

# Physical model in descriptive geometry – good idea?

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**Abstract** – The issue of shadow in architecture is very important. Architectural concepts as light and shadow design are known. For the professional architect it is always important to be able to determine how the shadows are cast. The descriptive geometry course attended by students of Faculty of Architecture covers issues related to the light and shadow problems. The construction of shadows is carried out by three different methods: parallel projection (axonometry), orthogonal projection (Monge projection) and central projection (perspective). The paper presents ideas of design exercises for the students using two of the above methods - parallel projection (axonometry) and orthogonal projection (Monge projection).

*Index Terms* – Descriptive geometry, geometry, graphics, engineering graphics, shadows.

## INTRODUCTION

The descriptive geometry course run in Silesian University of Technology Faculty of Architecture takes place during the first year of studies and lasts for two semesters. The full course includes 30 hours of lectures and 60 hours of exercises in design. The initial semester covers geometry issues related to Monge projections and, additionally, to parallel projections. The shadow problems such as construction of shadows of solid objects are demonstrated in these representations and they usually evoke lots of interest in Faculty of Architecture students. Light & shadow problems are important to sketching courses. Manual sketching is usually trained during junior year of study in Polish technical universities. The entrance examination to architectural faculties is obligatory in most of Polish universities and as a rule it is devoted to manual sketching. The students who passed this exam and entered the faculty think that they had mastered light & shadow problems already. However, when they start to determine the object shadow basing on the graphical constructions used in projections unexpected difficulties are encountered. These difficulties may be categorised into three groups:

- determining the shape of shadow edge
- determining refraction of shadow at surrounding planes
- defining elements located in their own shade.

The sketching exercises including drawing from nature and information on light & shade related to the object come from observation. Looking at the model, students draw the model itself, the shadows cast by the model as well as elements

located in the cast shade. They draw shadow cast, which is geometrically constructed.

So the light & shadow's skills used in manual drawing do not help to solve any problems related to determining shadows cast by designed objects. In traditional course of descriptive geometry for students of Faculty of Architecture students solved tasks of shadows using descriptive construction in Monge projection and parallel projection. Mostly construction of shadows is based on construction of piercing point of line and surface.

## CONCEPTION OF DESIGN CLASSES

The problems peculiar to the students and occurring cyclically during the design classes inspired the instructors to work out the idea of design exercises which might utilise two different skills: construction and observation.

The design task was split into three parts:

- erecting a physical model of three-solid complex (rectangular prism, cube, prism),
- determining shadows of construction in Monge projections,
- determining shadows of designed construction in axonometry, taking into account the light direction assumed previously in Monge projection.

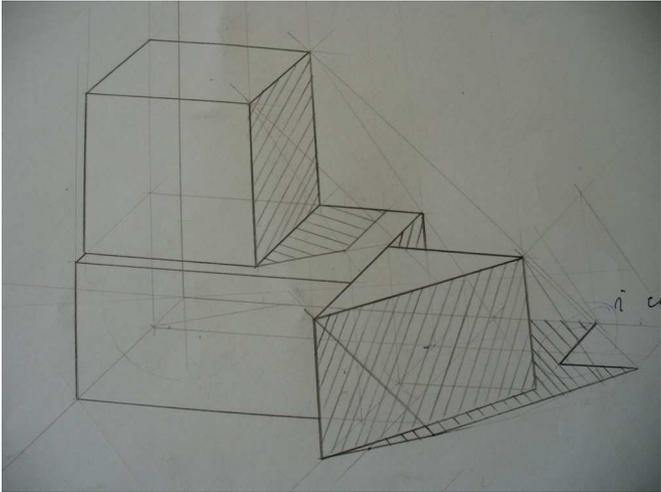
Implementation of the initial phase of the project would help the students to understand how to interpret and represent the solid complex by Monge projection. Second and third phases should make possible comparison of two different methods of object representation and constructions used. The physical model produced in the first stage should help in using observation of properly lighted model if student's constructional skills were not sufficient.

## PROJECT

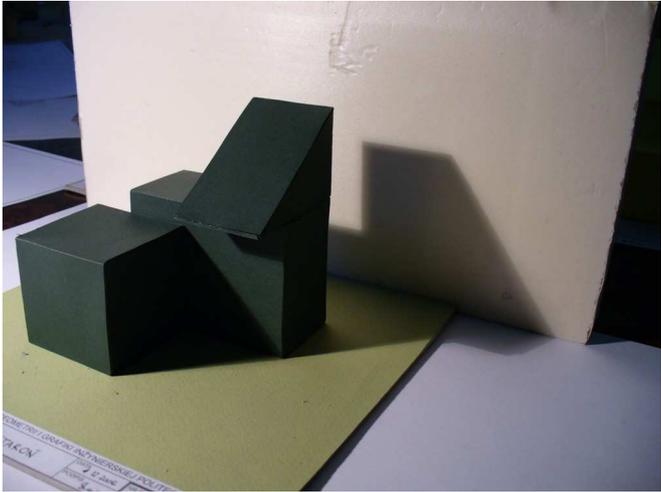
Three different solid shapes were given as project foundation. On this basis the students produced individual cardboard models. The placement of the solids in relation to each other was talked over with the teacher, so that the different objects should be characterised by similar difficulty level. This phase of the project proved to be really easy, the models and, later on, space compositions were executed most precisely and carefully. This actual composition was then to be represented in Monge projections (horizontal and vertical projections both) and in axonometry (isometry with a defined slope). In this part of project students assumed direction of parallel light rays, lighting the compositions. The lighting direction was defined as two orthogonal projections of light flux – vertical and horizontal.

The light direction defined according to these rules had then to be determined by axonometry. During last phase of the project the students tried to determine the shadow cast by the space composition taking into account vertical and horizontal projection planes from Monge planes configuration. Then the shadow cast at other planes (i.e. walls of solids of the given composition) had to be properly ascertained.

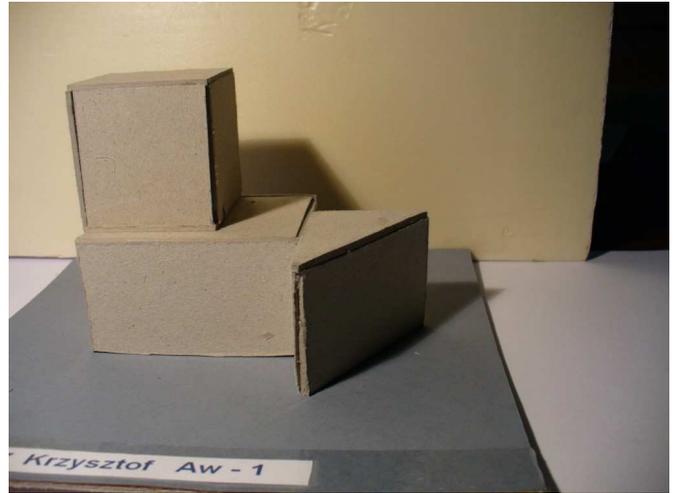
The final element of the task was to determine the objects located in their own shadow. The difficulties in realization of project were encountered, during construction of shadows in orthographic projections. On this stage the greatest difficulties for students was to properly read projections of particular planes (walls of solids comprising the composition, projection planes) so that using construction of piercing point of plane and line the shape of cast shadow might be determined. In axonometry the shadow cast by solid complex was determined by using construction of piercing point of plane and line too. During this phase it was observed that students were able to “read” axonometric drawings more easily. Generally, there were no cases of improper “reading” of different planes-obstacles where shadow had been cast. The greatest difficulty presented by the project was determining light direction in axonometry, which had to be ascertained by the light direction assumed previously in orthogonal projections. More than half of students had to have this simple problem explained face to face. This issue came rather as a surprise to the instructors, since the same group of students encountered no difficulty at all when confronted with constructing axonometry of given space composition on the basis of orthogonal projections defined earlier. The last phase of the project (determining elements of composition located in their own shade) presented no particular difficulty to the students.



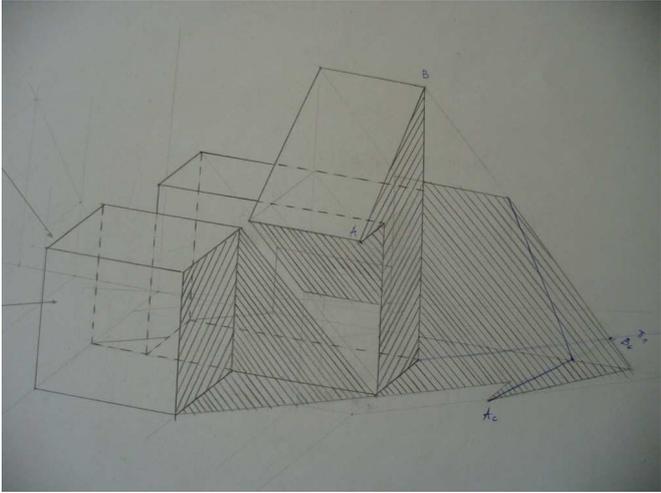
PICTURE 2  
FIRST EXAMPLE OF STUDENT’S WORK. AXONOMETRY WITH SHADOWS CUT AND WITH SOME PROBLEMS WITH DETERMINING SHAPE OF SHADOWS – THERE ARE NO SHADOWS ON VERTICAL PROJECTION PLANE



PICTURE 3  
SECOND EXAMPLE OF STUDENT’S WORK. PHYSICAL MODEL WITH SHADOWS CUT



PICTURE 1  
FIRST EXAMPLE OF STUDENT’S WORK. INDIVIDUAL DESIGNED PHYSICAL MODEL WITH SHADOWS CUT



PICTURE 4  
SECOND EXAMPLE OF STUDENT’S WORK. AXONOMETRY WITH SHADOWS CUT AND WITH SOME PROBLEMS WITH DETERMINING SHAPE OF SHADOWS

## CONCLUSIONS

Understanding the space shape of 3D object on the basis of its orthogonal projections presents greatest difficulties to the students during the course of descriptive geometry. Acquiring this skill is one of fundamental goals in teaching descriptive geometry. The project described above is implemented during the first semester of the course. For the students beginning to study the subject, a more difficult part of the project is the one related to Monge projections, where it is necessary to learn to use orthogonal projections.

Isometric drawing is in Faculty of Architecture students' opinion is similar to manual sketching perspective. It does not present particular problems to the students undertaking the project. The constructional problems which arise during the project are usually related to determining the light direction in axonometry and this means that students are not accustomed to use some abstract conceptions such as a line representing the light ray.

It is noted that students are used to compare the solutions obtained on their own (insofar as they relate to the shape of shadow cast by space composition and are determined by two different drawing methods , i.e. orthogonal projections and axonometry).

The physical model of the object is mostly used to explain some doubts and problems as to shadow construction during consultations with teachers. Some students (c. 20 per cent of the group) use the model in order to conduct their own observations and tests.

The whole concept of the project and students' work must be thoroughly analysed and some changes should be introduced, so that the physical model might be used more effectively to graphically describe geometric issues.

Probably it will be good idea to reconstruct concept of classes and add the last part connected with solid modelling design with using CAD systems but traditional, descriptive constructions which are drawing by hand are very important in architects education too.

## REFERENCES

- [1] Grochowski B. "Geometria wykreślna z perspektywą stosowaną" *book*, Wydawnictwo Naukowe PWN, Second Edition 1995
- [2] Pare E. G., Loving R. O., Hill I. L. "Descriptive Geometry", *book* Macmillan Publishing Co. Fourth Edition 1971
- [3] Otto F., Otto E. "Podręcznik geometrii wykreślnej" Wydawnictwo Naukowe PWN Fifth Edition 1994.