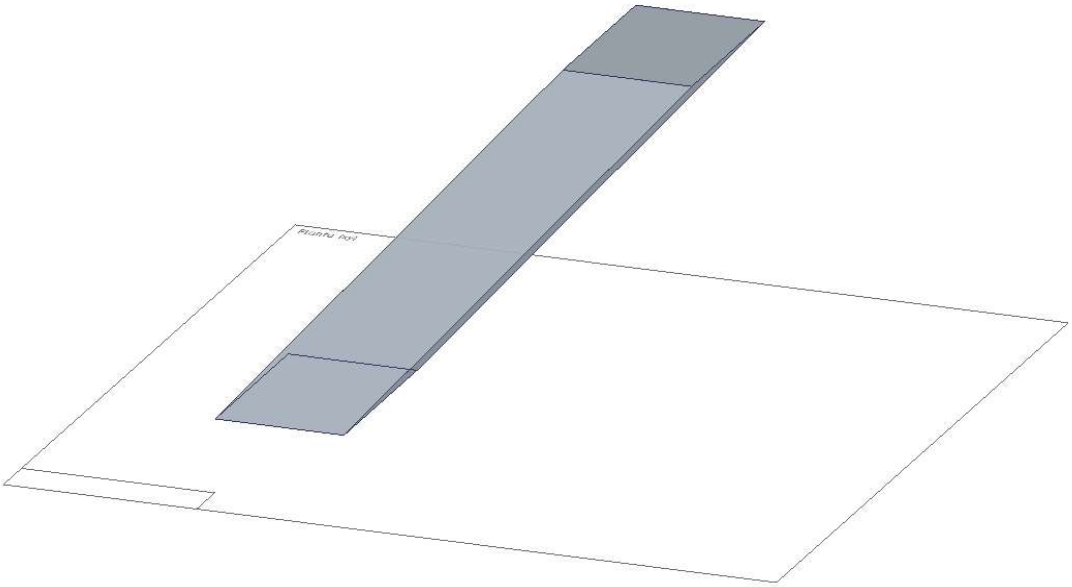
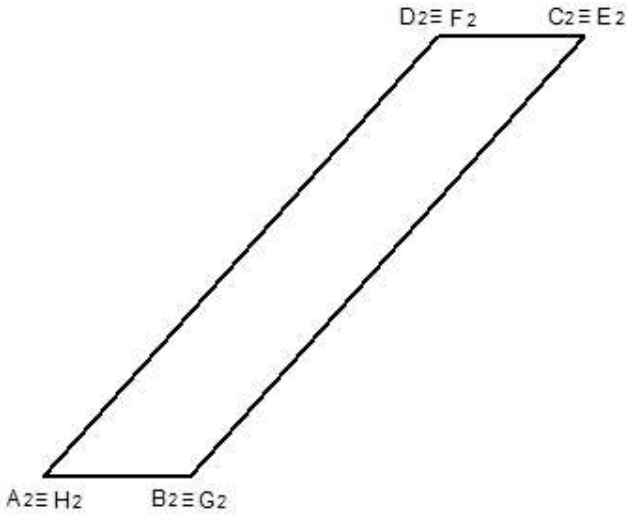


Figure 4.13. Oblique prism (Image made with Solid Edge)



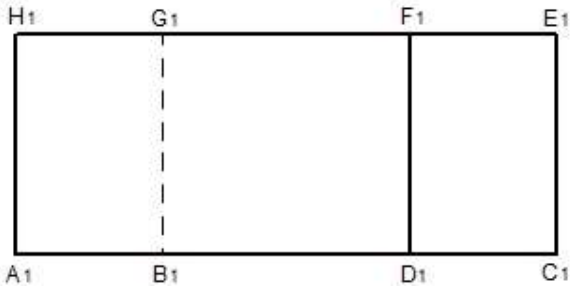


Figure 4.14. Projections from an oblique prism (Image made with Solid Edge)

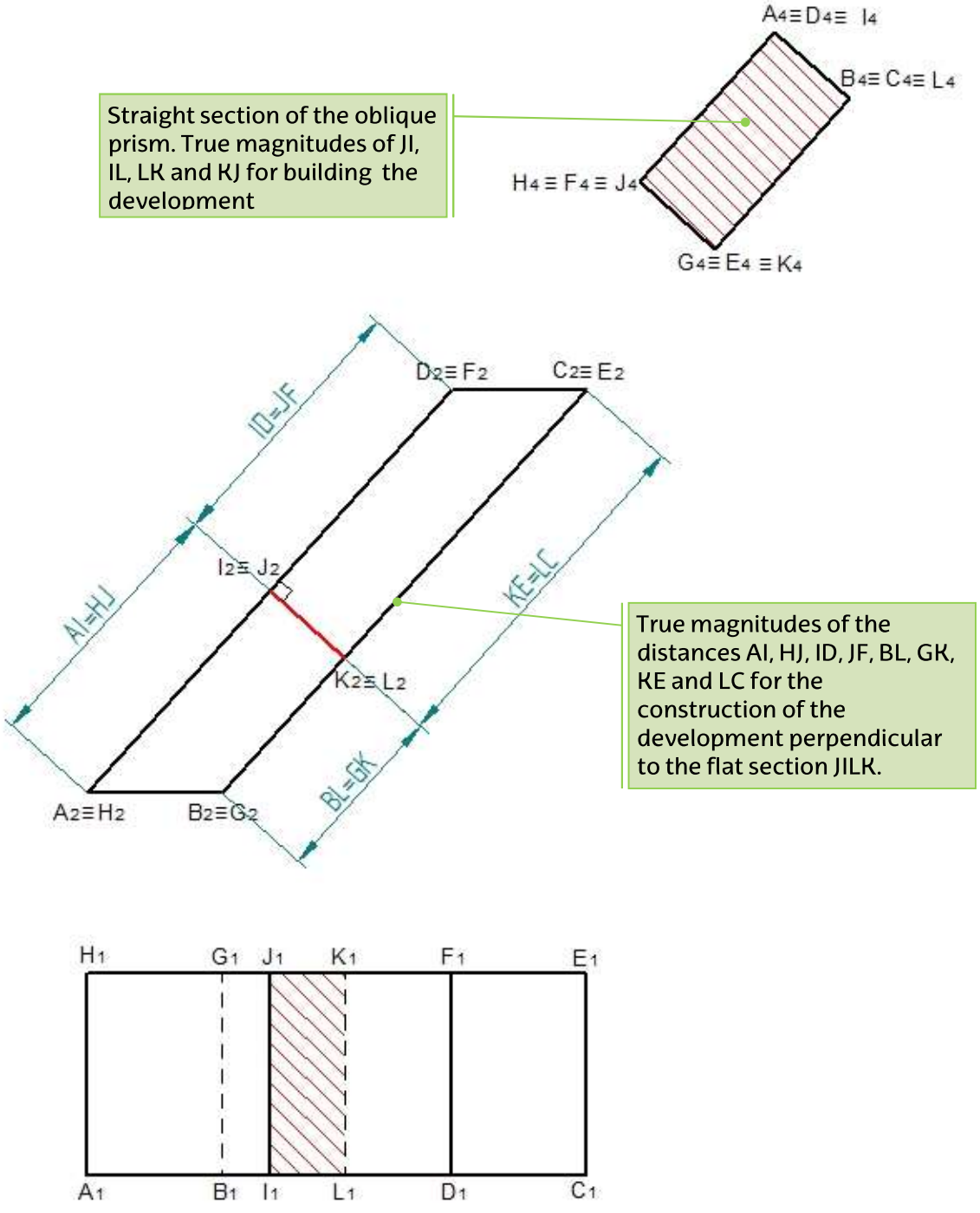


Figure 4.15. Method for tracing the development of an oblique prism (Image made with Solid Edge)

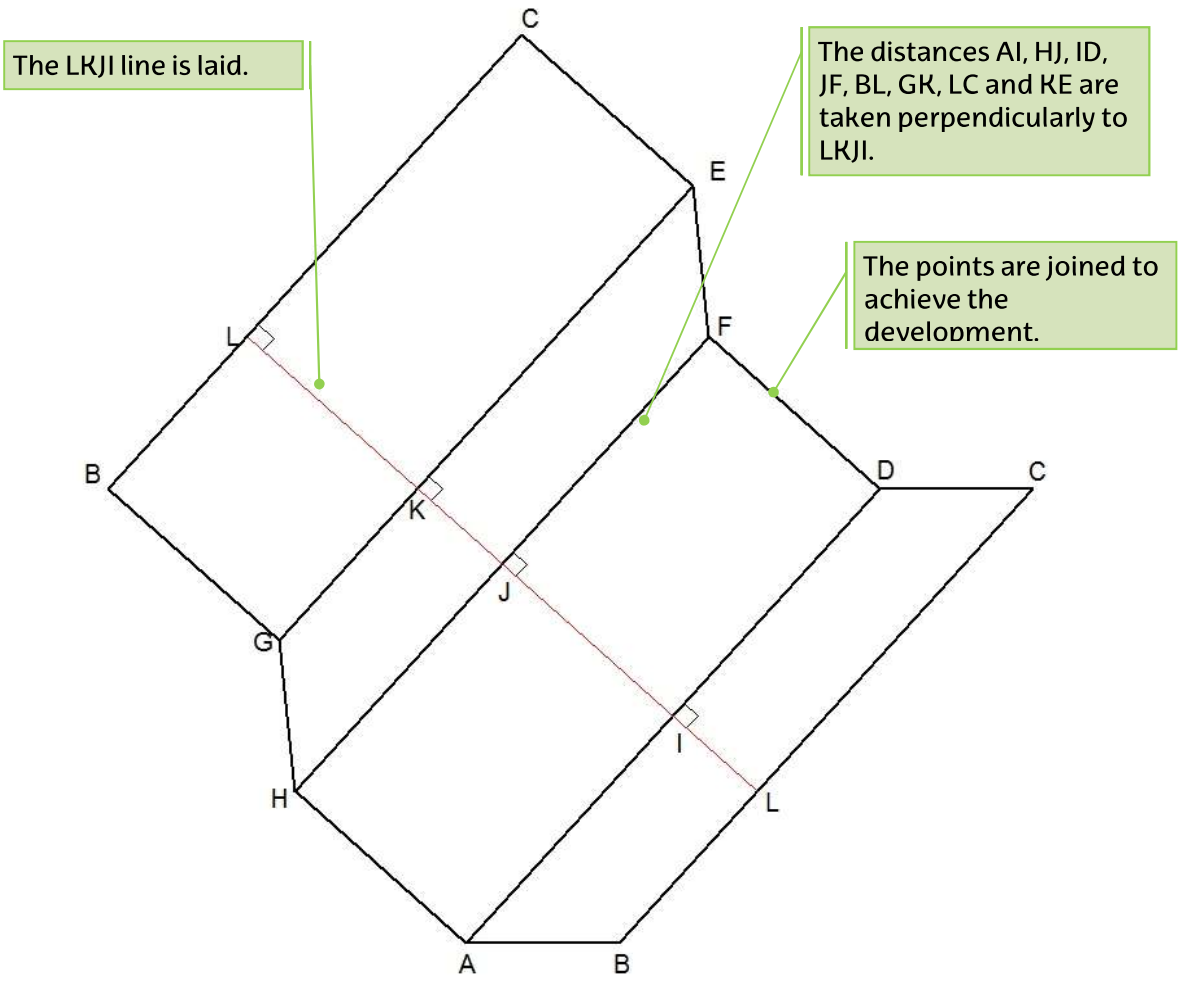


Figure 4.16. Method for tracing the development of an oblique prism (Image made with Solid Edge)

4.1.4 Cylinder

Straight cylinder:

When the cylinder is straight, the development of the lateral surface is a rectangle of sides the length of the generator and the perimeter of the guideline. The generatrix and the directrix are perpendicular in the development because the directrix is a straight section of the cylindrical surface. See Figures 4.17 and 4.18.

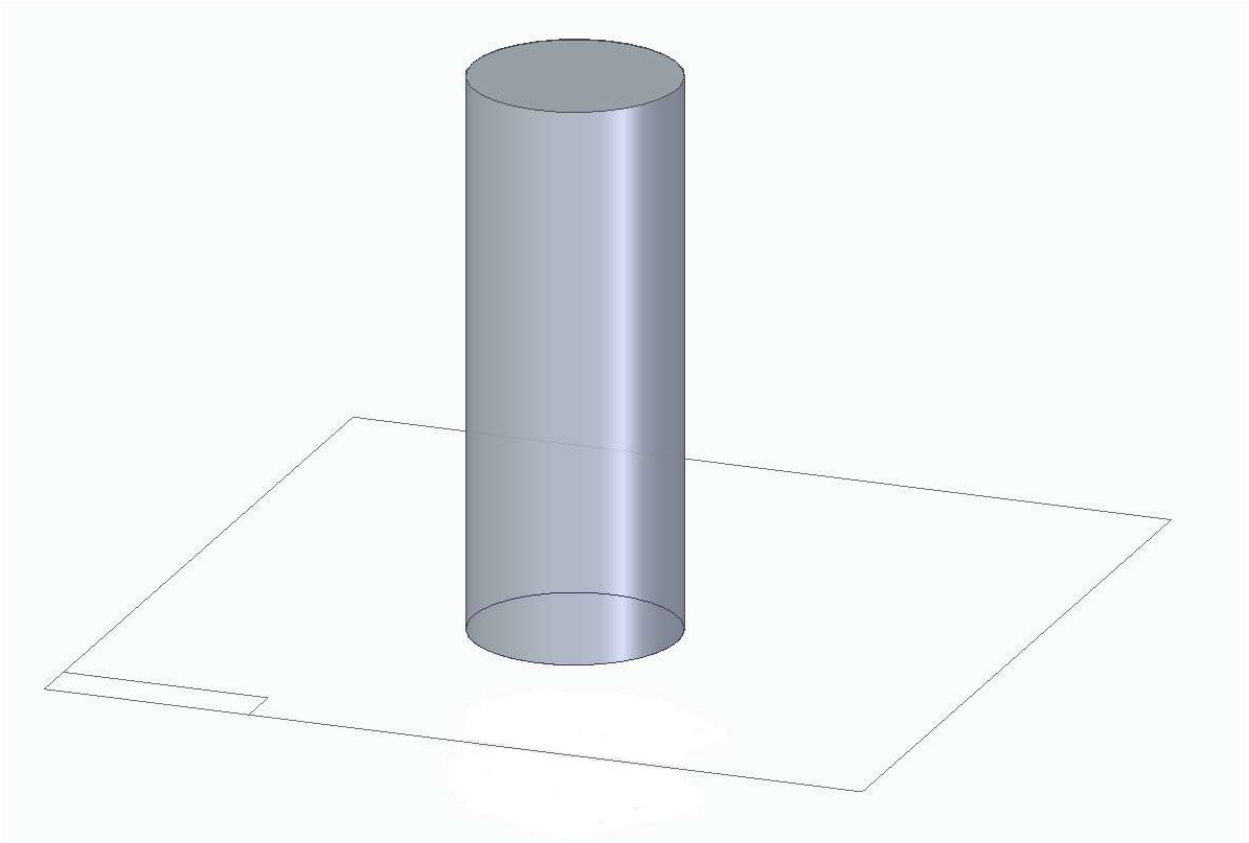


Figure 4.17. Straight cylinder (Image made with Solid Edge)

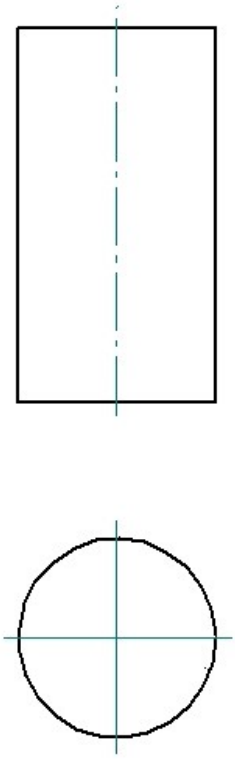


Figure 4.18. Projections of a straight cylinder (Image made with Solid Edge)

The development can be calculated mathematically. As it is a straight cylinder, its development will be a rectangle. Its width will be the same as its perimeter (π.d) and its height will be the same as the height of the cylinder (AM). See figure 4.19.
It can also be found approximately as follows: We divide the perimeter of the guideline into 12 parts (A to L) and on the other side we place the generator (AM).

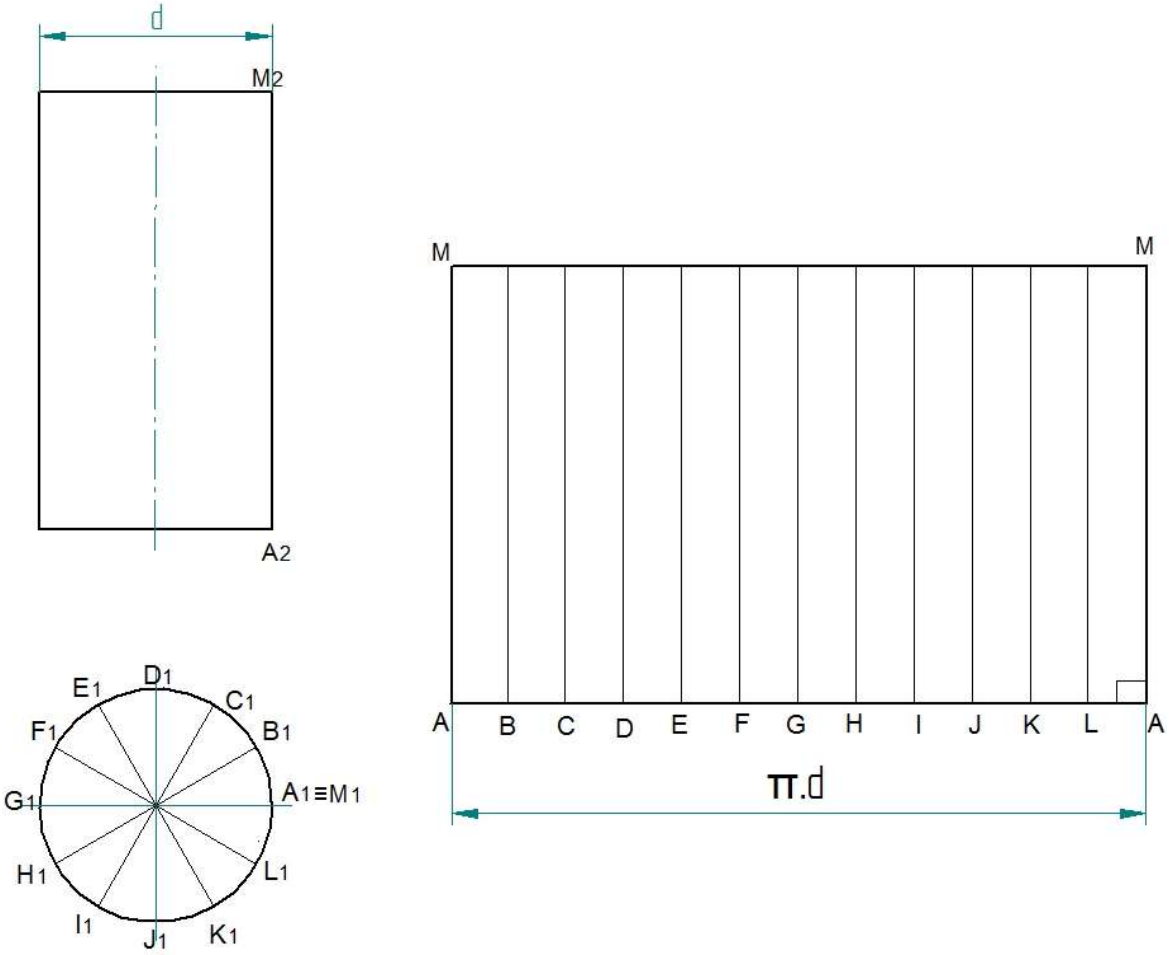


Figure 4.19. Development of a straight prism (Image made with Solid Edge)

Oblique cilinder:

When the cylinder is oblique, the general method for finding the development of the side surface is to replace it with an inscribed prism. The development obtained is approximate and the curve of the guideline in the development is drawn with some imprecision.

If the cylinder is oblique, but has a circular guideline, the surface has a plane of symmetry. Then, for greater simplicity of the development, the plane of symmetry of the cylindrical surface must also be the plane of symmetry of the inscribed prismatic surface. The precision of the directrix curve in the development is improved by knowing that it is tangent to the perpendicular to the generatrices contained in the plane of symmetry.

See section DEVELOPMENT AND TRANSFORMATION EXERCISES OF THE SECTIONS.

4.2 TRANSFORMED FROM SECTIONS

The transformation of a section is the representation in the development of the line of the section produced on the surface.

The transformed section is equal in length to the perimeter of the corresponding surface section.

In order to obtain a transformation, a sufficient number of points must be taken to the development so that it is defined.

In the case of pyramidal and prismatic surfaces, the flat section is a polygon whose vertices are on the lateral edges of the surface. See section 3.1. Therefore, there are as many points as there are vertices.

In the case of conical and cylindrical surfaces, the flat section is a conical one. See section 3.4.4. Therefore, the number of points is sufficient for the number of vertices in the inscribed surface used for the development.

The transformation of the straight section of the prismatic and cylindrical surface is a straight line perpendicular to the generatrices. See section 3.4.3.

The method for finding the W-plane transform in the development of the straight pyramid is presented below: See Figure 4.6.

The points of intersection (D, E and F) are found (see Figure 4.20) and the true magnitudes (VD, VE and VF) are taken to the development. See figure 4.21.

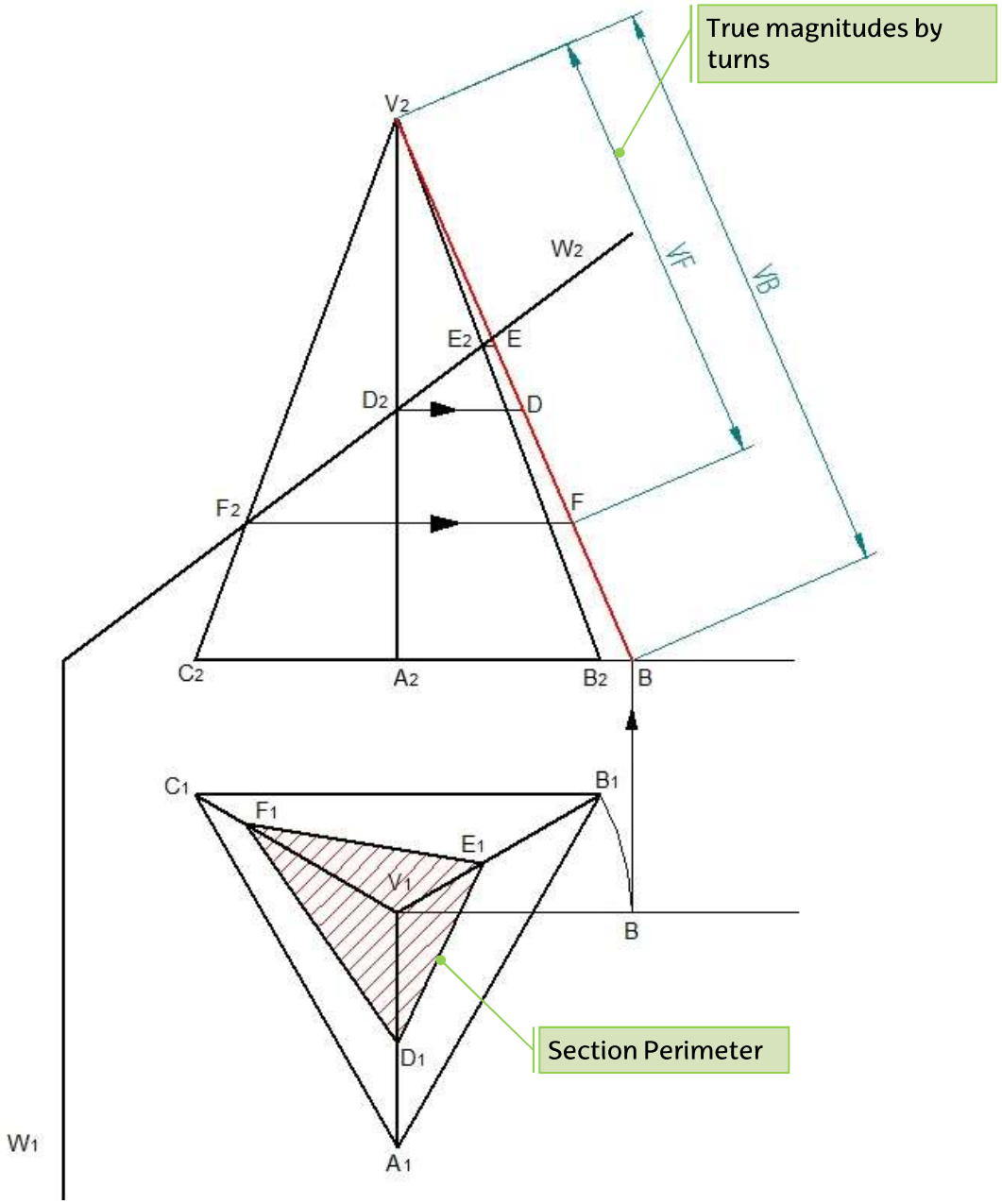


Figure 4.20. Method for drawing the transformed of a straight pyramid (Image made with Solid Edge)

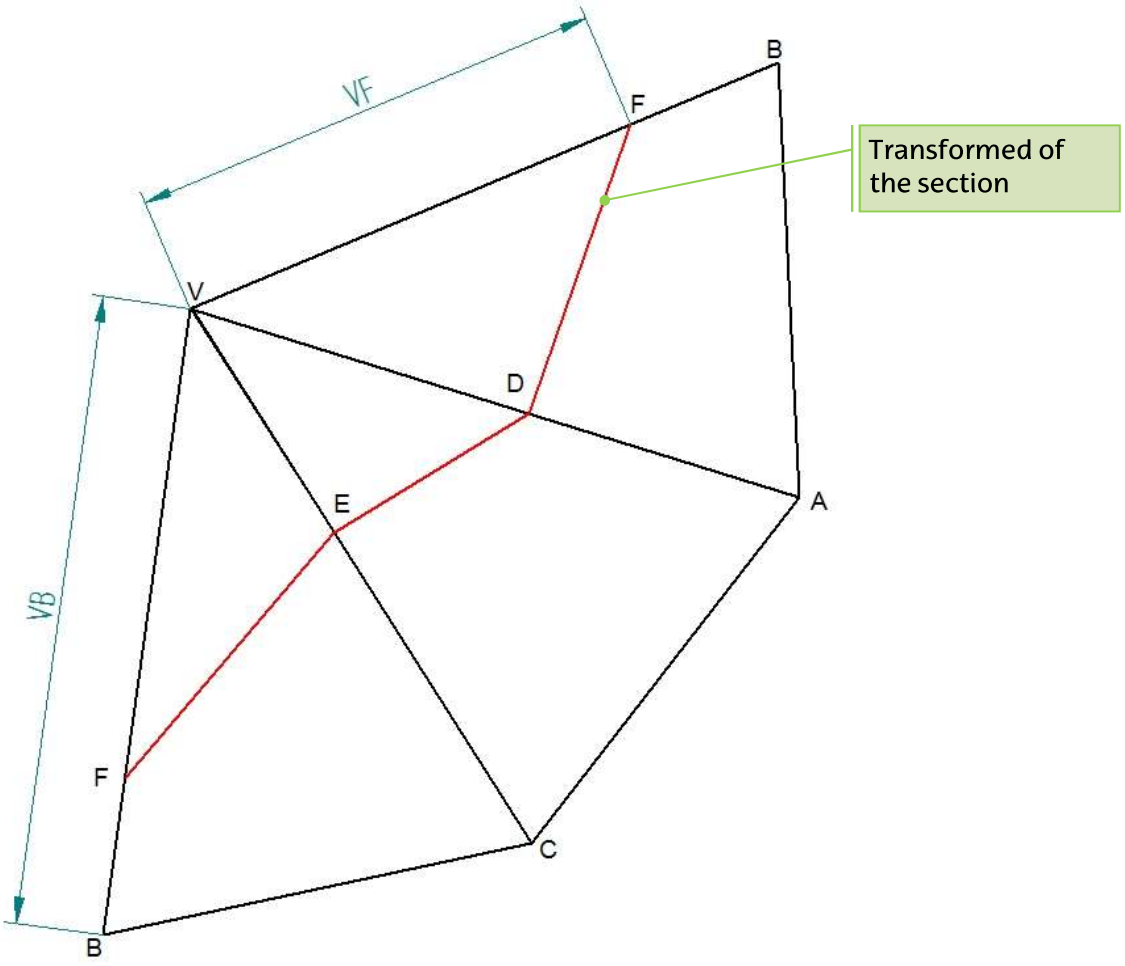


Figure 4.21. Method for drawing the transformed of a straight pyramid (Image made with Solid Edge)

The method for finding the transformation of the W-plane in the development of a **straight cylinder** is presented below (see figure 4.19):

The 12 points of intersection (A1-L1) (see figure 4.22) and the true magnitudes (AA1-LL1) are found and taken to the development where the length of the perimeter has been placed (π.d). See figure 4.23.

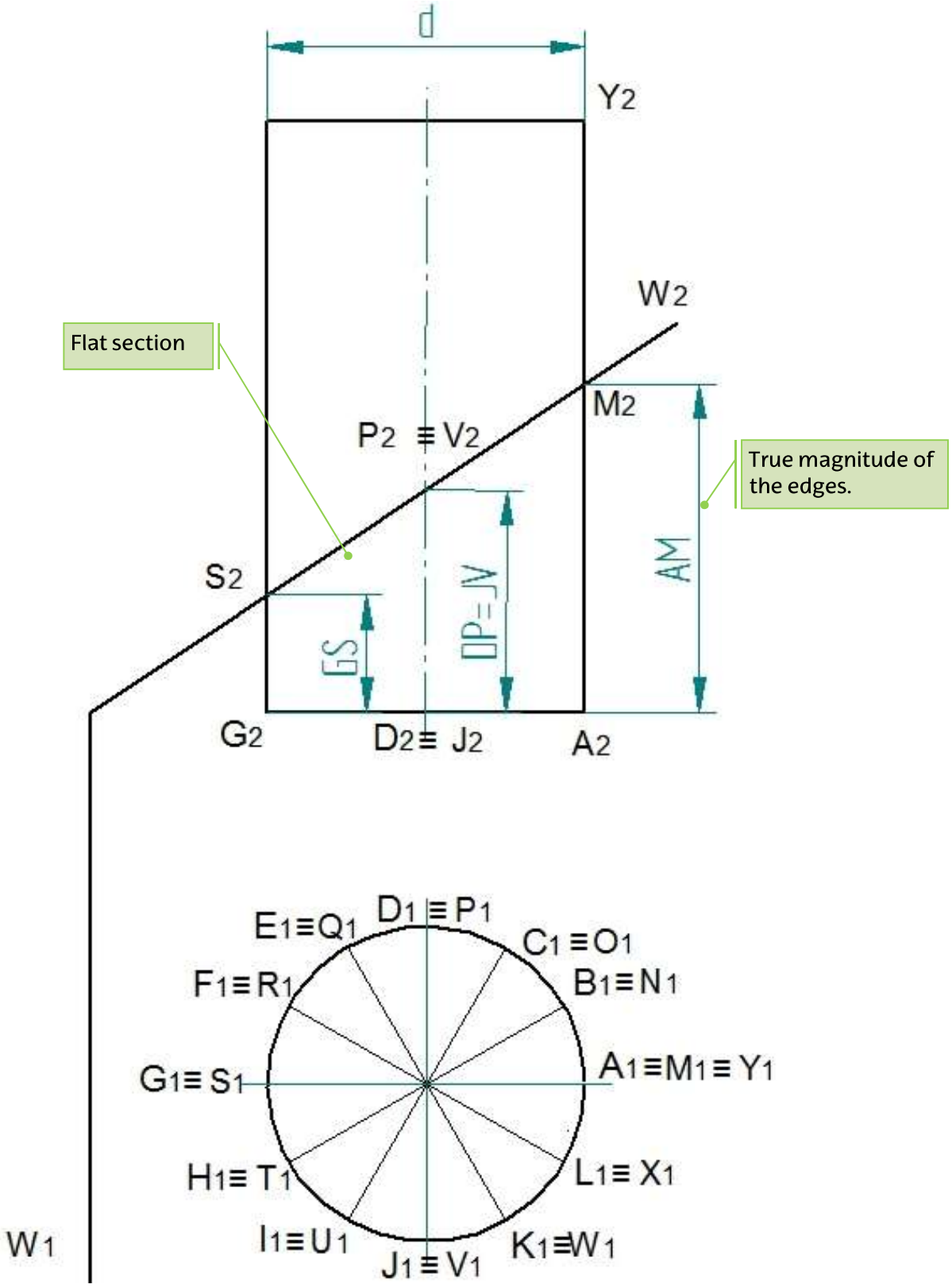


Figure 4.22. Method for drawing the transformed of a straight cylinder (Image made with Solid Edge)

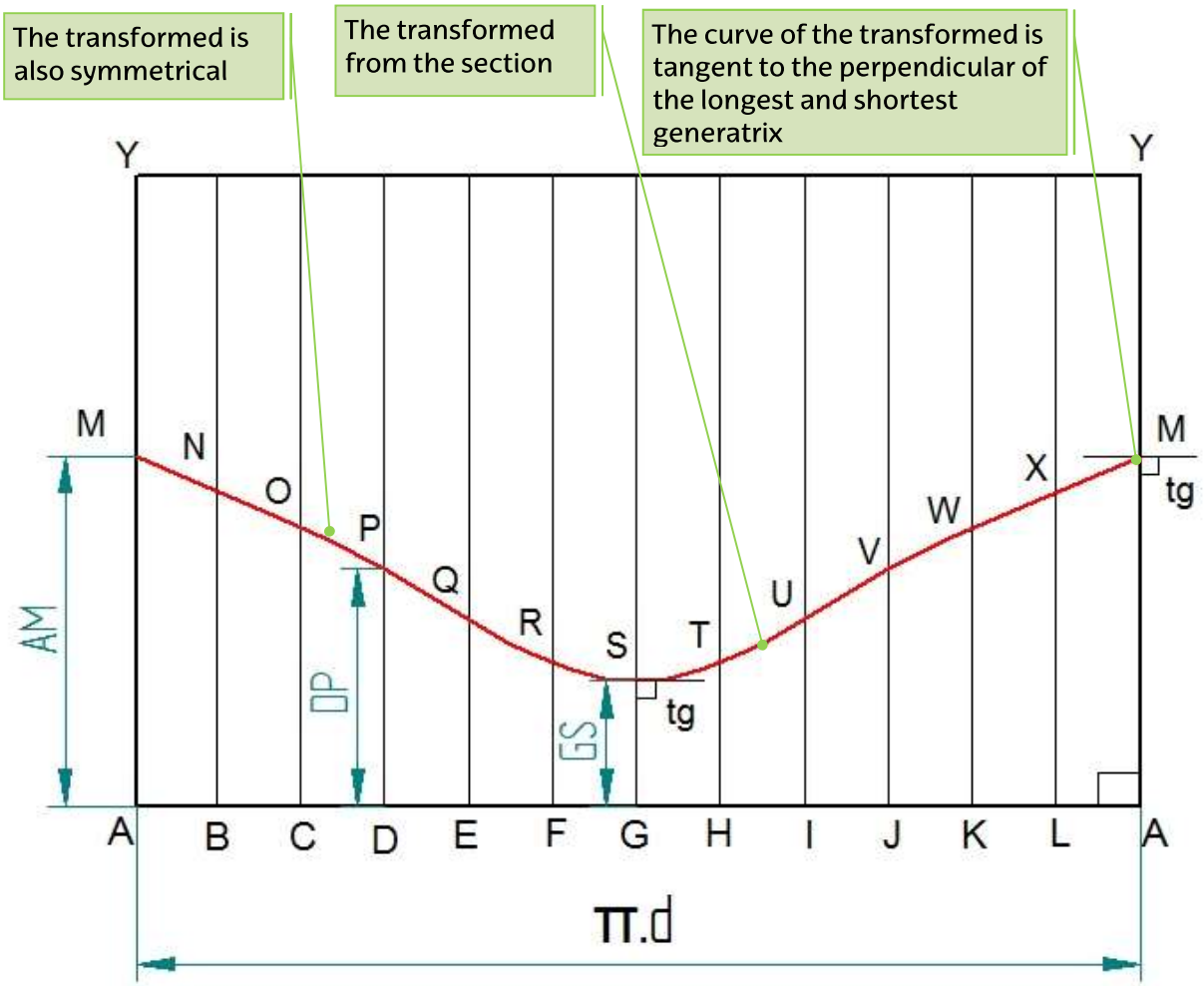


Figure 4.23. Method for drawing the transformed of a straight cylinder (Image made with Solid Edge)