

Saimaa University of Applied Sciences  
Technology, Lappeenranta  
Degree Programme in Civil and Construction Engineering

Nikita Ilenko

## **Application for Tekla Structures -TSMATCH application**

Thesis 2016

## **Abstract**

Nikita Ilenko

Application for Tekla Structures - TSmatch application, 18 pages

Saimaa University of Applied Sciences

Faculty of Technology, Lappeenranta

Double Degree Programme in Civil and Construction Engineering

Bachelor's Thesis 2016

Instructors: Lecturer TimoLehtoviita, Saimaa University of Applied Sciences

Senior BIM expertPavel Khrapkin, The companyNIP «Informatica»

The main purpose of the thesis was participation in TSmatch application development, especially in part of Supplier price-lists and Catalog collection and handling. The company NIP «Informatica» in the person of Pavel Khrapkin commissioned the study.

The development was carried out using Tekla Open API in C# using Visual Studio and Microsoft Office Excel. The Tekla Open API provides an interface for third party applications to interact with model and drawing objects in Tekla Structures.

In the result of the third-party application has been received, which is able to bind a model with a set of suppliers price lists and generate an Excel report which contains the number of different building elements of different material, the amount of work and the final price, counted on the basis of available price lists.

Keywords: Tekla, Tekla Structures, BIM, application for Tekla Structures, Tekla Open API, IFC

## Table of contents

1	Introduction .....	4
2	Tekla Structures.....	4
3	Types of Tekla Structuresexpansions.....	6
4	TSmatch – the main idea and architecture of the application .....	9
5	Instruction for setting TSmatch and example of report .....	14
6	Suppliers section .....	16
7	Future development.....	16
8	Conclusions .....	17
	Figures.....	18
	References.....	18

## 1 Introduction

At the present time many construction companies develop their own proprietary instrumentation tool and administration system to manage and timely update BOM - Bill of Materials, and SCM - Supply Chain Management. This activity is guided by BIM standard BSI-1192. TSmatch is an Open Source application aimed to make the progress in the this direction.

The main goal for the thesis is participation in TSmatch application development, especially in part of Supplier price-lists and Catalogs collecting and handling.

As a result of this work TSmatch application could provide BOM reports in a timely manner, which reflects:

- Total concrete and stle materials used in CAD model;
- Price according to selected Suppliers price-lists;
- Highlight model elements, not in match with the selected Suppliers;

Besides connection with the design model in Tekla Structures, IFC interface is widely used. It was included in TSmatch recently to allow input from many other CAD systems.

## 2 Tekla Structures

Tekla Structures is a software, which supports BIM technology (BIM - Building Information Modeling). It is a powerful tool to create and manage accurate 3D models of constructions and buildings of any complexity and any material. Tekla Structures models can be used at all stages of the construction from sketches and design to fabrication, erection and construction management.

Tekla Structures has a long history in the construction industry - a company called Teknillinenlaskenta Oy ( "Technical computer calculations"), was incorporated in February 1966 in Helsinki, Finland. That same spring, the company's name was shortened to Tekla. Now the company is called Trimble.

The basis of the work in this program is the BIM modeling, it means that, instead of drawing two-dimensional plans, elevations and sections it is much more convenient to create a detailed three-dimensional model of the building, with a portrayal of all joints, which combines a physical and analytical model. Then it can be used for various types of analysis, for example for getting a complete design documentation. Thus, the scope of the Tekla Structures software is a complete process of erecting the structural object from conceptual design to construction.

Tekla Structures software solutions are available in multiple specialized configurations, so users can choose the configuration that best suits their needs:

- Full
- Steel Detailing
- Precast Concrete Detailing
- Rebar Detailing
- Engineering
- Construction Modeling
- Primary
- Project viewer
- Drafter

Tekla Structures, Full is a comprehensive configuration, which contains modules for metallic structures and precast monolithic concrete products detailing. It provides creation of three-dimensional models of steel and concrete constructions. Modules Tekla Structures, Full let you perform a variety of functions - from the mapping phases of the work, to automatic generation of drawings.

Tekla Structures, Steel Detailing - configuration that is aimed for the design of steel structures. It can be used for creation of a detailed three-dimensional model of all metal structures and to obtain relevant data for production and assembly.

Tekla Structures, Precast Concrete Detailing - standard configuration, supplemented by functions for detailing of precast concrete structures.

Tekla Structures, RebarDetailing - standard configuration, supplemented by functions for detailing reinforced concrete products.

Tekla Structures, Engineering - standard configuration, which allows to perform synchronized design. Design of steel structures and engineering systems takes place in the shared model. This configuration also allows making an analysis model and adding loads.

Tekla Structures, Construction Modeling- standard configuration, which allows to perform synchronized design. Design of steel structures and engineering systems takes place in the shared model.

Tekla Structures, Primary- standard Tekla Structures configuration.

Tekla Structures, Project Vieweris contributing to the work of contractors who need to model, plan and manage projects, regardless of the material and its type.

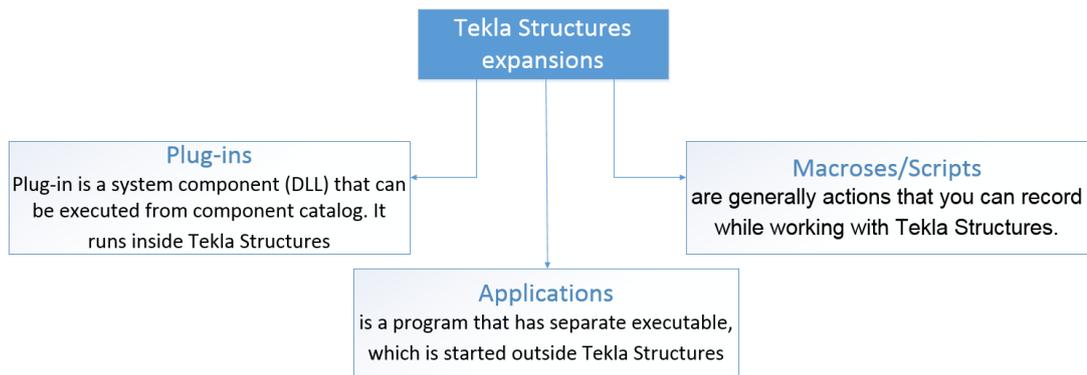
Tekla Structures, Drafter- standard configuration, which allows to focus in generating documentation.[1]

Tekla Structures software package allows you to share models and drawings with major architectural and industrial programs, such as Archicad, ADT, Revit Building, NemetschekAllplan and Bentley Architecture, as well as with all IFC-compatible programs. Other Formats DGN and DWG are also available.[2]

### **3 Types of Tekla Structuresexpansions**

There are several types of Tekla Structuresexpansions, which could be divided into three types (see Figure 1):

- Applications
- Plug-ins
- Macroses/Scripts



**Figure 1.Types of Tekla Structuresexpansions. [3]**

The application is a program that has a separate .exe file, which is started outside Tekla Structures. For example a sided application may be a Multi converter to other formats, it can export Tekla Structures objects in multiple file formats: IFC, STEP, IGES, OBJ ,STL, DGN, DWG, DXF, SKP. Objects can be exported by part mark, assembly mark, phase, object ID or for the selection.This extends the basic functionalityof Tekla Structures.

Plug-in is a system component (DLL) that can be executed from the component catalog. It runs inside Tekla Structures. For example a sided plug-in can help user to create the reinforcement cage for continuous beam or column more fast and easily.

Macros/Scripts are generally actions that you can record while working with Tekla Structures. Macros are basically C# (.cs) source files that are compiled at run-time, which could be edited; applications and plug-ins are compiled executables or DLLs.

All these extensions are able to be formed by Tekla Tekla Open API(Application Programming Interface) [4]. Interface is a common boundary between two entities.Tekla Structures user interface enables human users to communicate with the software.Tekla's Open API, Application Programming Interface, facilitates interaction between Tekla Structures and other software.The Tekla Open API, provides an interface for third party applications to interact with model and drawing objects in Tekla Structures. It also allows the creation of plug-ins.

Tekla Open API can be utilized with a variety of tools. Tekla Open API enables users and vendors to for example:

- Automate routine tasks
- By recording and running user interface actions it is possible to automate routine tasks such as creating daily reports.

With the Tekla Open API you can automate for example the creation of modeling and drawing objects. These creation tools are typically frequently needed in projects and can for instance:

- Create basic structures to model such as type base hall
- Insert typical AutoCAD details to drawings based on drawing information
- Automate creation of dimensions for general arrangement drawing based on model information
- Integrate Tekla Structures into your own process, workflow, and software

Tekla Open API can be utilized in integration of Tekla Structures to other software. Information can be transferred between Tekla Structures model and drawing database and other software used in your office such as:

- Office tools
- A&D (Autodesk)
- MIS & ERP (Management Information System&Enterprise Resource Planning)

With the API you can, for instance, get full geometric information for CNC (computer numerical control) and develop additional functionality to extend and enhance Tekla Structures.

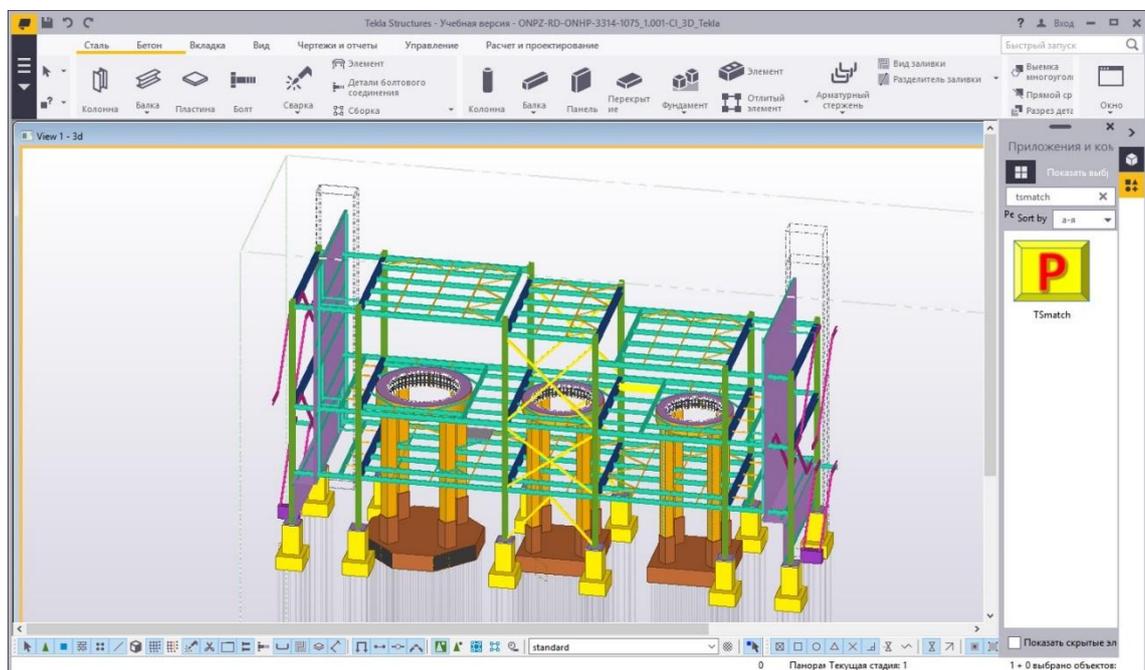
It is possible to create tools which will add functionality or information to Tekla Structures through the API such as:

- RFI (Request for Information) management
- New connection creator between parts
- Model check and correction tools
- Erection and site planning tools

- Calculating externally values for reports
- Recording and running recorded UI macros.[5],[6]

TSMATCH is using all three approaches:

- It can be called inside Tekla Structures by push button in “applications and components” bar (see Figure 2). That would activate macros which would launch TSMATCH as a plug-in.
- It can be called outside Tekla Structures as a regular Windows program. So that it could be considered as an application.



**Figure 2. TSMATCH button in “applications and components” bar in Tekla Structures.**

#### **4 TSMATCH – the main idea and architecture of the application**

Many CAD suppliers nowadays are trying to provide the reports, which calculate the total weight, steel and concrete volume, works and material price of the designed construction. These efforts are directly pointed by recent BSI standard PAS 1192-2:2013 in Procurement Chapter, describing preparation of the supply information. [7]

In Tekla Structures there are some built-in tools to generate various reports, for example, a material report, which already contains information about the size of ele-

ments, material, profile, areaandweight. However, none of the Tekla Structures reports give cost estimatesbased on price lists. Therefore, Tekla Structures standard tools have no opportunity to assess the financial side of the project so that there is a need to provide expansion for these purposes.

However, before supply chain preparation, the designers need to have estimation numbers on the early stages of the project, similar to ones generated by TSmatch, for many large and small decisions made over the project development process.For example: could a company do this block, balcony, another room, etc., or is it out of the budget, parameters, set for the project, like weight, volume and others.

A typical issue is that the designer cannot keep all details, like local availability of supplied components, in his mind. As a result, many construction projects run out of the defined time and budget. Quite often, the designis based on the general, or his local requirements, when the targetconstruction and procurement happened far away. As a result, the changes in the supply process are not reflectedto the design model, which would create the issues later on.

The calculation is based on the comparison of model components – items in the documents - price lists from suppliers’ assortments, which show the availability of the used components and so-called rules(see Figure 3) by which the application searches and establishes the suitable element correspondence – match. We name such components set a “Satellite base” to express the relation between the model and set of supplies required to this model implementation.

13.04.16 0:25 Matching Rules -are the search rules for correspondences between the model and price lists						
Date/Time	Rule Name	Type	Rule Text	Component	Supplier	
24.02.2016 13:05	Corner Stalholding	I/1	Material:Cr3fnc , Cr3fnc=C255;Profile: L \$p1x\$2 Length - *\$p3, Waste 10%; Weight column #3, Price column #4	Corner	Stalholding	
24.02.2016 13:05	Strip Stalholding	I/1	Material:Cr3fnc , Cr3fnc=C255;Profile: — \$p1x\$2 Length - *\$p3 Waste 10%; Weight column #3, Price column #4	List	Stalholding	
22.02.2016 15:20	C255 L Corner Cee3anM	I/1	Material:Cr3fnc , Cr3fnc=C255;Profile: L \$p1x\$2 Length - *\$p3, Waste 10%; Weight column #3, Price column #4	Corner	Base SEVZAPMETALL	
22.02.2016 15:20	C255 — Strip	I/1	Material:Cr3fnc , Cr3fnc=C255;Profile: — \$p1x\$2 Length - *\$p3 Waste 10%; Weight column #3, Price column #4	Strip	Base SEVZAPMETALL	
29.02.2016 19:20	C255 Strip from list	I/1	Material:Cr3fnc , Cr3fnc=C255;Profile: — \$p1x*\$2 Length - *\$p3 Waste 20%; Weight column #3, Price column #4	List	Base SEVZAPMETALL	
22.02.2016 15:20	C255 Strip from list	I/1	Material:Cr3fnc , Cr3fnc=C255;Profile: — \$p1x*\$2 Length - *\$p3 Waste 20%; Weight column #3, Price column #4	List	Base SEVZAPMETALL	
12.03.2016 0:30	C245 Corner Stalholding	I/1	M: C245=Cr3nc5 , Cr3cn5; P: L p1xp2; Length #2, Price #3	Strip	Stalholding	
12.03.2016 21:30	C245 Strip Stalholding	I/1	M: C245=Cr3nc5 , Cr3cn5; P: PL = — \$p1x\$2; Length #2, Price #3	List	Stalholding	
05.04.2016 22:30	Warehouse Rosmetallo	I/1	M:?: P:?:	Availability sale	Rosmetalloprokat	
13.04.2016 22:30	Corner Steel Industrial	I/1	M:?: P:?:	Part 1	Steel Industrial company	
15.03.2016 0:00	Uraltrubostal	I/1	M: C245=Cr3nc5 , Cr3cn5; P:L = Corner \$p1x\$2; Length #2, Price #3	List 1	Uraltrubostal	
Totla Lines = 14						

Figure 3. Rules listfrom TSmatch.xlsx.

Typically, the local suppliers provide the documents in Excel format, stored in files which can be updated by TSmatch Loader utilities, using an Internet hyper-

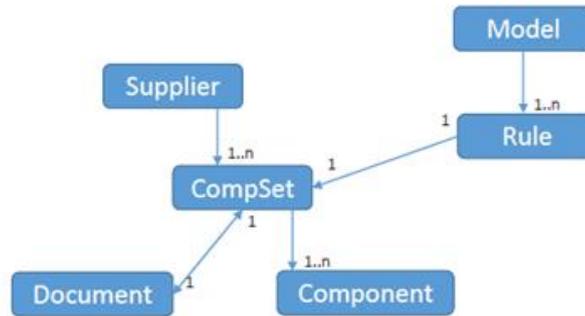
link stored in the system, or other information sources, but only when the user deems it necessary.

The data in the TSmatch report can be changed by replacing one supplier with another as well as adding or replacing models, one using the simple editing in Excel, for example, from another city or get taken from the register of the organizations' warehouses. Certainly, the structure of the data in this - or an alternative document have to be already known by TSmatch, or being included in TSmatch directory by application in semi-automatic mode by the user's command.

The application runs by pressing the button in the Tekla's environment or as a regular Windows program. In the first case the current model in Tekla is processed; otherwise the location of TSmatch's files, database-assortments, rules and models is pointed in the dialog with user.

The rules that define the correspondence between the profiles of the model components and similar data in satellite bases are very simple. They can be easily created and edited by every member of the design and construction organization or a member of the business department on the basis of similar rules already stored in TSmatch. It is important that this work does not require Tekla, because an Excel file can be sent or copied to another computer. Even for quite large models the file is quite small, since TSmatch includes information in groups of elements with the same material and profile values, as well as summing weight, volume of element its ids and other data included into the group attributes. In this way, the model which consists of several hundred thousand elements, usually gets in grouped form file few hundred lines in the file in several minutes.

As the result, TSmatch creates the report file, which contains a list of element groups used in the model, the list of required supplier companies, and the total volume, weight, and even the price to be purchased for on the project build stage for this model.



**Figure 4. Diagram, which illustrates how TSmatch works.**

In the simplest approximation, it looks like this (see Figure 4): TSmatch first reads the entire model and receives information about each of its elements like its material, profile, length, weight, volume. Then using the existing Rules it compares elements Component Sets, which is the suppliers price lists, with each element from the analysed model.

TSmatch application gets connected with a Tekla Structures model and material repository in local information bases to seek and setup the materials in match with ones, listed in the repository. As a result the TSmatch Report file is placed into the model directory. This Report could be updated when the model is changed. The repository is also a matter of updates - both manually, and automatically from the Internet sources, however, after user command.

Access to Tekla model is available over Tekla Open API. In future we expect to make this access bi-directional: when materials get changed, the model in Tekla should also be upgraded. To the moment we read Tekla model into Report only.

Material Repository consists of the Documents. Now the Documents are just the Excel files - tables with a list of available materials from the variety of suppliers. Further we are going to expand it with the html and XML files, taken from the Internet.

The Documents in Repository are recognized with their Stamps - small text fragments existing in the original Documents. It is necessary, when the Document get upgraded from the external file, and also during getDoc sub-program to ensure the Repository consistency.

The List of Documents as well as other detailed information, including Stamp description, CRC, Handlers links etc.is stored in TSmatch.xlsx file on the Sheet TOC - Table Of Content (see figure 6).

Figure 5. Table of content from TSmatch.xlsx.

Let us look at the TOC in more detail. In Figure 6 we can see reports, which are generated by TSmatch (ModelINFO, Raw, ModSuppliers, Report) and the list of documents, which it uses as inputs in the work process (TOC, Suppliers, Models, Rules, Messages, Forms, Constants). There is also various service information such as: the date of inclusion in the database, the rules, links, checksum verification of documents etc. It is necessary to say that all these documents are actually sheets of Excel document (see Figure 5 and Figure 8)

Figure 6. Reports, which is generated by TSmatch.

In Figure 7 we can see a list of suppliers, which would participate in report generation.



ronment\common\macros\modelling with the name of Macros, you'd like to see in Tekla Application. Default name is CallMacroExample. In file CallMacroExample.cs pointed the path to the exceldesign directory – please, adapt it to your PC.

5) Now TSmatch is ready to work. You could run it by button in Tekla Applications on the right part of Tekla Screen, or start as a usual Windows application in Windows.

No	Material	Profile	Length (mm)	Weight (kg)	Volume (m3)	Supply	Price-list	Price.line#	Weight (kg)	Price (Rub)
0	B12,5	1900X1600	2 400	15.44	6.432					
1	B12,5	4400X4400	400	16.4256	6.844					
2	B12,5	6200X6200	200	13.0128	5.422					
3	B20	1700X1400	18000	101.7	40.68					
4	B20	900X900	39600	80.19	32.076					
5	B25	1100X350	2800	2.695	1.078					
6	B25	300X300	1113750	246.13875	98.4555					
7	B25	4200X4200	3600	153.135	61.254					
8	B25	500X500	99200	62	24.8					
9	B25	6000X6000	1800	125.3475	50.139					
10	B25	600X600	72000	64.8	25.92					
11	B25	700X700	12000	14.7	5.88					
12	C235	HC44-1000-0.7	529524	4.030914428	0.513492284					
13	C235	PL30	4500	1.361272983	0.173410571					
14	C235	Corner50X5	71390	0.26899752	0.0342672					
15	C245	I-BEAM20W1	34384	1.053181057	0.134163192					
16	C245	Profile(sq.)120X120X7.0	514024	12.08917616	1.54002244					
17	C245	Corner75X6	353228	2.434637862	0.310144951					
18	C245	ROLLED STEEL CHANNEL12П	156885	1.637872048	0.208646121					
19	C245	ROLLED STEEL CHANNEL24П	232494	5.584714072	0.711428544					
20	C255	I-BEAM25W1	601368	26.54996479	3.38216112					
21	C255	I-BEAM30W2	140796	9.657662267	1.230275448					
22	C255	I-BEAM35W2	498720	39.74067775	5.06250672					
23	Concrete_Undefined		50	26560	4.730494016	1.971039173				
24	Concrete_Undefined		600	16580	32.94604101	13.72751709				
25	Concrete_Undefined		800	9980	31.75984969	13.2332707				
26	Concrete_Undefined	900X900	1200	2.0832	0.868					

**Figure 8. An example of report of TSmatch.**

In the figure you can see the example of TSmatch application report, which is generated after the whole Tekla Structure model analysis. For each model element is shown: material, profile, length, weight, volume, the name of supplier, the name of the Excel file, which contains the price list of the supplier, the line number in Excel file that includes the specified material and profile and finally the price for the purchase of this material of the profile from the supplier.

Unfortunately, the functional responsible for the price calculations based on the existing supplier databases, has not been implemented, but it will be included in the nearest versions of TSmatch.

## 6 Suppliers section

In this project my main task was to search for rolled metal suppliers's websites for the particular cities (Ekaterinburg, Moscow, St. Petersburg, Kazan, Novosibirsk). Since almost every major supplier had a price list in an excel format directly on the site, in the future the routine work may be replaced with a small supplement which is a separate small program - loader, which would automatically check the online price list in the proper format (for example excel or pdf format) and automatically download it.

Date/Time	Supplier Name	URL	Country	Index	City	Address	Tel	price-list worksheets
15.03.16 22:02:52	ROSmetalloprokat	<a href="http://www.rosmetalloprokat.ru/">http://www.rosmetalloprokat.ru/</a>	Russia		Ekaterinburg	Str. Kirov, h. 28 (factory territory "VIZ")		1 Available
15.03.16 22:02:54	Ltd. "Metallopromyshl"	<a href="http://varuse.com/">http://varuse.com/</a>	Russia	620017	Ekaterinburg	Prospect. Cosmonauts, h. 18		1 List1
15.03.16 22:02:52	Uraltrubostal	<a href="http://www.uraltrubostal.com/index.php?page=price">http://www.uraltrubostal.com/index.php?page=price</a>	Russia		Ekaterinburg	Str. Industrial passage 28, Suite 210	+7(343) 219-1808	1 List1
15.03.16 22:02:52	Stal'Ehnergo-96	<a href="http://www.stalenergo-96.ru/">http://www.stalenergo-96.ru/</a>	Russia	620017	Ekaterinburg	Street Patronage 2a of-24 base "VostokNeftegasStroyKomplekt"		
15.03.16 22:02:52	IVB al'yans	<a href="http://ivb-al'yans.ru/">http://ivb-al'yans.ru/</a>	Russia		Ekaterinburg	Str. Kirov, h. 32 / a		1 Aluminum
15.03.16 22:02:52	Life-med	<a href="http://www.life-med.ru/">http://www.life-med.ru/</a>	Russia	420095	Kazan	Str. Vasili, 1, of.120		1 Price
15.03.16 22:02:51	STALNOI DOM	<a href="http://stalnoydom.ru">http://stalnoydom.ru</a>	Russia		Moscow	str. Stahanovskaya, 21	+7 (495) 105-98-63	1 Price List
15.03.16 22:02:52	Ltd.Promtekhmet-M	<a href="http://prom77.ru/">http://prom77.ru/</a>	Russia		Moscow	Malyi Sukharevsky per., D. 9, p. 1	(495) 661-60-58 (Multi-char	1 List1
15.03.16 22:02:52	Sibirskij centr stali	<a href="http://metalloprokat-rs.ru/">http://metalloprokat-rs.ru/</a>	Russia	630132	Novosibirsk	Str. Chelyuskintsev, d. 18/2, office 309		
15.03.16 22:02:52	Stalepromyshlennaya	<a href="http://www.omsk-sek.ru/">http://www.omsk-sek.ru/</a>	Russia	644105	Omsk	str. Zelyonaya, 10		5 Part1 Part2 Part3 Pipe Mason's net
15.03.16 22:02:53	OmskMetalNefteKhim	<a href="http://omsk-omh.ru/">http://omsk-omh.ru/</a>	Russia		Omsk	transit Ovoshchnoj, house 7		
15.03.16 22:02:55	Ommet	<a href="http://www.ommet.com">http://www.ommet.com</a>	Russia	644105	Omsk	str. 22 Partsezda 105		1 List1
12.03.16 21:15:33	Base SEVZAPMETALL	<a href="http://szmetal.ru/">http://szmetal.ru/</a>	Russia		Saint-Petersburg	str. Pinegina, h.4 (metro "Elizarovskaya")	+7(812)325-7920	24 ПРОФИЛ/Листы CORRUGA ANODIR_ f Copper Brass
02.04.16 4:40	StalHolding	<a href="http://steel-holding.ru/">http://steel-holding.ru/</a>	Russia		Saint-Petersburg	str. Gromova, h. 4, office 226-228	+7(812) 646-79-90	3 List r.k Strip corner equal-

Figure 9. Supplier list from TSmatch.xlsx

Information about the suppliers is entered into the section Suppliers in the main file TSmatch.xlsx. Columns in the list are filled in this way: date and time of filling, supplier name, supplier's web site (URL) address, country, index, city, address, telephone number and price list work sheet—the name of the sheet in Excel file that contains the price list itself (for example: "Sheet 1" or "Steel profile")

Each supplier's price list has to be entered in the table of contents (TOC) in order to have a record of all reports and documents in the TSmatch database (see Figure 5).

Further, for the correct work of TSmatch it is necessary to create the so-called matching rules. Matching rules are the search rules for correspondences between the model and price lists (see Figure 3).

## 7 Future development

In the future versions of TSmatch it would be possible to edit and modify TSmatch reports in Excel format. Thus, after the formation of the next report a user would be able to return it to Tekla Structures with some changes. According

to the updated report in Excel format it would be possible even to build a new model in Tekla Structures. In this way a large model file with a large number of parts and elements would be replaced by the compact Excel file and it would not be necessary to have a Tekla Structures on the computer to make some changes in the model. Considering TSmach IFC format support, all of the above also applies to all CAD systems which support the IFC format.

For example, somebody in the project team could change the TSmach report file by replacing one supply component to another, available on the construction stage. This changed file you could transfer back into Tekla Structures; the changes in the model are highlighted. Confirmation of the possibility of replacing is the responsibility of the designer; if he/she allows this alternative possibility of replacing supplies, the model is saved with changes.

This approach is a good implementation of SCM – Supply Chain Management discipline, which is seriously underestimated in AEC industry. At the same time SCM is widely used in high-tech aerospace companies Boeing and NASA, where it becomes a lively important source of progress.

## **8 Conclusions**

In conclusion, it should be noted, that the idea of a binding model for suppliers and the constant control of the project budget is very promising. Serious corporations more and more often use such a tough bunch in their major projects. This is because in case of a failure to implement the project in reality due to costs exceeding the budget or due to lack of materials from suppliers, this will lead to costly corrections. TSmach helps to avoid these two problems, because after the analysis of a pre-specified model it checks the availability of material in suppliers price lists and gives a monetary value, so the designer can evaluate all the weaknesses of the decisions in the design phase. Thus this is a definitely perspective direction of development.

The actual version of TSmach's source code may be found on this link <https://github.com/PavelKhrapkin/TSmach>. [8]

## Figures

Figure 1. Types of Tekla Structures expansions. [5] .....	7
Figure 2. TSmatch button in “applications and components” bar in Tekla Structures. ....	9
Figure 3. Rules section from TSmatch.xlsx.....	10
Figure 4. Diagram, which illustrates how TSmatch works.....	12
Figure 5. Table of content from TSmatch.xlsx. ....	13
Figure 6. Reports, which is generated by TSmatch. ....	13
Figure 7. A list of suppliers, which would participate in report generation.....	14
Figure 8. An example of report of TSmatch. ....	15
Figure 9. Supplier list from TSmatch.xlsx.....	16

## References

1. Tekla Structures [web source] URL:[www.tekla.com](http://www.tekla.com) (date of reference 06.12.2016)
2. Help. Tekla Structures 2016
3. Tekla Open API. Self Learning Exercises. Tekla Structures 2016; Trimble Solutions Corporation.
4. Tekla open API [web source] URL:<https://www.tekla.com/openAPI>, (date of reference 06.12.2016)
5. Tekla Open API. Developer's Guide. Tekla Structures 2016; Trimble Solutions Corporation.
6. Tekla Structures 2016. Open API Release Notes; Trimble Solutions Corporation.
7. PAS 1192-2:2013 Specification for information management for the capital/delivery phase of construction projects using building information modeling
8. Actual version of TSmatch's source code  
<https://github.com/PavelKhrapkin/TSmach>