POSSIBILITIES OF RISK ANALYSIS IN THE PROCESS OF SUSTAINABLE CONSTRUCTION TIME PLANNING

Diana Car-Pušić[1]

[1] Faculty of Civil Engineering, Rijeka, Croatia

Abstract

The paper deals with the problem of sustainable construction time planning in the situations where it is possible to estimate the occurrence and impact probability for particular risk factors. The goal is to present the risk analysis procedure and the process of determining a sustainable construction time, depending on the main risk factors.

The basis of the proposed procedure rests on the impact assessment of the time extension for the particular risk factors. An adequate classification of the risk factors is proposed, in which these are divided into classes regarding their forecast and impact possibility. Tha algorithms for the time extension assessment for diverse classes of the risk factors are proposed next. The impact of some factors are calculated according to the newly proposed procedure, which is based on the least squares method, and supported by examples. Some risk responses are recommended, which enable a significant reduction or even complete elimination of certain risks.

Key words: risk analysis, sustainable construction time, risk factors, time extension, risk classes, risk response

1 Achievements in sustainable construction time planning

Sustainable construction time determining is one of the most demanding project management tasks.
The researches conducted so far were all base on linear regression analysis aplication. Although all based on linear regression, they are classified with regard to the number of independent variables considered, often called «predictors». Models with more variables were divided into those with basic orientation towards design characteristics, as well as towards group activities.
Bromilow's «time-cost» model has been appraised by many researchers as the most appropriate for civil engineering practice due to its simplicity and satisfactory results precision for «normal» risk level.
The basic Bromilow's formula is:

$T = K*C^B$
T = construction time
C = project value (in national currency)
K,B = constants calculated using simple linear regression method

2 Defining of the problem

Basic problem this paper deals is the problem of sustainable construction time planning in conditions when it is possible to estimate the occurence and impact probability for particular risk factors.

Construction is the process where the risk factors are always present, but in, so to speak, «normal» level. In order to determine construction time, Bromilow's formula can be used.

However, situations with particular increased risks are very common in construction practice. Some researches conducted in Croatia (2) indicate that the problems with technical documentation (delay, incompleteness, imprecision, new solutions etc.), then bad management and bad organization of works are particulary frequent and have a significant impact on project delay.

In such conditons, sustainable construction time could not be, precisely enough, evaluated according to Bromilow's «time-cost» model or to the other existing models. It is more appropriate to add still time extensions caused by particular increased risks.

3 Model settings

Model rests on the following settings:

1) Risk factor classification with regard to forecast and impact possibility
2) Significant risk factors choice
3) Finished structures database
4) Algorithm for time extension calculation

3.1 Risk factor classification

Here the risk factor classification based on a division with four level classification is proposed. The base is the three level classification (15). Another classification level has been introduced, according to prediction plausibility and impact possibility at that. According to these criteria, risk factors are divided into two classes. Class «A» factors cannot be plausibly predicted and cannot be influenced (policy changes, elections, war etc.). They are all outer factors. Class «B» factors can be predicted with greater plausibility. Some of them are outer, and the rest are all inner factors. Classification division into four level is shown in table 1.

	FACTORS		CLASS
OUTER FACTORS	LEGISLATIVE	1 – local regulations	B
		2 – permits and agreements	B
		3 – law changes	B
		4 – standards	B
	POLITICAL	1 – policy changes	A
		2 – elections	A
		3 – war	A
		4 – existing agreements	B
	ECONOMICAL	1 – economic regulations	B
		2 – price rises	A
		3 – exchange rates	B
		4 – financing conditions	B
		5 – economic policy changes	A
	SOCIAL	1 – education, culture	B
		2 – seasonal work	B
		3 – strike	A
		4 – human fluctuation	B
	NATURAL	1 – climate	B
		2 – soil	B
		3 – subterranean waters	B
		4 – natural disaster	A
INNER FACTORS	CONTRACT	1 – unrealistic deadline	B
		2 – unrealistic price	B
		3 – other contract provisions	B
	TECHNICAL	1 – delay	B
		2 – incompleteness	B
		3 – imprecision	B
		4 – new solut. as a cons. of 2 and 3	B
	ORGANIZATION	1 – bad management	B
		2 – bad organization of works	B
	TECHNOLOGY	1 – poorly chosen tech. solutions	B
		2 – obsolete technology	B
	RESOURCES	1 – shortage of workers	B
		2 – shortage of machinery	B
		3 – machinery breakdowns	B
		4 – late delivery of materials	B
	HUMAN FACTOR	1 – productivity	B
		2 – sick leaves	B
		3 – motivation	B
		4 – errors and omissions	B

Table 1: Review of risk factors and its levels

3.2 Algorithm for time extension calculation

3.2.1 Basics of algorithm

Basic construction time can be calculated according to Bromilow's «time-cost» model, with K and B for realized values for «normal» risk level. Time extensions caused by increased risks need to be calculated.
Basic formula is:

$T_s = T + \Delta T_{(r)}$

T_s = sustainable construction time
T = construction time according to Bromilow's formula for realized values
$\Delta T_{(r)}$ = time extensions for increased risks

$\Delta T_{(r)} = \Delta T_{(rA)} + \Delta T_{(rB)}$
$\Delta T_{(rA)}$ = time extension caused by «A» class risk factors
$\Delta T_{(rB)}$ = time extension caused by «B» class risk factors

$\Delta T_{(rA)} = \Delta T'_{(rA)} * T$
$\Delta T_{(rB)} = \Delta T'_{(rB)} * T$

$\Delta T'_{(rA)}$ = relative time extension (share) caused by «A» class risk factors
$\Delta T'_{(rB)}$ = relative time extension (share)caused by «B» class risk factors

Time extension assessment caused by «A» class risk factors is different from «B» class for the reason of remarkably worse forecast plausibility. Here is suggested significant «A» risk factors choice and time extension assessment caused by them. But the «B» class risk factors time extension calculation has to be done on the quite different way. Significant «B» risk factors also have to be chosen. It could be done in the same way as the «A». The frequency of occurance is significant, as well as its expected impact.
$\Delta T'_{(rB)}$ needs to be calculated according to this formula.:

$\Delta T'_{(rB)} = B'_1 * \beta_1 + B'_2 * \beta_2 + ... + B'_i * \beta_i + ... + B'_n * \beta_n$

B'_1 B'_2,..., B'_n = time extension shares caused by «B» risk factors
$\beta_1, \beta_2, ..., \beta_i, ..., \beta_n$ = time extension coefficients caused by «B» risk factors

In this formula β_i coefficients are known numbers, whereas «B» shares have to be assessed.

3.2.2 The procedure of β coefficients determining

Time extension coefficients can be calculated due to mentioned finished structures databases. β coefficients are calculated for the particular similiar characteristics structures group. In order to β coefficients could be calculated, the construction time and delay reasons database has to be formed. For each structure, an equation needs to be set up.
β coefficients are unknown, whereas «B» shares are known values. So, we get system of equations that can be:

a) unequivocally determined
b) non-determined

c) over-determined

Case «c» is very often in real work. It should be calculated by appropriate computer programme. Here, Maple V Release 4-Student Edition has been used.

3.2.3 Example

In this case, lower rank roads (local and regional) β coefficients are calculated. Eight roads are here considered. Risk factors are grouped in five groups as follows:

- regulations: law, economical, contractual
- social: social and human factor
- technical documentation: delay, incompleteness, imprecision, new solutions
- organization and technology: bad organizational and technological solutions
- resources: shortage of particular resources

Associated coefficients are: β_{REG}, β_{SOC}, β_{TEH} , β_{OG} , β_{RES}.

The system of following equations is set up:

«B» shares have been assessed. Its sum in each equation has to be 1. Prediction and assessment are possible on the basis of experience from previous similar projects, as well as by particular conditions analysis.

$0{,}75\beta_{SOC} + 0{,}25\beta_{RES} = 0{,}1334$

$0{,}50\beta_{TEH} + 0{,}50\beta_{RES} = 0{,}25$

$0{,}50\beta_{REG} + 0{,}25\beta_{SOC} + 0{,}25\beta_{TEH} = 1$

$0{,}75\beta_{REG} + 0{,}25\beta_{TEH} = 0{,}3636$

$0{,}4285\beta_{REG} + 0{,}1428\beta_{TEH} + 0{,}2857\beta_{OG} + 0{,}1430\beta_{RES} = 3$

$0{,}20\beta_{SOC} + 0{,}40\beta_{RES} + 0{,}40\beta_{TEH} = 0{,}3333$

$0{,}3333\beta_{REG} + 0{,}4444\beta_{SOC} + 0{,}2223\beta_{RES} = 0{,}25$

$0{,}4952\beta_{REG} + 0{,}5048\beta_{OG} = 1{,}40$

The system is compound of eight equations with five unknown, so it is «over-determined» and has been by Maple V solved. The β coefficients, that have been calculated, are:

$\beta_{REG} = 0{,}819$

$\beta_{SOC} = 0{,}132$

$\beta_{TEH} = 0{,}855$

$\beta_{OG} = 3{,}615$

$\beta_{RES} = 0{,}187$

Obviously, β_{OG} is several times higher then the others. It points to a bad management and bad organization of works. β_{REG} and β_{TEH}, are also fairly high, probably for the reason of unrealistic contractual terms.

When β coefficients are calculated, then construction time extension can also be be obtained.

Estimated risk shares are, e.g.:

$B'_{REG} = 0{,}20$

$B'_{TEH} = 0{,}30$

$B'_{RES} = 0{,}50$

$\Delta'T_{(r)} = ?$

$\Delta'T_{(r)} = 0{,}20*0{,}819 + 0{,}30*0{,}855 + 0{,}50*0{,}187$

$\Delta'T_{(r)} = 0{,}51$

It is total relative extension.
If estimated time in «normal» risk level is, e.g. 50 days, then sustainable time is:

$T_S = 50 + 0{,}51*50$
$T_S = 75{,}5$ days

4 Risk response measures

Some risk response measures which can enable decrease or even complete elimination of certain risks will be suggested. Here, only the risks with the higher β coefficients will be considered.

4.1 Measures regarding construction contracting

Sustainable construction time contracting is suggested. Time planning mistake could also put in question chosen organization and technological solutions what can generates a new damage in project.

4.2 Measures regarding technical documentation

There are several measures regarding technical documentation. Very important is quality choice of design engineer. It is quite wrong to put the price on the first place, before quality. Also, a high level of cooperation among project participants, particulary client, consulting and design team is indispensable, also monitoring and solutions aligning during the process of design. Design contracting in time is of primary importance.

4.3 Measures regarding work organization

As it has been mentioned, organizational problems have been recognized as one of the most frequent reason of construction time extension. In order to avoid these problems construction organization design compound of organizational and tecnological solutions is recommended.

5 Conclusion

Sustainable construction time determining is one of the most demanding project management items. Construction is the process where the risk factors are always present, but in, so to speak, «normal» level. In order to determine construction time, Bromilow's formula can be used. However, in civil engineering practice, very often we have situations with particular increased risks. In such conditons, sustainable construction time could not be , precisely enough, evaluated according to Bromilow's «time-cost» model or to the other existing models. It is more appropriate to add still time extensions caused by particular increased risks. Here, the model for time extension calculation is presented. Model application is by appropriate example explained.
Some measures with regard to particular risks have been recommended.

REFERENCES

1. Bromilow, F. J.; Hinds, M.F.; Moody, N. F. (1980): *AIQS Survey of Building Contract Time Performance,* The Building Economist vol 19., no 2., 79 – 82.
2. Car-Pušić, D. (2004): Metodologija planiranja održivog vremena građenja, doktorska disertacija, Građevinski fakultet Sveučilišta u Zagrebu,
3. Chan D.W.M.; Kumaraswamy M.M. (1995): *A study of the factors affecting construction durations in Hong Kong,* Construction Management and Economics, no 13., 319-333.
4. Chan D.W.M.; Kumaraswamy M.M. (1999): *Modelling and predicting construction durations in Hong Kong public housing*, Construction Management and Economics, no 17., 351-362.
5. Frame, J.D.(1996): Establishing project risk assessment teams, Managing risks in projects, E&FN SPON, London, .
6. Chan D.W.M.; Kumaraswamy M.M. (1999): *Forecasting construction durations for public housing projects: a Hong Kong perspective,* Building and Environment, vol 34., no 5.,
7. 633 – 646.
8. Chan, A. P. C. (2001): *Time-cost relationship of public sector projects in Malaysia*, International Journal of Project Management, vol 19., no 4., 223 – 229.
9. Chan D.W.M.; Kumaraswamy M.M. (2002): *Compressing construction durations: lessons learned from Hong Kong building projects,* International Journal of Project Management, vol 20., no 1., 23 – 35.
10. Dissanayaka S.M. Kumaraswamy M.M. (1999): *Comparing contributors to time and cost performance in building projects,* Building and Environment, no 34, 31-42.
11. Kaka, A. P., Price,A. D. F. (1991): *Relationship between value and duration of construction projects,* Construction Management and Economics., vol 9., no 4., 383 – 400.
12. Kenley, R., (2003): Financing construction, SPON Press, 137-160.
13. Khosrowshahi F.K.; Kaka, A.P. (1996): *Estimation of Project Total Cost and Duration for Housing Projects in the U.K.*, Building and Environment vol 31., no 4., 375-383.
14. Nkado R. N. (1992): *Construction time information system for the building industry,* Construction Management and Economics, no 10., 489 – 509.
15. Radujković, M. (1997): Upravljanje rizikom kod građevinskih projekata, Građevinar, vol 5., no 49., 247-255.
16. Radujković, M.(1996-1999): Upravljanje rizikom i resursima kod građevinskih projekata, znanstvenoistraživački projekt MZITRH, Građevinski fakultet Sveučilišta u Zagrebu
17. Radujković, M.(1999): Izvor prekoračenja rokova i proračuna građevinskih projekata, Građevinar, no 512, str. 159-165.
18. Sharif A, Morledge R. (1996): *Procurement Strategies: The Dependency Linkage,* CIB W92, North Meets South, Procurement Systems Symposyum, Durban, South Africa, 566-577.