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DETERMINATION OF CONSTRUCTION TIME AS ONE OF THE OBJECTIVES OF PROJECT MANAGEMENT

Abstract

In general, time and cost are the two critical project objectives in project management. In real building project, time and cost may be changed by the action of inflation, economic and social situation, designer mistakes, contractor mistakes, weather variations... On the basis of these factors, it is necessary to simulate the degree of uncertainty in estimating the construction time and costs. Find appropriate compromise between time and cost is an important issue in project management. In this paper demonstrated possible approach to planning the construction time. This paper deals with research of time parameters in construction. Article aims to processing model for estimating the construction time.

Introduction

Optimize construction time and cost can be defined as the process for identification of suitable construction activities to accelerate the construction period. We want to achieve the maximum possible time and cost savings. In general, time and cost in project management are the two critical targets of construction projects. Find a good compromise between time and cost is an important issue in project management. It should be noted that shortening the duration of the project causes an increase in labor productivity, productive machinery and equipment and so on. Since that correct relationship of time-costs should be fixed, so shortening the construction period may ultimately costs increase or reduce. Therefore, it is necessary to address the issue set several options -project sets- for the best deal and it is subject to optimize cost versus time relationship. In the real building project may change the time and cost due to the existence of uncertainties such as inflation, economic and social situation, the designer errors, errors contractor, weather events ... Based on these factors, it is necessary to simulate the degree of uncertainty in estimating construction time and costs. For correct estimation of the construction period is also necessary to involve the contractor in the early stages of the design process for future construction work. In many cases it is difficult to meet, since the contractor is known from the competition, when complete construction project already exists.

From extensive research risks to the preparation and realization of construction projects realized in the workplace of Civil Engineering Faculty of the Technical University in Košice since 2007 [21,24,25,26], emerged a clear fact that the time parameter significantly affects all other important aspects of construction - cost, quality, safety at work, labor resources, etc. (Fig.1).

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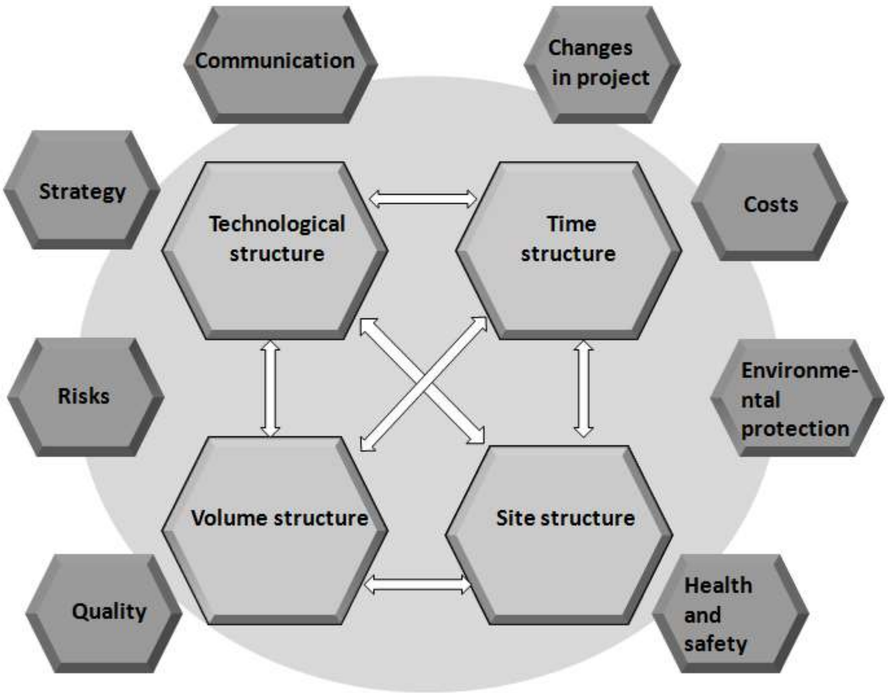

Fig. 1 Action of structures for shortening the construction time

As part of the project focused on the construction risk analysis [12], with emphasis on the risks of accelerating the construction process, an analysis was prepared several methodological planes to deal with the construction process [18,23]. From realistic view for the management of construction projects are decisive the following contractual construction parameters [19]. These include:

- cost of construction work
- delivery time construction work
- response (object) delivery
- quality of construction work

The article analyzes this relationship of the preparation and realization of construction projects, in order to bring new approaches to objectification in determining the necessary construction time.

Background

The issue of objectification construction period is studied abroad at different levels and from different perspectives. For the very first originator of the idea of determining the estimated construction time based on certain input data was already in the 1976 Australian Bromilow [1], who tried to express mathematical dependence the construction duration on the construction cost. The first strand of scientists, including, for example Ireland [2] made a replica of the model to determine the construction time of high-rise buildings in Australia. Kaka and Price [3] conducted a similar survey for the building construction and civil engineering in England. Chan [4] did similar research in terms of the Malaysian construction industry. In 2002 was again verified model for health construction in Bangladesh. All of these studies found that the mathematical model known as the BTC model (Bromilow's Time-Cost model) is valid for estimating the time of construction, if known, the cost of construction. Today this model is considered to be a standard for estimating the contract duration of the project [1]. The aim of working scientists, which include Ng, Mak, Skitmore and Varnam was renew BTC model with current Australian data obtained from projects in the 1991-1998 period, when was stable economic situation. The result of the research was the determination of two different models - for industrial and non-industrial buildings construction [6]. Then Choudhury and Rajan [7] verify the validity of the BTC model in the implementation of housing in Texas (Fig.2). Research sample consisted of 55 completed residential buildings. The result was to determine the construction duration per unit costs ($ 1,000), which was 18.96 days for the construction of the conditions in this country. The second group of scientists, who include Kumaraswamy, Love, and later, also Chan, argued that the determination of estimated construction time must be specified in addition to costs also other project properties, such as the construction extent and type of the structure.

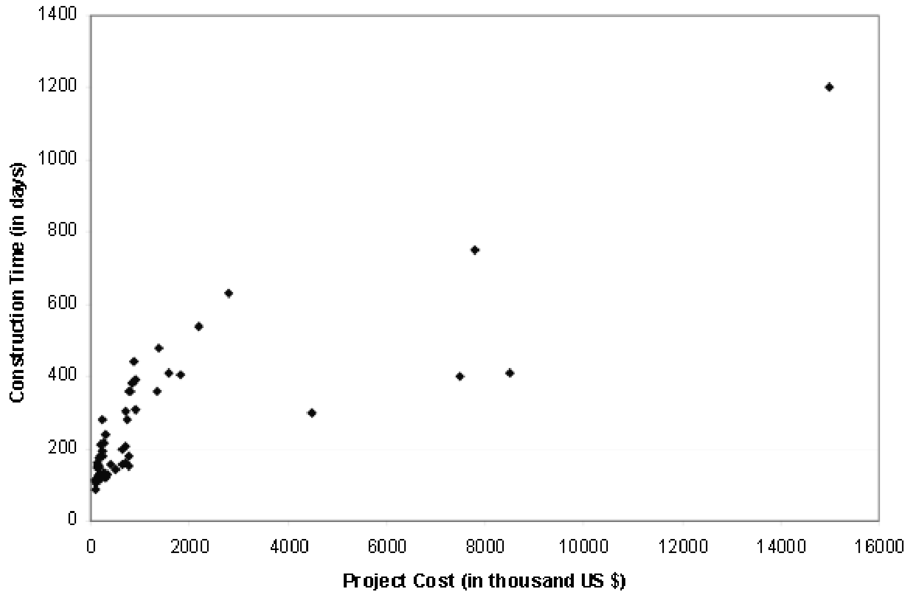

Fig. 2 Relationship between construction time and project cost [7]

For example, in a study done by Chan and Kumaraswamy [8] presented research about the construction time in Hong Kong. The research was aimed at finding a critical contributor to accelerating the construction time in the three sectors of Hong Kong's architecture - the public residential sector, public sector and private non-residential sector. For research were invited various experts, such as suppliers, customers, industry experts, consultants and others who helped to specify the technical and managerial strategies, leading to shorter construction time increases so-called construction speed. Similarly, Australian scientists Love et al. [9] argue that the relationship between time and cost is largely influenced by the size of the project. The sample consisted of 161 Australian buildings, where construction time analysis was carried, due to other entrant factors, such as project type, method of procurement, the procurement procedure, built-up area and number of floors. The result of this analysis were the presentations that just built up area and number of floors, were key factors in the more exact time of construction. Another systematic method for measuring the Construction Time Performance was developed by Walker [10]. This method allows comparisons the performance of building construction in practice around the world. Analysis was identified four factors affecting the performance of construction: effective construction management, client sophistication and his authorized representative for the maintenance of good relations between the management team and the client team, and to a lesser extent, the scope of the project and its complexity. In other studies, the subject of research estimated construction period, if the speed indicator was the size of buildings. Indicator determines the rate of construction using various independent variables. [11] The survey sample consisted of 216 buildings (Germany). Fixed regression model and determined the speed of construction index indicates how many m^2 of floor space will be made per unit time, i.e. a month.

Materials and methods

The aim of research leading to objectification time parameter of the total construction time was:

- demonstrate that there is an objective investor pressure to shorten the construction time of building projects
- processing model for the objectification of the construction time, based on the spatial structure and technological parameters.

Model for the objectification of the construction time generalizes facts which can be detected before contract between an investor and a contractor which for both participants can answer it:

- what is the standard construction time for the particular segment of construction
- what are the 'trendy' construction time for a particular segment of construction
- what are the variances in determining the construction time based on commonly used measures which allow to shorten the construction time.

The key parameters of the examination for filling the aim of research was to investigate the construction time in the context of the built-up area of construction and type of buildings that have been observed on a sample of 55 construction projects in Slovakia. In addition, an objective parameter - built-up area - has been studied and subjective parameter - construction time - which research is referred to as Contract Construction Time (CCT). The contractual construction time is real time of construction, or planned time of construction. This contract is agreed with the contractor and investor. From the duration of the contractual construction time must be properly evolve the whole construction process planning without elongation. Information about buildings from the sample was obtained directly from contractors and also from presentations of works in specialized journals. A sample of 55 buildings was for the mutual comparison divided according to the purpose of their use in the following segments of the construction:

- shopping centers (SC)
- multipurpose building (MB)
- industrial building (IB)
- houses (H)

Standard construction time was obtained using the CONTEC [13], which is an automated system for the preparation and realization of constructions (Fig.3). Allows you to handle a variety of preparation and management construction document of pre-production and production preparation of construction:

- Technical analysis,
- Schedules (timelines, network diagrams)
- Balance of funds at a time
- Operating plans,
- Control plans, environmental plans, ...

The program is mainly used to produce tender and structural - technological design in Construction Company. The big advantage is processed type network diagrams, according to the classification of buildings. This helps you quickly simulate all outputs for specific building objects according specify a built-up space and cost. For this feature it was chosen as a tool for finding the time construction on the built-up area of the building. Because network type graphs work with standard operating conditions, i.e.:

- 8-hour shift,
- 5 days a week
- a standard deployment of a working team (number and compositions personnel necessary to carry out the process),

therefore, as a term was chosen the name "standard construction time." Because for the composition of working platoon regarding the minimum number of employees, calculated construction time is actually a maximum construction time. This time is however regulated by the spatial structure coefficients. They characterize the work queues for different groups of works, depending on the number of selected images on the site.

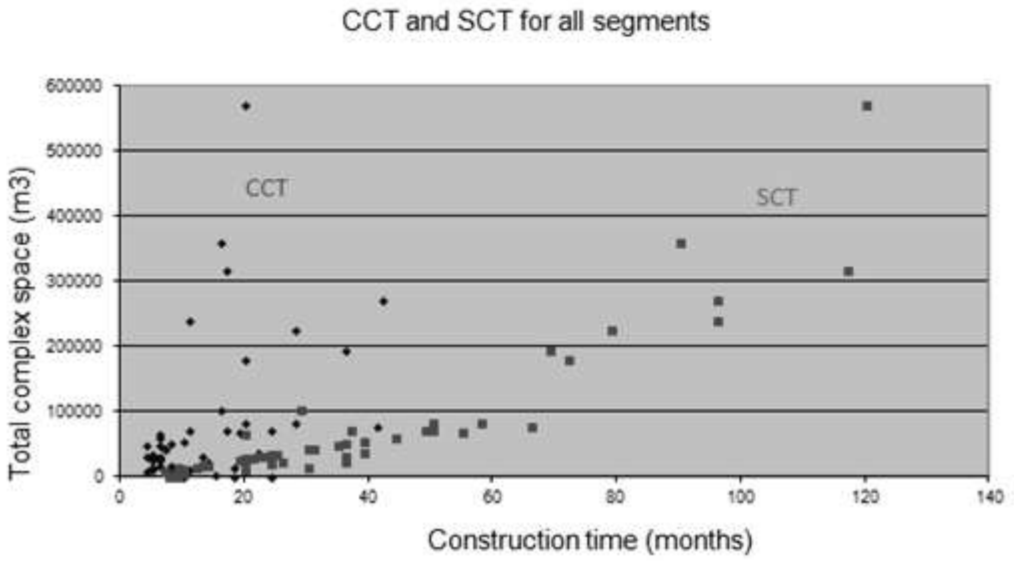

Fig. 3 CCT a SCT for the whole sample *with all segments of construction*

For a more detailed analysis (Tab.1), demonstrating investor pressure to shorten the construction time shows the greatest pressure to shorten the construction time in the segment of shopping centers. The survey showed that 97% of projects with short construction are in this segment. A similar pressure is demonstrated in the segment of industrial buildings, where 83% of projects have been identified short-term construction. Demonstrate the greatest pressure in these segments of the construction is logical and follows the requirements of the investor for a fast return of investment.

Tab. 1 Comparison of CCT and SCT for all construction segments

	number of buildings	CCT < SCT (short construction time)		CCT ≥ SCT	
		number	%	number	%
MC – Multipurpose centres	14	11	79	3	21

OC – Shopping centres	29	28	97	1	3
IB – Industrial buildings	6	5	83	1	17
H1 - Houses - solo	4	0	0	4	100
H2 - Houses - files	2	2	100	0	0
TOGETHER	55	**46**	**84%**	**9**	**16%**

For the purposes of drawing up the model was studied the existence of depending and type of depending on the duration and volume of construction. Computational tool for finding statistical function was selected MS Excel. Dependence was studied using statistical regression analysis LINEST and LOGEST [14]. Because the data plotted in the graph most resemble the shape of these dependencies. If there is an addiction, it is necessary to define the regression analysis regression line or curve. The next task was to describe dependence by regression function to calculate the estimated construction time for the specified enclosed volume. After entering the input data into statistical functions LINEST and LOGEST, the resulting matrix was created. When dependence exists, remains to be determine the strength of dependence. This was realized using correlation analysis. The force dependence is determined by the value of the coefficient of determination, r^2, which is calculated using the above-mentioned functions. Coefficient of determination r^2 values shall range from 0 to 1. While the value of r^2 approaching to 0, has the effect that the regression equation cannot predict the value of y. The dependence of standard construction time (SCT) on the volume of construction is determined especially. Also, dependence of contracting construction time (CCT) on volumes of construction is determined separately.

To test this dependence is used F-test at the significance level alpha = 0.05. This test confirmed the hypothesis that there is a relationship between SCT and total complex space. Then you can write LOGEST regression $y = bm^x$ in the form:

$$\ln Y_{TCS} = \ln b + X_{SCT} \ln m \ \Rightarrow \mathrm{X}_{SCT} = \frac{\ln Y_{TCS} - \ln b}{\ln m} \qquad (1)$$

and after substituting the constants b, m is a function of the regression curve for the estimation of the construction time for segment SC defined in the form (2):

$$\mathrm{Y}_{SCT} = \frac{\ln Y_{TCS} - \ln 13204{,}52}{\ln 1{,}033327} \qquad (2)$$

Where: X_{SCT} is the estimated standard construction time (months)
Y_{TCS} is the total complex space (m^3)
b = 13204,52
m = 1,033327
(b, m constants are obtained from the matrix of exponential dependence (SCT) by using the function LOGEST).
Follows from the above that between SCT and volume building exists an exponential dependence, which showed F-test. This dependence is shown in Fig.2. Consequently, the confidence intervals of the curve were determined for segment SC. The vertical displacement of the curve provides in the regression equation (1) parameter b. This is necessary for calculate the value of the parameter b1, which ensures lower limit of the confidence interval

for the regression curve, the parameter b2, which ensures the upper limit of the confidence interval for the regression curve, the parameter b3, which ensures lower limit of the confidence interval around the regression curve and the parameter b4 that provide an upper limit of the confidence interval around the regression curve. A similar procedure was used for other construction segments and the other functions of regression curves were determined for the estimation of time of construction.

Results and discussion

These mathematically formulated dependences create a complex model for the objectification of the construction time in the segment of shopping centers (fig. 4), because they are based on information corresponding to reality. Investor as well as the contractor can deduct the construction time for their projects, from the model. To follow up evaluation of situation, based on the characteristics of the areas between the points of the model 1-2-3-4:

- If the construction time specified enclosed volume demanded from investor falls into the interval between points 2 and 3, which is part of the standard construction time so it can be considered for acceptable, with acceptable low level of risk of non-compliance with the agreed construction time.
- Construction period between points 3 and 4 is unlikely, since the value at point 3 can be considered as a maximum construction period. Item 4 in the other models will not render.
- If construction time falls in the interval between points 1 and 2, this space is an area for subsequent objectification of the construction time, taking appropriate measures, which of course implies a greater degree of risk from accelerating the construction period.
- If the construction time gets before 1 point, so you can handle it, but only with further detailed analysis of spatial and technological structure of a work. It is also necessary to take further measures to shorten the construction time.

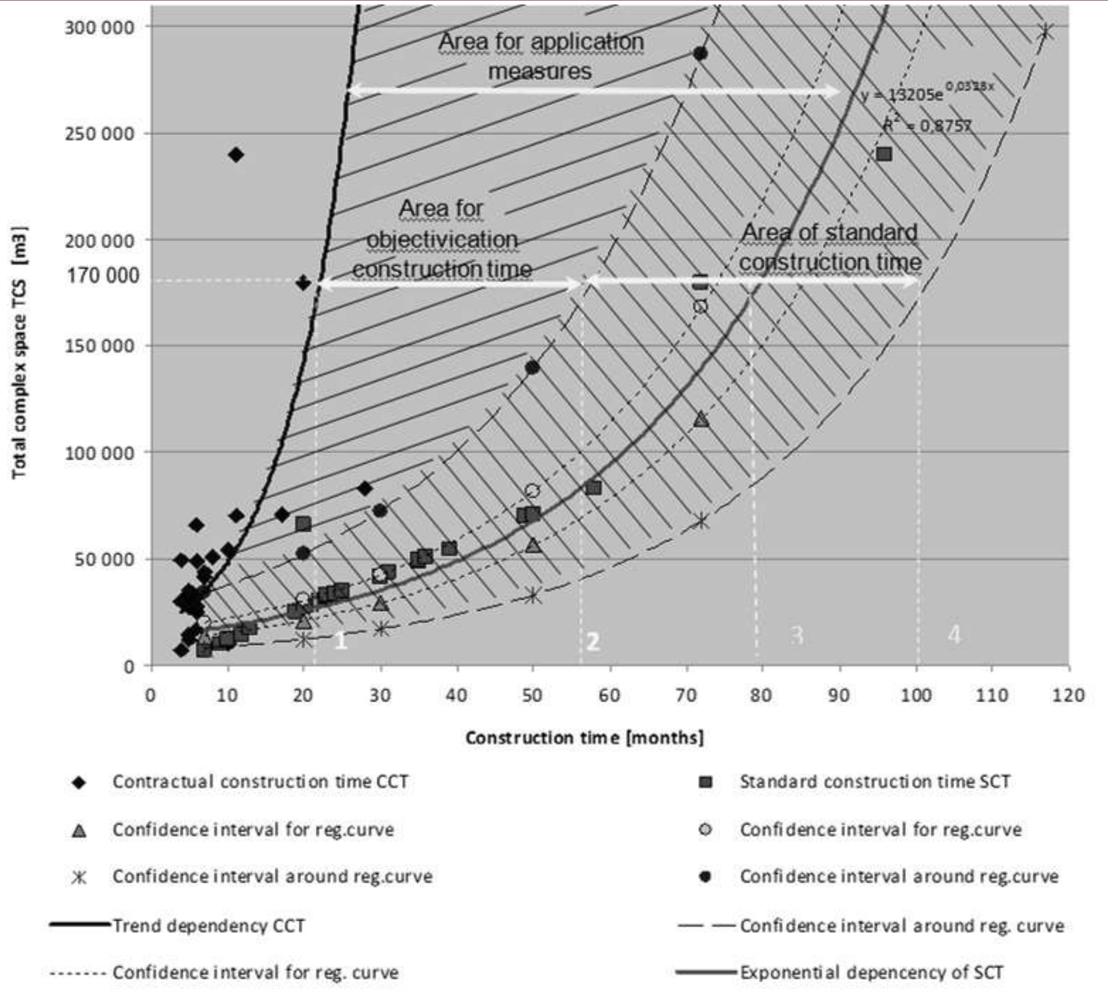

Fig. 4 Model for objectification construction time in segment of shopping centers

Characteristic points of the model:
1 – Contractual construction time
2 – Lower limit of standard construction time
3 – Standard construction time
4 – Upper limit of standard construction time

According to the above model, area between points 3 and 1, provides a space for shortening construction time by taking measures that are shown in the tab.2.

Tab. 2 The effects of measures in all segments of the construction

Measures	Average shortening %						
	SC		MB		IB		All Segments
	value	variance	value	variance	value	variance	
A – addition of two workers for each process	20	-1	17	-2	19	0	**19**
B – a six-day working week	17	-1	15	1	17	1	**16**
C – a seven-day working week	28	0	26	2	29	-1	**28**

D – a working in two shifts	45	-1	47	-3	40	4	**44**
E – two parallel working teams in processes on the critical path	27	-1	27	-1	25	1	**26**
F – a combination of measures B + E	37	0	39	-2	34	3	**37**
G – a combination of measures A + B + E	48	-1	50	-3	42	5	**47**
H – a combination of measures C + E	47	-1	47	-1	44	2	**46**
I – a combination of measures A + C + E	55	-1	56	-2	51	3	**54**
J – a combination of measures C + D	58	-2	60	-4	51	5	**56**
K – a combination of measures A + C + D	65	-2	65	-2	60	3	**63**

Each of designed measures in the various segments of construction brought more or less shortening construction time. The interim conclusions in a detailed analysis of all segments of building began derive another fact. In the Tab.2 we can see that the resulting average values of shortened construction time in examined segments of buildings, expressed in percentage terms, are almost identical.

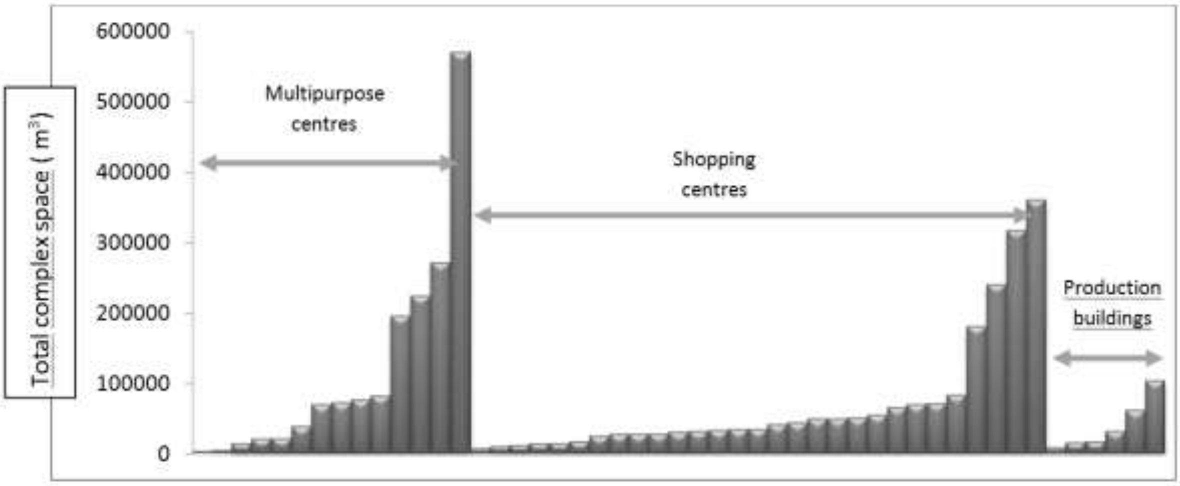

Fig. 5 Dispersion data about the sample (Total complex space) for the individual segments of buildings

It is also possible to conclude that the degree of shortening the construction period, with specific technological and organizational measures strongly depend on the type of building, the size of the building, whereas the studied sample was characterized by significant differences (Fig.5).

Conclusion

Thus, the model presented in an easy to read graphical form, allowing yet before the conclusion of the contract, as an investor, as well as the contractor to determine whether the planned construction period is in the range of objectively defined variances construction period, respectively. at what measures can be achieved shorter construction time.

References

[1] BROMILOW F.J.: Measurement and scheduling of construction time and cost performance in the building industry. Chartered build 1974,10(9):57-65.

[2] IRELAND V.: The role of managerial actions in the cost, time, and quality performance of high rise commercial building projects(1986

[3] KAKA, A.P., PRICE, A.D.F.: Relationship between value and duration of construction projects, Construction Management and Economics,1991, Vol. 9, No. 4, pp. 383-400

[4] CHAN, A.P.C.: Time-cost relationship of public sector project in Malaysia. In: International journal of project management (2001) 19(4):223-229

[5] CHAN D.W.M., KUMARASWAMY, M.M.: A study of the factors affecting construction durations in Hong Kong. Construction Management and Economics, Vol. 13,No. 4, pp. 319-333.

[6] NG S. T., MAK M., SKITMORE R. M., VARNAM M., The predictive ability of Bromilow´s time cost model. (2000)

[7] CHOUDHURY I., RAJAN S.S.: Time-Cost Relationship For Residential Construction In Texas (2008)

[8] CHAN D.W.M., KUMARASWAMY, M.M.: Modelling and predicting construction durations in Hong Kong. Construction Management and Economics,1999, Vol. 17, No. 3, pp. 351-362.

[9] LOVE,P.E.D., RAYMOND Y.C.T., EDWARDS D.J.: Time-costs relationships in Australian building construction project. Construction Management and Economics, Vol. 13, No. 4, pp. 319-333.2005, 131(2):187-94

[10] WALKER D.H.T. An Investigation into Construction Time Performance. Construction Management and Economics, 13(3):263-274

[11] STOY,Ch., POLLALIS, S., SCHALCHER, H.R.,:Early estimation of building construction speed in Germany. In: International journal of project management 25(2007) 283-289

[12] KOZLOVSKÁ M., STRUKOVÁ M.: Synergické účinky rizík spojených s projektmi výstavby. (Synergy effects of building projects risks) In: Kvalita 2008. - Ostrava : DTO CZ, 2008 B-35-B-40. - ISBN 9788002020325

[13] KALICKÁ, J., KRIVÁ, Z.: Praktická štatistika v Exceli. Vydavateľstvo STU Bratislava, 2005

[14] BHATTACHARRYYA, G.K., JOHNSON, R.A.: Statistical concepts and methods. New York

[15] KREYSZIG, E., Advanced engineering mathematics. Wiley, New York

[16] BAŠKOVÁ, R.: Modelling of the line construction of building by the method network analysis. In: CCE 2012: International Symposium: Iasi, Romania. 2012. s. 62-71

[17] JARSKÝ, Č. Auomatizovaná příprava a řízení realizace staveb. Kralupy nad Vltavou: Doc. Ing. Čeněk Jarský, CSc - CONTEC, 2000

[18] KOZLOVSKÁ, M.: Space-time analysis of building process safety risks. In: Quality, environment, health protection and safety management development trends: International scientific conference: Proceedings: NEUM (Bosnia and Herzegovina): Tribun EU, 2008. p. 154-159

[19] TAŽIKOVÁ, A.: Building process modeling through parameters of building structure. In: Mladý vedec, Košice 2010

[20] BAŠKOVÁ, R.: Časové plánovanie výstavby v programe MS Project. 1. vydanie. Košice: SvF TUKE, 2011

[21] KOZLOVSKÁ,M., TAŽIKOVÁ A.,: Pôsobenie výstavbových štruktúr pri skracovaní doby výstavby. In: Navrhovanie a príprava realizácie stavieb: Medzinárodná vedecká konferencia – CONECO 2010 Bratislava

[22] BOUSSABAINE,A.H.:Neurofuzzy modeling of construction projects´ duration II: aplication. Eng Construction Architect Management, 2008(2), 114-129

[23] KOZLOVSKÁ, M.: Prístupy k realizácii stavieb s krátkymi termínmi výstavby. In: Konstrukce. vol. 6, no. 2 (2007), p. 78-80

[24] STRUKOVÁ Z.: Lean production principles in construction projects design and delivery. In: Geodesy, architecture and construction 2011: proceedings of the 4th international conference of young scientists : 2011, Lviv, Ukraine. P. 72-73

[25] HYBEN I., SPIŠÁKOVÁ M., HEREDOŠ P.: Monitorovanie vzniku a vnímania environmentálnych rizík v stavebníctve. In: Inovatívny prístup k modelovaniu inteligentných konštrukčných prvkov v stavebníctve, Košice : TU, 2011 S. 44-55

[26] SPIŠÁKOVÁ M.: Prefabrication – an innovative approach to reducing of construction and demolition waste In: Geodesy, architecture and construction 2011 : proceedings of the 4th international conference of young scientists : 2011, Lviv, Ukraine. P. 74-75

[27] STRUKOVÁ Z.: Construction safety consideration in site layout planning / - 2012. In: Multi-dimenzionálne prístupy podporujúce integrované navrhovanie a riadenie stavebných projektov: zborník vedeckých prác.- Košice: TU, 2012 p. 111-120. - ISBN 978-80-553-1230-9