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# Information system for construction contracts structural analysis

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**Abstract**

The luck of all projects is closely related to the right prepared contract. Construction contracts are regulated under civil law. There are major and additional conditions in the contract. The main problem is that construction contracts are related to different spheres: law, construction, management and so on. All those conditions have to be evaluated and properly described in the contract. It makes construction contracts multimodal and difficultly considerable document. In order to make considerate construction contract it is necessary to make its structural analysis. The aim of this article is to present the model of information system which main purpose is to help prepare construction contracts by presenting instrument for contracts structural analysis.



*Keywords:* Civil law; construction contract; information system; structurall analysis.

## 1. Introduction

One of the most important sectors in economy is construction. According the Ministry of Economy of The Republic of Lithuania 1* in year 2012 part of investments in construction sector was more than 55 percents of all country material investments. The construction sector is very important not only for Lithuania but also in all Europe Union countries. This sector creates about 10 percents of GDP. The number of firms in this sector also is one of the biggest. Most of those firms are small or very small. According international NACE classification the main activities related to the construction sector are construction of buildings, civil engineering, specialized construction activities like demolition and site preparation, electrical, plumbing and other construction installation activities, building

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completion and finishing. Those make construction not only one of most important but also one of most complicated processes with a number of stages, which must be appropriately adjusted and managed.

All the construction process, terms, financing conditions, security requirements, risk management and final results (Mitkus & Trinkuniene, 2008) must to be considered and clearly described in construction contract. It means the construction contract defines the luck of all construction or separate construction stages.

The importance and complexity of construction contracts making process requires huge and extensive knowledge and experience. This makes construction contract making difficult process where founds the pale using of specialised information systems. Using specialised information system allows not only collect big amount of related data, implement specialised models for contracts evaluation, but also made contract making structured, more clear process with possibility use collected experience in different fields negotiated under the contract. The objective and is formation of information systems model for construction contracts structural analysis. The novelty of presented article is model which helps to realise complex view to contract preparation and can be very helpful for construction contractors, subcontractors, investors and other related construction process participants.

## 2. Review of related researches

It was made an analysis of different publication related to the construction contracts making, use of information systems and technology in construction, decision making and structural analysis. In this part it is briefly reviewed some publications related to mentioned areas.

Construction process associates with great responsibility, important decisions, effective management and etc. Because of the significance and various risks, complexity and importance the construction sector is under consideration by different authors. More and more challenges are related to information and communication technologies. Different authors describe those research results in this field. Those researches are related to general usage of information technologies. For example Chen & Kamara (2011) introduced a framework for the implementation of mobile computing on construction sites, which comprised an application model and a technical model. Some research works are more concentrated on different level decisions. Chen, Okudan and Riley (2010) described Construction Method Selection Model (CMSM), which is designed to aid building team members during early project stages in evaluating the feasibility of prefabrication and exploring an optimal strategy to apply prefabrication in concrete buildings. Gustavo, Aguilar and Hewage (2013) described the system that transmits safety related information of multiple construction projects into a centralized database, where real-time safety indicators are generated.

Scientific literature increasingly pays attention to analysis of all construction contract, separate parts and stages of the contract also. Construction contracts by various aspects were analysed by Skitmore. He alone and with coauthors prepared a lot of different publications on research in this field. In last year's of this research Xiong, Skitmore, Xia, Masrom, Ye and Bridge (2013) analyzed how the performance of construction project participants affects contractor project satisfaction in terms of the client's clarity of objectives and promptness of payments, designer carefulness, construction risk management, the effectiveness of their contribution and mutual respect and trust, Skitmore (2008) analysed construction auctions organising theory and practice, Skitmore and Smyth (2007) described pricing of construction works from marketing viewpoint, Skitmore, Pettitt, and McVinish (2007) analysed possibilities to use Gates' method In evaluating closed-bid competitive procurement auctions in order to determine the probability of placing a winning bid for a given mark-up level.

Tieva and Junnone (2009) analysed possibilities of proactive contracting in Finnish public-private-partnership projects. They clarify what proactive law is about in terms of contract law and contracting especially in public-private-partnership. They discussed the risks in risk management in terms of proactive law and focused on public-private-partnership in Finland.

Dutch housing associations use procurement methods such as performance-based maintenance in order to maintain their housing stock. For contractors a performance-based approach implies major changes in methods and work processes. Straub and Mossel (2007) analysed the execution of activities such as providing advice on maintenance strategies, the design of maintenance scenarios, performance measurements and conducting customer satisfaction surveys in order to contractors selection for performance-based maintenance partnerships.

Even when the construction contractor is selected and the price, work terms and other conditions are negotiated, there is the possibility to choose at least several variants of contracts. Selection of the most favourable variant is a multiple criteria task, and different methodology can be used for its solution.

Important role in every process as in construction belongs to consultants. Chow and Thomas (2007) derived that more and more clients seek to measure the performance of Engineering Consultants and amass a set of Consultant Performance Evaluation records with an intention to monitor the quality of consultancy service and facilitate subsequent decisions. In those research set of common Consultant Performance Evaluation criteria pertinent to the service offered at the design stage and the Quantitative Indicators pertinent to each criterion are first identified. In order to improve the fairness of Consultant Performance Evaluation, the expectations that best describe the various performance levels of each Quantitative Indicator are unveiled. Having a better understanding on the expectations of various performance levels could ensure the Consultant Performance Evaluation conducted in a more objective and unified manner.

Multicriteria methods may be used not only for selection of contractors or consultants. Zavadskas, Ustinovičius and Stasiulionis (2004) have analyzed possibilities to apply *Electre III* method evaluating the effectiveness of investment to commercial objects. The authors note that while evaluating effectiveness of investment to commercial objects, total effect of various criteria must also be evaluated: amount of construction works in commercial objects, trends, legal issues and available construction solutions.

Maintenance of existing buildings is also important. It is expedient to make a multicriteria system for decision-making related to buildings' maintenance. Vilutienė and Zavadskas 2003 have presented a system of criteria, which helps to make decisions related to maintenance of residential houses. Evaluation was made using the following multicriteria methods: WSM (weighted sum model), WPM (weighted product model), AHP (analytic hierarchy process), ELECTRE and TOPSIS methods' variation and the multicriteria complex proportional evaluation method. A model was introduced after the research. The model helps to organize management processes in buildings' economy more effectively and to improve work quality.

Possibilities to use various methods of the game theory while making decisions in the construction sector were analyzed by Zavadskas, Ustinovičius, Turskis, Peldschus and Messing (2002). Authors have created a software which enables calculations using simple min-max principle, extended min-max principle, Wald‘s rule, Savage criterion, Hurwicz‘s rule, Laplace‘s rule, Bayes‘s rule and Hodges-Lehmann‘s rule. Investment to construction or reconstruction of a residential house in Nida is provided as an example of this software.

One more important issue in construction is selection of construction materials. Zavadskas, Kaklauskas and Trinkūnas (2002, 2003) have analyzed systems of e-trading for construction materials and goods and have offered the model of an internet decision support system for trading in construction materials. The model is based on determining criteria which define construction materials and goods, on importance of the criteria and on application of multicriteria evaluation methods. A pilot internet decision support system for trading in construction materials was created on the basis of the model suggested by the authors.

Multiple criteria methods can vary depending on different criteria. Different authors described usability of different multiple criteria methods: MOORA method (Braurs et al. 2008; Braurs & Zavadskas, 2009), SAW and CLARA methods (Shevchenko, Ustinovichius & Andruskevicius, 2008), Game theory methods (Peldschus, 2008), AHP approach (Podvezko, 2009).

Some of authors (Turskis, 2008; Ustinovichius, Barvidas, Vishnevskaja & Ashikhmin, 2009; Ginevicius, Podvezko & Raslanas 2008) analysed the use possibilities of different multiple criteria methods for different purposes.

To sum up, it can be proposed that observations and literature analysis according to the construction contracts making, use of information systems and technology in construction, decision making and structural analysis show that different techniques and methods can be applied but there is still the question how those useful researches connect in to one system which makes the possibility for construction contracts structural analysis.

## 3. Contracting and contract life cycle

Each process has its own life cycle. The same is with the contract life cycle. The main elements in contract life cycle can be presented by different ways. Through the process of contracting information system creation it is very important to define proper construction contract life cycle. The basis of developed model is made on construction contract life cycle model which is presented in Fig. 1.

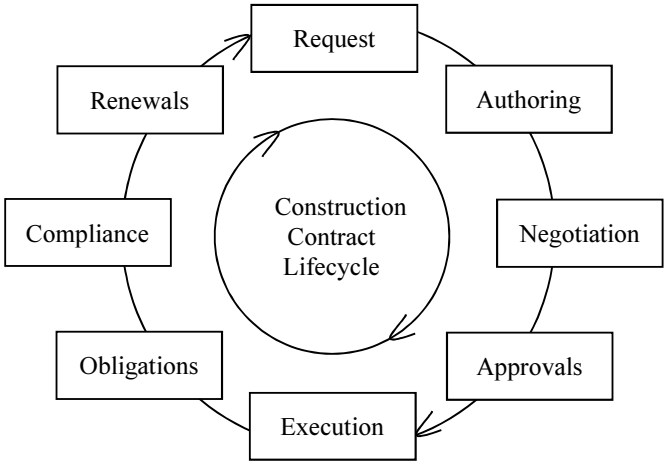


Fig. 1. Construction contract lifecycle model

Each of the construction contract lifecycle phases have its input and output information. Each phase has its own purpose:

- Contract request phase – different parties of the construction process can us such system and there are different type of the contracts. In this phase user can is at starting point and have to decide which type of the contract he needs.
- Authoring phase – there are a lot of different contracts, but in most cases it is impossible to use exactly the same contract few times. At this point user can edit existing contracts so it passes to existing needs.
- Negotiation phase – this phase is related to the presentation of drafts and versions of authorized contracts for review by other employees, or even vendors/customers/clients, etc.
- Approvals phase – in most cases construction contracts are complex and have to be checked by different stakeholders, even in the same organization. Such reviewers can be authorized staff, different subject matter experts, legal and appropriate.
- Contract execution phase – at this phase have to be prepared and signed final contract.
- Obligations phase – the life of a contract and its relationships continue doesn't stop after signing the contract. At this moment starts very important post-execution stage with alerts, workflow processes, risk assessment, spend management, compliance monitoring, and advanced reporting metrics.
- Compliance phase – reporting capabilities provide organizations with visibility into all contractual relationships including fully audit for contract.
- Contract renewal phase – this phase is related to organizations possibility to capitalize on each and every renewal opportunity by identifying candidates for renewal, alerting employees to these contracts in time to make business decisions, and creating new contracts or drafts based on existing ones.

Each phase consists of different elements which are very important in the realization of the purpose related to exact phase. There are different structures for each phase, and those have to be analyzed separately.

At the same time if we talk about contract request ir renewal phases we can see stronger or not so strong relations among different contracts. This makes the possibility to use an existing experience and organize all information system as multilayer contracts modeling system.

## 4. Multilayer contracts modeling system

Throughout construction contract making process numerous models are needed, which are often created independently and designed to solve different tasks.

In order to make construction contract there is no one right model. There are different models with different strong and weak sides. Taking in to account this principle was created multilayer construction contracts modeling system architecture Fig. 2.

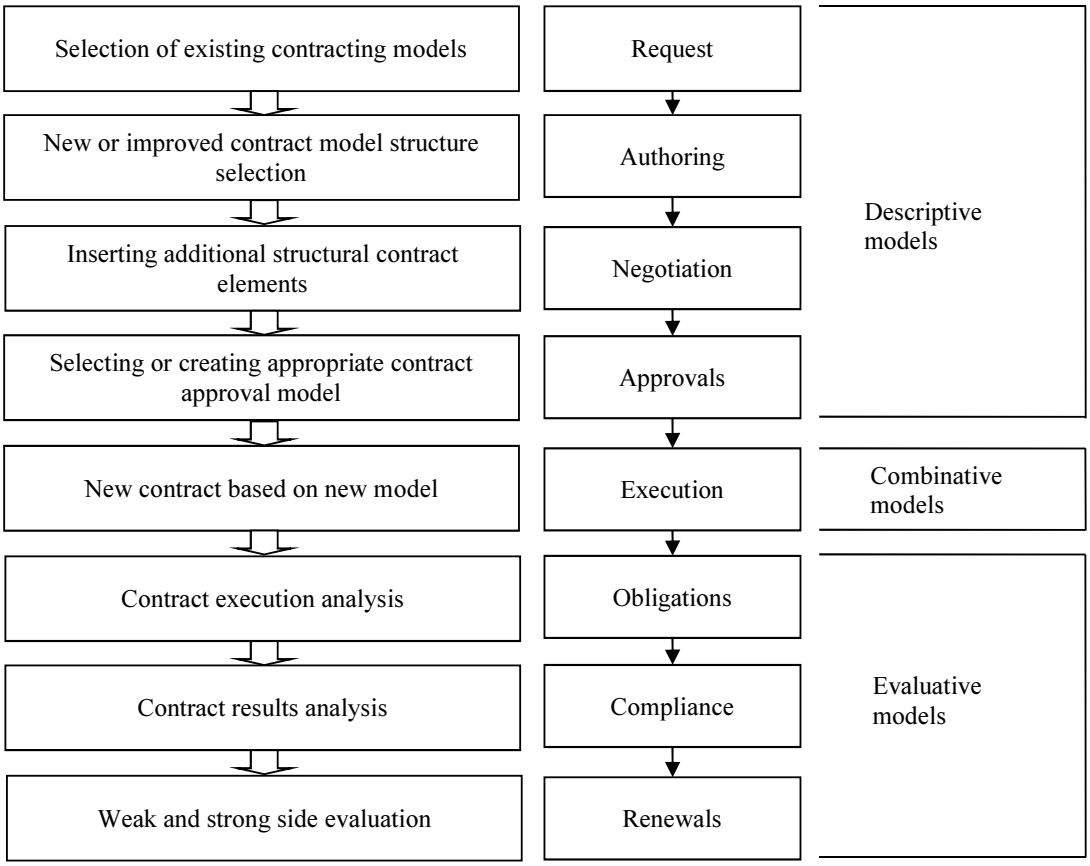


Fig. 2. Multilayer construction contracts modeling systems structure

The basis for this model is taken from construction contract lifecycle model (Fig. 1). One phase of construction contracts life cycle constrains one layer in construction contracts modeling system structure. There are 8 separate layers. Each layer consists of its own schemas and discovered gaps in those schemas are filled by creating new schemas. The main idea is that number of schemas is no limited and each new schema helps to solve different tasks and makes possibility to improve contracts in the future. According those principle models are grouped in three classes: descriptive models, combinative models and evaluation models (Fig. 2).

Descriptive models class consists of four levels. Those levels are situated in hierarchical manner. All those levels are described in construction contract lifecycle model description.

The class of combinative models contains from only one element or one layer. It means that upper four layers are linked together via process model.

Evaluative models class is constructed from free levels which represents evaluation in different stages of construction contracts implementation. With the process-centric integration of engineering, management, legal and other information and properly organized ontology it is possible to create a variety of new formalized evaluative models which helps to use semi automatic or automatic analysis of created structures.

## 5. Descriptive and combinative models implementation

There are dozen possible schemes for descriptive and combinative models implementation. In order to make clear multilayer construction contracts modeling system implementation it will be presented possible implementation of this model. The basis for the model is taken from previous researches made by authors. This contract structure is provisions based.

The number of construction contract provisions is so great that it is impossible to include all available information. In order to assess such a complex phenomenon with interrelated contract provisions as precisely as possible, it is necessary to develop a structure defining the interrelations between these provisions (Adriaanse, 2007). Provisions affect one another and are interdependent, i.e. they are hierarchically interdependent, and thus the structure reflecting the set of provisions and their interrelations should be hierarchical as well.

Using an expert method, provisions have been determined which influence construction contract contents:

- performance of construction works according to the contract and following the requirements specified in normative documents of construction;
- performance of construction works keeping to the environment protection and work safety requirements;
- performance of construction works keeping to the environment protection and work safety requirements;
- permits for construction works;
- supply of the construction site with construction materials, equipment, spare parts and other constructions;
- contractor ‘s duty to do all works independently, if not specified otherwise in the contract;
- a right to require recalculation of the contract price, if the factual price of the construction works increased over 15% due to circumstances not influenced by the contractor;
- client’s duty to provide a land plot for construction in time;
- to obtain required construction permits;
- client’s duty to pass to contractor buildings and equipment for use and to install temporary energy or water supply networks in cases specified in the contract;
- allow to use buildings and temporary energy or water supply networks;
- client’s duty to pay for all works performed before conservation;
- implementation of client’s rights related to construction supervision and control;
- acceptance of constructions works;
- cooperation of parties;
- recognition of the building as suitable for use;
- quality guarantee terms;
- payment for construction works;
- contract guarantee;
- contract suspension.

When construction contract contents are divided to separate provisions, which influence smooth construction process, in such way, we get a model (Fig. 3), which is broadly applicable in construction contract preparation. It is possible to distinguish the following advantages of a hierarchical structure:

- hierarchical structure describe how lower level priorities influence change of higher level priorities;
- hierarchy provides considerably more detailed information about lower level structures, functions and their influence on higher levels;

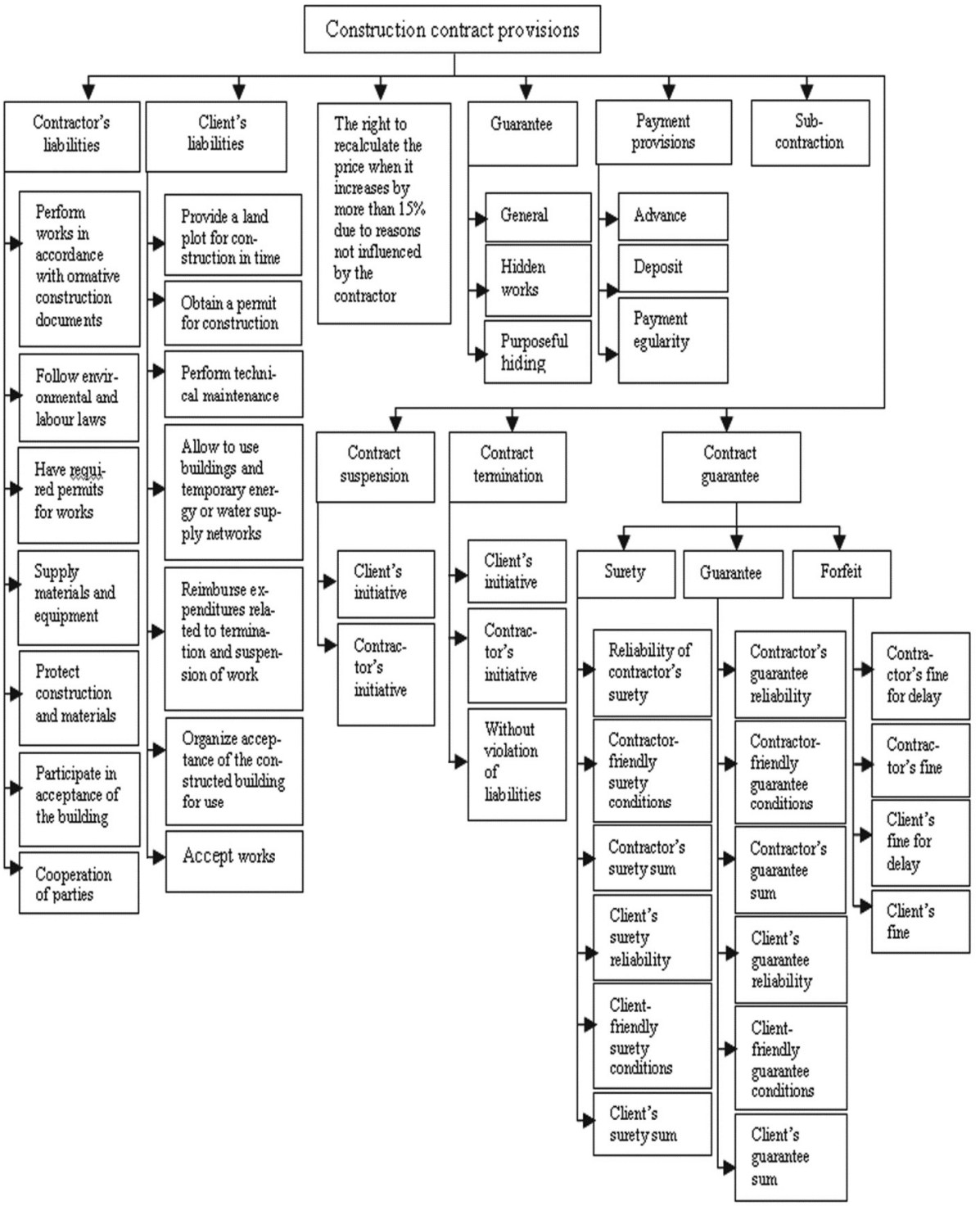


Fig. 3. Functions based contracts structuring model of construction contract provisions

- when systems reflecting real situation are developed by means of hierarchy, i.e. by developing and later uniting models, their development is more effective than in cases when the system is made at once;
- a hierarchical system is both stable and flexible. Stability means that slight modifications in the hierarchy cause very small changes. Flexibility means that introduction of several new criteria does not change the essence of a well-developed hierarchy.

The system of construction contract provisions may be also modelled considering the functions of contract provisions. All construction contract provisions have a certain function. For example, contract provisions regulating guarantees, surety or forfeit have the function of liability guarantee. All provisions regulating the aforementioned function may be joined to a separate subsystem. Similarly, other contract provisions may also be joined to subsystems. Following the aforementioned principle, a hierarchical model of construction contract provisions based on their functions has been made and provided in Fig. 2.

Considering distribution of contract provisions they are grouped or, in other words, joined to subsystems. Subsystems distinguish their common features and are considered elements of another system of a higher level. On their turn, these contract provisions are grouped according to their characteristic features and thus form elements of another, higher, level. At the end of the process, the top of the structure of the system of contract provisions is reached, and this top is identified as the aim of the decision-making process. This model is the most suitable for development of the methodology for multi-aim assessment of construction contracts. Such conclusion can be made due to the following reasons:

- experts find it easier to evaluate the significance of contract provisions when the provisions are grouped from a functional perspective;
- all construction contract provisions have equal legal power irrespective of the group to which they are attributed using any of the analysed classifications; however, the latter classification shows the real effect of a construction contract and its functions in the best way.

During assessment or interpretation of evaluation results, different construction contract provisions may be treated differently. This, on its turn, may cause some misunderstanding, erroneous results or erroneous interpretation of the results. Therefore, it is very important to elaborate each construction contract provision.

As the authoring layer possible structure it was used scheme were expert evaluation methods was adapted. In order to determine indicator significance in calculations more objectively, an opinion of a group of experts was evaluated.

The experts were surveyed by questionnaires. The questionnaire was prepared on the basis of the method of paired evaluation of indicator significance. The generalised calculations of survey results showed that the compatibility of expert opinions meets the requirements; therefore, it is possible to claim that indicator significances derived during the expert survey are reliable and can be used for typical evaluation of contract. However, these indicator significances would change with changing economic situation and upon evaluation of specific requirements of a construction project; anyway they serve as a basis for initial calculations.

During the pilot calculations, three contracts were evaluated using the indicator significances derived from the survey of the expert group. It was determined that the first variant of the contract meets the requirements in the best way.

This example illustrates only first layers of the multilayer construction contracts modeling system structure (Fig. 2). The system is more and more useful as the new contracts are developed and new schemes in different layers are implemented. Such structural contracts analysis allows carefully evaluate contracts and use and use collected experience in order of new contracts preparation.

## 6. Conclusions

Specialised information systems for construction contracts preparation allows not only collect big amount of related data, implement specialised models for contracts evaluation, but also made contract making structured, more clear process with possibility use collected experience in different fields negotiated under the contract. There for information systems model for construction contracts structural analysis was prepared. This model is based on

construction contract lifecycle and multilayer structure. The structure of proposed model allows realising complex view to contract preparation and can be very helpful for construction contractors, subcontractors, investors and other related construction process participants which can improve construction contracting using collected experience.

In order to present the possibilities of using prepared model it was described one of the possible schemas for structured contracts preparation. Pilot model implementation shows that presented structure is vertical, but there is still untouched horizontal structure of presented layers. The usefulness of this model is related not only to vertical but also to horizontal structure. The development of such structures is the direction of future researches for authors.

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