GENERAL SYSTEMS PERSPECTIVE ON ACHIEVING CONTINUOUS SYNERGY IN A PROJECT ORGANIZATION

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Studies of construction labour productivity have revealed that limited predictability and multi-agent social complexity make long-range planning of construction projects extremely inaccurate. Fire-fighting, a cultural feature of construction project management, social and structural diversity of involved permanent organizations, and structural temporality all contribute towards relational failures and frequent changes. The main purpose of this paper is therefore to demonstrate that appropriate construction planning may have a profound synergistic effect on structural integration of a project organization. Using the general systems theory perspective it is further a specific objective to investigate and evaluate organizational effects of changes in planning and potentials for achieving continuous project-organizational synergy. The newly developed methodology recognises that planning should also represent a continuous, improvement-leading driving force throughout a project. The synergistic effect of the process planning membership duality fostered project-wide integration, eliminated internal boundaries, and created a pool of constantly upgrading knowledge. It maintained a creative environment that resulted in a number of process-related improvements from all parts of the organization. As a result labour productivity has seen increases of more than 30%, profits have risen from an average of 12% to more than 18%, and project durations have been reduced by several days.

Keywords: construction planning, off-site production, organizational effectiveness, project organization, systems theory.

INTRODUCTION

Project-organizational efficiency

It appears that construction project management has landed in an unenviable position. Projects are becoming more complex, clients more demanding and the market is offering a variety of materials which demand a highly-skilled and professional labour-force. On the other hand, the technology has improved and hence more efficient and positive progress would be expected. There is actually plenty of literature on productivity, methods for measuring productivity, improvements of productivity, factors affecting productivity, etc (Harris *et al* 2006, Thomas and Završki 1999, Jayawardane *et al* 1995, Luxhoj *et al* 1990). Why is it then that, with all the research going on and the new, more efficient equipment to hand, the construction industry has not managed to improve its efficiency considerably? It seems that by mostly concentrating on productivity and on-site management-related issues, construction management research is trying to suppress problems rather than define real causes for

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organizational efficiency/inefficiency. Other reasons are complexity and uniqueness of construction projects (Proverbs *et al* 1998, 1999, Bertelsen 2003). Approach that resulted in higher efficiency in one project may prove totally inappropriate in others.

Projects clearly vary in their efficiency but it remains unclear as to what makes some of them more efficient than others. However, it is clear that project organizations are social systems characterised by their temporal existence at the intersection of various, often very different, permanent organizations. That being the case, it then must be possible to determine organizational efficiency parameters.

Synergy

One of the most useful organizational efficiency parameter stems from a general systems perspective of social organizations. According to general systems theorists all systems consist of components and relations of interactions between them (Scott 1987, Kajzer 1982, Bertalanffy 1950). They recognise social systems as open systems of relations because they interact with other social systems and their environment. Furthermore, social systems may be constituted by components, themselves being social systems, so they can be viewed as systems of *n*-th order. They are created and re-created through two diametrically opposing processes, *folding* and *composing*. While folding represents a simple sum of components and relations without any changes in the quality of relations and components, composing represents a sum that establishes new relations bringing new quality to a higher order system. The qualitative difference between a composed higher order system and the sum of qualities of “old” sub-systems is thus called synergy. Unfortunately, synergy is an unpopular term. This may be a consequence of unsuccessful corporate mergers (Chatterjee 2007). Nevertheless, apart from attention given by systems theorists, synergistic effects within organizations are hugely neglected.

Synergy within construction project organizations in particular should be investigated more closely since they in many aspects resemble merger situations where synergistic effects have already been extensively analysed (Hitt *et al* 2001).

Problems, aims and objectives

Cultural clashes, potential issues of mistrust and organizational incompatibility are all difficulties that threat both mergers and construction project organizations. It is therefore of vital importance to be able to appropriately model temporary construction project organizations and their constitutive permanent organizations in order to investigate internal synergistic effects. In light of such understanding, this study aims at uncovering evidence of a continuous synergy in a project organization with the following specific objectives:

- to present systems interpretation of the so called Process Planning Methodology (PPM), a newly adopted short-term planning process in the off-site construction projects that triggers a continuous process of internal re-composition
- to present relational differences between a traditional approach to managing such projects and the newly established approach
- to identify potentials for assessing qualitative difference in relations within a continuously re-composed organization.

DATA AND METHODOLOGY

The core of the study is an off-site project in Slovenia that was divided into two separate sub-projects. The PPM was applied to one of the sub-projects by applying a double-loop framework. The other sub-project was managed using firm's traditional project management approach. It is worthwhile mentioning at this point that off-site projects in Slovenia are not characterised by a very distinctive project organization. They are mostly managed through heavy reliance on main contractor's internal organizational structure. This is the main reason why both project and firm organizations are discussed intertwiningly from this point forward.

The details of the PPM, its framework, necessary constitutive elements and application are not relevant here and have been, nonetheless, extensively covered elsewhere (Radosavljevic 2005, Radosavljevic and Horner 2007). Therefore, according to the above objective, this study is to create a theoretical explanation of the organizational restructuring that occurred after the PPM was fully in place.

The mathematics of achieved continuous organizational re-composition is presented according to the systems theory, which was found to be the only analytical way that could be used in order to illustrate these relational changes (Kajzer 1982).

SYSTEMS PERSPECTIVE

Traditional project management

One of the sub-projects was managed traditionally where firm's project managers, although being responsible for a number of projects, were operationally intertwined in the firm's hierarchy. All off-site construction projects thus required full commitment of firm's departmental directors (i.e. purchasing, R&D, quarries, production units, etc.). These are responsible for managing supporting activities like logistics, material testing, supplies, etc. The traditional approach normally resulted in delays due to seemingly unknown reasons and poor relations within project and firm organizations. Project delivery was regularly under pressure due to disputes and power clashes between various directors and project managers. The systems view of the firm organization reveals major reasons for often unsatisfactory project delivery. Figure 1 shows that departments may be subject to four types of boundary relations, namely managerial, interdepartmental, inter-level and external relations. Boundary relations can be further split into internal (between sub-systems) and external boundary relations (between sub-systems and the environment):

$$BR_i^{(n-1)} = IBR_i^{(n-1)} + EBR_i^{(n-1)} \qquad (1)$$

where,

$IBR_i^{(n-1)}$ internal boundary relations of the constituent sub-systems

$EBR_i^{(n-1)}$ external boundary relations of the constituent sub-systems

Equations 2 and 3 show that internal boundary relations between sub-systems (level *n-1*) represent relations within an organization so they can be called system relations at the *n*-th level. Clearly, it is of interest to organizations to maximise internal relations in order to improve communication.

$$SR^{(n)} = \bigcup_{i=1}^{m}\bigcup_{j=1}^{m}\left(BR_i^{(n-1)} \cap BR_j^{(n-1)}\right); \quad i \neq j \qquad (2)$$

$$SR^{(n)} = IBR_i^{(n-1)} \quad (3)$$

However, this tendency towards better communication goes on account of external relations, making highly hierarchical and departmentalised organizations alienated from their environment (Levinthal 1991, Child 1984). In other words, maximising system relations minimises external relations (*see* Equations 4, 5 and 6).

$$IBR_i^{(n-1)} = BR_i^{(n-1)} - EBR_i^{(n-1)} \quad (4)$$

$$SR^{(n)} = BR_i^{(n-1)} - EBR_i^{(n-1)} \quad (5)$$

$$SR_{\max}^{(n)} = IBR_i^{(n-1)}; EBR_i^{(n-1)} \rightarrow \emptyset \quad (6)$$

where,

$IBR_i^{(n-1)}$ internal boundary relations of the constituent sub-systems

$EBR_i^{(n-1)}$ external boundary relations of the constituent sub-systems

$SR_{max}^{(n)}$ maximised system relations at the *n*-th level.

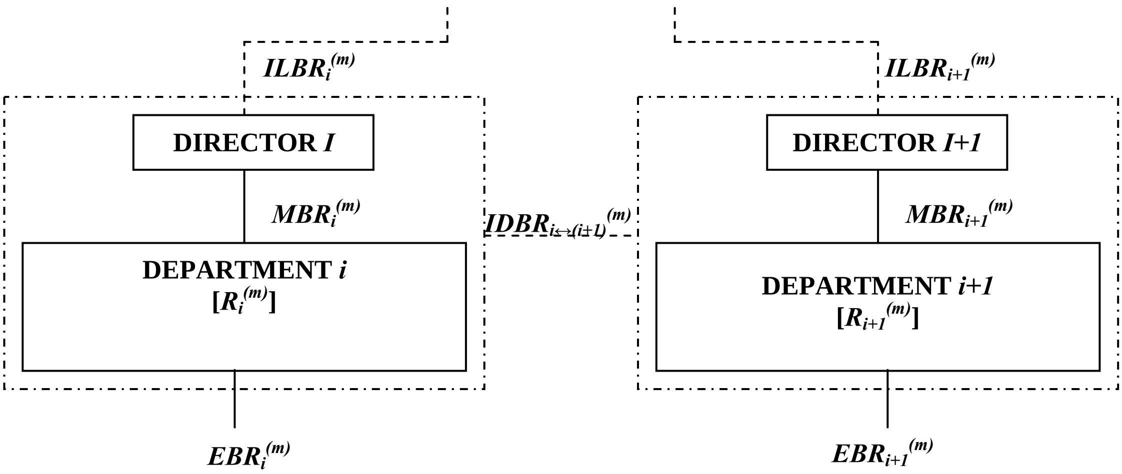

Figure 1: Relations of interactions within departments at m-th level ($R_i^{(m)}$ represents internal relations in i-th department; $MBR_i^{(m)}$ represents managerial boundary relations; $IDBR_{i\leftrightarrow(i+1)}^{(m)}$ represents interdepartmental boundary relations; $ILBR_i^{(m)}$ represents inter-level boundary relations and $EBR_i^{(m)}$ represents external boundary relations.

With a rising number of levels and departments, external relations become restricted to only a limited number of people, making organizational adaptability to external changes extremely difficult (Robbins 1998, Pugh 1997). They become prescribed within bureaucratic rules hindering individual participation and initiatives (Torrington and Hall 1998). Furthermore, maximising system relations necessarily deteriorates creativity of human beings by restricting their possible interactions outside the prescribed ones.

The organization of the traditionally managed sub-project suffered significantly due to these problems. On top of issues within the project organization, the project manager had to deal with obstacles internal to the firm. This was also claimed to be the main reason for frequent fire-fighting and a lack of time.

Process Planning Methodology

The second sub-project was managed using the so called Process Planning Methodology which means dividing it into several week-long sub-processes. A process is here defined as a sum of successfully accomplished activities, which are interconnected by a specific logic of order to represent a functional totality. The PPM relies on improved definition of planning, a process planning group and two iterative improvement loops but a much more detailed description can be found elsewhere (Radosavljevic and Horner 2007).

Interestingly, the new planning methodology changed the operational structure of the firm's organization. It has become project-centred with a control group having a major and fluctuating position between emerging greater production and greater management sub-systems (*see* Figure 2). This is probably one of the reasons that even traditionally managed sub-project was completed within budget and on time.

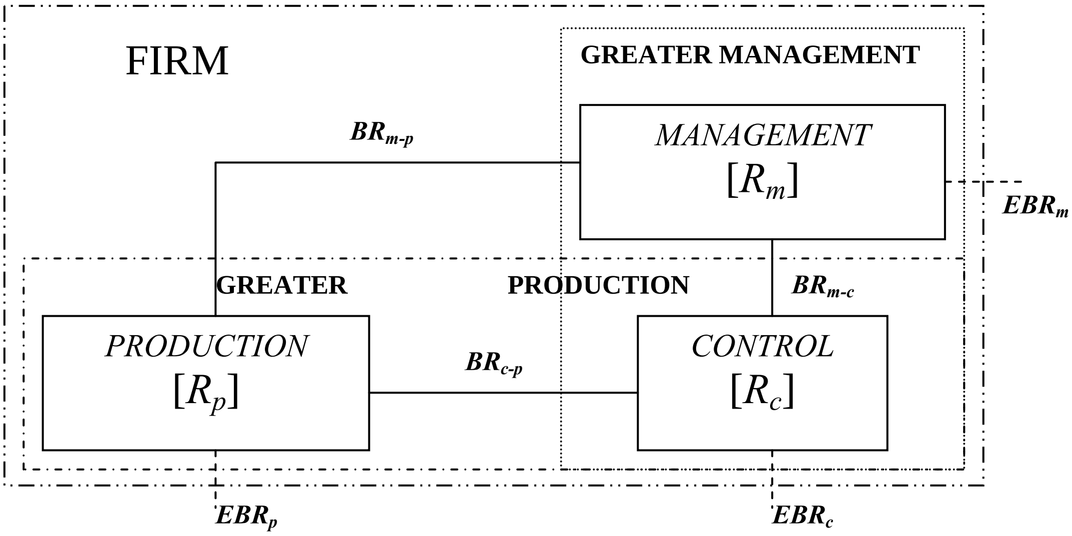

Figure 2: PPM-induced relations of interactions that only divide a firm into three functionally different sub-systems (production, control and management).

The dynamic characteristic of a control sub-system as a constituent category of both greater production and greater management sub-systems plays a mediatory role between "pure" production and "pure" management. The question is why boundaries between *production* and *control* and between *management* and *control* are not so called "real" internal boundaries? What, then, is the difference between the managerial boundary relations from the hierarchy and these relations? The essential point is that the boundary between departments and the managerial sub-system prevents direct participation of departmental members in the activities of the managerial sub-system which consequently diminishes individual initiative (Torrington and Hall 1998). The members of a control sub-system, on the other hand, participate in the activities of greater management and greater production (everyday work). There is no isolation from what is happening in greater management and greater production. They actively participate in all activities within greater management due to the feedback they receive from pure production and they also facilitate managers to modify their decisions according to what is happening in the production. Their position within organizational structure is equal to any other (positions are not hierarchically differentiated). They also actively participate in

Greater Production because their role is to implement agreed activities. Members of the *Pure Production*, due to their participation in production, usually cannot fully participate in process planning and, on the other hand, members of the *Pure Management* most of the time cannot be present in the production. This is the only “pure” internal boundary in this case. It is equivalent to the ones between departments and different levels, but such a boundary is physically and functionally indispensable since:

$$R_p^{(1)} \cap R_m^{(1)} = \emptyset \qquad (7)$$

The *Control* is a first order sub-system that is subject to a dynamic membership by being a constitutive element of both second order sub-systems. This is a unique property that enables a continuous process of decomposition and re-composition. Firstly, members of a control sub-system participate in the production by gathering knowledge about the processes of production, accompanying difficulties and possible solutions that might be revealed by observing the processes. When the *Control* team participates in the process planning they trigger composition of the greater management sub-system and decomposition of the greater production sub-system. During the process of composition, they bring in new relations enriched by gathered knowledge from greater production and help to bring up ideas for enhancing the process of production (the double closed loop of the process planning activities). They move back on a daily basis and recompose the greater production sub-system by bringing in iteratively derived instructions for the planned processes of production. Such iterative and dynamic processes of re-composition and decomposition are necessary and, regardless of the level, create changes in relations within all sub-systems. The most significant changes appear among the internal boundary relations that are now split into two new categories, pure and seemingly boundary relations, in the following way:

$$\bigcup_{j=1}^{2} SR_{j^*}{}^{(2)} = \bigcup_{j=1}^{2} R_{j^*}^{(2)} - \left[\bigcup_{i=1}^{3} R_{i^*}^{(1)} \right] = \bigcup_{i=1}^{3} IBR_{i^*}^{''(1)} \qquad (8)$$

where

$$\bigcup_{i=1}^{3} IBR_{i^*}^{''(1)} = IBR_{i^*}^{'(1)} + IBR_{i^*}^{(1)} = BR_{C\leftrightarrow M}^{'(1)} + BR_{C\leftrightarrow P}^{'(1)} + BR_{P\leftrightarrow M}^{(1)} \qquad (9)$$

$$IBR_{i^*}^{(1)} = BR_{P\leftrightarrow M}^{(1)} \qquad (10)$$

where

$IBR_{i^*}{}^{''(1)}$ all boundary relations (real and seemingly) of *i-th* first order sub-system

$SR_{*j}{}^{(2)}$ system relations within greater management (*j=1*) or greater production (*j=2*) second order sub-system

$R_{*j}{}^{(2)}$ internal relations within greater management (*j=1*) or greater production (*j=2*) second order sub-system

$R_{i^*}{}^{(1)}$ internal relations of *i-th* first order sub-system

$IBR_{i^*}{}^{'(1)}$ internal seemingly boundary relations of *i-th* first order sub-system

$BR_{C\leftrightarrow M}{}^{'(1)}$ seemingly boundary relations between control and pure management

$BR_{C\leftrightarrow P}{}^{'(1)}$ seemingly boundary relations between control and pure production

$BR_{M\leftrightarrow P}{}^{'(1)}$ boundary relations between pure management and pure production

$IBR_{i*}{}^{(1)}$ "real" internal boundary relations of *i-th* first order sub-system.

If we now consider the above dynamic participation of the *Control* in the relational domain of both the second order sub-systems and take in the account *Equation 9*, then boundary relations between the *Control* and *Pure Management*, and between the *Control* and *Pure Production* are clearly not "real" boundary relations. This is so because of iterative internal relational activity within both second order sub-systems, which these seemingly boundary relations depend on and can be expressed in the following way:

$$BR^{'(1)}_{*(C\leftrightarrow M)j} = f\left(R^{(2)}_{*(C\leftrightarrow P)j}\right); \quad j = 1,2,...,\infty \qquad (11)$$

$$BR^{'(1)}_{*(C\leftrightarrow P)j} = f\left(R^{(2)}_{*(C\leftrightarrow M)l-1}\right); \quad l = 2,3,...,\infty \qquad (12)$$

where

$R_{*(C\leftrightarrow P)j}{}^{(2)}$ internal relations within greater production in *j-th* participation of the control sub-system

$R_{*(C\leftrightarrow M)l\text{-}1}{}^{(2)}$ internal relations within greater management in *(l*-1*)-st* participation of the control sub-system

Moreover, the system relations within *Greater Management* and *Greater Production*, constituted by the internal boundary relations of their integrands, can entirely depend on these seemingly boundary relations. Even if "real" boundary relations between *Pure Production* and *Pure Management* are halted, a firm would still preserve its operational characteristics and would not disintegrate, which can be shown by:

$$\bigcup_{j=1}^{2} SR_{*j}{}^{(2)} = BR^{'(1)}_{*C\leftrightarrow M} + BR^{'(1)}_{*C\leftrightarrow P}\,; \quad BR^{(1)}_{*P\leftrightarrow M} \rightarrow \emptyset \qquad (13)$$

In other words, pure internal boundary relations are not necessary conditions for the functioning of such an organization. All sub-systems (regardless the level) can therefore maintain an equability of relations with the external environment. The firm can continuously absorb external project level or market level disturbances and subordinate them to the maintenance of their integral organization. Such unrestricted equability takes place with no harm to the system relations (*see* Equation 13). Furthermore, by implementing the PPM, the *Greater Management*, in this manner, deliberately incorporates components of systems operationally outside of a firm, such as a number of client's and designers' representatives.

The synergistic effect of the continuous membership duality fosters project-wide integration, eliminates the need for internal boundaries, and creates a pool of constantly upgrading knowledge. It maintained a creative environment that resulted in a number of process-related improvements coming from all parts of the organization.

Continuous synergy in the PPM

Continuous re-composition, experienced in the PPM-managed sub-project, is hence a process that continuously regenerates involved sub-systems, with new characteristics. In the similar way, by regenerating sub-systems, it also changes quality of the constituent components. The composition **C** of the *Greater Management* and *Greater Production* second order sub-systems can be expressed in the following way:

$$S_*^{(2)} = \overset{m}{\underset{i=1}{\mathbf{C}}} S_i^{(1)} \qquad (14)$$

such that:

$$S_*^{(2)} = S_*^{(2)}\left(C^{(2)}, R_*^{(2)}, BR_*^{(2)}\right) \qquad (15)$$

where

$S_*^{(2)}$ new system of the second order

$C^{(2)}$ set of components of the second order system (they obviously do not change)

$R_*^{(2)}$ changed set of internal relations in the second order system

$BR_*^{(2)}$ changed set of boundary relations in the second order system.

In this manner, for an *n*-th order system $S_i^{(n)}$ Kajzer (1982) determines composability as a measure of quality $q_i^{(n)}$:

$$S^{(1)} = \left\{\left(S_i^{(1)}, q_i^{(1)}\right); \quad i \in I\right\} \qquad (16)$$

The quality of the second order system in Equation 14 is therefore different from the sum of qualities of its first-order sub-systems before the composition. This difference of the sum before and the resulting second order system after the composition is called synergy. However, synergy is only suitable if it brings new, better quality in relations which can be expressed as follows:

$$q^{(2)} > \sum_{j \in J} q_j^{(1)} \qquad (17)$$

This is a necessary condition for composability but not sufficient because one may increase the quality of the original systems without composing them. The process of continuous re-composition yields a set of compounds of the second order system $S_i^{(2)}$ with its related measures of quality $q_{ip}^{(2)}$:

$$S_i^{(2)} = \left\{\left(S_{ip}^{(2)}, q_{ip}^{(2)}\right); p = 1,2,...q\right\}; \quad i \in I \qquad (18)$$

It is hoped that an iterative process will yield optimal possible quality $q_{io}^{(2)}$ after every iteration in the following way:

$$q_{i0}^{(2)} = \max\left[q_{ip}^{(2)}\right]; \quad i \in I; \quad p = 1,2,...,q \qquad (19)$$

with a qualitative leap $\rho_i^{(2)}$:

$$\rho_i^{(2)} = q_{i0}^{(2)} - q_i^{(2)}; \quad i \in I \qquad (20)$$

This qualitative leap is a positive synergy that the PPM hoped to achieve after every iteration. Quantifying synergistic effects in such a way is not yet possible and future research will be needed. However, final results were very promising. Labour productivity been increased by more than 30%, profits have risen from an average of 12% to more than 18%, and the project duration has been reduced by three days.

CONCLUSIONS

Although problems of hierarchical departmentalisation have been well documented, no studies have been found that would be able to explain these problems in a generic, theoretical way. The aim of this research was therefore to uncover evidence of a continuous synergy in the PPM-based project organization that was, in the case of the firm under study, intertwined with the firm's organization. The general systems perspective of the created traditional and PPM-based sub-systems reveals important and as yet unanalysed relational differences.

The importance of this perspective is obvious. It enabled the firm to investigate relational weaknesses in the organization and it also exhibits great potentials for the pre-analysis of organizational compositions regardless of the organizational structure. General systems theory thus provides a vehicle for understanding relational differences between different organizational settings.

The most important message of this particular research is thus not the improvements achieved through the implementation of the new approach per se. What really matter is the ability to explain major differences between the traditional and this new approach. General systems theory provides a generic quantitative means to scrutinise organizations and reveal why some of them are more successful than others.

REFERENCES

Bertalanffy, L von (1950) The theory of open systems in physics and biology, *Science*, **3**(1), 23-29.

Chatterjee, S (2007) Why is synergy so difficult in mergers of related businesses? *Strategy & Leadership*, **35**(2), 46-52.

Child, J (1984) *Organization: A guide to problems and practice*, Harper & Row.

Harris, F, McCaffer, R and Edum-Fotwe, F (2006) *Modern construction management,* Oxford: Blackwell Publishing.

Hitt, M A, Harrison, J S and Ireland, R D (2001) *Mergers & acquisitions: a guide to creating value for stakeholders*. Oxford University Press.

Jayawardane, A K W, Price, A D F and Harris, F C (1995) Measurement of brickwork and blockwork productivity: Part A, *Building research and information,* **23**(2) 147-155.

Kajzer, Š (1982) *Istraživanje strukture i kompozicije mikroekonomskih sistema u udruženom radu*, Unpublished PhD thesis, Faculty of Economics, University of Zagreb.

Levinthal, D A (1991) Organizational adaptation and environmental selection – Interrelated processes of change, *Organization science*, **2**(1), 140-145.

Luxhoj, J T and Tao P-C (1990) Measuring the Productivity of Construction Maintenance Operations, *Journal - American Water Works Association*, **82**(8), 35-39.

Proverbs, D G, Holt, G D and Olomolaiye, P O (1999) Factors impacting construction project duration: A comparison between France, Germany and the UK, *Building and environment,* **34**(2), 197-204.

Pugh, D S (1997) *Organisation theory, Selected reading,* 4th Ed., Penguin Books.

Radosavljevic, M (2005) The process based short-term planning methodology as a tool for maintaining knowledge sustainability in the construction industry, *In:* Ribeiro, F L *et al*, (Eds.), *2nd Annual CIBW102 Conference*, 19-20 May 2005, Lisbon, Portugal.

Radosavljevic, M and Horner, R M W (2007) Process planning methodology: dynamic short-term planning for off-site construction in Slovenia, *Construction Management and Economics*, **25**(2), 143-156.

Robbins, S P (1998) *Organisational behaviour*, 8th Ed., Prentice-Hall International Inc.

Scott, W R (1987) *Organisations: Rational, natural, and open systems,* 2nd Edition; Prentice-Hall International editions.

Thomas, H R and Završki, I (1999) Construction Baseline Productivity: Theory and Practice, *Journal of Construction Engineering and Management*, **125**(5), 295-303.

Torrington, D and Hall, L (1998) *Human resource management,* London: Prentice Hall Europe.