THE BALTIC JOURNAL
OF ROAD AND BRIDGE ENGINEERING

2011
6(4): 258–266

FLEXIBILITY AS RISK MANAGEMENT OPTION IMPLEMENTED IN THE BRIDGE REPAIR

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Abstract. Risk management in the sphere of Construction Management concentrates, on principle, at the level of projects or organizations which coordinate them. The construction business, however, when compared to many other branches of industry, is characterized by considerable operational risk. Therefore it seems that a direct impact on risk through implementation of flexibility with the proactiveness priority taken into account at the operational (source) level is a unique chance for successful risk management in the construction process engineering. The flexibility is understood in this case as the ability of an organization executing construction processes to adjust to dynamically changing environment through preparation of alternative variants (options), easy to switch over to. The specific character of implementation of flexibility has been illustrated with an example of repairing a road construction structure, with dissimilarity of that application to typical situations being emphasized.

Keywords: flexibility, risk management, construction, proactive, monitoring, repair.

1. Introduction

Risk and uncertainty, typical to construction activities at all management levels, may bring about not only disturbances of financial liquidity (Kapliński 2008) but also bankruptcy of enterprises. One can consider five (region, organization, project, process, task), three (strategic, tactic and operational) or two (strategic and operational) levels in hierarchical approach. The most popular seems the three-levels one. A hierarchical approach makes easier both risk analysis and systematic quality/risk management improvement (Gintalas 2010). An analysis of the problem of the right conduct under the conditions of risk and uncertainty may indicate, first of all, the possibilities for reducing them by (Ballard, Howell 1998; Mitropoulos, Howell 2001):

1. Risk assessment before commencement of the works;
2. Estimation of the additional costs;
3. Restriction of interdependencies between groups of processes;
4. Application of dynamic planning;
5. Improvement of the exchange of information between authors of the plans and persons implementing them.

The importance of implementation of the first of the above actions, consisting in the assessment of risk connected with various undertakings and selecting the most profitable ones, is confirmed by considerable interest in such problems (Kapliński 2009; Kim 2010; Zavadskas *et al.* 2010). Risk management at this level typically involves a four-stage procedure: risk identification, classification, analysis, and reaction to risk (El-Adaway, Kandil 2010). The fact that the stage enabling introduction of changes to typical operational procedures (as an effect of systematical improvement) is seldom used results, first of all, from the unique character of a project and the general transfer of risk to subcontractors. The isolated example of application of similar projects in power plant construction (Smith 2003) seems to confirm that observation. The management of transport of dangerous cargos (Batarlienė 2008) is an example of application of the loop of gradual improvement. However, the interest in risk management at the operational level should be justified not only by an opportunity for constant learning but also by

– relatively high risk at this level of management in the construction industry (compared to other branches of the economy);
– possibility of influencing the risk and uncertainty factors in a direct way (e.g. modification or materials, processes);
– possibility of considerable reduction or elimination of risk due to working at the source level;

ISSN 1822-427X print / ISSN 1822-4288 online doi: 10.3846/bjrbe.2011.33

– possibility of forecasting and creating scenarios of the impact of the environment (e.g. weather risk).

Despite various actions (prefabrication, robotization, automation etc.) being undertaken with a view to reduce the influence of the environment on construction processes (Zavadskas 2010), the problem remains an important one. Even in case of max advancement of prefabrication certain construction processes must take place under the changing influence of the environment (earthworks, foundation works, erection works, etc.), since the cost of isolating them from the environment would be very high and technically complicated (e.g. construction of a motorway, bridge, airfield). Therefore the existence of risk in construction industry has to be considered an important problem, not only at the tactical and strategic, but also at the operational level. Basing on the management practice consisting in employing managers for various levels of operation can be distinguished two key levels:

1. the level focused on management of projects;
2. the operational level focused on management of processes.

The basic differences substantiating distinct approaches to risk management in these two cases have been presented in Table 1.

An important element of risk management at the operational level is its division into active and passive methods. The typical passive methods include establishing buffers (Horman, Thomas 2005) and assessment of asset contingency (Thal *et al.* 2010). The assessment of assets aimed at passive acceptance of risk without undertaking any action is to a large extent justified in relation to external risk of unpredictable character (political turmoil, catastrophes – floods, earthquakes, unpredictable financial crisis). However, if predictable external risks are considered (weather elements like temperature, precipitations, wind etc. can be a grateful example here), a proactive approach consisting either in quick adjustment to the monitored changes (adaptation) or in providing means for obtaining the required results despite changing conditions of execution (robustness) seems to be more favourable. Adaptation and robustness constitute two alternative strategies of application of flexibility as the effective concept of construction process risk management in a changing environment (Paslawski 2008).

Attention should be paid to possible application of flexibility in other fields beside the typical flixibility application in production (Flexible Manufacturing Systems – FMS) which has been known and widely used for many years. It can be mentioned here e.g. construction of satellite devices (Nilchiani, Hastings 2007), mining (Mayer, Kazakidis 2007), power engineering (Ku 2003), noise management (Paslawski 2009) as well as construction industry (Lim *et al.* 2011; Paslawski 2008).

The presence of risk at the operational level in construction manifests itself in the influence of various disturbances, e.g. (Zavadskas *et al.* 2010): changes of the scope and requirements, design errors and omissions, inappropriately defined roles or scopes of responsibility of the partners, insufficient qualifications of the employees, unreliable subcontractors, insufficient experience of the contractor, novel techniques, defaulting on the supply terms, unfamiliarity with the local conditions, inconsistency of documents, force majeure.

They can be arranged by indicating five key sources (Fig. 1):

1. Owner (e.g. change of the scope of the order);

Table 1. Differences in risk management between the strategic and operational levels

Factors	Risk management level	
	Strategic	Operational
Subject of the analysis	projects	processes
Time scale	long	medium or short
Key target of the activities	choosing a project	active reduction of risks
Prevailing risk management strategies	risk avoidance and transfer	risk reduction and retention

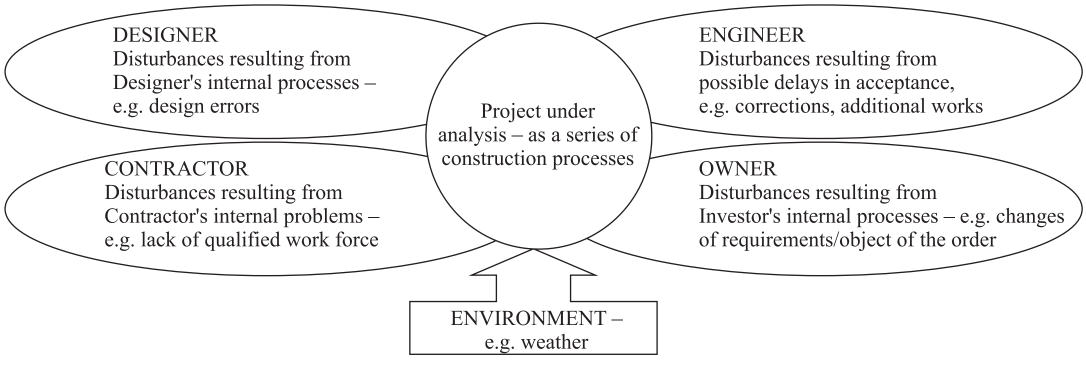

Fig. 1. Principal sources of disturbance in execution of construction processes

2. Engineer (e.g. delayed acceptance of works);
3. Designer (e.g. changes resulting from design errors);
4. Contractor (e.g. changes connected with the necessity to carry out corrective works);
5. Environment (e.g. weather impact, soil and groundwater conditions).

Obviously the concept described in Fig. 1 can be developed in more detail e.g. by indicating the role of the supplier (absence of appropriate material or its inadequate quality can be examples of disturbance in this case). It could be said from the point of view of responsibility for the emerged changes that the influence of the environment is the principal problem taken by the contractor upon himself on the time of signing of the contract. It seems logical, therefore, that a contracting organization should develop an ability to chose the possibly most advantageous variant of operation under the conditions of changing environment.

The risk can be even bigger in case of repairs due to the scope of work being difficult to define (e.g. the amount and distribution of the degraded material within the structure is not known). One may notice an analogy to the sources of risk and uncertainty in the mining industry, where distribution of raw material strata (grade distribution) is one of the important elements. The principal decision making problem in the case under discussion is achieving the best consistency between the contractor's powers (which define availability of technical and organizational options for repairing the structure) and the requirements of the task.

The complexity of the task, considerable impact of the environment, complicated technique and highly restricted time for execution of the processes justify application of the flexible approach in the discussed case of repair of a bridge structure. The presented example concerned an over bridge abutment, which had to be repaired due to an uncontrolled addition of ash connected with a defect at the concrete mixing plant. The described bridge structure repair process engineering illustrates the possibility of flexibility application when variants (flexibility based on repair technique options) concern not just the environment where the processes are executed, but also the scope of work resulting from the specific character of the damage. The aim of this article is to present the possibilities of operational risk management with the use of flexibility in the sphere of repairs of concrete structures.

2. The idea of flexibility

The idea of flexibility, which is being used with success in many areas of production activities (electronics industry, machine industry etc.), is aimed at quick adjustment to the changing environment with the lowest possible cost (understood not just in direct financial terms but also as time losses etc.). In case of flexible manufacturing systems the idea makes it possible to change the production range in response to changing market demand. On the other hand the utilization of the flexibility idea in management of construction processes should focus in adjustment to changing realization conditions, which are the cause of a majority of problems there. Of course the typical application of flexibility (i.e. FMS) can be utilized in the construction industry as well but, it seems, restricted to certain special situations (e.g. production of prefabricated concrete elements). The general definitions of flexibility consider it, first of all, from the point of view of the strategic level as:

– characteristics of an organization which makes it less susceptible to losses due to unpredictable external changes and better positioned to respond successfully to such a change;
– a measure of ability of a manufacturing system to adjust to the changing conditions of the environment and process requirements;
– an ability to change or react with a low deterioration of effectiveness in the sphere of time, resources, costs or results;
– the opposite of rigidity – it is a characteristic which enables effective functioning of the system in regard to both the existing external conditions and the internal ability to operate, with its direction depending on the level of initiative and the ability of the system do control itself;
– a specific form of system effectiveness and, at the same time, a measure of its independence: it is set to maintain the state of equilibrium which can be the volume of effects and/or index of system functionality, e.g. durability, reliability or intensity of its operation.

The suggestions formulated by Wadhwa and Rao (2004) which pointed out to the possibility of application of many variants which, after analyzing them, facilitate making the right decision, as a result leading to improvement of functioning of the system (subsystem), seem to be interesting from the point of view of application of flexibility in the management of construction processes. The views of Bucki and Pesqueux (2000), which defined flexibility as ability to adjust to the current situation in a reversible way, as opposed to the evolution, which they consider as an irreversible method of adjustment, are important due to the possibility of switching the options on and off. Switching the emphasis from perfecting of planning to perfecting of the ability to foresee and act quickly in a changing environment (Wiltbank *et al.* 2006) and to formulate uncertainty in a positive way as possible opportunities beside prospective risks, seems to be very important as well. The above was the background for formulating the following definition of flexibility in relation to the construction processes engineering: the flexibility is an ability of the system to act which enables switching between different tactics from the point of view of time and method in relation to the changing environment (in regard to both the existing external conditions and the internal ability to act) which is based on the proactive multivariate approach and assessment from the point of view of effectiveness of execution of processes with the aim to reduce risks and utilize prospective opportunities.

3. The management of flexibility of construction processes

FLEMANCO method (Paslawski 2008), which reduces the problem of flexibility management to making a decision about using such a flexibility option, which corresponds to the expected conditions of its execution with the progress of realization of the processes at the preceding stage taken into account, has been developed with the above definition taken into account. Minimizing of the cost of execution of the processes, assuming that the aim is to achieve a compatibility between the planned and actual course of the construction processes (important from the point of view of mutual relations of various processes) with the impact of the environment taken into account, can be the global criterion for such an approach. It corresponds to a typical decision-making situation of a contractor in the course of realization of a contract for execution of a series of processes in accordance with the technical specification, within a given time and for the agreed payment. A basic decision table which is being perfected according to the principle of constant learning on the basis of examples of realization of typical processes (resulting from the assumed specialty of the contractor) in similar conditions is shown in Table 2.

Five states of the environment (corresponding e.g. to various rain forecasts – from absence of rain to continuous rainfall precluding realization of processes) and three states of process progress (SLO as a realization delayed in relation to the plan, PLA – realization in compliance with the plan, and FAS – realization ahead of the plan) have been distinguished in the presented table. Those states are assigned, according to the knowledge at our disposal, realization variants selected from several possibilities (e.g. A1÷A6), always assuming that the knowledge is being perfected from experience (learning from examples).

Frequent disturbances in the course of construction processes make it obvious that one should focus on key factor/factors – e.g. rainfall during concreting of runways, logistics yards, wind during erection of facades of high rise buildings etc. The described typical cases of flexibility management are aimed, first of all, on the influence of the environment, with weather as a typical example, assuming that the scope of the analyzed processes is known. The situation gets more complicated in case of rehabilitation and repair works due to the scope of works being difficult to foresee at individual stages (which obviously does not preclude the weather impact as well).

4. Monitoring of the environment of current processes as the basis for decisions

The analysis of current processes enables evaluation of functioning of individual tactics in specific conditions. A typical situation of the analysis of tactics selection is shown in Fig. 2.

It was supposed to achieve the result r_i at stage e_{i-1} (preceding the situation under analysis). The achieved result was r_i, which differs from the required on by $\Delta C_i > 0$ in the sphere of costs and by $\Delta A_i < 0$ in the sphere of progress of the current processes. In that situation it is necessary to choose flexibility tactics FT_i in order to achieve at the next stage e_i the results r_{i+1}, conforming to the plan, at the min cost. As a result the decision table defines decision tactics in regard to the expected condition of the environment and the state of progress of the processes. In order to simplify the decision making situation during selection of flexibility tactics the deviations of the progress of processes and the costs from the planned values can be described by applying a classification into ranges corresponding to three states: SLO – delayed in relation to the plan, PLA – in compliance with the plan, FAS – ahead of the plan. A similar approach to deviations of actual costs from the plan can be described by the following three states: LPC – costs lower than planned, APC – costs conforming to the plan, and HTP – costs higher than planned. It needs to be emphasized that in case of a relatively wide range of cost deviations (ΔC_1, ΔC_2, ..., ΔC_m) considered as conforming to the plan (APC), decisions should be based on the progress of the current processes. If the above assumptions

Table 2. Example of a decision table in flexibility management

Expected condition of the environment	State of process progress		
	SLO	PLA	FAS
F1	A1	A2	A3
F2	A2	A2	A4
F3	A3	A4	A5
F4	A4	A5	A5
F5	A6	A6	A6

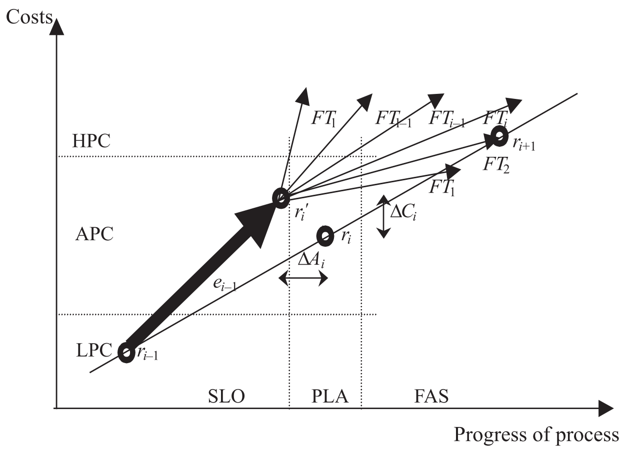

Fig. 2. Analysis of the progress of current processes (Paslawski 2009)

are accepted a decision table corresponding to the costs conforming to the plan (Table 2) can be sufficient only in case of relatively small deviations of actual costs from the planned ones. In a general case should be considered three decision tables (beside conformity to the planned costs should be taken into account the remaining two options: costs lower than planned (LPC) and costs higher than planned (HTP)). Naturally the number of ranges of cost variation can be increased e.g. to seven, distinguishing the following states: high increase, medium increase, low increase, according to plan, low, medium and high reduction of costs. The same with the analysis of compliance of the progress of processes could be done. The decision situation gets complicated when the influence on the result of construction processes of risk is included and uncertainty coming from other sources, e.g. from uncertain scope of the repair works to which the realization variant based on the appropriate flexibility tactics has to be adjusted. In such a case (described upon the example of repairs of a bridge structure) difficulties in ascertaining the scope of degradation of the structure constitute an example of risk and uncertainty elements connected with the scope – parallelly to the mining industry (Mayer, Kazakidis 2007).

5. Repairs of a bridge abutment as an example of application of flexibility

The typical approach used in flexibility management described above needs certain corrections in case of repair works due to risk and uncertainty in regard to the scope of planned works.

There were disturbances in operation of a concrete plan during concreting of the viaduct abutment (ash and cement were fed simultaneously at difficult to ascertain proportions). After the plant failure was discovered production was taken over by the standby plant, which provided concrete conforming to the specification until the end of concreting of the entire abutment structure. As a result

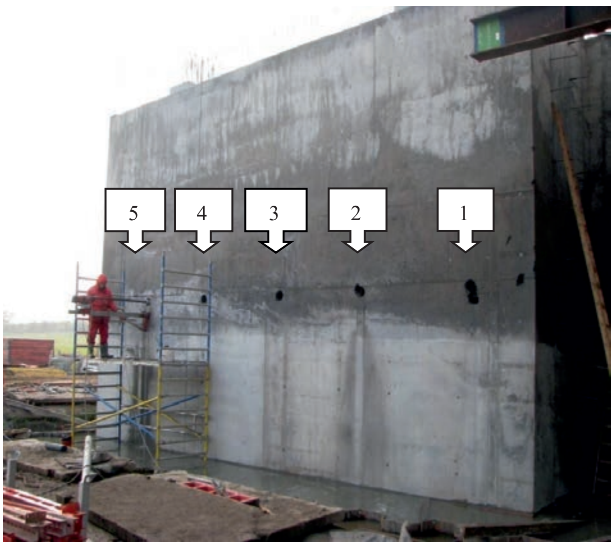

Fig. 3. Abutment in the course of execution of drilling No. 5 (drillings marked with numbers)

about 27 m^3 of concrete of difficult to ascertain contents of ash and cement have been put in during the concreting operation. The decision to collect concrete samples for analysis from the lower part of the visible colour variation zone (Fig. 3) had been taken during a visual inspection.

The compressive strength results of concrete from the samples are presented in Table 3, although the strength of concrete from samples 2 and 3 was too low to subject them to tests. The analysis of the results of tests on samples from drillings 1, 4 and 5 shows absence of a clear reduction of strength (the concrete hardening time at reduced temperature (+5 to –5 °C) amounted to 18 days), and the range of variation was not wide.

As a result the decision was taken to hammer out some concrete in order to assess the area of repairs consisting of replacing faulty concrete with repair concrete. The decision to take another 7 drillings in the upper part of visible colour variation zone was taken during a visual inspection aimed at deciding about the methods to apply in further operations (staging of the works, composition of repair concrete, execution possibilities etc.). That series of drillings had not revealed any cases of drastically low concrete compressive strength, but the spread of strength results was higher than in the first series of tests. The results obtained in the 2nd series of tests made it possible to assess the concrete in the structure more favourably as compared to the results of the 1st series, but they provided no sufficient data for determination of the location of the zone of faulty concrete within the structure under analysis and, therefore, for defining the scope of repairs at individual stages.

In that situation a repair method was proposed based on a division into six zones (side and central zones at both sides of the abutment) with the following stages of the works:

In the first stage it is required to remove concrete in the central zone of the abutment – it means widening and deepening of the previously hammered out pit to the width of ca 3–4 m, assuming that the removed concrete will be replaced with repair concrete (self-compacting concrete containing 25 kg/m^3 of steel fibres), taking into account varying of the concrete mix composition on account of grain size grading and temperature (heated mix). In view of the limited time for repairs (21 days) it was proposed to carry out similar operations at the opposite side of the abutment, taking into account a possibility of single- or two-stage concreting.

Then a technological break of about 7 days was planned, during which it was necessary to guarantee concrete hardening conditions of at least +5 °C.

The second stage was to include surface repairs of the side parts at both sides of the abutment assuming that the concrete chips were relatively shallow, possible to repair by concrete spraying (in case of bigger cavities filling with repair concrete was planned).

A similar technological break was planned after the end of stage two (ca 7 days), with concrete hardening assured by the use of screens and heaters.

The third stage was to include a sprayed concrete apron within the entire damaged zone (thickness ca 0.03 m) to provide surface protection. That stage was to include execution of resin injections to guarantee cooperation of the repair concrete with the existing one and repairing of minor defects. After concrete spraying the entire surface was to be patched to prepare it for painting.

The execution of the third stage was to be effected in more favourable conditions (the first two stages had to be executed within three weeks) – at least after abating of low temperatures (average daily temperature above 5 °C).

From the point of view of the flexible approach a decision table for the discussed repair works is presented taking into account the cavities after removal of faulty concrete established at a given stage on one hand, and the weather conditions during that stage on the other (Table 4). The following execution variants have been assumed:

– application of a repair mix of self-compacting concrete with steel fibres in the amount of 25 kg/m^3 and 2/8 grading, C30/35 class, at the initial temperature of 20 °C, 25 °C or 30 °C (SCC1, SCC2, SCC3 respectively);
– application of a repair mix of similar concrete to the above but with typical grading (SCC4, SCC5, SCC6 respectively);
– thin layer of sprayed concrete – SC1;
– medium layer of sprayed concrete – SC2;
– thick layer of sprayed concrete – SC3.

The possibility of repairing a given zone during the third stage under very favourable conditions) was also discussed. Theoretically it was also possible that the discovered damage would be exceptionally extensive, making it impossible to repair the abutment (e.g. at the adjoining repair zones), which was not the case.

Table 3. Results of the compressive strength tests of concrete – 1st series of drillings

Code	Position, m	Diameter, mm	Height, mm	Weight, kg	Slenderness, H/d	Force, kN	Strength, MPa	Comments
Drilling 1								
A1	0.13	98	105	1.829	1.071429	337	44.70	
A2	0.22	98	98.5	1.8	1.005102	322	42.71	
A3	0.33	98	98.5	1.807	1.005102	356	47.22	
A4	0.43	98	98.7	1.797	1.007143	376	49.87	Max value
A5	0.53	98	100	1.824	1.020408	318	42.18	Min value
A6	0.64	98	98.2	1.343	1.002041	335	44.44	
A7	0.86	98	100.2	1.822	1.022449	356	47.22	
A8	0.96	98	100	1.83	1.020408	321	42.58	
A9	1.07	98	100.5	1.822	1.02551	333	44.17	
A10	1.17	98	99.7	1.821	1.017347	331	43.91	
A11	1.27	98	99.9	1.812	1.019388	345	45.76	
						Average	44.98	
Drilling 4								
B1	0.13	98	98.7	1.758	1.007143	285	37.80	Min value
B2	0.24	98	99.7	1.795	1.017347	314	41.65	
B3	0.34	98	99.7	1.802	1.017347	311	41.25	
B4	0.58	98	99.9	1.802	1.019388	327	43.37	Max value
B5	0.68	98	98.5	1.824	1.005102	320	42.45	
B6	0.78	98	99.9	1.807	1.019388	318	42.18	
B7	0.98	98	100	1.808	1.020408	314	41.65	
						Average	41.48	
Drilling 5								
C1	0.07	98	99.8	1.777	1.018367	293	38.86	
C2	0.17	98	100.2	1.795	1.022449	280	37.14	Min value
C3	0.27	98	99.1	1.781	1.011224	300	39.79	
C4	0.5	98	99.2	1.782	1.012245	294	39.00	
C5	0.6	98	99.7	1.786	1.017347	298	39.53	
C6	0.82	98	99.2	1.766	1.012245	314	41.65	
C7	0.92	98	99.5	1.822	1.015306	306	40.59	
C8	1.02	98	99	1.771	1.010204	315	41.78	Max value
C9	1.12	98	95	1.791	0.969388	136	18.04	∅22 bar inside
						Average	39.79	

Note: Position was defined as a distance from the sample face to the start of the drilling.

Table 4. Decision table for repairs of the abutment structure

Category of damage in the repair zone	Average daily air temperature		
	H (5–0 °C)	M (0–(–5) °C)	L (–5–(–10) °C)
D0	E3	E3	E3
D1	SC1	SC1	SC1
D2	SC2	SC2	SC2
D3	SC2	SC2	SC2
D4	SCC1	SCC1	SCC1
D5	SCC2	SCC2	SCC2
D6	DE	DE	DE

It should be emphasized that the influence of ambient temperature had to be taken into account despite heating under the screens, since concreting under the screens was not possible – due to large size of the repaired abutment heating under the screens was performed in sections. Absence of any significant influence of the progress of processes (compared to the typical decision Table – Table 2) due to very limited time for repairs needs to be emphasized as well.

The damage in the zone of repairs has been divided into six principal categories:

– D0 – minor defects requiring no immediate repair (repairs possible during the third stage);
– D1 – small surface defects of depths up to 0.05 m;
– D2 – medium defects of depth up to 0.15 m;
– D3 – large damage of depth up to 0.3 m;
– D4 – extensive damage of depth and width up to 1.0 m;
– D5 – very extensive damage of depth exceeding 1.0 m and width exceeding 2.0 m;
– D6 – exceptionally extensive damage – practically absence of any concrete to be accepted (demolition).

The execution of the discussed repairs in the first stage included application of the repair concrete mix in the central zone (both sides), of the total volume of ca 20 m^3. Current repairs with sprayed concrete were used in the side zones. It was decided to repair minor defects in the 3rd stage (after abating of the winter weather risk). It has to be emphasized that the presented decision table (Table 4) is considerably simplified due to very limited time for the works. In case of a longer planning period a three-dimensional decision table (which makes it possible to correct the realization compliance to the plan – like in Table 2) should be taken into consideration.

Naturally the presented example is exceptionally simple, while construction processes are often realized in many stages, with changes of the environment exerting considerable impact on their effects. It seems that the monitoring of environmental data and current processes alone justifies application of computer techniques. It is planned to initiate agent advisory system of hybrid structure for that purpose. Such a structure makes it possible to develop the system gradually on the basis of various technologies, e.g. automatic gathering of data on current processes (Karlowski, Paslawski 2008) or knowledge (Gajzler 2010), application of game theory (Kapliński, Tamošaitienė 2010) or multiple criteria analysis (Kapliński, Tupenaite 2011; Turskis, Zavadskas 2010; Zavadskas *et al.* 2009, 2010; Zavadskas, Turskis 2011).

6. Summary

The presented theoretical principles of management of operational risk with the use of flexibility as well as the example of repairs to a bridge structure make it possible to formulate the following conclusions:

1. The practice of risk management in construction industry justifies introduction of the analysis at two levels: the project and the processes (usually performed by different managers).

2. The prevailing strategies at the level of projects are risk avoidance and risk transfer. At the same time the key importance at the operational level is assigned to risk retention and reduction.

3. In a typical case flexibility introduced at the operational level provides the possibility to adjust the capabilities of the organization to changing environmental conditions (e.g. weather). In case of repair works it includes also e.g. adjustment of the method of works to the extent of damage.

4. The profits from introduction of flexibility at the operational level result, first of all, from the possibility to influence the risk at source, in a direct and proactive way. That possibility is considerably restricted at the higher levels.

5. Application of flexibility assumes selection of the methods of execution of repair processes with not only weather conditions but also condition of the structure at a given repair stage taken into account (the latter requires that the contractor is prepared to realize repair processes by variable methods).

6. The method assumes gradual perfection of flexibility management in planning and execution of construction processes by a specialized contractor on the basis of learning from examples (drawing conclusions from realization of processes under similar conditions).

7. Introduction of flexibility means reaching a production potential of the organization, which enables continuation of the works (and achieving the planned results) despite the impact of dynamically changing environment.

8. Application of flexibility understood in that way requires certain costs to be expended for obtaining tolerance of the production system in relation to the environment, but it is justified by the cost of the system remaining in the state of unbalance and then returning to the state of dynamic equilibrium.

9. The important factors substantiating application of flexibility include: the scale of planned processes, degree of environmental impact, possibility of influencing the effects of that impact (with both risks and opportunities taken into account), time restrictions (in the case under discussion finishing the repairs within 21 days despite all the disturbances was of principal importance – the cost criterion was of secondary importance).

When analyzing the operational activities of construction enterprises one may encounter the application of flexibility in typical conditions of influence of changing environment on the processes under execution (temperature during concreting of engineering structures in the winter season, wind during erection works, or rainfall during concreting of airfield pavement), which is justified by the possibility of reducing of the passive approach in risk acceptance. Proactive activities depend to a considerable degree on the possibility of utilization of modern information and telecommunication technologies and advancement of the techniques of realization of construction processes, which – if the dynamic development in these areas is taken into account – is a good reason for optimism in regard to perspectives of application of the proposed approach.

Acknowledgements

A financial support for presented research from Institute of Structural Engineering (Poznan University of Technology) is gratefully acknowledged.

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Received 7 July 2011; accepted 3 November 2011