MODELS OF SCIENTIFIC DECISION MAKING IN CIVIL ENGINEERING USING THE LINEAR PROGRAMMING METHOD

Славко Здравковић [1]
Драгослав Стојић [2]
Живко Цуцкић [3]
Стефан Цонић[4]

УДК: 519.852:624
DOI:10.14415/konferencijaGFS 2015.098

Summary: *In this paper the scientific decision-making is based on a rational approach to problem situations, or on models of scientific analysis and logical methods instead of intuitive approach. Also displayed are the technology of decision making and model type. In a nutshell, the used method of linear programming (LP) is described. Methods that are specific to the solution of the problem of the construction profession were described, such as: the simplex method, transportation method and method of deployment, but due to space limitations they have not been analyzed. Optimization criteria determines the objectives to be achieved by solving problems. Limiting factors determine the area in which there is the optimal solution, which is shown graphically.*

Keywords: *Models, scientific decision-making, civil engineering, linear programming*

1. INTRODUCTION

Decision-making as an integral part of everyday life, falls into categories that are as old as humanity. Human existence has begun with some decision, it is also the beginning of one of the major human activities-decision making. The decision making process, in its essence, is the choice of one among several possible solutions. Decisions are not posible without the existence of alternative, because when it comes to just one possibility, the solution is known in advance. The decision making theory as a scientific discipline has a major influence in decision-making. In the development of human society decisions were made in different ways, but it is still possible to distinguish two basic approaches to decision-making:

[1]Prof. Dr, Academic of Serbian Royal Association of academics, innovators and scientists, Expert of the former Federal Ministry of science, technology and development, The Faculty of Civil Engineering and Architecture, University of Niš, Aleksandra Medvedeva 14, Niš, Serbia, slavko.zdravkovic@gaf.ni.ac.rs
[2] Prof. Dr, GAF Niš, Aleksandra Medvedeva 14, Niš, Serbia, dragoslav.stojic@gmail.com
[3] Mr, dadge internatonal L.L.C, dadge_serbia@yahoo.com
[4] MSc. C. Eng. PhD student, Scholar of the Ministry, The Faculty of Civil Engineering and Architecture, University of Niš, Aleksandra Medvedeva 14, Niš, Serbia, stefanvl989@yahoo.com

- intuitive decision-making and
- scientific decision-making

The essence of intuitive decision-making is based on very simple models and experience, particularly in the civil engineering and construction industry. Scientific decision-making is based on a rational approach to problem situations, or on models of scientific analysis and logical methods. Instead of intuitive approach, which is the methodology of decision making based learning from mistakes (their own and others), man is now in situation where using the cases described in the literature, uses the past to rapidly find methods and paths of development of the future. Decision-making is, in its essence, reduced to a choice one of a number of alternative possibilities, but not any alternative, but one that gives the optimal solution to the problem. Success in the selection of the optimum range of possible alternatives, depends on the nature of the problem and possibilities of getting to know its structure. If the characteristics and structure of problems are known, then the choice of the optimal solution is relatively simple. However, in contemporary conditions the decision-making is most often performed in conditions of insufficient certainty, because the characteristics of the problem and its structure is not sufficiently known. For example: Security of buildings from the impact of the earthquake should be optimal and is associated with many uncertain data for which it is not possible to find an optimal solution. The decision taken in such circumstances gives no certain security in terms of choice of optimum, but it expresses the probability of safety. The basic human tendency is to behave rationally in all situations, and thus to make rational decisions. Hence the notion of rationality is one of the central concepts of decision-making processes.

2. THE TECHNOLOGY OF DECISION MAKING AND TYPES OF MODELS

The decision process can be viewed from several angles, depending on the type and nature of decision-making and similar concepts. On the other hand, the decision-making process as well as any other process, consists of certain phases, which can be determined by various criteria. In the literature it is known more access to separate decision-making process in stages, for example in the civil engineering, based on different approaches to technology of decision-making. Technology of decision-making can be broken into the following main stages:

- identification of problems,
- analysis of the problem,
- gathering the necessary information,
- choice of methods of decision making,
- definition and selection of alternatives,
- decision-making,
- execution of the decision.

Depending on the relation between the variable in the model, all models can be divided into two basic groups:

- deterministic and,

- stochastic models.

Both of these groups used the same apparatus, mathematical and statistical analysis, however, the connections between the variables in the models are different. In the deterministic model relationship between the variables is functional because it is 2 * 4 = 8 always and no exceptions. In stochastic models, which include nearly all econometric models, the deviations are allow, and the accuracy is shown as a probability. From the point of time dependencies, all models can be grouped into two main groups:

- static and,
- dynamic models.

Static models show the system at equilibrium in a given interval of time so that the variables relate to the observed period. The transformation process of initially in the next state of the system is included in the dynamic model. By comparing the initial and subsequent state of the system model is performed sensitivity analysis system to changes of its parameters in time. Dynamic models display a more realistic economic processes, because in the real economy variable values are very depending on the time. The division of models can also be performed by other criteria such as generality, dimensionality, openness, degree of quantification, etc.

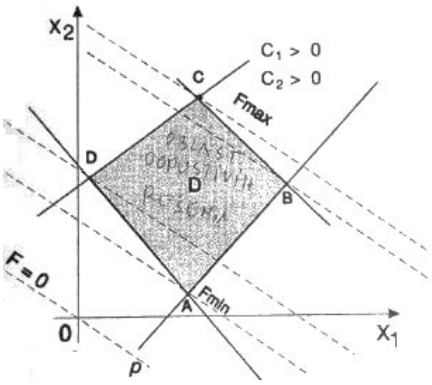
3. LINEAR PROGRAMMING (LP)

There are several types of problems in mathematical programming such as: linear programming, nonlinear programming, dynamic programming, network programming, Monte Carlo method, multicriteria programming and others. Linear programming is a new field of applied mathematics and refers to solving problems in which it is necessary to determine the maximum or minimum value of one size for the given conditions, ie. selection of optimal solutions among the possible solutions. It is one of the simplest methods for determining optimal solutions in technical, technological, military, economic and similar management problems. Some examples can be solved by elementary geometric methods, while in the general case of complex problems require the use of electronic computing machines. The methods that are specific to problem solving in civil engineering are displayed, because the different methods are developed for a certain class of problems. The special case of the general task of linear programming (LP) is the transport task and it is associated with the task of transmitting continuous mass which was formulated in 1939 by mathematician Kontorovich. Mathematician George Dantzing 1947 has laid the basis of modern programming with his work "Maximizing the linear form subject to restrictions in the form of a system of linear equations (inequality)". The mathematical papers on the theory of linear programming, convex sets, theorems ductility and others, have contributed to the development of linear programming and the works von Neumann's, Tucker's, Gale's, Kohn's and others, also opened a new methodological issues, such as dual LP problem.
The problems in which the objective function **F (x)** and / or a set limit (**L**) defined by non-linear dependence, ie. when the exponent (**x**) greater than one is non-linear programming. If the exponent of (**x**) two, then it is the quadratic programming. Most often, these problems are more difficult to compute. For solving economic problems, in

most cases, it is usually available a greater number of possible, alternative (permissible) solutions. Between these alternatives should be chosen the solutions, which will be optimal for given conditions. If there is a large number of possible solutions it is almost impossible to determine the optimal solution without appropriate scientific methods. A need to develop methods that will allow for optimum search with the help of exact sciences was created. For solving of such problems quantitative methods are used, most notably linear programming, which includes a series of scientific methods suitable for solving various problems. There are a lot of construction problems of an economic nature that can be solved using linear programming, such as optimal planning of production programs, investments, deployment of machine, a choice assortment of production, assembling optimal transport plans, supplies, food, etc. According to the current results may be noted that the linear programming provides great theoretical and practical results in the modern construction industry. Linear programming includes several methods, among which the most important are:

- simplex method,
- transport methods and,
- scheduling methods.

Methods of linear programming can be used only if the problem is set in the form of a mathematical model, which means that the predetermined criterion of optimality, as well as identified and quantified limiting factors. Optimality criterion to determine the purpose sought to be achieved by solving problems. Limiting factors determine the area in which there is an optimal solution.



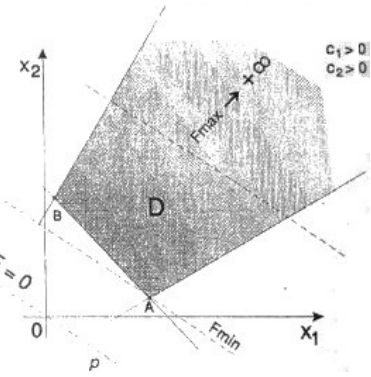


Figure 1. Limited area D
Figure 2. Unlimited area D

Among the variables must be a linear relationship, which represents a linear dependence. To solve the problem, goal sought to be achieved, must be clearly defined. In other words, without a defined objective function or management criteria is impossible to achieve specific management. Every problem that should be solved using linear programming should be located within the boundaries that define the area in which there is an optimal solution. To find the optimal solution graphically, it is necessary to draw the line *p* which represents the objective function. Finding the line *p* ie. functions of the

goal, which with the area of permissible solutions **D** has at least one common point, and at the same time achieve the highest possible value, represents a solution to the problem. The maximum (minimum) the goal function **F(x) = F**($x_1, x_2, ..., x_n$) is on the border of the area **D**. If we suppose that the line *p*, which graphically represents the objective function is not parallel to any of the lines, lines that divide the plane into two parts, then the objective function, **F(x)**, have a maximum (minimum) at one of the vertices of the polygon, Fig. 1. In some cases, the area of permissible solutions **D**, can be unlimited, Fig. 2.

4. CONCLUSION

Human existence has begun with some decision, it is also the beginning of one of the major human activities-decision making. It is possible to single out two basic approaches to decision-making: intuitive decision-making and scientific decision-making. The essence of intuitive decision-making is based on very simple models and experience. Scientific decision-making is based on a rational approach to problem situations that often arise in the civil engineering. The concept of rationality is one of the central concepts of decision-making processes. In modern conditions, decision-making is usually carried out under conditions of uncertainty because the buildings are constructed in seismically active areas. The entire territory of our country is located in seismically active area, and seismic effects are usually authoritative for designing structures. However, we are faced with a lot of unreliable data and therefore the most accurate calculations do not guarantee the stability of structures under seismic actions, ie. there will be no damage or destruction, for that reason safety of buildings expresses the probability and level of seismic risk. The paper analyzed the method of linear programming (LP) as a form of quantitative analysis. Linear programming is aimed at creating a scientific basis for making optimal decisions for the given conditions. Linear programming is a relatively young scientific discipline that solves the problems which consist of the goal function and a set of constraints that sets the system of linear equations and / or inequalities. Linear programming is a quantitative scientific method that is widely used in civil engineering because it deals with the problem of finding the minimum or maximum of a linear function, given the constraints in the form of linear relationships. Very often solves the dual task of linear programming.

ACKNOWLEDGEMENT

This research is supported by the Ministry of Education, Science and technological development of the Republic of Serbia, for project cycle 2011-2014, within the framework of the project TR36016 “Experimental and theoretical investigation of frames and slabs with semi-rigid connections, from the view of the second order theory and stability analysis” of the research organization The Faculty of Civil Engineering and Architecture of University of Niš, and innovation project named “Seismo – Safe 2G3 – Goseb Building System” (Project IF ID 476) financed by Innovation Fund of the

Republic of Serbia, wich is conduced in 2014. in "Projektinženjering Tim" d.o.o. in Niš, Serbia.

REFERENCES

[1] Славко Здравковић: *Математички методи оптимизације, део I- Линеарно програмирање*, Ауторизована предавања на последипломским студијама, Грађевинско-архитектонски факултет Универзитета у Нишу, **1990**.
[2] Сарић, М., Лековић, М., Петковић, Д.: *Примена квантитативних метода у одлучивању*, Просвета, Ниш, **1994**.
[3] Mentor Llunji: *Асеизмичко пројектовање и архитектура*, МС Пројект, Улцињ, **2014**.
[4] Славко Здравковић: *Динамика конструкција-збирка решених задатака*, Грађевинско-архитектонски факултет Универзитета у Нишу и АГМ књига, Београд, **2013**.
[5] Sorad, Dj.: *Економско-математички методи и модели, основи теорије.*, Суботица, **1992**.

МОДЕЛИ НАУЧНОГ ОДЛУЧИВАЊА У ГРАЂЕВИНАРСТВУ МЕТОДОМ ЛИНЕАРНОГ ПРОГРАМИРАЊА

Резиме: *У раду се научно одлучивање заснива на рационалном приступу проблемским ситуацијама, односно на моделима научне анализе и логичким методама уместо интуитивног приступа. Приказане су технологија одлучивања и врста модела. У најкраћем је описана метода линеарног програмирања (ЛП) која се користи. Наводе се методе које су специфичне за решење проблема грађевинске струке: симплекс метода, транспортна метода и метода распоређивања али због ограниченог простора нису анализиране. Критеријуми оптималности одређују циљ који се жели постићи решавањем проблема. Ограничавајући фактори одређују подручје у коме се налази оптимално решење што је приказано графичком методом.*

Кључне речи: *Модели, научно одлучивање, грађевинарство, линеарно програмирање*