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MODELS OF INDICATOR SYSTEMS OF CONSTRUCTION CONTRACTION AGREEMENTS

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Abstract. A number of multicriteria decisions must be made during construction investment processes. A number of support systems for multicriteria tasks of construction investment processes are available. A part of them is reviewed in this article. Effectiveness of the construction investment process is greatly influenced by an appropriate formulation of a construction contraction agreement (CCA). In order to formulate the effective contraction agreements, multicriteria techniques for evaluating and comparing CCAs must be created. Besides technical, organisational and economic aspects of construction, legal aspects of a CCA must be also analysed in order to prepare such techniques. Therefore, legal decision making systems are also reviewed in the article. A conclusion can be made from the review that legal decision making systems for CCAs are not available currently. One of the main tasks in the creation of multicriteria support systems is the formation of a multicriteria indicator system. Three models of multicriteria indicator systems of CCAs are analysed in the article, and the best model for creating multicriteria evaluation technique is determined. On the basis of this model, significance of indicators should be determined and a multicriteria decision support system should be created in further research stages.

Keywords: decision support systems, construction contracts, multiple criteria evaluation.

1. Introduction

Construction is a complicated process with a number of stages, which must be appropriately adjusted and managed. The entity that commissions construction must make different multi-aim decisions at various construction stages.

Most problems encountered during construction depend upon the selected contractor. Therefore, selection of a contractor is a very important stage in implementating an investment project. Patrick Sik-Wah Fong and Sonia Kit-Yung Choi [1] have analysed methods of contractors' selection and noted that some methods are non-exhaustive and tend to be biased: there is a lack of opportunities to evaluate abilities of a contractor and meet time, price, quality and security requirements at the same time. These authors have analysed possibilities to apply the Analytic Hierarchy Process (AHP) Method in contractor's selection according to different criteria.

Construction contracts by various aspects were analysed by R. M. Skitmore. His research work is described in different publications. R. M. Skitmore and Z. Hatush [2] analysed contractor selection using multicriteria utility theory, S .T. Ng and R. M. Skitmore [3] described client and consultant perspectives of prequalification criteria, D. Drew, R. M. Skitmore and Hing Po Lo [4] offered a bidding strategy model for use by contractors as part of a more informed approach in selecting which contracts to bid for, S. T. Ng, Kam Pong Cheng and R. M. Skitmore [5] examined the importance of Safety Performance Evaluation through a questionnaire survey conducted in Hong Kong and developed a Safety Performance Evaluation framework suitable for use in the construction industry and protocols for evaluating the safety performance at the organisational and project level.

Architects are not less important in the construction process. F. K. T. Cheung et al [6] claim that price cannot be the only criterion influencing the selection of an architect. Authors have compiled a questionnaire and made an expert research, which helped to determine criteria that influence architect's selection and the significance of the criteria. An architect was selected using AHP method. The system for selecting of architects was created on the basis of the model formed during the research.

Multicriteria methods may be used not only for selection of contractors or architects. E. K. Zavadskas, L. Ustinovičius and A. Stasiulionis [7] have analysed possibilities to apply *Electre III* method in 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.

J. Antuchevičienė [8] notes that rural buildings are an important part in Lithuania's economic potential. The author has introduced a system of criteria specially designed for reconstruction of rural buildings. The priority of rebuilding may be determined using the author's model, and multicriteria analysis methods may be used.

When information is incomplete or under-defined, methods based on the uncertainty theory are offered.

While analysing multicriteria building evaluation from the sustainable development perspective, J. Šaparauskas [9] reviewed guides, manuals, recommendations, databases, software and internet tools. The author offered an evaluation system on the basis of the performed analysis. Software based on MCDM-23 (multi-criteria decision-making) method was used for evaluation, and projects of individual houses *Kedras* and *Vasaris* were compared to check the principles.

Maintenance of existing buildings is also important. It is expedient to make a multicriteria system for decision-making related to buildings' maintenance. T. Vilutienė and E. K. Zavadskas [10] 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 organise 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 analysed by E. K. Zavadskas, L. Ustinovičius, Z. Turskis, F. Peldschus and D. Messing [11]. 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.

A more important issue in construction is selection of construction materials. E. K. Zavadskas, A. Kaklauskas and V. Trinkūnas [12, 13] have analysed 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 of 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.

The construction industry is among the most important branches in every country's economy. The fact is witnessed by the attempts of various authors to increase effectiveness of construction solutions. Most of the above-mentioned authors solve different issues related to construction investment process. However, such an important question as evaluation of CCAs remains unanalysed or almost unanalysed. Even when a contractor is selected and price and terms of work agreed, at least several contract variants are still available. Selection of the most favourable variant is a muticriteria problem, and a technique must be created for its solution.

In order to create a multicriteria evaluation technique for CCAs, it is a must to make a system of indicators characterising CCAs, to determine importance of the indicators and to select and adjust appropriate multicriteria evaluation methods. The system of CCA provisions is analysed in this article, contract provisions which may be considered indicators of CCAs are determined and models of CCA indicator systems are created.

2. Legal decision support systems

Many and different systems to alleviate contract making and legal issue solving are already created in the world. Two different types of rules were used in the system Meldman [14]: general norms defined in claims and special norms taken from precedent cases. Disputable situations are immediately compared to precedents and the system determines a precedent that is closest to the violation of the civil law.

TAXADVISOR [15] used *EMYCIN* system in order to assist lawyers in land tax administration. The audit company *Ernst and Young* has created three legal expert systems: *VATIA*, *Latent Damage Adviser* and *THUMPER*.

The main attention in *VATIA* (Value Added Tax Intelligent Assistant) [16] system is paid to VAT calculation. With the help of *VATIA* system auditors could analyse VAT payments of a client.

Latent Damage Adviser [17] was created on the basis of 1986 Latent Damage Act (Australia). With the help of this system experts of latent damage could solve some difficulties with less efforts; however, it was too complex for non-experts, because they were not knowledgeable in abundant interrelated rules, which are characteristic to this sphere of law. The law is barely commented, complex and difficult to understand.

THUMPER [18] system was meant for employees of *Ernst and Young* who specialise in general taxation issues. With the help of this system information about applied taxes could be retrieved and activities could be planned considering the taxes. Three abstract legal models were implemented in *THUMPER* system:

- The farthest level: consumer problems;
- Middle level: expert explanations and legislation;
- The level which represents legislation and legal cases.

One of the first *Rand* Corporation expert systems is *LDS*, which helps lawyers to solve inheritance disputes. *LDS* system consists of laws, court cases and law principles; lawyers use this information operatively when they are preparing claims in inheritance cases.

SAL [19] is another system created by the *Rand* Corporation; it is also used to solve inheritance issues. Knowledge about losses, liability of the defendant, liability of the complainant, the main property distribution characteristics such as type of parties and legal mastery of the opponent were used in *SAL* system. These two systems are important in that they represent first steps of IT in property distribution solutions.

WIRE IQ (Wire Intelligent Quantum) [20] is an internet decision support system, which enables lawyers, insurers and reinsurers perform quantitative analysis for

claims in property distribution and personal damages rapidly. In 1999, Douglas and Toulson analysed value determination structure in torts, property distribution and personal damage. A rule-based system must be the basis in this process. Claims are detailed (claim type, complainant, age, gender, salary, etc.) and included in the system. Rules used in the system help to determine the value of litigious property or tort. *WIRE IQ* database consists of thousands of records including disputes on property distribution and claims on damage remuneration. The system analyses variants, performs comparative analysis, selects precedents and forecasts.

Within 10 last years, Donal Berman created a number of legal decision support systems in the IT and law laboratory; the systems are described in Table 1 [21].

Although the above-mentioned systems are created by different authors, in different time and for different tasks, it is possible to distinguish one common feature: information and the sequence of problem solutions are detailed on the basis of certain principles. In order to reveal peculiarities of contraction agreements and to determine the system of indicators defining CCAs, it is expedient to classify and to model provisions of such contracts and to perform their systematic analysis.

3. The system of provisions in construction contraction agreements

From the philosophy perspective, a system is a sum of interrelated and interconnected elements, which are integral and united. The system is more than a mechanic unity of its constituent elements. Interconnected elements of the system bring new quality to the totality. The whole system and the relations among elements change when elements are changed, supplied or removed. Each system may be an element of another macrosystem, and each element of a system may be a microsystem.

Such complex thing as a CCA cannot be analysed without taking it as a system with own elements and own relations among elements. The view to a CCA as a system is especially important when creating techniques allowing multicriteria evaluation of CCAs and comparison of CCA variants.

CCAs have peculiarities when compared to other types of contracts. The main features of a CCA are the following:

- The object is specific. In contrast to objects in other types of contracts, it is usually larger, technically more complex, more expensive, unique and in all cases real estate;
- CCAs usually have longer implementation terms;
- The contractor performs works at its own risk and independently determines how to implement client's tasks. Besides, the contractor makes the work specified, in the contract with its own materials, own tools and power, if not specified otherwise. This feature is found in other contraction agreements as well.

Not only specific contract provisions determine uniqueness of this type of contracts but also large long-term financial liabilities and participation of many other entities (designers, construction managers, state supervisory institutions, banks etc) in implementation of the contract. The person who makes CCAs must be knowledgeable not only in legal regulations on construction but also in the building process.

After analysis of contents of CCAs, the conclusion can be made that the smallest element of a CCA as a system is a contract provision. While analysing a CCA (like any system), different models of systems can be formed depending upon research aims. Therefore, it is necessary to determine which model of a CCA best suits the aims specified in the article.

Table 1. Legal decision support systems created by Donal Berman in the IT and law laboratory [21]

System	Application	Used argumentation technique	Status
IKBALS I [Zeleznikow 1991]	Remuneration of damage to employees	Argumentation based on rules and facts	Unused since 1992 due to changes in the legal system
CAAS	Credit law	Argumentation based on rules	Was used until 1995 for internal purposes in Melbourne Bank
IKBALS III [Zeleznikow 1994]	Credit law	Argumentation based on rules and facts. Factors describing certain facts were studied using rules	Used only for research
Spulit Up [Stranieri 1999]	Issues related to family law and property distribution	Argumentation based on rules and neural networks. Separate argumentation section created	The first version was used by legal intermediaries for private purposes. The second version was used in internet, which enabled to expand functions
Family_Negoti ator [Bellucci and Zeleznikow 2001]	Dealing with family law issues	Argumentation based on rules and facts	Exceptional use for clarification of family law principles
Embrace [Yearwood ir Stranieri 1999]	Refugee law	Argumentation based on rules and facts	Political changes influenced by the new government (Australia) determined the use of this system only for educational purposes
GetAid [Stranieri and Zeleznikow 2001]	Legal assistance	Networks for sequential argumentation are used. Available in internet	The system is commercially successful. It is used in legal consultations
RightCopy	Informs software authors about their copyrights	Networks for sequential argumentation are used	The system is not commercial
Sentencing Informatikon System	Consults lawyers about possible verdicts in criminal cases	Networks for sequential argumentation are used	The system is being developed
Kamily_Winner	Compilation of marriage contracts	Argumentation based on rules and facts, the uncertainty theory applied	The system is being developed

The Model of a CCA Provisions System Based on Significance of Provisions

One of the most important elements of a contract is its contents which include the system of contract provisions. One of the main principles of the civil law is followed in formulation of contract provisions: contract freedom. On the basis of this principle, parties have a right to make contracts independently and determine their provisions.

S. Raslanas [22] analysed the experience related to selection of a contractor. On the basis of the analysis, the author offers to evaluate contract price and economic effectiveness expressed through qualitative and quantitative characteristics. Multicriteria decision making method *COPRAS* is offered for this purpose. However, the author analyses only essential contract provisions; non-essential provisions, which may have significant influence on the whole process of contract implementation, remain unanalysed. Insufficient attention is often paid to non-essential provisions, and this may cause failure to keep to contract terms, idling and other critical events.

Provisions have different significance in a contract. Lithuanian legal doctrine divides all contract provisions to essential and non-essential. The model of the system of CCA provisions is formed on the basis of this classification; its principle scheme is showed in Fig 1–3.

Essential contract provisions are those that are necessary and sufficient in order to make a contract which would create rights and liabilities to the parties after coming into force. Essential contract provisions have two features: necessity and sufficiency. Necessity is understood in the following way: the contract is not valid until parties agree on all essential contract provisions. If agreement is not achieved, it is considered that parties have pre-contract relations. Sufficiency is understood in the following way: when parties agree on all essential contract provisions, the CCA is considered valid although adjustment of non-essential provisions is postponed.

The analysis of the Civil Code shows that three essential contract provisions are distinguished in a CCA: the contract object, the contract price and the fulfilment terms. When these provisions are adjusted, the CCA is considered valid and creates rights and liabilities to its parties. It is not required that parties agree on all possible contract provisions in all cases. Parties may agree on non-essential contract provisions later at the request of the interested party; non-essential provisions may also be determined by the court in accordance with contract specifications, dispositive legal norms, traditions, legal principles, parties' interrelations etc [23].

It is important to note that essential contract provisions may be determined not only by law but also by parties of the contract. Suppose parties agree that the term of intermediary completion must also be considered an essential contract provision. In such case the term of intermediary completion becomes an essential provision and will have the same significance on contract validity as the essential provisions described in the law.

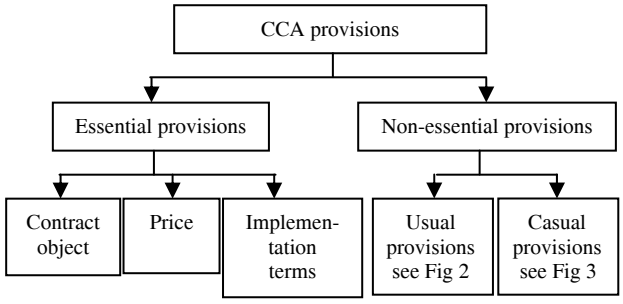

Fig 1. The principle scheme of the model of CCA provisions' system based on significance of provisions

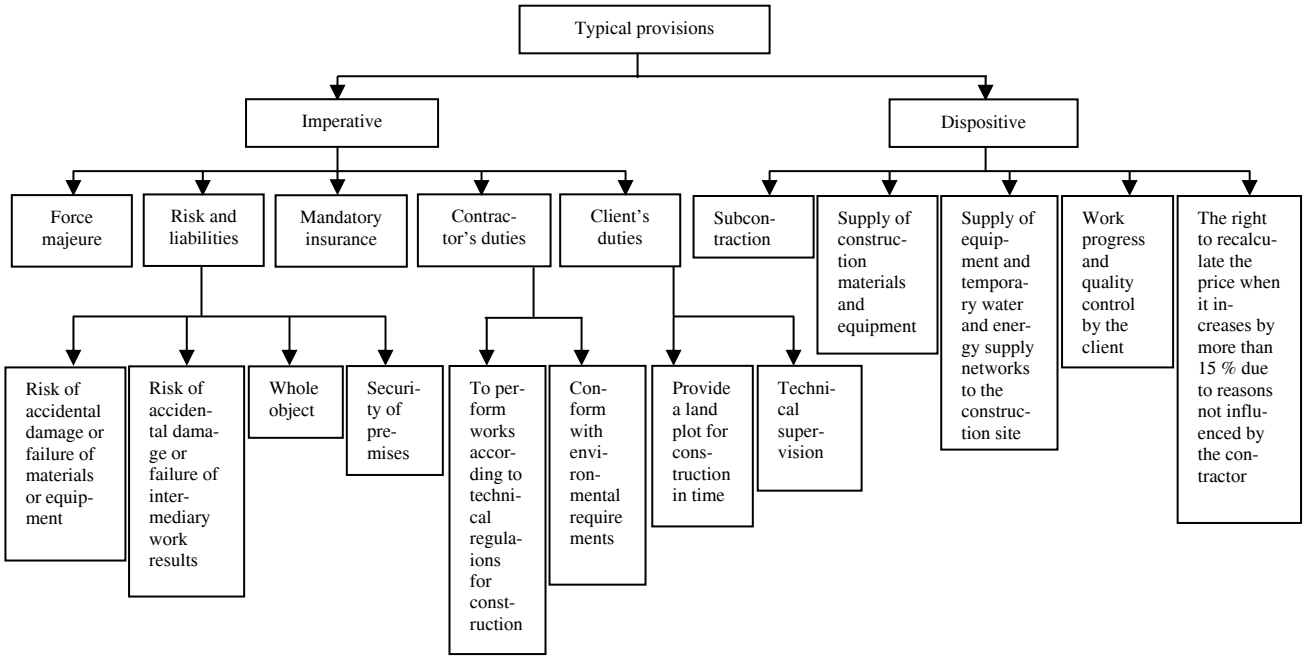

Fig 2. The model of typical CCA provisions

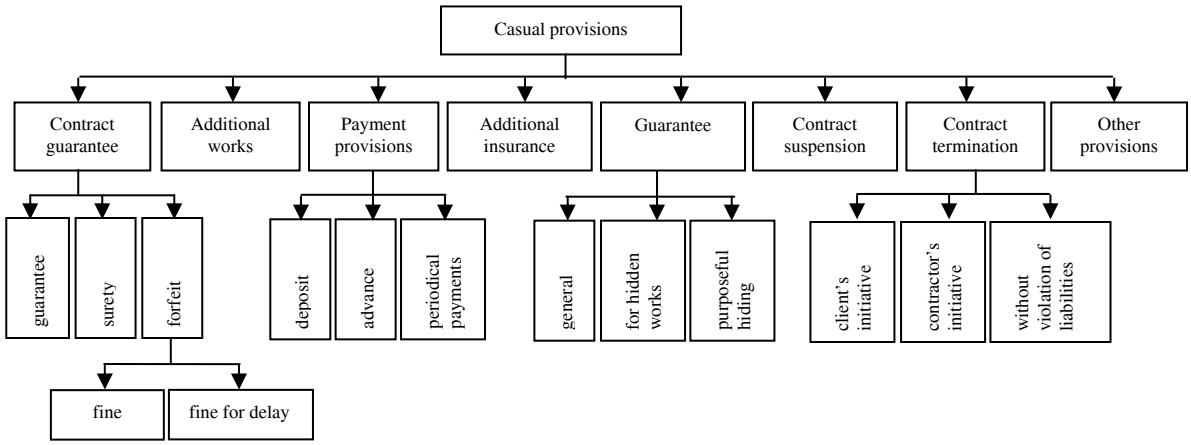

Fig 3. The model of casual CCA provisions

Non-essential contract provisions are all other provisions that are not essential. It means that non-essential contract provisions are neither necessary nor sufficient for the contract. Their presence or absence does not have influence on validity of the contract. If all non-essential provisions are adjusted but at least one essential provision is not adjusted, then the contract is not valid. Two types of secondary contract provisions may be distinguished: typical and casual.

Typical provisions are the provisions set by laws, which become mandatory to parties due to the fact of contract making. They differ from essential provisions in that it is not necessary to adjust them: if parties agree on all essential provisions, then upon making the contract they adjust typical contract provisions as well. When a CCA is signed, they automatically are included in the contents. Typical CCA provisions can be imperative and dispositive.

Imperative contract provisions are determined by imperative legal norms and are mandatory to contract parties whether included in the contract or not. Parties cannot neither change nor cancel these provisions. For example, the Civil Code, Chapter 6.682, Part 1 sets a typical imperative CCA provision: "The risk of accidental damage or failure of the construction object and its part is the responsibility of the contractor before the object is accepted by the client when the damage occurred not due to bad quality of materials, parts and constructions provided by the client or not due to execution of wrong orders of the client".

CCA provisions may also be determined by dispositive legal norms, for example, the Civil Code, Chapter 6.686, Part 1 includes a dispositive norm which sets a typical CCA provision that materials, equipment and other constructions must be provided by the contractor if not specified otherwise in the CCA (the duty may be prescribed to the client). This is a typical dispositive CCA provision and need not be adjusted by the parties; it will be valid ipso facto (due to making the contract). Dispositive legal norms may be changed by the parties in their contract upon agreement. In such case the provisions agreed by parties will be superior over the provisions set by dispositive legal norms. If parties have not changed contents of dispositive legal norms upon agreement or have not discussed legal relations regulated by dispositive norms, then legal relations between parties are regulated by dispositive legal norms. Thus dispositive legal norms are valid when contract parties do not specify otherwise.

The Model of the CCA Provisions' System Based on Grouping of Provisions to General and Special

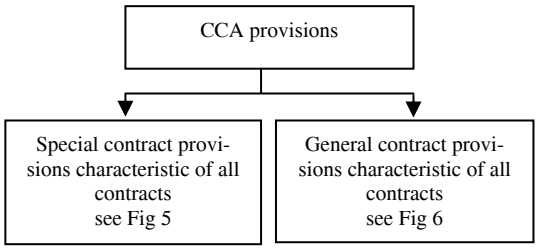

Fig 4. The principal scheme of the model of the CCA provisions' system based on grouping of provisions to general and special ones

Casual contract provisions are non-essential and determined by the parties and not by laws. They are not automatically included in a CCA as typical provisions. Absence of such provisions does not influence validity of the contract, because they are determined upon mutual agreement between the contractor and the client. It is important to note that without regard of the group to which a certain contract provision is attributed according to the provided classification, all these provisions are equally obligatory when the CCA comes into force, and all contract provisions have legal power over the parties.

Such classification of CCA provisions helps to determine the hierarchy of provisions, and even non-experts can see legal significance and importance of provisions. This way he/she can clearly see what will be legal outcomes when some contract provisions are not discussed, in which cases CCA provisions discussed in the Civil Code shall be applicable and in which cases CCA provisions will be valid.

CCA provisions may also be divided in to two main groups according to types of contracts to which they are

typical. One group would include contract provisions that are characteristic only of a CCA. The other group would include contract provisions that are characteristic of other types of contracts as well. The model of the contract provisions' system based on this classification does not specify essential and non-essential provisions. The model of the CCA provisions' system based on grouping of provisions to general and special is shown in Figs 4–6.

The Model of the System of CCA Provisions Based on Functions of Provisions

The system of CCA provisions may be also modelled considering functions of provisions. All CCA provisions have certain functions. For example, contract provisions regulating guarantees, surety and forfeit have liability guarantee function. All provisions regulating this function may be joined to a separate subsystem. Other contract provisions may be joined to subsystems analogically. The model of the system of CCA provisions formed on the basis of this principle is shown in Fig 7.

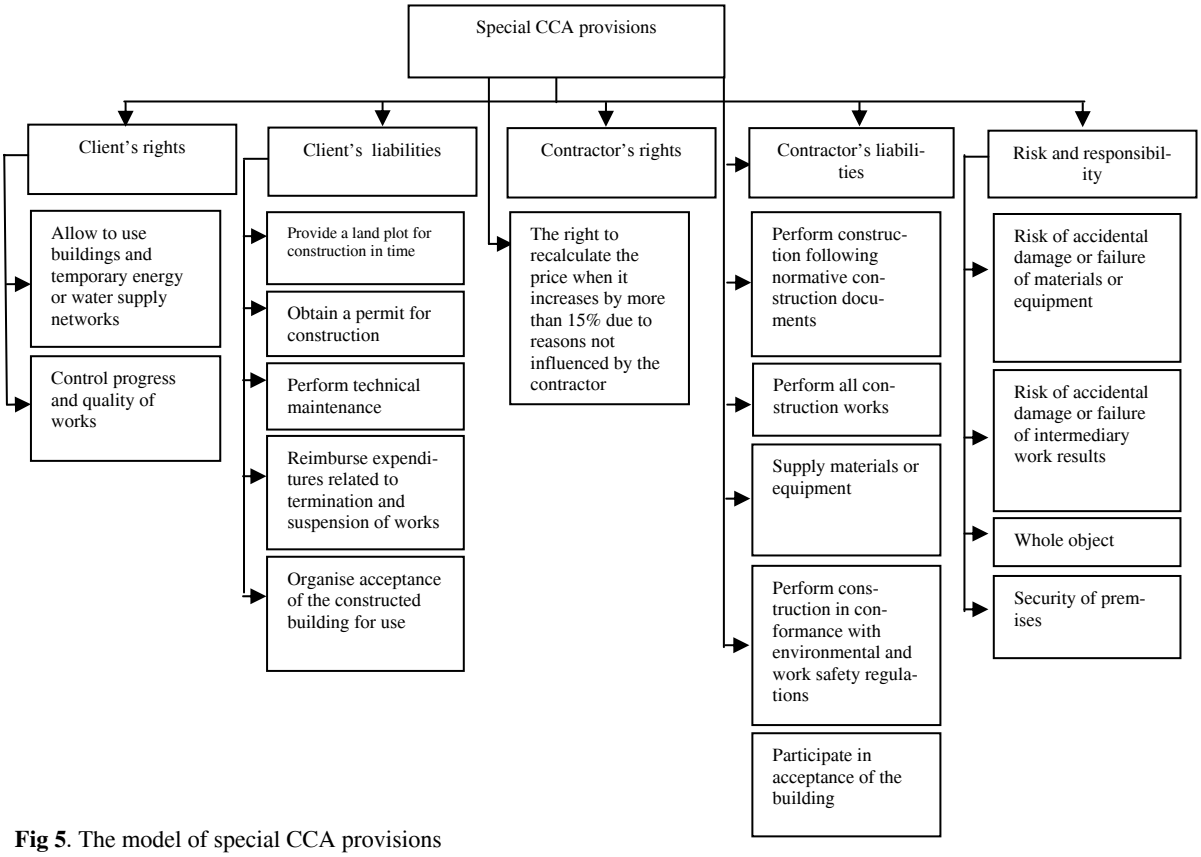

Fig 5. The model of special CCA provisions

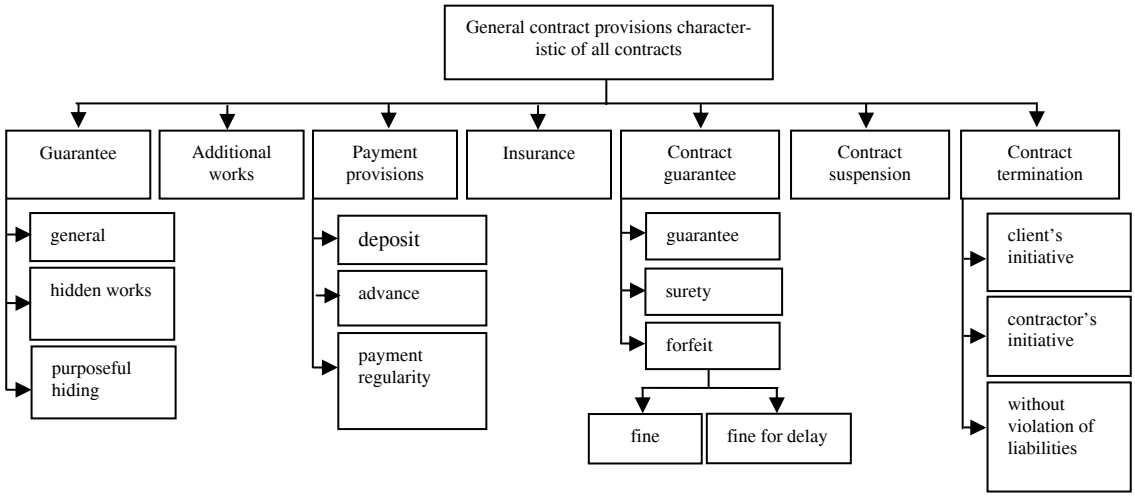

Fig 6. The model of general CCA provisions

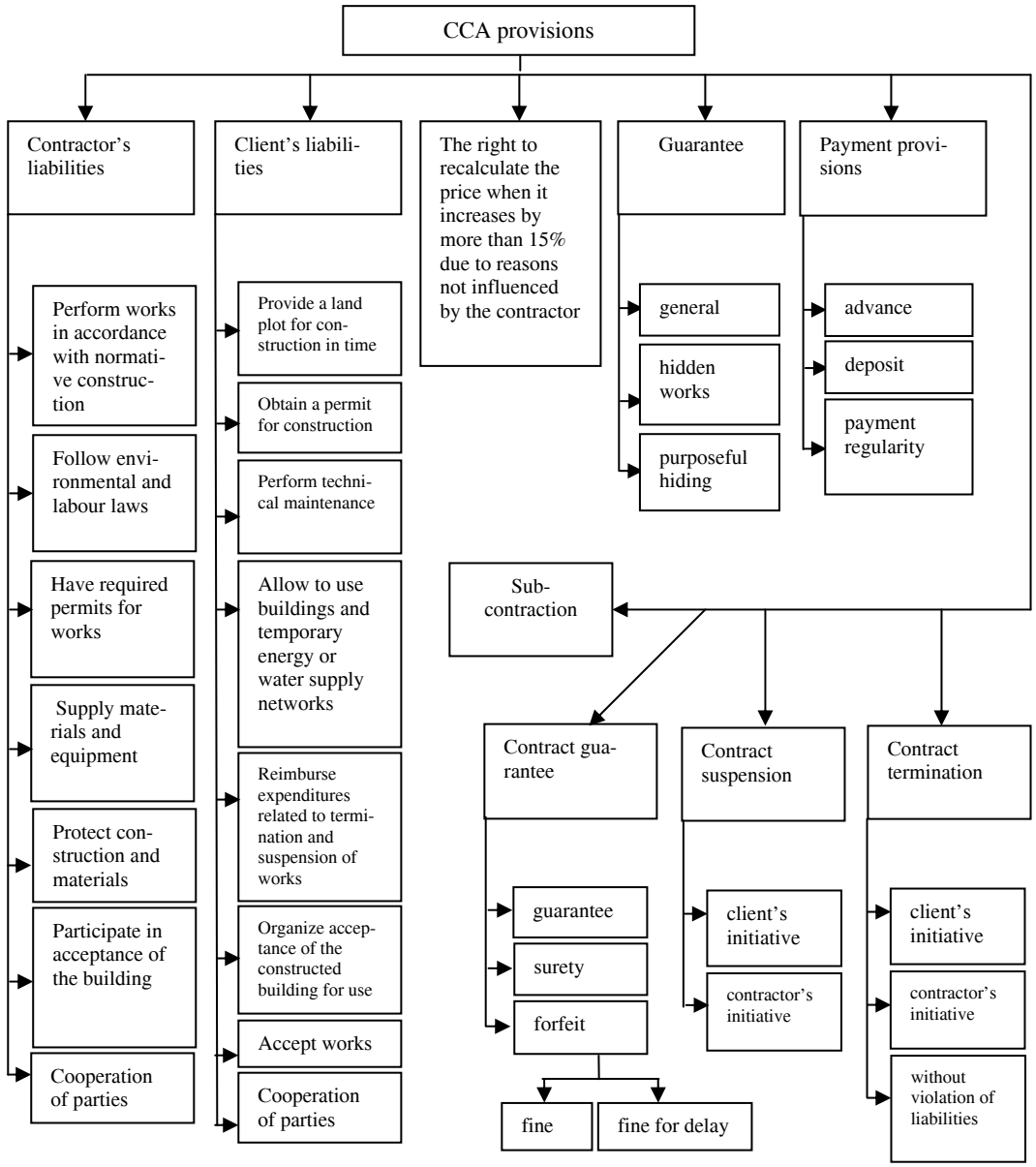

Fig 7. The model of CCA provisions based on functions

We think that this model is the most suitable for creation of the multicriteria evaluation technique for CCAs. Such conclusion can be made due to the following reasons:

- experts can more easily evaluate importance of contract provisions when the provisions are grouped according to their functions;
- legal power of all CCA provisions is equal despite the group they are attributed to according to any of analysed classifications; however, the latter classification shows real operation and functions of a CCA best.

4. Conclusions

1. Construction is an expensive, long-term and complex process during which various problems occur and then multicriteria decision-making methods must be applied. Various authors offer different multicriteria decision-making methods for problem solving at various stages of an construction investment process: selection of a contractor and architects, evaluation of priority for building reconstruction, evaluation of buildings from the perspective of sustainable development, making of decisions related to building maintenance, selection of construction materials etc.

2. Problem solving in many analysed systems is made by determining criteria which influence the solution and by applying special multicriteria decision making methods. Criteria and their amount usually depend on the nature of the problem being solved. This also influences the selection of mathematical methods.

3. Currently multicriteria methods and models are available to increase effectiveness of solutions on various issues related to construction; however, insufficient attention is still paid to making, evaluation and comparison of CCAs. In order the construction process is effective and well run, the CCA must be well formulated. The model of the CCA provisions' system is created in order to successfully solve this problem.

Currently there are many systems alleviating contract making and legal issue solving in the world; they help determine precedents and civil law violations, to consult on tax organisation, to solve disputes on inheritance etc. Although these systems are created by various authors, in different time and for different tasks, it is possible to distinguish one common feature: information and the sequence of problem solutions are detailed on the basis of certain principles. In order to reveal peculiarities of contraction agreement making, it is expedient to make a scheme showing CCA provisions and their relationships in detail.

4. After the analysis of CCAs and laws regulating their making, three different models of CCA provisions' systems were created:

The model of the CCA provisions' system based on importance of provisions. This model is useful for persons who are not knowledgeable in civil law, because CCA provisions are divided according to their legal importance in this model, ie outcomes are shown when some provisions are not included in the contract. However, persons who are knowledgeable in law know this classification very well.

The model of the CCA provisions' system based on grouping of provisions to general and special. It shows the differences of a CCA in contrast to other contract types regulated by the CC. The model has one drawback: it is difficult to determine significance of provisions and apply in decision making.

The model of the CCA provisions' system based on functions of provisions. This model helps to determine significance of contract provisions. Thus this model enables to create an internet based legal CCA decision support system.

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STATYBOS RANGOS SUTARTIES RODIKLIŲ SISTEMOS MODELIAI

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Santrauka

Investicinio statybos proceso metu reikia priimti nemažai daugiakriterių sprendimų. Yra sukurta daug statybos paramos sistemų daugiakriteriams uždaviniams spręsti statybos investiciniame procese. Dalis iš jų apžvelgta straipsnyje. Statybos investicinio proceso efektyvumui labai svarbus tinkamas statybos rangos sutarties sudarymas. Siekiant sudaryti efektyvias statybos rangos sutartis, reikia sukurti daugiakriteres statybos rangos sutarčių įvertinimo ir palyginimo metodikas. Siekiant parengti tokias metodikas, reikia išnagrinėti ne tik statybos techninius, organizacinius, ekonominius, bet ir teisinius statybos rangos sutarties aspektus. Todėl straipsnyje pateikta ir teisinių sprendimų priėmimo sistemų apžvalga. Iš šios apžvalgos taip pat darytina išvada, kad šiuo metu nėra statybos rangos sutarties teisinių sprendimų paramos sistemų.

Vienas iš pagrindinių uždavinių kuriant daugiakriteres paramos sistemas yra daugiakriterių rodiklių sistemos nustatymas. Straipsnyje nagrinėjami trys daugiakriterių statybos rangos sutarties rodiklių sistemos modeliai ir nustatytas geriausiai daugiakriterio įvertinimo metodikai kurti tinkantis modelis. Remiantis šiuo modeliu tolesniuose tyrimo etapuose turėtų būti nustatomi rodiklių reikšmingumai ir kuriama daugiakriterė sprendimų paramos sistema.

Reikšminiai žodžiai: sprendimų paramos sistemos, statybos rangos sutartis, daugiakriteris vertinimas.

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