Andrei SLONOVSCHI, Liviu PRUNĂ

COMPUTER-ASSISTED DETERMINATION OF THE DEVELOPMENTS OF POLYHEDRA AND INTERSECTION POLYGONS DETERMINED BY THE INTERSECTION OF TWO OR MORE POLYHEDRA

Abstract: *The authors present, in this paper, a working model for obtaining the unfolding of polyhedrons. This model uses computer-aided graphics and targets the case where two or more polyhedrons intersect. The working model presented by the authors takes into consideration not only the intersecting surfaces but also the resulting intersecting polygons.*

Key words: *Descriptive Geometry, polyhedrons, polyhedrons intersection.*

1. INTRODUCTION

In the design and execution activities, are often found bodies with a polyhedral form like the prisms or pyramids. These bodies intersect and it is necessary to establish the intersection polygons. At this stage, it is necessary to determine the intersection points (input and output) between all edges of one polyhedron and faces of the other polyhedron and vice versa. The exact determination of these points is critical because it is necessary to cut some parts of those bodies to make their assembly possible [2] (Figure 1 and 2).

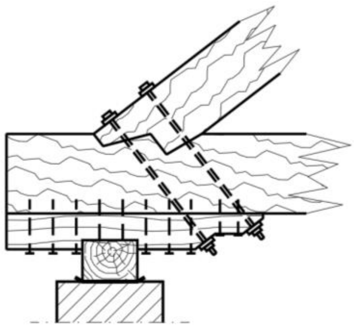

Figure 1 Roof timber frame. Detail on the joint between the rafters and the wall purlin.

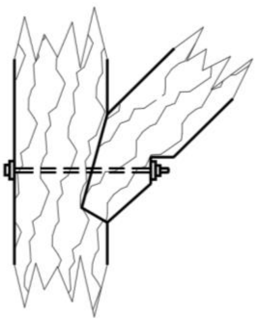

Figure 2 Roof timber frame. Detail on the joint between the brace and the post.

Application of the classical variant of determining these points (they are the vertices of the intersection polygons) can be accomplished relatively easily on physical bodies. But the previous statement is valid only if only two bodies intersect. In this case, there are two steps to be taken, one for the office and one for the construction site.

In turn, these two stages can be divided into several steps as follows:

- design stage (office):
  - determination in double orthogonal, in the draught, of the polygon or polygons of intersection, depending on the type of intersection obtained;
  - positioning on the polyhedron or polyhedra that will be unfolded of the points that determine the vertices of the polygon or polygons of intersection;
  - carrying out the deployment for one or both polyhedra;
  - determination, according to the horizontal and vertical projections of the vertices of intersecting polygon or polygons, of the positions of these points on the unfolding of the polyhedron or polyhedra.
- execution stage (construction site):
  - marking on the physical body, depending on the data obtained from the unfolding, of the points that will determine the vertices of the polygon or polygons of section;
  - making the cut-out or cut-outs both according to the positions of the points that determine the vertices of the section polygon or polygons and according to the three-dimensional model of the joint.

But if more than two polyhedra intersect, the classic solution is hard to apply.

The authors analysed all the aspects presented above and, they proposed themselves to find a new work method for determining, on the physical body, the vertices of the intersection polygon or polygons. The new method must rely on computer graphics.

2. MATERIAL AND METHOD

The starting point of this study and the method proposed by the authors is based on the shortcomings of the classical method. Specifically, how the points of intersection between the edges of one polyhedron and the faces of the other polyhedron are determined, because:

- no matter how fast and knowledgeable a person is in the field of Descriptive Geometry, the determination of

the points of intersection between two polyhedra and the points on the unfolding of the polyhedra, which have their bases simultaneously in the horizontal plane [H], vertical plane [V], or in parallel planes with these, it will take at least 150 minutes as there are practically two problems to be solved, the intersection and the unfolding of the polyhedra;
- if the bases of the polyhedra are located in general position planes the time required will be longer as the problem is much more complex;
- the solving using the classical method can be applied only for the simultaneous intersection of two polyhedra.

To be able to use the advantages offered by computer-assisted graphics, the authors proposed that the realization of the polyhedra under study (Figure 3) [3] be made in a volume model [1].

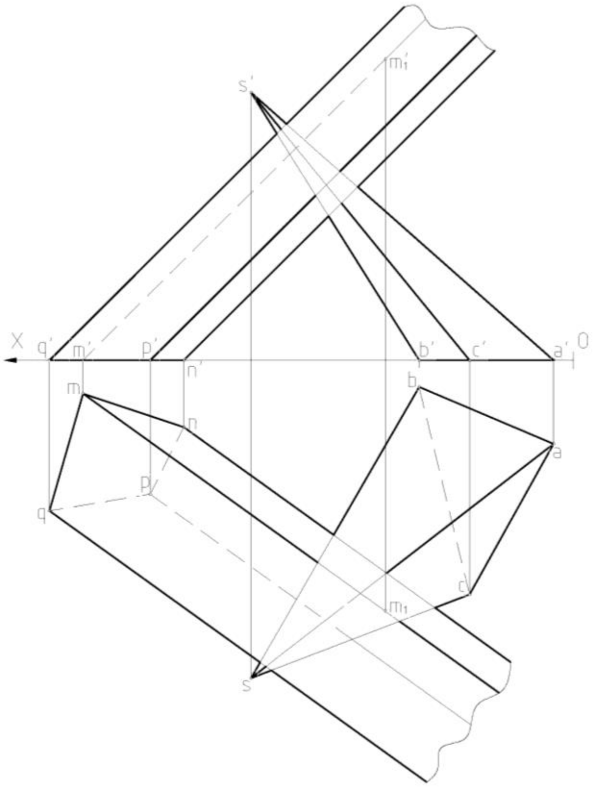

Figure 3 Polyhedra under study.

Previously, the directions of the X, Y and Z axes were modified in order to follow the directions in Descriptive Geometry (Figure 4).

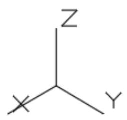

Figure 4 The directions of the axes adopted by the authors follow the directions of Descriptive Geometry.

Further, using a series of 3D modelling commands specific to the AutoCAD program, the authors built the two polyhedra in turn. Figures 5 and 6 show the top and front views of the prism and the pyramid under study.

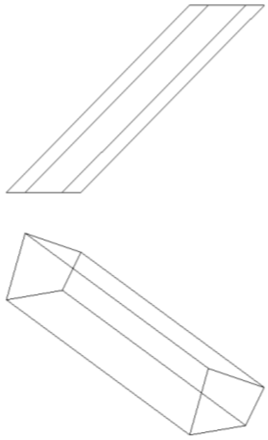

Figure 5 The top and front views of the studied prism.

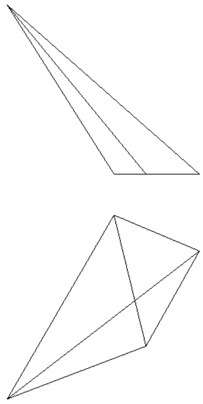

Figure 6 The top and front views of the studied prism.

Overlaying the representations of the two polyhedra and changing the viewing mode from 2D Wireframe to Shaded with edges, the representation in Figure 7 is obtained.

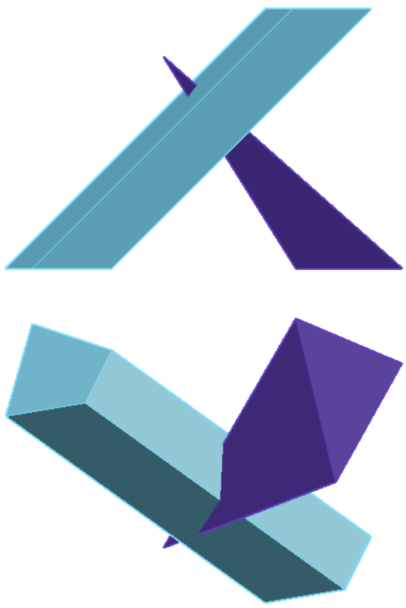

Figure 7 Volume representation of the assembly consisting of the two polyhedra.

The intersection obtained is penetration type, the pyramid entering the prism. It follows that we will have two polygons, both of which are located on the prism.

In the next stage of the study, using the commands specific to 3D modelling, the pyramid was removed from the whole, obtaining the two intersecting polygons on the prism (Figure 8).

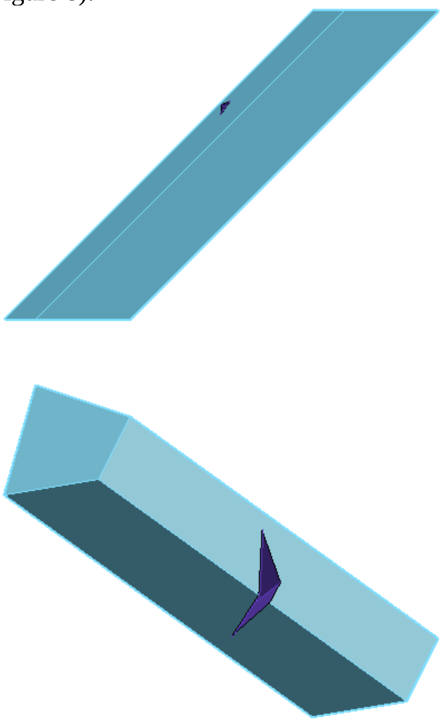

Figure 8 Prism with the two intersecting polygons.

To better highlight the two intersecting polygons, in figure 9 is shown the cut-out prism from two different directions.

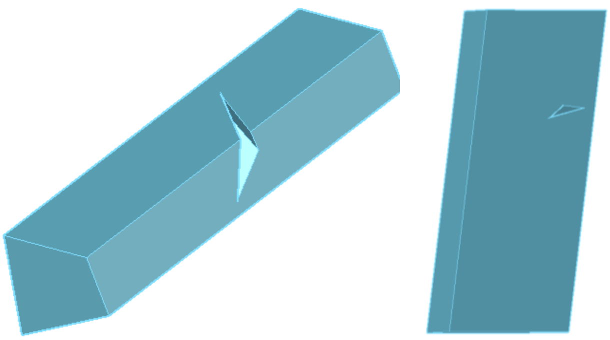

Figure 9 Prism with the highlighting of the two intersection polygons.

Next, in the classic version, the unfolding of the prism should be performed, the positioning on the undeveloped prism of the points that determine the intersection polygons and the positioning on the unfolding of the prism of these points.

Instead, using the commands specific to the AutoCAD program, the study's authors were able to easily determine the unfolding of the prism and, at the same time, position the points that determine the intersection polygons on it (Figures 10 and 11).

Figure 10 Development of the prism with the highlighting of the points that determine the intersection polygons (view *Shaded with edges*).

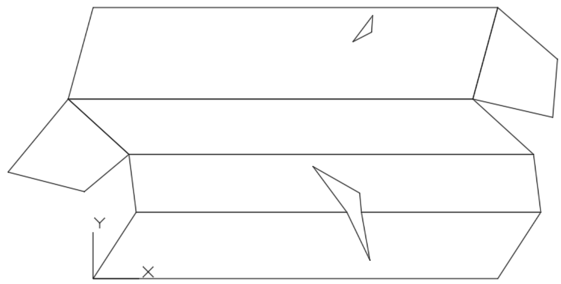

Figure 11 Development of the prism with the highlighting of the points that determine the intersection polygons (view *2D Wireframe*).

Continuing the study, the authors intersected two prisms, this time, the intersection being of the breaking type (Figures 12 and 13).

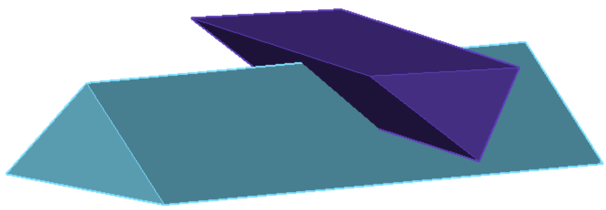

Figure 12 The intersection between the two prisms is of the breaking type.

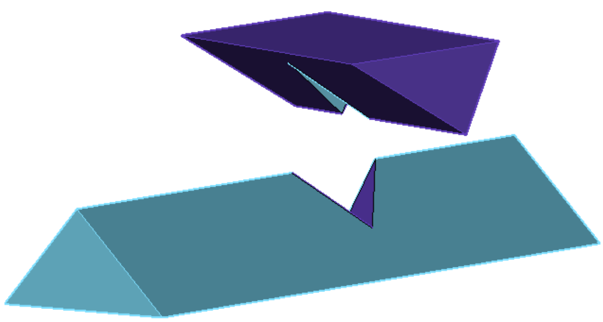

Figure 13 Highlighting the break on both prisms.

Following the steps used previously, the authors also easily determined the unfolding of the two prisms and the unfolding contours of the two intersecting polygons. (Figures 14 … 17).

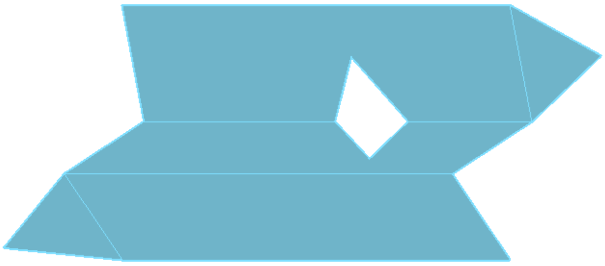

Figure 14 Unfolding the first prism with highlighting the points that determine the intersection polygon (view *Shaded with edges*).

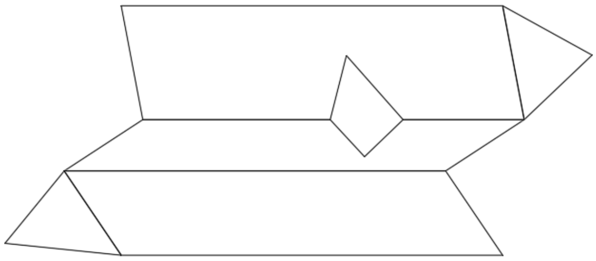

Figure 15 Unfolding the first prism with highlighting the points that determine the intersection polygon (view *2D Wireframe*).

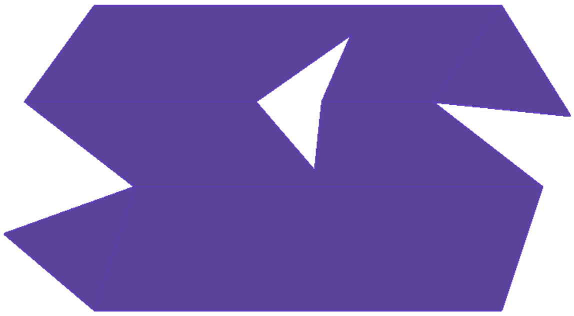

Figure 16 Unfolding the second prism with highlighting the points that determine the intersection polygon (view *Shaded with edges*).

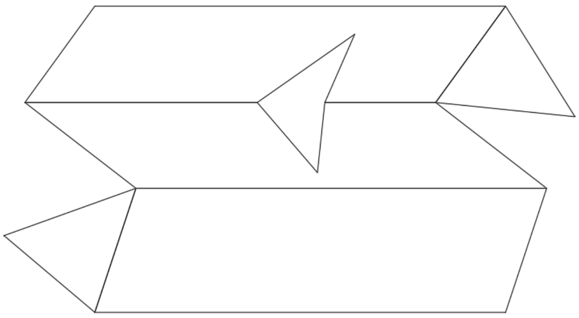

Figure 17 Unfolding the second prism with highlighting the points that determine the intersection polygon (view *2D Wireframe*).

3. DISCUSSIONS AND CONCLUSIONS

Following the study, the authors came to the following conclusions:

- regardless of the number of sides, polyhedra's type (prism or pyramid) and their number, the presented steps that allow the determination of the unfolding of the polyhedron or polyhedra but also of the intersection polygons are identical;
- the reasoning is similar regardless of the positions of the bases:
  - both located in the horizontal projection plane [H];
  - both located in the vertical projection plane [V];
  - both located in general position plane [P];
  - one base located in one type of plan and the other base in another type of plan;
- compared to the classical variant, the duration of determining the unfolding of the polyhedra but also of the intersection polygons is much shorter;
- the working method proposed by the authors can be used only by people who have in-depth knowledge of both Descriptive Geometry and 3D computer modelling. This knowledge is necessary as they need to know both the theory of how to solve problems concerning the intersection of two polyhedra, the unfolding of polyhedra and the specific commands regarding volume modelling, drawing and editing of solids.
- the advantage of the method is that it allows the determination of points both at the level of 3D body and at the level of unfolding.

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Authors:

Sen. Lect. Eng., Ph.D Andrei SLONOVSCHI, "Gheorghe Asachi" Technical University of Iaşi, Faculty of Civil Engineering and Building Services, Department of Engineering Graphics, Email: andreislonovschi@yahoo.com

Assoc. Prof. Eng., Ph.D. Liviu PRUNĂ, Director of Department**,** Technical University of Iaşi, Faculty of Civil Engineering and Building Services, Department of Engineering Graphics, Email: liviu.pruna@tuiasi.ro