

Saimaa University of Applied Sciences

The Faculty of Technology, Lappeenranta

Double Degree Programme in Construction and Civil Engineering

Iuliia Gradusova

Creating drawings with Tekla according to GOST

Bachelor's Thesis 2013

CONTENTS

Abstract.....	4
1. INTRODUCTION.....	5
2. ACTUAL RUSSIAN NORMS.....	5
3. TEKLA STRUCTURES	8
3.1. General information.....	8
3.1.1. Using Tekla in the world.....	9
3.1.2. Using Tekla in Russia.....	10
3.2. Development of the FMC Tekla Russian Environment.....	10
3.2.1 Past of the FMC Tekla Russian Environment.....	10
3.2.2. Tekla FMC-Russian Environment nowadays	11
3.2.3. Tekla FMC-Russian Environment and planes for future.....	13
4. COMPARISON WITH THE STANDARDS	13
4.1. Databases.....	14
4.2. Templates	14
4.2.1. Tables	15
4.3. Marks	16
4.4. Dimensions	16
4.5. Texts	17
5. IMPROVEMENTS MADE.....	17
5.1. General technology of programming in Tekla.....	17
5.2. Action plan	21
5.3 The trial model of block of flats.....	33
5.3.1. Dimensional layout drawing	34
5.3.2. Layout of columns and walls	39
5.3.3. Pillar reinforcement drawing.....	40
6. GIVING OUT THE DRAWINGS	41
6.1. Exporting to DWG/DXF format	42
6.2. Printing with TS	43
CONCLUSIONS.....	44
FIGURES.....	45
REFERENCES	46

APPENDIX 1. INTERNATIONAL PROJECTS CARRIED OUT IN TEKLA STRUCTURES	47
APPENDIX 1. Russian projects carried out in Tekla Structures.....	48
APPENDIX 2. COMPARISON OF THE TEKLA AND GOST	49
APPENDIX 3.....	53
APPENDIX 3.1. Dimensional Layout of slab.....	53
APPENDIX 3.2. layout of columns and walls	53
APPENDIX 3.3. pillar reinforcement drawing. Pillar 1000x400mm.	53
APPENDIX 3.4. pillar reinforcement drawing. Pillar 960x250mm.	53

ABSTRACT

Iuliia Gradusova

Creating drawings with Tekla according to GOST, 47 pages, 3 appendixes

Saimaa University of Applied Sciences, Lappeenranta

Technology, Double Degree Programme in Civil and Construction Engineering

Bachelor's Thesis 2013

Instructors: Mr Timo Lehtoviita (Saimaa University of Applied Sciences),

Mr Pekka Narinen (Finnmap Consulting Oy),

Mr Jari Sydanmetsa (FM Stroiproject).

The study was commissioned by Finnmap Consulting Oy. The purpose of this thesis was to study the opportunity to create drawings with Tekla Structures according to the Russian norms, to study what can be changed and what has already been changed.

The thesis should be of interest to design engineers working with 3D modeling and for design engineers who are going to start working with 3D-software in Russia and according to the GOSTs.

The first part of the thesis contains the description of the actual Russian norms, their history and the prospects of the development, general information about Tekla Structures, using it in the world and in Russia, information about the development of Russian environment in FMC.

The second part includes the comparison of Tekla Structures with Russian Norms. The most important element of the drawing are described: marks, dimensions, tables and texts. It also describes the description of the general technology of programming in Tekla and the improvements which have been done: table changes, creating of the templates.

The last part describes the process of giving out the drawings, exporting them to DWG and printing from Tekla Structures.

As a result of this project, the advices on the environment development have been given; the template for dimensional layout drawings has been created. Based on these, the possibility of using Tekla Structures in Russia has been considered.

Keywords: Tekla, drawings, GOST.

1. INTRODUCTION

The client of this thesis is Finnmap Consulting Oy, which is a part of FMC Group. Finnmap is an international company with clients all over the world. The area of its activity covers all aspects of structural engineering. A lot of projects were made for Russia and with the help of Russian and other foreign offices of Finnmap. As a leading company Finnmap uses different software for modeling and calculating the structures. Tekla is widely used in Finland but it still is not used in Russian. The accordance of the Tekla Russian Environment to the GOST is the main problem of implementing Tekla in modeling process in Russia. That is why it is important to study all the problems of the Russian Environment.

The main aims of this work are: to try to get drawings of the Tekla model according to GOST; to identify all problems and mistakes in drawing execution; to correct the mistakes and to make settings for easier drawing execution.

2. ACTUAL RUSSIAN NORMS

List of specific words is given below:

- GOST is a set of technical standards maintained by the Euro-Asian Council for Standardization, Metrology and Certification (EASC), a regional standards organization operating under the auspices of the Commonwealth of Independent States (CIS).
- The System of normative documents in construction (SNIP) is a set of regulations maintained by executive authorities, governing the implementation of urban planning and engineering, architectural design and construction. The System of normative documents in construction in the USSR acted along with standardization system in the building, which is part of the State system of standardization. Since 1995, the building codes are a special case of technical regulations. In 2010, the existing building codes were recognized as national regulations.

- The standards of the Unified system for design documentation (ESKD) is the Unified System of Design Documentation, a subset of the GOST standard. This system governs everything from font type and size to text placement on a page.
- The system design documentation for construction (SPDS) is a set of documents which establish uniform rules for implementation of project documentation for construction, providing:

GOST standards were originally developed by the government of the Soviet Union as a part of its national standardization strategy. The history of national standards in the USSR can be traced back to 1925, when a government agency, later named Gosstandart, was established and put in charge of writing, updating, publishing, and disseminating the standards. After World War II, the national standardization program went through a major transformation.

After the disintegration of the USSR, the GOST standards acquired a new status of the regional standards. They are now administered by the Euro-Asian Council for Standardization, Metrology and Certification (EASC), a standards organization chartered by the Commonwealth of Independent States.

At present, the collection of GOST standards includes over 20,000 titles used extensively in conformity assessment activities in 12 countries. Serving as the regulatory basis for government and private-sector certification programs throughout the Commonwealth of Independent States (CIS), the GOST standards cover energy, oil and gas, environmental protection, construction, transportation, telecommunications, mining, food processing, and other industries.

The following countries have adopted GOST standards in addition to their own, nationally developed standards: Russia, Belarus, Ukraine, Moldova, Kazakhstan, Azerbaijan, Armenia, Kyrgyzstan, Uzbekistan, Tajikistan, Georgia, and Turkmenistan.

The task of harmonization of Russia's standards and the GOST standards was set in 1990 by the Soviet Council of Ministers at the beginning of the transit to market economy. At that time they formulated a direction that obeying the

GOST standards may be obligatory or recommendable. The obligatory requirements are the ones that deal with safety, conformity of products, ecological friendliness and inter-changeability. The Act of the USSR Government permitted applying of national standards existing in other countries, international requirements if they meet the requirements of the people's economy.

During the past years a large number of GOST standards was developed and approved. Nowadays there is a process of their revision so that they conform international standard requirements. As the base is the system of international standards ISO, in Russia they created a series of Russian standards, which absorbed the best developments of the world community but they also consider the Russia's specific. [10]

Historically, GOST R system originated from GOST system developed in the Soviet Union and later adopted by the CIS. Thus, the GOST standards are used across all CIS countries, including Russia while GOST R standards are valid only within the territory of the Russian Federation.

This system is aimed at providing the Customer with safety and high quality of products and services. This right of the Customer for safety and quality is guaranteed by obligatory certification of not only native but as well foreign products.

- GOST 21.501-93 System of project documents for construction. Rules for creating architectural and construction working drawings. This standard set out the composition and rules for architectural working drawings of buildings and structures; used since the 1st of September, 1994 as the official standard of the Russian Federation. These norms are obligatory for use.

GOST 21.501-2011 System of project documents for construction. Rules for creating architectural and construction working drawings.

GOST 21.201-2011 Graphic symbols for building elements and structures. These standards are in use since 01.05.2013. They have replaced GOST 21.501-93. At the beginning of writing the thesis these

new GOSTs were not in use. That is why it is important to take into account new and old variant.

- GOST R 21.1101-2009 System of design documents for construction. The main requirements for design and working documents. This standard specifies the basic requirements for the design documentation for capital construction and working documentation of all types of construction projects. used since the 30th of November, 2009 as the official standard of the Russian Federation. These norms are obligatory for use.
- GOST 21.110-95 System of building design documents. Rules of developing specifications for equipment, products and materials. This standard specifies the requirements for the execution specifications for equipment, products and materials to the basic set of working drawings of buildings and constructions of various purposes; used since the 1st of July, 1995 as the official standard of the Russian Federation. These norms are obligatory for use.
- GOST 21.502-2007 Rules for creating project and working drawings of steel structures. In use since the 1st of January, 2008 as the official standard of the Russian Federation. These norms are obligatory for use.

The Russian system of Regulatory documents is at the stage of renewal of Soviet standardization. Every year newly established standards are published. There is no exact information about whether Russia is going to work with European standards or not. At the moment Authorities are fully occupied with renovation of old norms.

3. TEKLA STRUCTURES

3.1. General information

Tekla is a large company with world-wide partner network. Tekla was established in 1966. It is a part of Trimble Group since July, 2011. The headquarters are in Espoo, Finland. The company employs more than 500

people, of whom approximately 200 work in the area offices. There are two business areas: Building & Construction and Infra & Energy

Tekla Structures (TS) is Building Information Modeling (BIM) software that enables the creation and management of accurately detailed, highly constructable 3D structural models regardless of material or structural complexity. Tekla models can be used to cover the entire building process from conceptual design to fabrication, erection and construction management. There is a scheme of the construction management module on Figure 1.

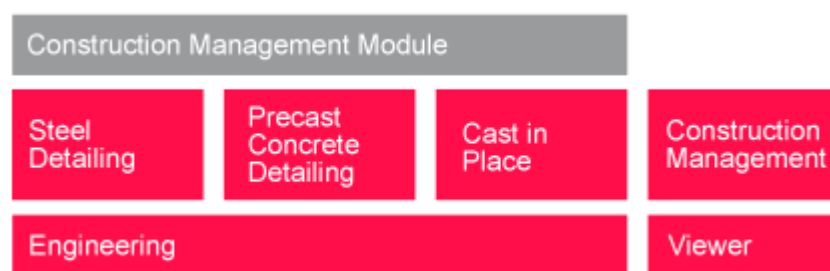


Figure 1. Different configurations of Tekla Structures [9]

Tekla BIM software can be used to interface with other existing applications, or solely as a platform to develop a customizable internal solution. It is an open solution that supports interoperability and standardization. TS links with various systems through Tekla Open API™ application programming interface that is implemented using Microsoft® .NET technology. Examples of standard formats supported by Tekla are IFC, CIS/2, SDNF and DSTV. Examples of proprietary formats supported by Tekla are DWG, DXF and DGN. See Tekla Structures Interoperability chart. [9]

3.1.1. Using Tekla in the world

Tekla has customers in 100 countries. Tekla offices are in Finland, Sweden, Denmark, Great Britain, France, Germany, the U.S.A, Singapore, Indonesia, Thailand, Korea, Japan, China, India and the United Arab Emirates.

TS is localized to 30 environments to suit the local design and construction industry standards. One of them is Russian Environment. TS even has its own

competition - the Global BIM Awards competition. The entries to the Global BIM Awards competition are the winners of regional Tekla BIM Awards organized by Tekla area offices and resellers worldwide.

Nowadays Tekla is discovered and widely used as BIM software. It means that it is used not only for getting readymade drawings but also for other parts of the life cycle of the building.

Tekla is useful for big and small projects. Many huge buildings were created with Tekla in the world and many smaller projects are carried out every day.

Projects carried out in TS are shown in Appendix 1.

3.1.2. Using Tekla in Russia

Tekla Structures is only at the beginning of its way in Russia. It is used only for about ten years. Steel detailing is used more often than other configurations of Tekla Structures in Russia. Most of the companies using TS are foreign. And they usually use TS for the internal purposes, for example: the drawings of the details for sending to the factory. That is why they do not have to be examined by the authorities and do not have to follow the GOST in drawings. Adapting Tekla Environment looks difficult for the great majority of construction companies in Russia. They are not in a hurry to embed this software because there are no regulations of using it in Russia.

Projects carried out in TS are shown in Appendix 1.

3.2. Development of the FMC Tekla Russian Environment

3.2.1 Past of the FMC Tekla Russian Environment

Finnmap started to use Tekla Russian Environment in 2005 for projects executed in Russia. The development of the Tekla FMC environment was started at that time. First it was only steel structures. Then in 2009 they started to work with concrete modeling. They also started to develop Russian

Environment for FMC (System Entrance screen is on Figure 2). For the first period they separated the projects for two stages: Steel and Concrete. It was impossible to model them together because of the file size. Nowadays computers provide an opportunity to work with such big files.

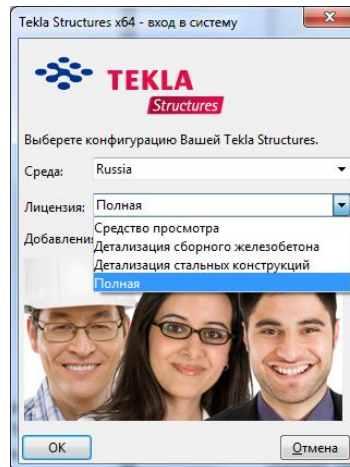


Figure 2. System Entrance for Tekla FMC-Russia Environment

For this period Finnmap has created an almost perfect FMC Environment.

3.2.2. Tekla FMC-Russian Environment nowadays

Nowadays the process of improving FMC-Russia is still one of the most important topics for Finnmap. The main principle of this process is doing improvements during the creation of the project. It means that changes happen when they are needed.

For example the first project was a Shopping Centre. So environment was adopted for its requirements. Specific drawing settings were added and templates created. And if the second project is a block of flats Finnmap will create a new version for it including all new aspects.

All in all it takes time (several projects) to adopt the environment for one's own purposes.

Today Tekla Russian Environment still is one of the least developed environments. With the help of Finnmap it improves every time. They have made such supplements as:

Steel structures:

- Templates:
 - Steel specification
 - Element specification
 - Stamp
 - Frame table
- Databases
 - Steel profiles acc. to GOST
 - Material list acc. To GOST
- Fonts
- Other:
 - Objects
 - Layouts

Here is one interesting point: Steel profiles catalog was created in the following way: Letter is modified into profile symbol Figure in drawing layout using special font. For each profile it is possible to use own symbol. It is possible to improve symbols catalog during the project especially for special cross-section.

Codes (Letters) of basic profiles included in GOST are listed:

I = I
H = H
O = O
C = ●
L = L
R = □
S = □
Z = J
T = T
U = C
P = P

3.2.3. Tekla FMC-Russian Environment and planes for future

Soon Finnmap plans to add:

- Layouts for prestressed and post tensioned structures
- Layouts for details
- Add some data bases
- Embedded parts (bolts, nuts)
- Reports according to GOST

4. COMPARISON WITH THE STANDARDS

All construction projects in Russia must pass through the state expertise. That is why all the documentation must follow Russian Norms and standards with sanitary-epidemiological, ecological requirements, the requirements of state protection of cultural heritage, with fire, industrial, nuclear, radiation and other safety. Documentation appearance is also important for the authorities. The standards of the Unified system for design documentation (ESKD), as well as the relevant standards SPDS must be used when doing the project or working documentation and reporting technical documentation for engineering surveys for construction (GOST P 21.1101-2009).

The thesis work includes examining of the Tekla Russian Environment in general and takes some improved parts from the FMC Russia Environment because there are still a lot of mistakes.

Tekla Russian Environment was examined for correspondence to GOSTs. The examination was carried out on amount of databases, quality of tables in templates, marks, dimensions and fonts.

4.1. Databases

Catalogs are databases containing the information you would normally expect to find listed in design code tables, or printed reference material. Two databases were taken into account: Material catalog and Profile catalog.

Profiles from the following GOSTs are used in Profile catalog:

- I-section: CTO AC4M 20-93, GOST 8239-89, GOST 19425-74, GOST 26020-83
- L-section: GOST 8510-93, GOST 8509-93, GOST 19772-93
- Channel-section: GOST 8278-83, GOST 8240-97
- Square and rectangular hollow section: GOST 8645-68, GOST 8639-82, GOST 30245-2003
- Secular hollow section: GOST 8732-78, GOST 10704-91
- T-section: GOST 26020-83
- Secular section: GOST 2590-88
- Square section: GOST 2591-88
- Profile sheets: GOST 24045-94

Material database:

There are readymade databases of concrete, steel and some other materials.

4.2. Templates

Templates are used for a variety of different purposes, for example to print a list of parts used in a construction assembly, to denote the legend on an electrical network map, or to provide statistics on the contents of the map such as city area, scale or date. An easy example of template and its tables is shown on Figure 3.

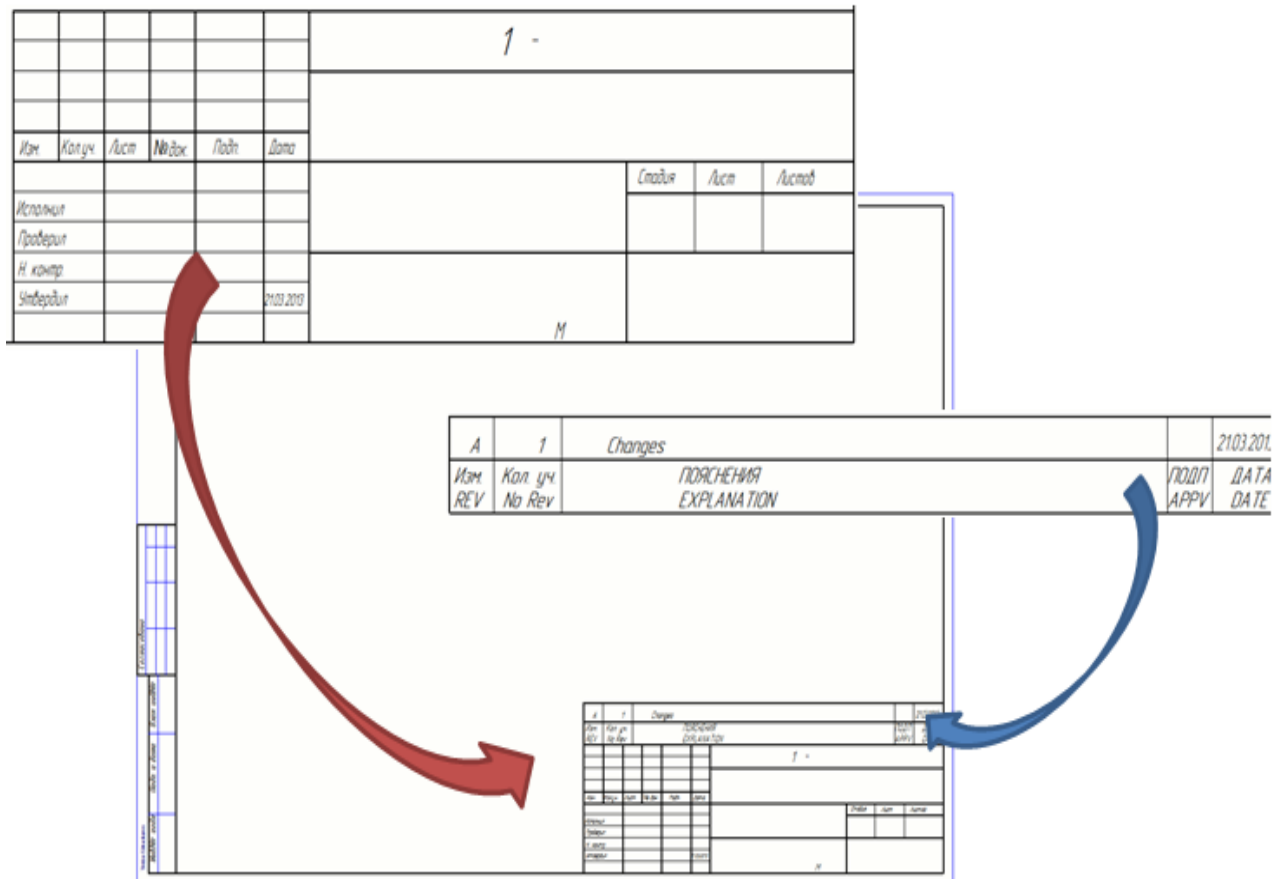


Figure 3. An example of a GA drawing layout for the A3 drawing sheet size

4.2.1. Tables

It is extremely important for drawings to be in accordance with GOST. Therefore, there was made a comparison of the tables embedded in Russian Tekla with Russian standards. During the study of the environment, a lot of gaps have been found in the design of the tables. They are presented in Appendix 1.

The most common mistake is wrong dimensions of the table. The dimensions are very strictly specified in the norms. It is easy to correct it with TplEd editor.

In some cases there is no opportunity to create the required shape of the table with TplEd at all.

4.3. Marks

It is possible to choose different types of marks, to view and modify the settings affecting the mark appearance in the Mark Properties dialog box. But it still is not possible to change the location of the text and to put it under the line. (See Figure 4)

This problem can be solved by adding the text by hand.

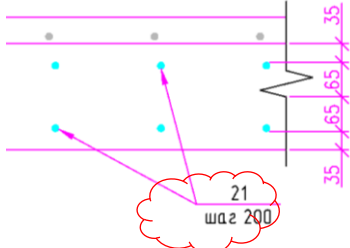
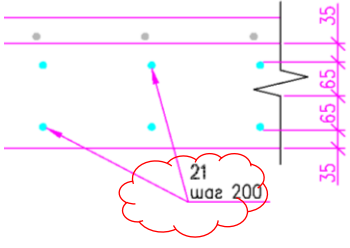
№	Mark according to GOST	Mark in Tekla
1		

Figure 4. Marks in Tekla

4.4. Dimensions

Another difficulty is a lack of opportunity to move dimensions. The guide line can only be at the level of the dimension. It also cannot be corrected in this step of programme developing. (See Figure 5)

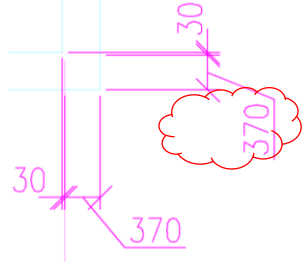
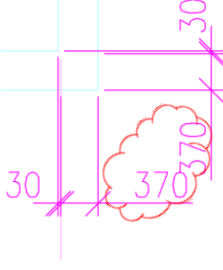
№	Mark according to GOST	Mark in Tekla
1		

Figure 5. Marks in Tekla

4.5. Texts

Tekla Russian Environment uses the fonts which are embedded in Windows. In Russia the following fonts are used for drawings: GOST type a, GOST type B (GOST 2.304-81), GOST_common, GOST_common italic. One of these fonts can be set as major. (According to GOST 2.304-81).

But there are still some problems with reflecting Cyrillic letters in the Model area. The names of the letter axes usually reflect as unidentified symbols. It makes working with the Model uncomfortable.

5. IMPROVEMENTS MADE

5.1. General technology of programming in Tekla

Tekla structures has its own template editor (TplEd). It is possible to create and to correct readymade templates. Template layout is designed with template components. Template objects are then placed inside template components to add either graphical or textual data. The properties of components, objects and the template itself determine the final appearance.

Templates can be made up of five different component types, but not all components have to be present to build a template. The components are:

- *Header*: a header appears once at the beginning of a template. It may contain, for example, the heading of the template.
- *Page header*: a page header appears at the beginning of template page. There are many different options for specifying the output policy, see Edit the output options of component.
- *Row*: a template can have multiple rows. A row defines the things that are listed in the template, each row usually representing an object from the Tekla product database. Rows contain Field objects that define the Attributes to get from the database.

- *Page footer*: a page footer is output at the end of template page. There are many different options for specifying the output policy, see Edit the output options of component.
- *Footer*: a footer appears at the end of a template. [1]

The template type determines what kind of objects can appear inside template components. The following template object types are available:

- *Drawing objects*: drawing objects are basic geometric shapes such as lines, rectangles and circles.
- *Text objects*: text objects display static texts such as headings or title line texts.
- *Symbols*: you can insert symbols from your Tekla product symbol libraries.
- *Figures*: you can insert Figures from raster format files.
- *Imported files*: you can import AutoCAD and MicroStation files.
- *Field objects*: fields contain textual or graphical data that is gathered from the Tekla product. [1]

Templates are descriptions of forms and tables that can be included in Tekla products. The forms can be graphical for inclusion in drawings as tables, text blocks, drawing headers, or ASCII text form for reports. Each Tekla product defines what kind of output options are available for different types of templates.

Textual templates only contain text. They are primarily used for creating reports or listings of application area specific objects, for example in material lists of steel construction assemblies in Tekla Structures.

The text can be output like newspaper columns. Even though TplEd lets you use different font types and settings, they do not appear in the output template.

Textual template definitions have the file extension .rpt.

Graphical templates are used in all Tekla products and they generally display map legends and labels, or project and company information. In addition to text, they can contain graphics, such as table outlines, Figures or symbols. Graphical templates can also use different font types and settings.

Graphical template definitions have the file extension .tpl.

Tekla Structures includes the following features for drawings.

All information comes directly from the model, which minimizes the work you have to do. In many cases all you need to do is to check the predefined settings or do some minor editing.

The drawings are actually part of the model. If you revise the model, Tekla Structures also updates the drawings, so they are always up to date. [1]

A master drawing is a Tekla Structures drawing or a set of drawing properties that is used for creating new drawings that look the same as the master drawing. There are several types of master drawings: cloning templates, saved settings and rule sets.

Tekla Structures generates drawings according to the properties defined for each drawing type. The way Tekla Structures connects the properties to the drawing is created depends on the method selected for creating the drawing:

- Drawings in the Master Drawing Catalog with a rule set, Tekla Structures uses the properties defined for the saved settings file or cloning template used in the rule set.
- Drawings in the Master Drawing Catalog with saved settings, Tekla Structures uses the properties defined in the saved settings file you select.
- Drawings in the Master Drawing Catalog with cloning templates, Tekla Structures creates the drawing using the properties that have been defined for the drawing used as a cloning template together with the manual modifications that you have made in the cloning template.
- Drawings through Drawings & Reports menu commands, Tekla Structures uses the current properties in the appropriate drawing type specific drawing properties dialog box. The current properties in the drawing properties dialog box are also used when drawings are created using toolbar command buttons or pop-up menu commands.

The variant of saved settings and cloning templates was used in this project.

The saved settings in Master Drawing Catalog (Figure 6) are drawing property files that have been created and saved in the drawing properties dialog boxes for different drawing types. There are many predefined drawing property files, and you can also create your own in the drawing properties dialog boxes (Figure 7).

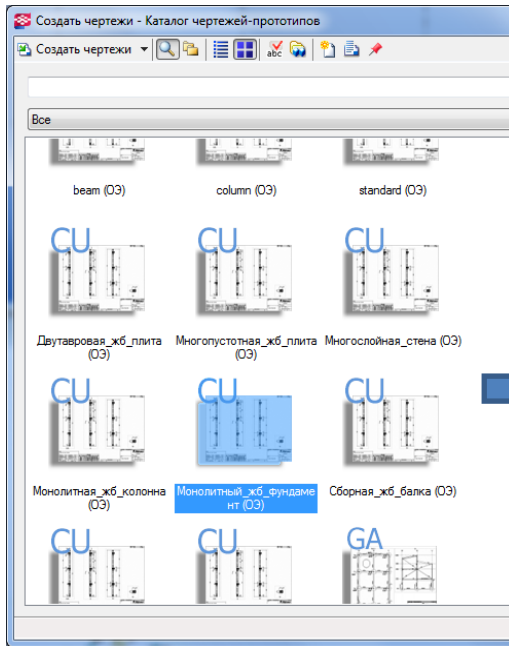


Figure 6. The search view of the Master Drawing Catalog

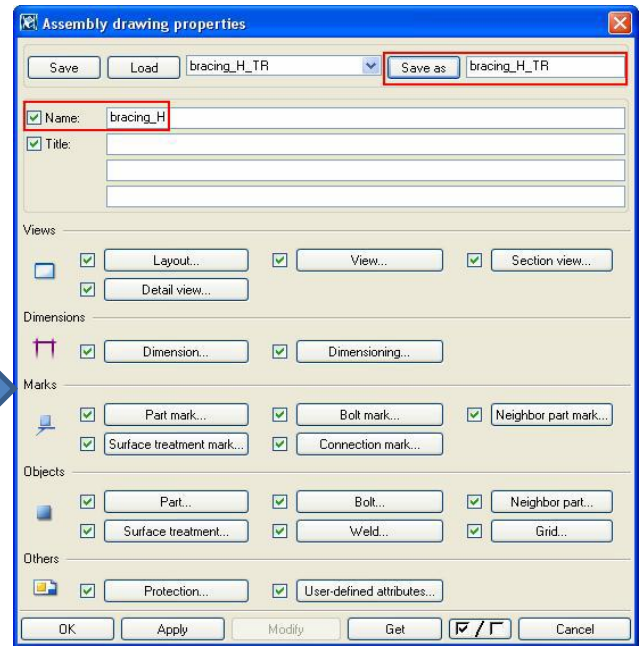
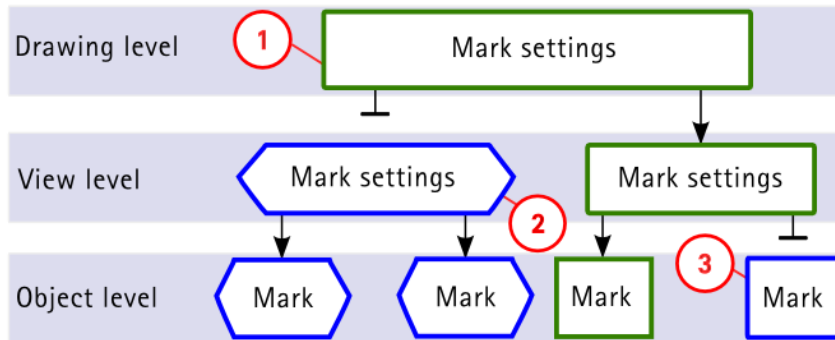


Figure 7. Drawing properties Window

It is possible to modify drawings on three levels, depending on how permanent and extensive modifications are needed. The scheme is presented on Figure 8.



- 1 The frame color and shape for the whole drawing can be changed on the drawing level. The changes propagate to the view level and to the object level.
- 2 The frame color and shape can be changed in the selected views. The changes take place in the selected views only. The properties do not change in the whole drawing.
- 3 The frame color and shape can be changed in the selected marks. The properties do not change anywhere else.

Figure 8. The idea of the three property levels. The frame color and the shape of the mark are used as an example

5.2. Action plan

The main idea of the Tekla Structures software is to increase the quality of the documents by automation of the process. So the aim is to make drawing creating as automatic as possible.

A pilot General Arrangements drawing template has been created for investigating the properties of the drawings. General arrangement drawings show the model from the most suitable direction. For example, in plan drawings it is possible to see structures of the previous floor from the upper floor of a building. GA drawings often contain enlarged views of complex areas or details, and other additional information that helps in the approval process and during the installation phase.

The steps of creating the template are presented below.

The creation was not started from the global settings, but in opposite from the local settings. It is easier to create templates for each element and then combine them in one global template.

There are 11 types of local element settings:

- Layout
- View
- Section view
- Detail view
- Dimensions
- Dimensioning
- Part mark
- Reinforcement mark
- Part
- Grid
- Reinforcement

Layouts:

It is convenient to create a new layout and to add there tables which are needed for the particular type of the drawing. It can be done in Layout Settings.

Drawings and Reports -> Drawing Settings -> Layout Settings

The main layout is called **GostThesis**. It contains several table layouts.

For example: GostThesis -> Main set of working drawings-> Stamp for main set of working drawings, Revision, Drawing framework

It includes:

- Steel expense register
- Revisions FMC
- Detail register
- Drawing framework
- Rebar specification of the cast-in-situ structures
- Element specification of the cast-in-situ structures
- Stamp for the main set of working drawings, graphics documents of design documentation, graphical documents for Engineering Survey.

Steel expense register / Ведомость расхода стали:

This table is one of the most difficult aspects in Tekla Layouts. The basic Tekla Russian Environment offers the following view of it:

<i>Ведомость расхода стали, кг</i>		
<i>Марка элемента</i>	<i>Изделия армирование Арматура класса</i>	
	A500	
	∅ 18	4.16
Ф-8	<i>Итого</i>	4.16
	A500C	
	∅ 10	8.5
	∅ 16	32.3
Ф-8	<i>Итого</i>	40.9

Figure 9. Steel expense register in Tekla Russian Environment

It does not follow the GOST (Table 1). The table develops vertically. Tekla TrpEd does not have an opportunity to make it horizontal.

Temporary solution can be the next: the table can consist of three separate tables. And then they are combined in particular layouts of the drawing.

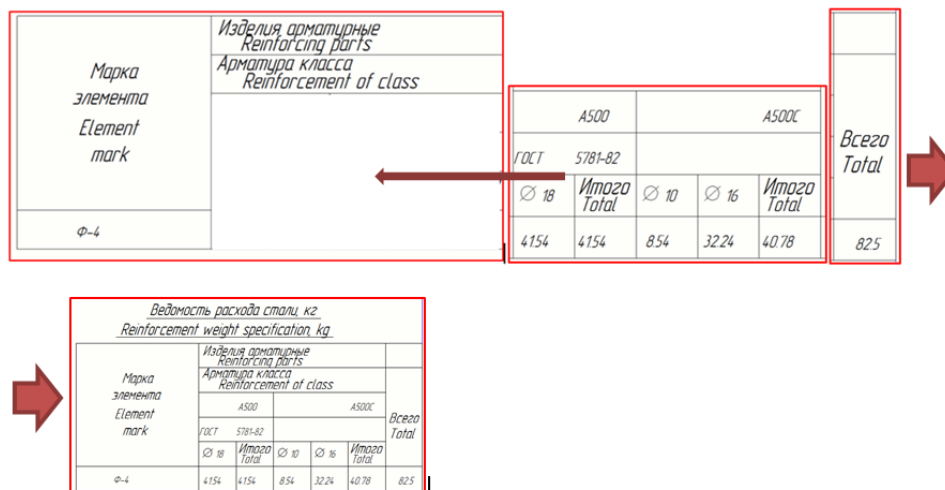


Figure 10. Steel expense register alternative option

Revisions FMC / Таблица регистрации изменений:

Wrong Dimensions and font have been corrected. English text was added.
Attributes were set in descending order;

D	4	Rebar changed		20.03.2012
C	3	Rebar changed		20.03.2012
B	2	Rebar changed		20.03.2012
A	1	Rebar changed		20.03.2012
Изм. REV	Кол. уч No Rev	ПОЯСНЕНИЯ EXPLANATION	ПОДП APPV	ДАТА DATE

Figure 11. Revisions table

Tekla Structures has a very convenient interface. The revision can be created by filling in the following forms.

The image shows two screenshots from the Tekla Structures software interface. The top screenshot is the 'Список чертежей' (List of drawings) window, which displays a table of drawing revisions. The table has columns for 'Опубликовано' (Published), 'Блок...' (Block...), 'Заморожено' (Frozen), 'Основное' (Main), 'Связано' (Linked), 'Изменения' (Changes), 'Создано' (Created), 'Изменено' (Modified), 'Редактор' (Editor), and 'Размер' (Size). A row is highlighted with a blue background, showing a revision with the code 'D', date '20.03.2012', and description 'Rebar changed'. The bottom screenshot is the 'Управление исправлениями' (Manage corrections) dialog box. It contains fields for 'Сохранить' (Save), 'Загрузить' (Load), 'Сохранить как' (Save as), 'Метка' (Code) set to 'D', 'Дата' (Date) set to '20.03.2012', and 'Текст' (Text) set to 'Rebar changed'. There are also checkboxes for 'Метка', 'Дата', 'Текст', and 'Создать' (Create), 'Изменить' (Modify), 'Удалить' (Delete), and 'Отмена' (Cancel).

Figure 12. Filling in Revisions forms

Detail register / Ведомость арматуры:

Wrong Dimensions and font size have been corrected. English text was added.
Correct font size: title 4, table header 3.5, others 2.5, line types and dimension types were also changed with help of attributes and advanced settings.

The weakest point of this table is it is difficult for ordinary user to edit graphic fields of this table. For example, there is no use to show straight ropes in this table. All attempts to exclude them were unsuccessful.

Ведомость арматуры
Detail register



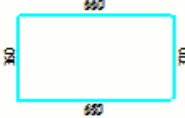

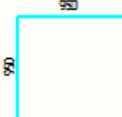
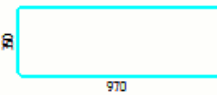






<i>Поз. Item</i>	<i>Эскиз Draft</i>
1	
2	
3	
4	
5	
6	

Figure 13. Detail register

Rebar specification of the cast-in-situ structures/ Спецификация элементов:

The table was adapted to GOST requirements. English text was added, the last column was added for counting the total weight.

Спецификация элементов
Specification of elements

<i>Поз. Item</i>	<i>Обозначение Designation</i>	<i>Наименование Description</i>	<i>Кол. шт. Number of</i>	<i>Масса ед., кг. Unit weight</i>	<i>Примечание Note</i>
		<i>Детали</i>			
		<i>Арматура ГОСТ 52544-2006</i>			
1		 16 A500C l=3740	16	5.9	94.4 кг
2		 16 A500C l=2200	16	3.5	55.5 кг
3		 8 A240 l=2000	31	0.8	24.5 кг
4		 8 A240 l=890	16	0.4	5.6 кг
5		 12 A500C l=2790	1	2.5	2.5 кг
6		 12 A500C l=2240	2	2.0	4.0 кг
		<i>Материалы</i>			
		Бетон В30	142 м ³		

* см. ведомость деталей
* see Detail register

Figure 14. Rebar specification of the cast-in-situ structures

Element specification of the cast-in-situ structures/ Спецификация элементов:

One of the basic tables was modified for calculating special detail on the drawing, for example ventilation blocks.

Спецификация элементов
Specification of elements

<i>Поз. Item</i>	<i>Обозначение Designation</i>	<i>Наименование Description</i>	<i>Кол. шт. Number of</i>	<i>Масса ед., кг. Unit weight</i>	<i>Примечание Note</i>
		<i>Сборочные единицы</i> <i>Assembly units</i>			
Б-1		Блок вентиляционный В 36.8.4-2 Vent unit В 36.8.4-2	9	1106	9956.2
Б-2		Блок вентиляционный БВ 36.93-0у Vent unit БВ 36.93-0у	8	1527	12213.8

Figure 15. Element specification of the cast-in-situ structures

Stamp for the main set of working drawings:

There are a lot of different ways of filling in the Stamp in TS. It is possible to fill the information from the model window through the Project Properties; and when the drawing is opened it also can also be done through the Drawing Properties and User-defined attributes.

Some information remains constant for the whole project. So it is convenient to leave it as a text in TplEd. Other parts of the Stamp are changed very often. They can be set with corresponding attributes and the Drawing Settings.

The scheme of filling in the Stamp is presented on Figure 16. Fields which are constant during the project are colored with green. Fields which can be changed are colored with red. The boxes describe where the setting can be made.

For example, all Names except one are set as text. They are the same for the whole project. And the name of drawing creator can change for different drawings. It is set with attribute "DR_DRAWN_BY" in Drawing Settings User-defined attributes. The similar situation is with Drawing number. It is divided into two parts: first there is a project number and it remains constant for whole the project and secondly there is individual for each drawing. The constant one is set in Project Properties and the attribute "PROJECT.NUMBER" in TplEd. The changing number is set in Drawing settings in the field TITLE2.

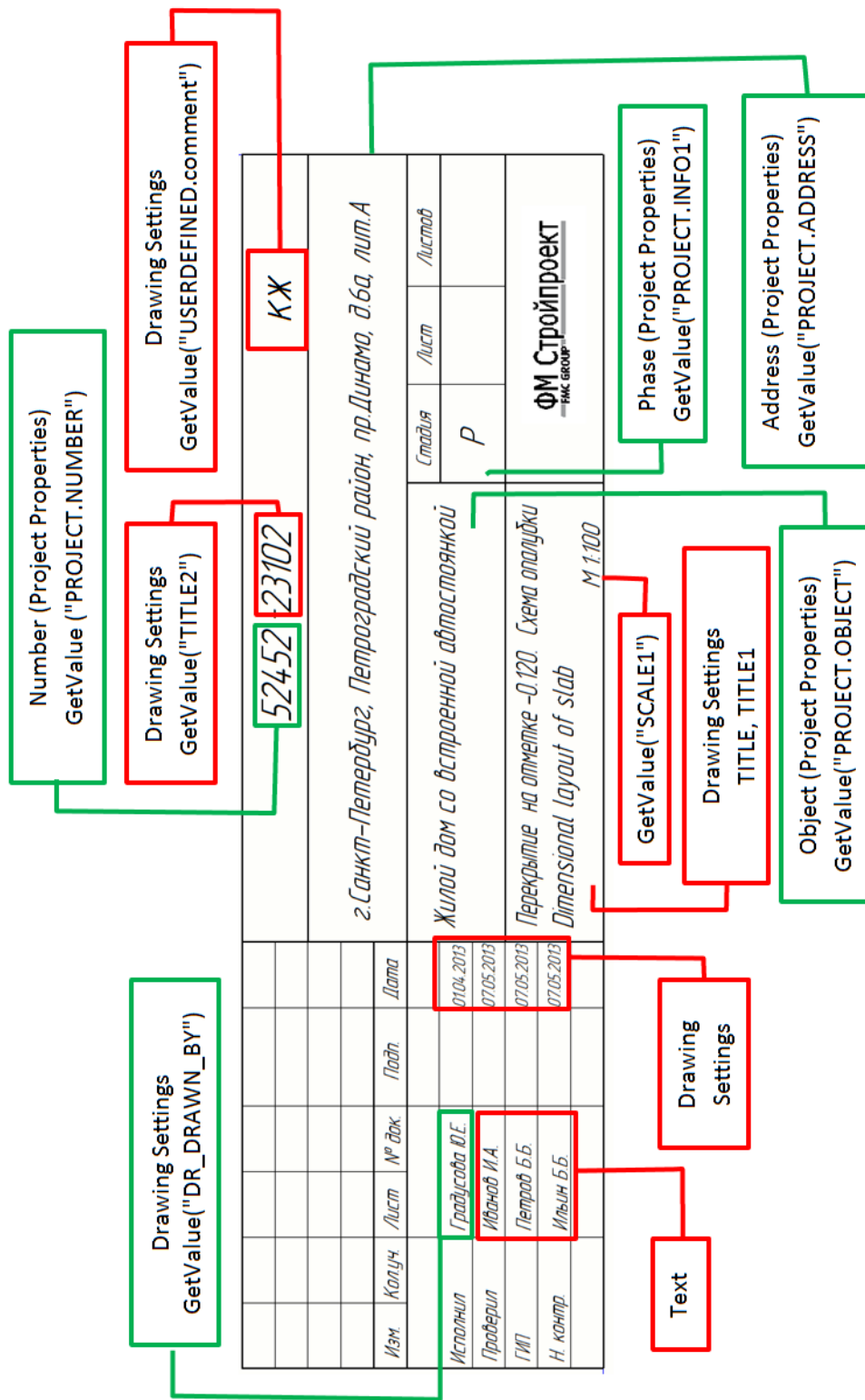


Figure 16. Filling the Stamp

These tables can be included in different layouts. Layouts can be applied for the different types of drawings. Figure 17 shows the principle scheme of the layout content.

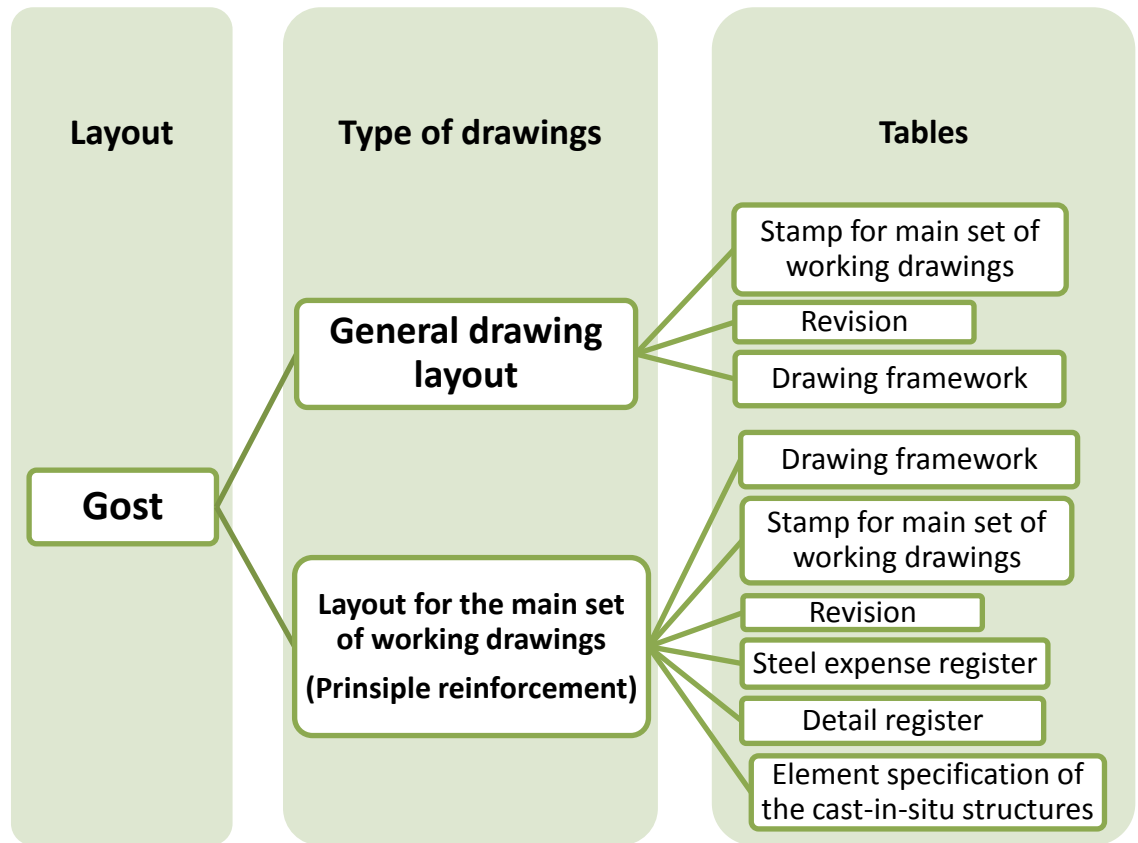


Figure 17. Scheme of the layout content

Going back to the drawing properties:

View:

Drawing Settings ->General arrangement drawings -> View

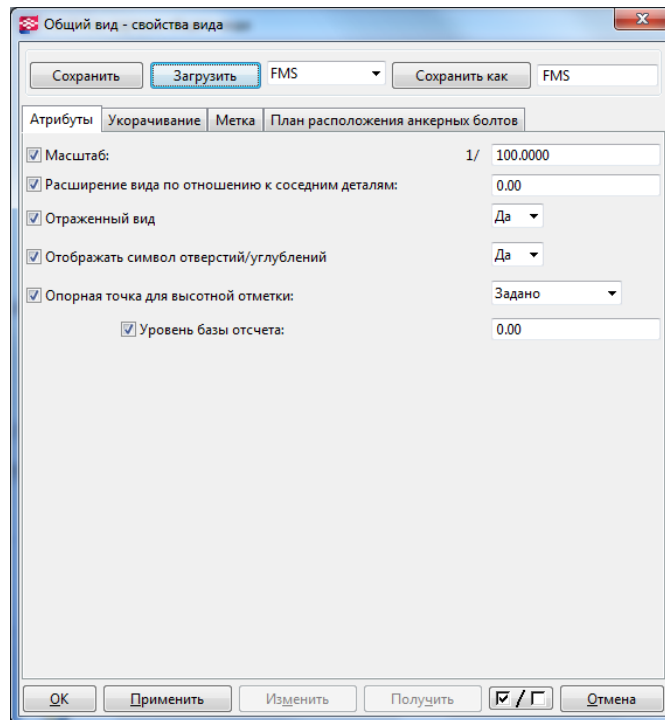


Figure 18. Drawing Settings. View

- **Scale:** 1:100
- **Reflected view:** Yes - Displays load bearing structures, such as columns and beams on a lower floor.
- **Show openings/recess symbol:** Yes (In the Advanced Options Reference Guide XS_USE_CROSS_FOR_OPENING_SYMBOL file determines how the openings/recesses are shown and the symbols to be used. The default value is TRUE, which means that a cross is used as the opening/recess symbol. This symbol is not widely used in Russia. It is the FALSE value when the shadows are used as symbols for openings.)

Drawing Settings ->General arrangement drawings -> Dimensions

General:

- **Dimension types:** Straight Relative
- **Short extension line:** No
- **Combine equal dimensions:** No

Dimension appearance properties: shown on Figure 19:

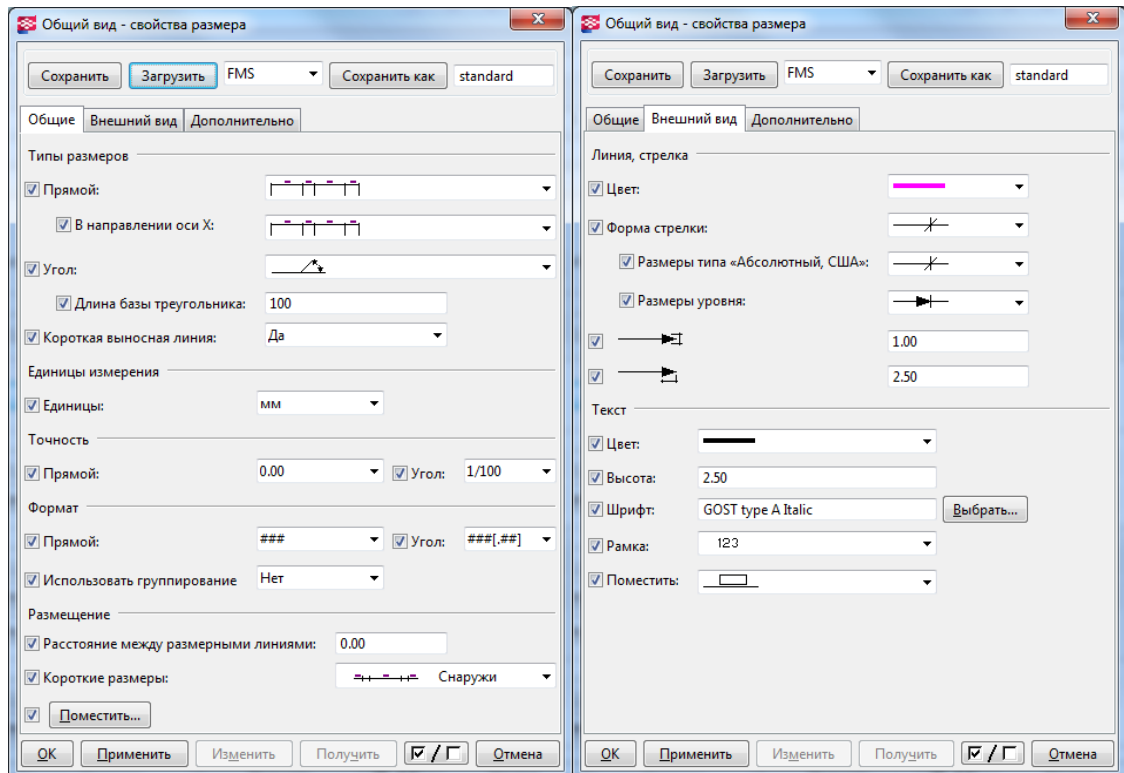


Figure 19. Dimension general and appearance settings

All the dimension properties have been saved as FMS template.

Drawing Settings ->General arrangement drawings -> Dimensioning properties

Grid dimensions:

- **Overall dimensions:** On
- **Individual spans:** On
- horizontally on the left, vertically on both sides.

The grid will be dimensioned with overall dimensions and individual spans dimensions.

Part dimensions: special settings are not made for automatic dimensioning. There is no use of creating object groups. This function does not work in GA drawings.

Drawing Settings ->General arrangement drawings -> Part Marks

All automatic part Marks are turned off. It is not required for this type of drawing.

Drawing Settings ->General arrangement drawings ->Object -> Part

Line type is set as dashed line. Later on the drawing line the type of the main detail will be changed to solid. It gives an opportunity to show the underlying structures and upper structures with different lines.

The filling is turned off.

Drawing Settings ->General arrangement drawings ->Object -> Grid

Settings for grid are shown on the Figure 20.

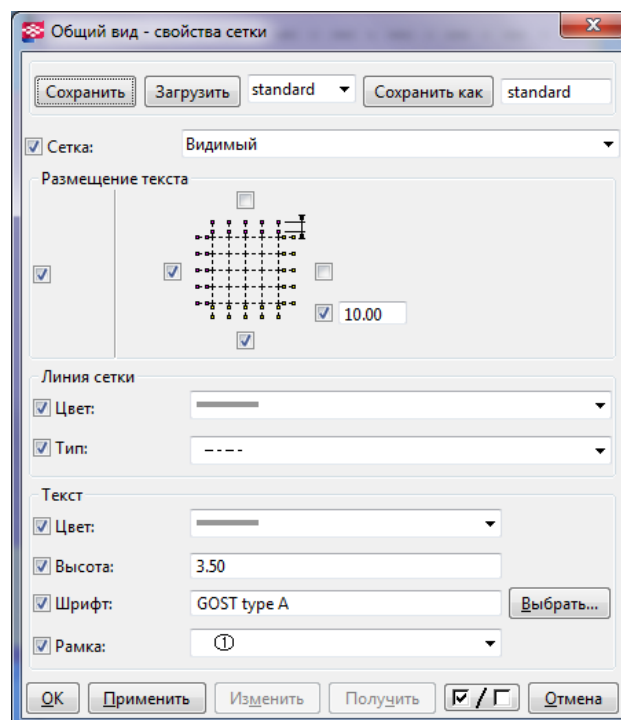


Figure 20. Drawing Settings. Grid

5.3 The trial model of block of flats

3D model has been created with Tekla Structures for checking the template. It was done according to the ready-made drawings from AutoCAD. The model is not highly detailed because of the fact that the project is still under construction and all drawings are not ready.

The building is executed in Saint – Petersburg. It is under construction now. The end of the constructing is expected at the end of the year.

The projected object is a residential building of sectional type.

The projected Height of the house is 30.0 m from the ground to the parapet of the attic. The maximum size in the plan is 35.7 m x 38.0 m, 8-9 floors above ground, 1-2 underground, including Technical and basement. The height of the residential floors is 3.3 m. The projected building is a single-section building with 34 apartments, the amount of rooms is 2-5 in each apartment.

The apartments on the first and second floors have 2 levels with separate exits; 3 - 7 floors have single-level apartments. The 8th floor apartments have access to the second level in the lounges on the exploited roof. All apartments have views on the Malaya Nevka river.

There are two parking places: outside and underground (in the basement) parking is mechanized, controlled by the operator; the participation of the driver is excluded.

The bearing frame of the building is made of reinforced concrete. The connection of the columns and slabs is considered as rigid. Vertical connections are external concrete walls, load-bearing walls and staircases. The overall stability of the building is provided by rigid connections of columns and slabs and pillars, as well as by anchoring of columns and pillars in the foundation.

The 3D model includes all load bearing structures, staircases, some parts have reinforcement according to the project.

5.3.1. Dimensional layout drawing

The first drawing which was created of the model is dimensional layout of slab at level +3.600. It has a lot of difficult places for Tekla drawings.

The General arrangements drawing template has been used for the drawing of the dimensional layout of slab.

It is impossible to use Cast unit drawings because it reflects only one element, for example, the slab, and does not reflect bearing structures under this slab. It is required to show structures under the main structure because the gaze direction is from the top to the bottom. They must be shown with dashed line.

It is possible to show underlying bearing structures for the General arrangements drawing. But it is important to remember about which part of the structure will be visible and which will be hidden. It is especially important for cast in situ structures. There is an example. A cast in situ wall element was created for the whole length of the building. The wall height is equal to the height of the floor. There is a lift shaft's hole in the upper slab. Part of this wall will be visible and others hidden on the drawing of Dimensional layout of the upper slab. But it is impossible to set two different types of line for one object. This problem can be solved by separating the wall for several parts and set view of the visible part as a solid line, hidden parts can be set as dashed line.

Object level settings were used for the template. It makes the process of creating the drawing much faster. At first, small templates have been made for properties of each element type and mark type. As a result following templates came out for parts:

- DL_beam
- DL_column
- DL_wall
- FMS
- FMS_dashed_blue

Templates came out for part marks:

- Cut_mark
- Vent_mark
- No_mark

All these templates are combined in object level settings window and connected to the following filters of the parts (Figure 21).

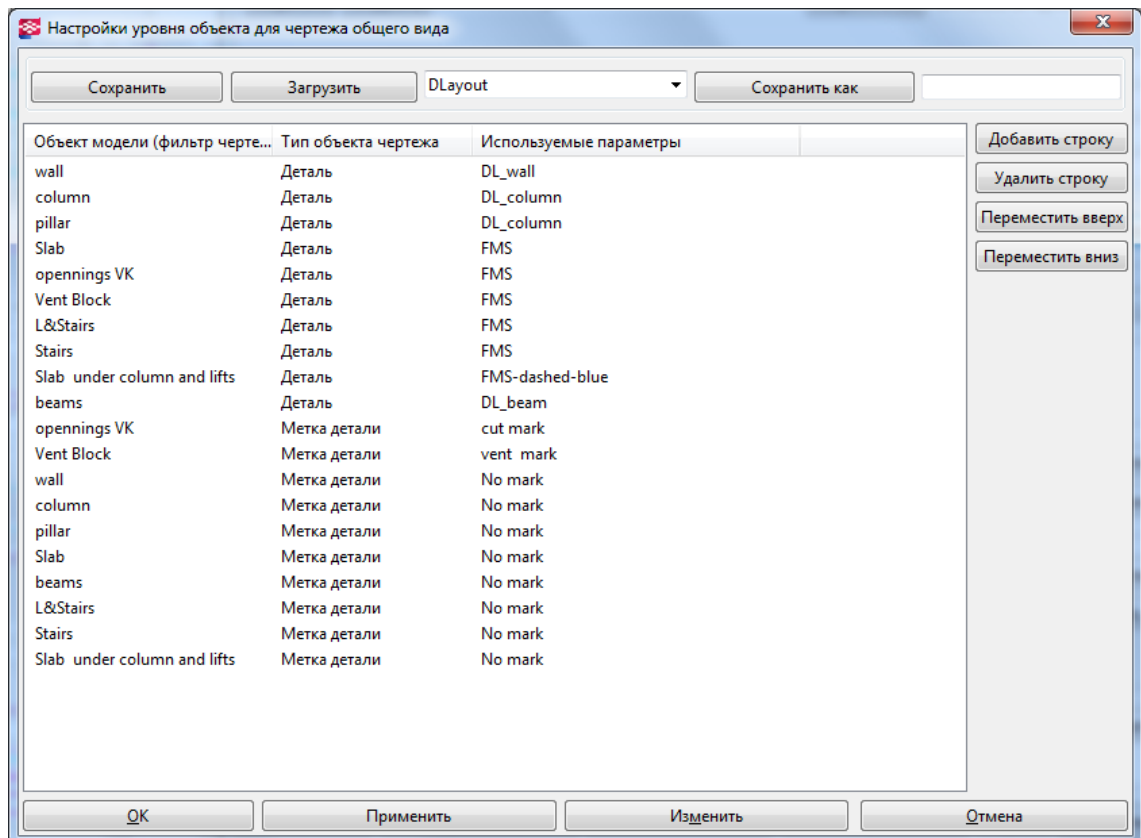


Figure 21. Object level settings for dimensional drawing

This method of making settings is really helpful and easy in use.

There are three problems which were discovered:

- There is no opportunity to create automatic marks for holes in the slab.

TS does not create marks for cuts. It has been asked for many times from Tekla but there is no result. The only workaround is to use **Cut Part With Another Part** function and leave the cutting part in the model and then create the mark from that part. This way has a lot of difficulties.

Example: the purpose is to make a hole for ventilation in the concrete slab. The dimensions of the hole are 150x150 mm, the thickness of the slab 250 mm. The cutting element is a concrete slab with hole-dimensions (150x150x250 mm) and goes through the main slab (See Figure 22). The marks of the holes should include the type of the hole (BK, OB, ЭО) and its size. So the cutting element is named as the hole “Отв. BK”.

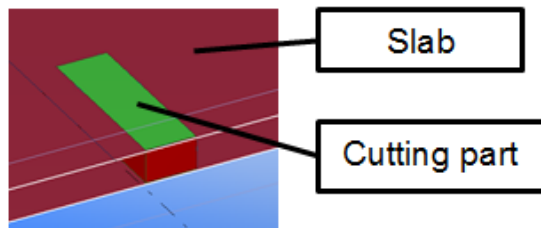


Figure 22. Cutting element inside the slab

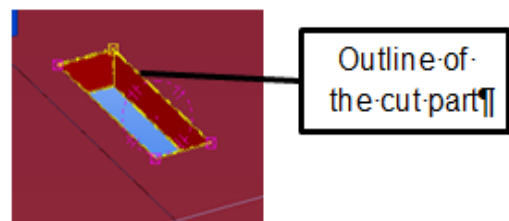


Figure 23. Hole in the Slab without cutting part

The hole has been done by function **Detailing > Cut Part > With Another Part** (See Figure 23). It is advised to delete the cutting part but the purpose is to leave it and get the dimensions of the hole with it.

The next step is to select the characteristics from the element list of the part mark dialog box. The three elements which can give the dimensions of the part: Profile - adds the profile name of part (width and height); size - adds the size of the part (width and height); length - adds the length of the part. So two of them give the same results. The list of elements for this mark can be following: **Name, Size, Length**. In this case the hole will be completely characterized. But it is not a common way of hole dimensioning in Russia. It is easy to mix up the length and height. (See Figure 24).

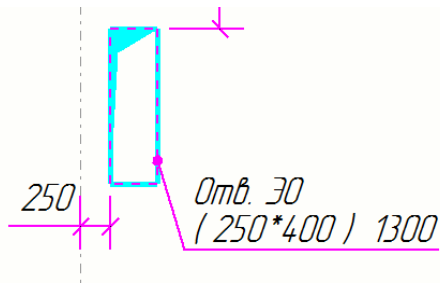


Figure 24. Part mark elements: Name, Size, Length

It is possible to overcome it in the following way. The height of the cutting part can be changed when the hole has been cut (250 mm -> 1300 mm). It will not affect the hole in the main slab because **Cut Part With Another Part** function creates a special cutting plate and the main slab will keep the hole (See Figure 25). Now there is a part with height equal to its length. And the part mark can be made with only **Name, Size** elements. (See Figure 26)

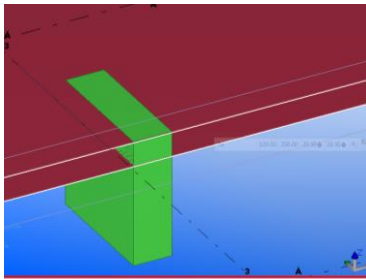


Figure 25. Part with changed height

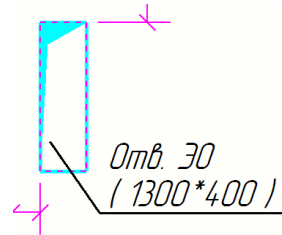


Figure 26. Part with changed height. Part mark elements: Name, Size.

The method of leaving part cut is not good because it makes incorrect calculation of the concrete volume.

That is why it can be done by hand too (**Mark Properties -> Text element**). Adding it by hand takes a lot of time and is contrary to the concept of Tekla drawings.

- Holes can not be dimensioned automatically with GA drawing settings.

The way of using object groups does not work in GA drawings. Leaving the cutting gives an opportunity to dimension it – but it still does not work right, since it only dimensions reference (center) points of the part – not the actual

dimensions of the hole (like Figure). As a result the easiest way to put the dimensions by hand.

- Basic settings of showing openings do not suit Russian norms.

A cross is used as the opening/recess symbol in default settings of showing openings. Russian norms require using shadows for opening and recesses (See Figure 27).

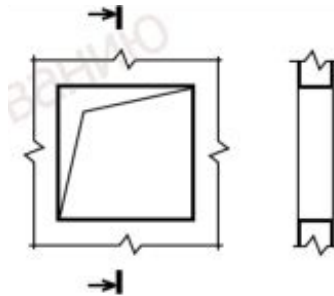


Figure 27. Hole symbol. ГОСТ 21.201-2011 paragraph 4.4.

Tekla Structures contains some advanced options that give an opportunity for showing the openings and recesses in such way.

Variable `XS_USE_CROSS_FOR_OPENING_SYMBOL` is responsible for the type of the symbol in openings and recesses. The default value is `TRUE`, which means that a cross is used as the opening/recess symbol. `FALSE` argument offers to show the openings and recesses in shadow type.

Opening/recess symbols in openings located at part borders are not marked with symbol. But there is an opportunity to change it with `XS_USE_OPENING_SYMBOL_IN_CORNER_HOLES` variable.

The drawing which can be created with such settings is presented in APPENDIX 3. The dimensions of the holes and their snapping to the axes were made by hand on this drawing. The marks of the holes are made automatic but with some preliminary work. Ventilation blocks are also shown on the drawing. There are two types of ventilation blocks. New macro has been created for both of them. Block marks are made with help of attribute `<<USER_FIELD_1>>`. It has been set in User-defined attributes of the block element (Figure 28, 29).

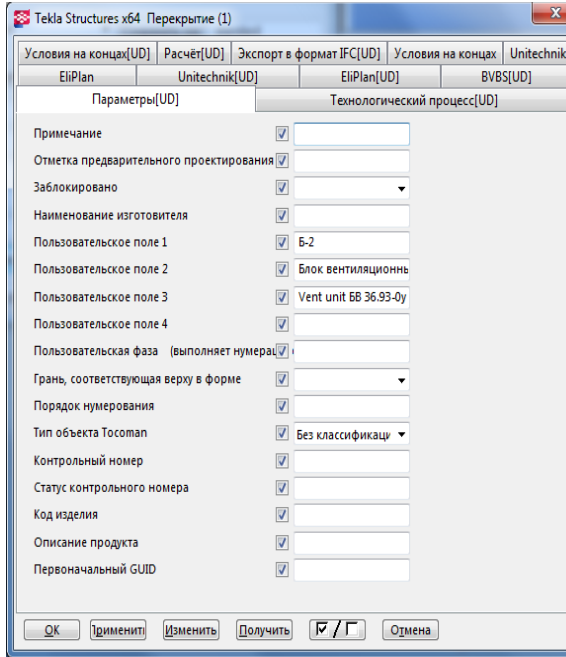


Figure 28. Vent blocks element properties

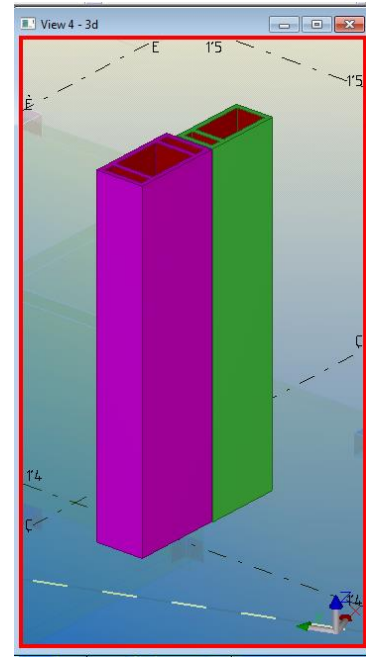


Figure 29. Vent blocks made by macros

5.3.2. Layout of columns and walls

A template for layout of vertical elements has been created. It was named **PVerticalElements**. It differs from the DLayout template by the line type of structures and amount of marks which are used.

Numbering settings are following. The mark of the columns and walls should look like Km-1-(-3). Where Km is structure type (column), 1 is number of structure type and -3 is level.

So column settings should be:

- prefix - Km(-3). It is used nowhere on the drawing. Its aim only to group elements in each floor because the numbering of elements should start from the beginning on each level.
- User-defined attributes: USER_FIELD_1 – Km, USER_FIELD_2 – (-3)

Mark settings should be:

<<USER_FIELD_1>>

-

<<SERIAL_NUMBER>>

-

<<USER_FIELD_2>>

Object level settings are following in this template (Figure 30).

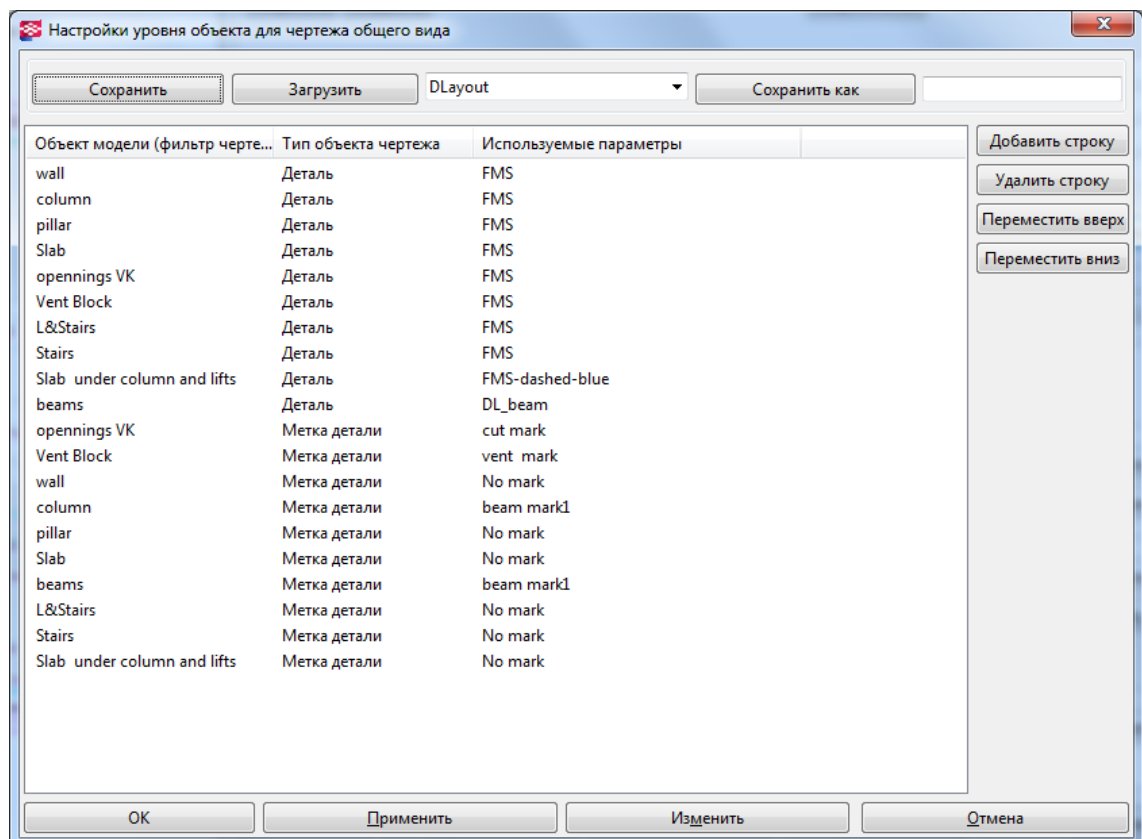


Figure 30. Object level settings for columns and walls layout

The drawing of columns and walls layout is presented in APPENDIX 3.

5.3.3. Pillar reinforcement drawing

A template for simple reinforcement drawings has been also created. It is named **Pillar** and cast unit type of drawing is used for it. The template contains 3 additional tables: Specification of elements, detail register, reinforcement

weight specification. All these tables take information from the model. For example, it numbers all rebar according to the model settings. Reinforcement numbering should start from the beginning in each different element. It is not comfortable to have numbers start from any place on one drawing. Following settings were made for this purpose.

For example, one column has size 1000x400 mm, prefix is ПЛ1 and start number is 1. Second column has size 960x250 mm, prefix is ПЛ2 and start number is 1. So that numbering starts from every beginning in the drawing of each column.

The number of the rebar can be shown on the drawing in marks by attribute **SERIAL_NUMBER**. In tables it can be achieved by the same attribute.

The drawings of reinforced pillars are presented in APPENDIX 3.

6. GIVING OUT THE DRAWINGS

The main goal for each designer and engineer is to get the drawings. Drawings must be printed, or exported to the required format. Special settings are also needed for printing and exporting. The line type must be reflected in a right way.

The line weight on the drawings must be specific according to GOST 2.303–68. Every type of the line is described in the table in these norms. For example, the contour line of the detail must have the thickness s , so the dimension line or mark line must have the thickness $1/2 s$. The thickness of the solid main line should be in between 0.5 and 1.4 mm depending on the size and complexity of the image and the format of the drawing.

Settings for exporting and printing have been made for the slab drawing.

6.1. Exporting to DWG/DXF format

TS exports drawings to DWG and DXF format. DWG is the native file format of AutoCAD. DXF enables the file exchange between various applications. (TS Help)

For this process TS has a file (LineTypeMapping.xml). It keeps settings for transformation at the drawing for the new format, line type, line weight and color.

All objects should belong to special layers in AutoCAD drawings. It makes the working process more comfortable and fast. The different layers can be defined in Export properties. The main idea is to separate parts for the different groups. It can be done by selection filters. TS selection filters should be set beforehand.

These filters have been created for the slab drawing.

- Slab
- Column
- Pillar
- Wall

Layers which are common in Finnmap were also created in the Drawing Export Layers dialog box. Then object groups are assigned to different export layers in the same dialog box.

It is important to note that the hole marks, created for cutting parts, refer to the object group details, and the hole marks created without snapping to the detail refer to the object group text.

The drawing contains a lot of templates created in TplEd. TS considers them as Other Type objects in Drawing Export Layers dialog box. So it is important to create settings for them, too.

The LineTypeMapping.xml file is supposed to define line type, weight and color for different layers.

Settings for exporting fonts must be done in dxf_fonts.cnv. The font conversion file defines which font file will be connected to the created AutoCAD style, and optional font width and height correction factors. The GOST type A font is used for the text in the slab drawing. It was set an equal for CS_Gost2304A.shx font in Auto CAD.

Settings for template font conversion should be made in template_fonts.cnv file. (GOST type A = GOST type A * 1.0)

6.2. Printing with TS

Printing with TS is a very easy process. The main thing is to make settings for Color table (See Figure 31). The table describes the thickness of the line on the printed drawing. The line weight depends on the line color.

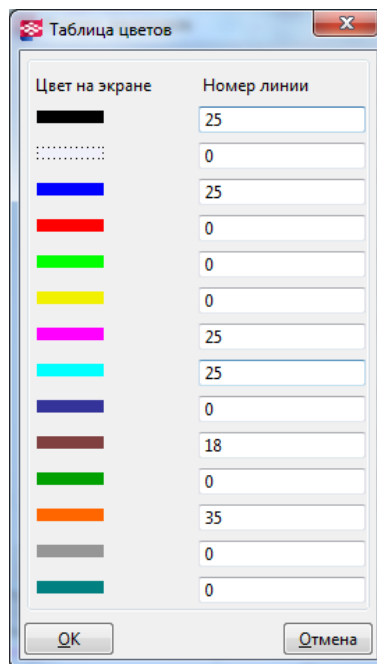


Figure 31. Color table

CONCLUSIONS

Nowadays Tekla Structures is a part of big software complex based on building information modeling (BIM). It has great opportunities for engineers; it can increase the speed of the working process very effectively. Tekla Structures will be really effective if it is used as automatically as possible.

The main problem of using it in Russia is a lack of opportunity to make drawings according to the norms. There are some important points which should be corrected by the TS technical support. Otherwise the effective use of TS in Russia will be impossible because of great amount of manual work.

There is a good opportunity for creating dimensional drawings. The drawing can be created entirely in Tekla without modifying in other programs such as AutoCAD. But not every element can be automated.

The situation with reinforcement drawings is not so optimistic. The reinforcement in the model is quite labor-intensive. Setting the dimensions and marks is difficult for complex reinforcement objects and could not be done automatically, too.

In conclusion, about the prospects of developing TS in Russia, as it was told Russian market is one of the most undeveloped Tekla users regions. The level of construction is developing intensively in the country. So Tekla Company must certainly continue developing the product on the Russian market and pay attention to the problems identified when using this program in Russia.

FIGURES

Figure 1. Different configurations of Tekla Structures [9]	9
Figure 2. System Entrance for Tekla FMC-Russia Environment.....	11
Figure 3. An example of a GA drawing layout for the A3 drawing sheet size...	15
Figure 4. Marks in Tekla	16
Figure 5. Marks in Tekla	16
Figure 6. The search view of the Master Drawing Catalog	20
Figure 7. Drawing properties Window	20
Figure 8. The idea of the three property levels. The frame color and the shape of the mark are used as an example.....	21
Figure 9. Steel expense register in Tekla Russian Environment.....	23
Figure 10. Steel expense register alternative option	23
Figure 11. Revisions table	24
Figure 12. Filling in Revisions forms	24
Figure 13. Detail register.....	25
Figure 14. Rebar specification of the cast-in-situ structures	26
Figure 15. Element specification of the cast-in-situ structures	26
Figure 16. Filling the Stamp	28
Figure 17. Scheme of the layout content	29
Figure 18. Drawing Settings. View	30
Figure 19. Dimension general and appearance settings	31
Figure 20. Drawing Settings. Grid.....	32
Figure 21. Object level settings for dimensional drawing	35
Figure 22. Cutting element inside the slab.....	36
Figure 23. Hole in the Slab without cutting part.....	36
Figure 24. Part mark elements: Name, Size, Length	37
Figure 25. Part with changed height	37
Figure 26. Part with changed height. Part mark elements: Name, Size.	37
Figure 27. Hole symbol. ГОСТ 21.201-2011 paragraph 4.4.	38
Figure 28. Vent blocks element properties.....	39
Figure 29. Vent blocks made by macros.....	39
Figure 30. Object level settings for columns and walls layout.....	40
Figure 31. Color table	43

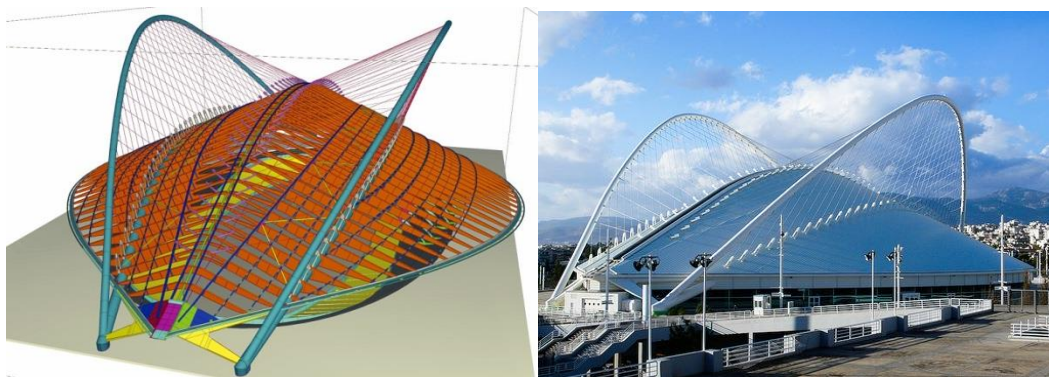
REFERENCES

1. Help. Tekla Structures 18.0
2. GOST 21.501-93 System of project documents for construction. Rules for creating architectural and construction working drawings. Main topics, 1994
3. GOST 21.501-2011 System of project documents for construction. Rules for creating architectural and construction working drawings. Main topics, 2013
4. GOST R 21.1101-2009 System of design documents for construction. Main requirements for design and working documents, 2009
5. GOST 21.201-2011 Graphic symbols for building elements and structures, 2013
6. GOST 21.110-95 System of building design documents. Rules of developing specifications for equipment, products and materials.
7. GOST 21.502-2007 Rules for creating project and working drawings of steel structures. Main topics, 2008
8. GOST 2.303-68 Unified system for design documentation., 1971.
9. Tekla Company web page, www.tekla.com, 2013
10. The Interstate Council for Standardization, Metrology and Certification webpage, www.easc.org, 2013

APPENDIX 1. INTERNATIONAL PROJECTS CARRIED OUT IN TEKLA STRUCTURES



Olympic stadium in Beijing

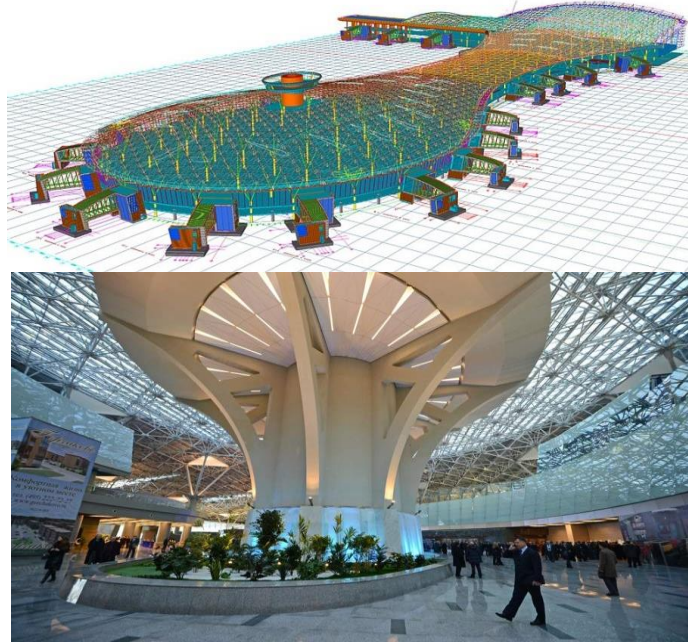


Athens Olympic Velodrome



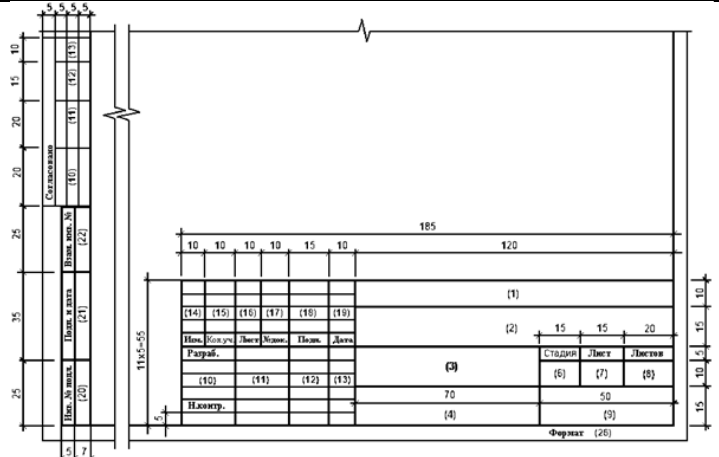
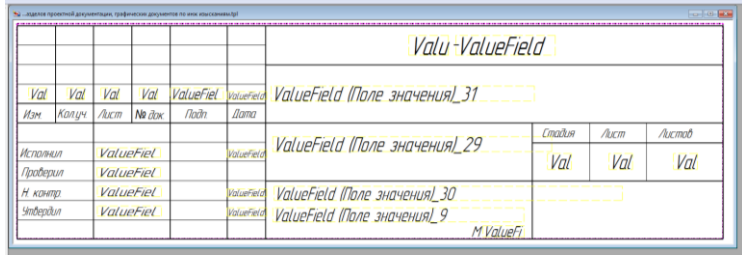
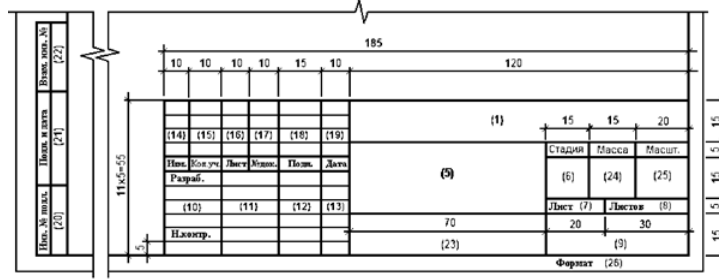
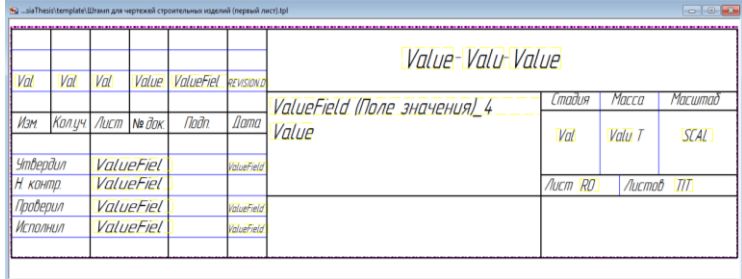
Finnforest Modular Office (FMO) in Tapiola, Finland

APPENDIX 1. RUSSIAN PROJECTS CARRIED OUT IN TEKLA STRUCTURES

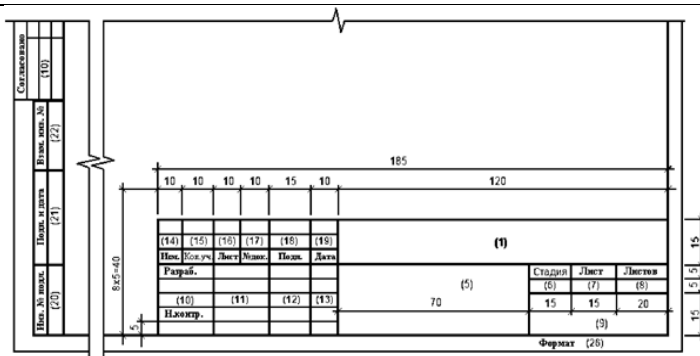


Airport in Moscow, Russia

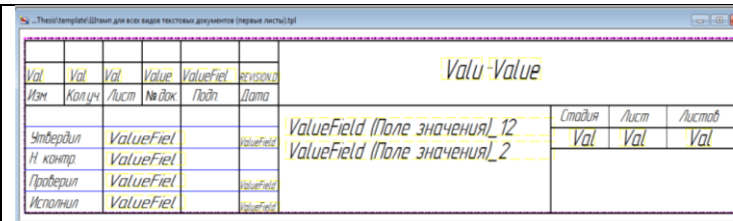
APPENDIX 2. COMPARISON OF THE TEKLA AND GOST

Title	GOST	Tekla TplEd	Must be corrected
<p>For the main set of working drawings, graphics documents of design documentation, graphical documents for Engineering Survey / Для листов основных комплектов рабочих чертежей, графических документов разделов проектной документации и графических документов по инженерным изысканиям</p>	 <p style="text-align: center;">GOST 21.1101-2009 form 3</p>		<p>Must be corrected Dimensions are correct;</p>
<p>For drawings for construction products (first sheet) / Штмп для чертежей строительных изделий (первый лист)</p>	 <p style="text-align: center;">GOST 21.1101-2009 form 4</p>		<p>Wrong dimensions; wrong text location;</p>

For all types of text documents (first sheet) / Для всех видов текстовых документов (первые листы)

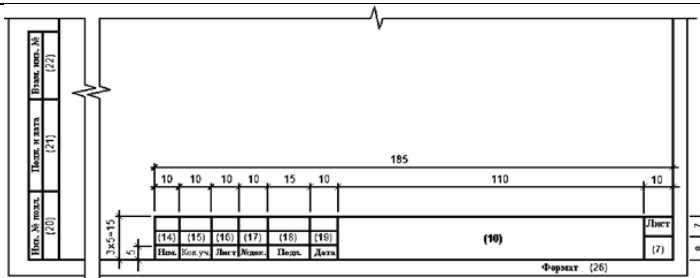


GOST 21.1101-2009 form 5

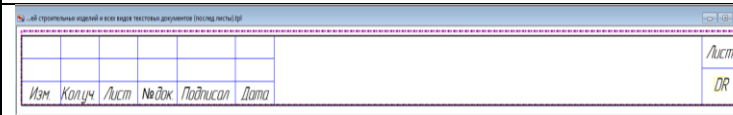


Wrong text location;

Drawings for construction products and all kinds of text documents (following pages) / Для чертежей строительных изделий и всех видов текстовых документов (последующие листы)



GOST 21.1101-2009 form 6

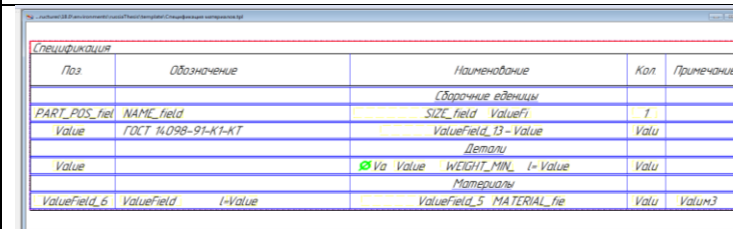


Dimensions are correct;

Element specification of the cast-in-situ structures / Спецификация элементов монолитных конструкций



GOST 21.1101-2009 form 7



Wrong dimensions of the table; Wrong font size; Add column «mass per unit»;

Revisions / Таблица регистрации изменений			Wrong dimensions of the table; Wrong font size;
Revisions FMC			Wrong dimensions; Change text font; set a sorting order for the attributes;
Detail register / ведомость деталей	<p>ГОСТ 21.501-93 form 6</p>		Wrong dimensions of the table; Wrong font size;
Steel expense register / Ведомость расхода стали	<p>ГОСТ 21.501-93 form 5</p>		Fully wrong format of the form.

Element register /
Ведомость
арматурных изделий

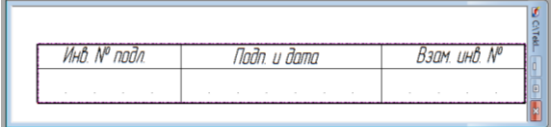
ВЕДОМОСТЬ АРМАТУРНЫХ ИЗДЕЛИЙ/Element register									
Масштаб	Эскиз	№ п.з.	Ø, мм	Длина, мм	Кол. шт	Общая длина, м	Выборка арматуры		
1	2	3	4	5	6	7	Ø, мм	Z, м	Q, кг
1	2	1	ØA500C	3250	2	6.5	ØA500C	6.5	5.8
		2	ØA240	210	13	2.73	ØA240	2.73	1.1
							Итого: 6.9		

No opportunity
to create

Additional stamp for
drawings for
construction products

Инв. № подл.	Подп. и дата	Взам. инв. №
(20)	(21)	(22)

Rotate left 90°
GOST 21.1101-2009 form 3



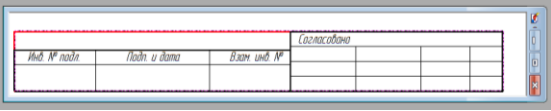
Rotate left 90°

Dimensions
are correct;

Additional stamp for the
main set of working
drawings, graphics
documents of design
documentation,
graphical documents
for Engineering Survey

Инв. № подл.	Подп. и дата	Взам. инв. №	Согласовано			
(20)	(21)	(22)	(10)	(11)	(12)	(13)

Rotate left 90°
GOST 21.1101-2009 form 3



Rotate left 90°

Wrong
dimensions of
the table;

APPENDIX 3.

APPENDIX 3.1. DIMENSIONAL LAYOUT OF SLAB

APPENDIX 3.2. LAYOUT OF COLUMNS AND WALLS

APPENDIX 3.3. PILLAR REINFORCEMENT DRAWING.

Pillar 1000x400mm.

APPENDIX 3.4. PILLAR REINFORCEMENT DRAWING.

Pillar 960x250mm.

