

HOW CADWORK CAN HELP FACILITATE YOUR TECHNICAL DRAWING TRAINING?

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Abstract. The main goal of delivering Technical Drawing to students of Civil Engineering Faculty at any technical university is to familiarize students with the ISO standards, which are used for constructional drawings as symbols and designations in design layouts, to introduce dimension standards and to place specific views into correct format in a drawing layout. In general, the students who enroll for their first year of Civil Engineering Faculty require no prior experience in design work. Therefore Cadwork software is a helpful tool in preparing virtual models of typical elements of a house construction, to serve as illustrations in the class-room presentation. Cadwork is one of the latest products in the 3D CAD/CAM market used for the creation of timber constructions. The basics for using the Cadwork software is outlined in this paper together with examples complimenting its environment, which is specifically used for facilitating/understanding Technical Drawing at the Faculty of Civil Engineering, here at the Cracow University of Technology.

Key words: Technical Drawing, Representation techniques, CAM software, Cadwork, e-Learning

1. Introduction

For Civil Engineering Faculties at all technical universities in Poland, Technical Drawing belongs to basic educational subjects, and its aim is to familiarize students with the drawing ISO standards. These are used as symbols and guides in designing layouts. These standards have been developed for the appearance of technical drawings to ensure that they are easily interpreted across the nation and around the world. Technical Drawing also focuses on the descriptions, how dimensions should be correctly drawn, along with the correct format in the layout. For many countries, including Poland, these ISO standards are set in place to create the correct constructional drawings for civil engineering design projects. The basic standards commonly used in Technical Drawing course are listed as follows:

PN-B-01025: Construction drawings: Graphical designations in architectural and building drawings,

PN-B-01029: Dimensioning standards in architectural and building drawings,

And finally, PN-B-01027: Construction drawings: Graphical designations for the landscape drawing practice.

As mentioned earlier, the students who enroll for their first year of Civil Engineering Faculty require no prior experience in designing work and the subjects on Construction Materials and Building Constructions are learnt simultaneously or further down the track as the year progresses. However, an introductory lecture will be beneficial to prepare students for such real-life solutions which are typically used for walls, slabs, roofs and staircase construction. This gives our students a good overview, giving them the ability to draw basic plans and cross sections of building, whilst still meeting the ISO Standards. Some examples provided by the author are used for the benefit of students who can understand the structure of a real-life construction. Many of these examples relate to roof constructions, which are typically used in Poland.

Teaching methodology

The objective of the Technical Drawing course is to ‘train students via doing design projects’. In the course of a semester we follow the procedure of some specific consecutive steps. At first we assign each student an individual design project of a single family-house in a form of a rough sketch. Then, we provide a series of short class-room lectures presenting how to prepare, either manually or with aid of AutoCAD software, the assigned drawings. Peculiarity of each drawing has to be thoroughly explained in the class-room environment. Following this, we have the students to look at how to prepare printouts of design layouts in a proper scale. And finally, we have the students look at how to complete a project by insertion. This will include a ‘Title page’ along with all drawing layouts.

Until 2006/07 academic year, the entire course of Technical Drawing has been divided into two parts. One part of this course was taught at our DGTGEG (Division of Descriptive Geometry, Technical Drawing and Engineering Graphics) and consisted of only 15 lab hours (1 teaching hour =45 minutes). It was a course included into freshmen level of undergraduate degree level. The other part of the course consisted of another 30 hours and was taught at a sophomore level by another institute of our university. Described conditions made learning more challenging since the procedure had to be very concise. Thanks to better technology, a large amount of the workload now allows a student to complete their projects at home. While demonstrations and multimedia presentations are still drawn from the classroom, part of the final evaluation is conducted via the Internet. In most cases, ongoing contact between the tutor and the student is carried out through email and web page.

3. Some general remarks on roof construction

In a series of the papers E. Koźniewski [1, 2] has dealt with the theory of shapes of roofs. There are two aspects, which should be considered in case of a roof construction: analysis of the geometry of a certain roof [1, 2] and the roof construction [3]. To assemble the roof construction the student needs to learn its framing principles. Roof framing ranges from the simplicity of prefabricated roof trusses to the complexity of cutting and assembling a complex roof design from an individual design plan. All the roof framings use rafters, which are the basic structural elements of the trusses. In Poland we can distinguish between a roof frame with purlins and roof ties (see Chapter 4 below) and the other, which uses collar ties or span beams (see Chapter 5 below).

The other roof framing components such as a ‘ridge’ or a ‘post’ will be constructed in Fig.1. The rafters in Polish roofs are placed at up to 1m intervals. The rafter trusses are then placed at up to 4m intervals. These are better known as ‘Load-carrying trusses’. The size, spacing and span of the roof rafters must be coordinated to effectively carry a given load weight for a specific area. This load includes such factors as roofing materials and snow or ice accumulation.

4. Cadwork

The Cadwork system is described in detail in [4]. The program itself consists of the following modules:

- a) Cadwork 2D: An architectural package to create 2D plan views, cross-sections and design plans. It automatically estimates information regarding heights of the constructed elements, which can be used in a Cadwork 3D mode,
- b) Cadwork 3D: This is the basic package to be used for 3D modeling of a structure individually defined by the user and for creating an output list of required for production data,
- c) Cadwork Roof Pro: A roof-design package, where on the base of a pre-defined outline of the roof eaves the program automatically sets up the roof surfaces together with the roof components and structural parts,

- d) Cadwork Shading: Still shaded pictures or animations as camera views from different viewpoints can be created with this module.

To communicate with the other programs, files can be exported from Cadwork in formats: *.dxf, *.jpg, *.tiff, *.lsti and *.lstm. The last two are the formats for creating material lists. Cadwork files will be also exported to Robobat in the nearest future, which will enable application independent software for load capacity calculation.

5. Roof frame with purlins and roof ties (rafter braces)

Some models of specific solutions for roof framing have been constructed by the author for educational purposes. In Fig 1, the virtual model of a roof frame with purlins and roof ties are shown. The subsequent stages of construction clearly explain specifications of the elements. Typical construction of this type of roof framing includes:

- Rafters (size 5x14 ÷ 8x16cm),
- Purlins (size 8x10 ÷ 10x12 cm),
- Two roof ties (5x14 cm),
- Angle ties (8x8 ÷ 10x10cm),
- Two posts (10x10 ÷ 12x12cm).

Constructed below the roof frame is mandatory for a ridge roof. In cases of a more complicated roof shape (e.g. hipped roof) additional elements of the roof framing must be constructed (hip rafters at the corners, hip jack rafters, etc.). These types of a roof framing can be applied for the roof spanning over a building width ranging up to 12m.

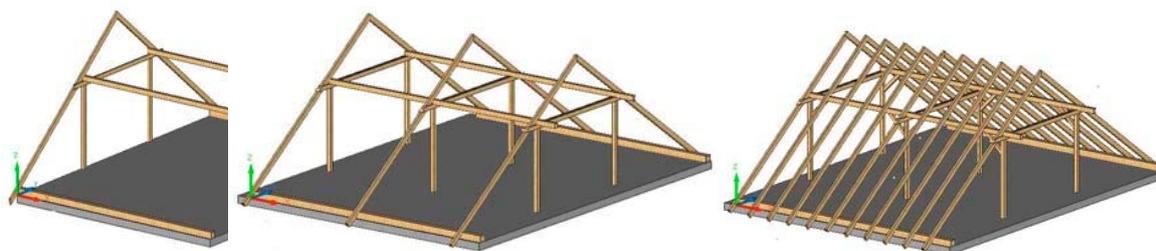


Fig.1: Roof rafter trusses construction and subsequent addition of intermediate rafters.

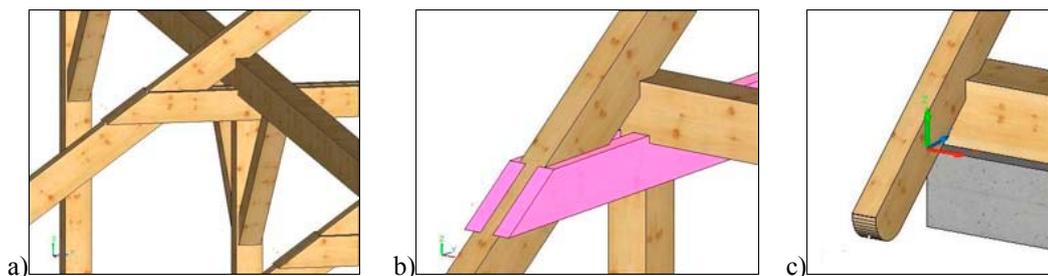


Fig.2: Details of a roof truss: a) knot in a rafter truss, b) detail with collar ties: shaded model, c) rafter ending.

6. Roof frame with collar beams (or collar ties)

This type of a roof truss construction will characterize the load capacity, where the whole load is being transferred into the external construction walls of a building. The details of such timber construction are shown in Figure 3. This type of a roof framing is very popular today in carpenter practice and used on a daily basis. This solution can be applied to any building with a roof span between 5 ÷ 12m provided the rafters are longer than 4.5m. The collar beam should be attached to the middle of a rafter span (or at 0.6 length of a rafter). In some cases, where the roof span is greater and the collar beam is too long, an intermediate post (or two posts) supported with a purlin must be used. The last case is where the collar

beams are longer than 3.5m and the roof framing span ranges between 7.5 and 10m. In the instance where the roof span is greater, more support on the purlins and walls must be applied

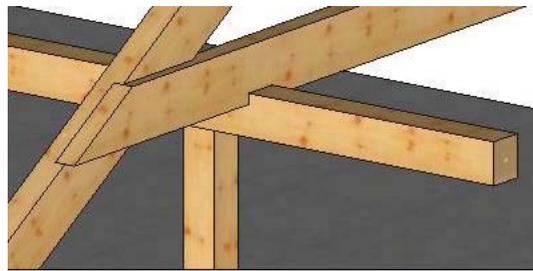


Fig.3: Details of a knot in a roof frame with a collar tie.

Roof trusses presented in Fig.1, Fig.2 and Fig.3 have been individually constructed by addition all of the beams, one by one, into a virtual design. Each part of the entire truss construction has to be as if it were ‘cut out’ of a log and correctly positioned in a 3D frame construction. Each part receives its general name and number. Materials, bitmaps and textures can be individually assigned to a single construction. Cadwork 3D provides options for special parts addition such as connectors (cuts, holes, bolts, pins). It can automatically generate work shop drawings on a specified scale with preformatted dimensioning and pre-defined drawing layouts. 2D drawings are automatically created in Cadwork 2D.

7. Creating various shapes for roofs with aid of ‘DachAbbund’ Module

Depending on the different shapes and dimensions of a pre-defined roof base Cadwork can also automatically estimate the geometry of the roof and will also add up constructive elements to it such as rafters or ridges. Fig.4 shows an example of this, where the original outline of a roof-base has been determined after Koźniewski (see [1] and [2]). The Module ‘DachAbbund’ automatically creates rafters and purlins. One can also simply add roof tiles or sheets and visualize the construction in a shaded or rendered mode. This software also provides options for element collision control.

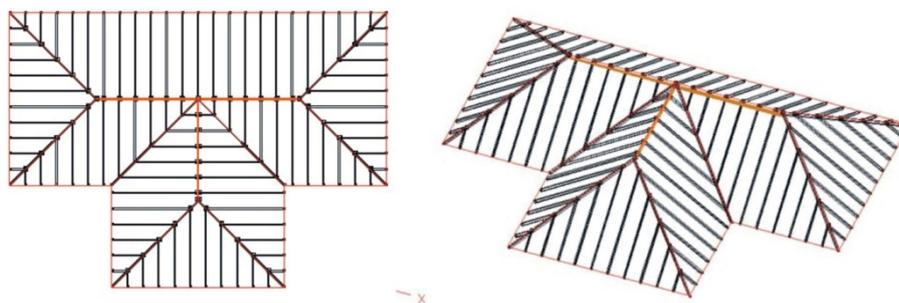


Fig.4: Example of a roof development automatization.

8. Concluding remarks

Depending on the knowledge, skills and attitudes targeted, various methods that favor the development of specific competences have been applied in the course of ‘Technical Drawing’ at the faculty of Civil Engineering, Cracow University of Technology. The methods include:

- A traditional lecture,
- A multimedia-presentation,
- A creation of virtual models for specific constructions.

The students are trained 'for projects via doing individual projects'.

Virtual models of timber constructions prepared by the tutor in Cadwork environment facilitate targeted teaching process and enhance teaching in a competency-oriented program.

References

- [1] Koźniewski E.: *Geometry of Roofs from the View Point of Graph Theory*. Journal for Geometry and Graphics 8 (2004), No.1, 41-58.
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- [3] Byrdy Cz., Kram D., Korepta K., Śliwiński M.: *Podstawy Budownictwa. cz.II, Skrypt dla studentów szkół wyższych*, Wyd. Politechnika Krakowska, 1998.
- [4] www.cadwork.com

W JAKI SPOSÓB CADWORK MOŻE UŁATWIĆ NAUCZANIE PRZEDMIOTU „RYSUNEK TECHNICZNY”?

Jednym z zadań realizowanych w programie nauczania przedmiotu „Rysunek techniczny” na wydziałach budownictwa lądowego jest zapoznanie studentów z normami i zasadami sporządzania rzutów i przekrojów budynków wraz z wprowadzeniem zasad wymiarowania na rysunkach architektoniczno-budowlanych. Obowiązujące normy to m.in. PN-B-01025: *Rysunek budowlany, Oznaczenia graficzne na rysunkach architektoniczno-budowlanych*, PN-B-01029: *Zasady wymiarowania na rysunkach architektoniczno-budowlanych* oraz PN-B-01027: *Oznaczenia graficzne stosowane w projektach zagospodarowania działki lub terenu*. Wymienione normy są zgodne z standardami ISO.

Na ogół studenci podejmujący studia na 1-wszym roku wydziałów budownictwa nie posiadają żadnego doświadczenia w wykonywaniu takich rysunków, tym bardziej, iż przedmioty takie jak „Materiały budowlane” czy „Konstrukcje budowlane” przypisane są według obowiązujących standardów nauczania wytyczonych przez Radę Główna Szkolnictwa Wyższego równoległe do tego samego semestru lub do wyższych semestrów na studiach inżynierskich. Zachodzi, zatem konieczność przygotowania „wprowadzenia do przedmiotu” w postaci krótkiego wykładu na temat podstawowych elementów konstrukcji budynku, a w tym ścian, kominów, schodów oraz dachu. Z oczywistych powodów wprowadzenie takie musi być przedstawione w sposób uproszczony, gdyż celem nauczania przedmiotu jest poznanie norm rysunkowych a nie podstaw konstrukcji budynku. W takim przypadku pomocne są te programy komputerowe wspomagające projektowanie, w których można w sposób przystępny stworzyć model wirtualny proponowanej konstrukcji.

W pracowni komputerowej ZGWRTGI Politechniki Krakowskiej znajduje się wiele licencjonowanych programów, które służą nie tylko do nauki i praktykowania przyszłym architektom czy inżynierom budownictwa lądowego, ale takich które można wykorzystać do tworzenia materiałów ilustrujących wykład do projektu z przedmiotu Rysunek techniczny w ich środowisku wirtualnym. Przykładem takiego programu jest Cadwork [3]. W artykule przedstawione zostały przykłady modeli wirtualnych konstrukcji dachów drewnianych.