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To cite this article: J. Paślawski PhD (2000) METHODS FOR RISK MANAGEMENT IN CONCRETING AT LOW TEMPERATURES, *Statyba*, 6:6, 415-419, DOI: [10.1080/13921525.2000.10531624](https://doi.org/10.1080/13921525.2000.10531624)

To link to this article: <https://doi.org/10.1080/13921525.2000.10531624>



Published online: 26 Jul 2012.



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## METHODS FOR RISK MANAGEMENT IN CONCRETING AT LOW TEMPERATURES

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### 1. Introduction

The notion of risk seems obviously associated with business activity. Although reduction of risk is enhanced by such elements as a reduced task complexity, on the one hand, knowledge of any possible event liable to occur during the task execution, having complete information, all the necessary means required for the task, execution and the necessary experience to fulfil the task, on the other, such situation would be exceptional in business practice. Therefore, the notion of risk must not be underestimated in business.

The construction industry is a specific kind of business as regards its exposure to risk [1]. One of the basic elements of risk involved in the construction industry is the influence of climate and weather, which for obvious reasons affect the process of concreting at low temperatures. Being highly variable, weather conditions are liable to cause serious problems in the process of concreting, such as demolition of a structure or element having a poor quality. Therefore, it seems advisable to investigate the problem for identifying the sources of risk and defining acceptable strategies of risk management.

The notions of risk and uncertainty will be defined in the first place, since these key terms are variously interpreted by authors. Discussion of methods of how to proceed in conditions of risk and uncertainty as well as the applicable strategies of risk management will follow.

### 2. Risk and uncertainty

Since the notions of risk and uncertainty are variously explained due, first of all, to an approach based on probability and mathematical statistics and, second, to their informal interpretation, these notions need to be clearly defined.

In most references [2–4], Knight is indicated as the first author to have formalized the notion of uncertainty. When examining phenomena connected with economic competition, Knight noted problems arising out of our inaccurate knowledge of the future. In his classification, three categories of probability are involved [5]:

- a priori probability – entirely known and invariable mathematical probability;
- statistical probability – experimentally determined occurrence of events;
- estimated probability – one that is not based on any values, whether mathematical or experimental.

The a priori probability is defined by logical reasoning and based on the knowledge of possible events and their identity, ie the chance of their happening. Therefore, empirical research to determine the chance of a certain event out of a definite set of events happening is not required in the case of the a priori probability. This kind of probability is obviously more typical of gambling rather than running a business.

The second category of probability in the Knight classification, the statistical probability, involves the necessity to find empirically the frequency of certain possible random events happening. It is not possible to indicate any set of events with the same probability. Unlike the a priori probability, the statistical probability provides just empirical generalization within a given group of events, without providing much information on a specific single event.

Although the statistical probability tends to occur more frequently in business practice than does the a priori probability, the type of probability that is typically encountered in business is one that has no measurable basis for classification of events [3]; it is referred to as 'estimated probability'. Association of a

given estimated probability with an element of a given set results from one's knowledge and experience. According to Samecki [3], all three categories of probability have one characteristic in common: there is a finite set of alternatives and determination of probability results from one's objective knowledge in all three cases. The difference is that probability distribution is objectively expressed in a numerical form in the two former cases, while in the third case, it is based on a subjective opinion of a person in his or her probabilistic reasoning.

As regards the question of differentiating between risk and uncertainty, having examined the works of Knight and Shackle, Samecki [3] finds that risk requires the possibility of definition according to one of the three groups of probability indicated by Knight, each of them is based on objective knowledge. Probability, the essence of risk, assumes knowledge which, in turn, excludes uncertainty. The latter is the case whenever probabilistic reasoning is inapplicable. Under the circumstances, anticipation of a result may just be an act of creative imagination while the consequences of the decision taken can not be accurately indicated. According to the above definition, unexpectedness, a feature inherent in such decision, is the key element.

On the other hand, in Perrouty and d'Harteville's [5] interpretation of the Knight theory, the type two of risk is most frequently encountered while according to Knight, risk is connected with the type one (a priori) probability, while uncertainty is with the type three (estimated) probability. A notable difference between the two opinions is the approach to the estimated probability: some authors (eg Samecki [3], Poplawski [2]) perceive it as a definable value while others (eg Perrouty and d'Harteville [5]) do to the contrary.

According to Nogalski and Rybicki [4], problems with determining a univocal approach in the nomenclature of risk and uncertainty may be interpreted as proof of their complex nature and the necessity of the realization that actions taken in conditions of risk are not dependable ones. Furthermore, they emphasize an important difference in various approaches to the issue of risk: it may be perceived either as a hazard alone (possibility of loss) or also positively (possibility of either loss or gain). A similar approach is presented by Poplawski [2] who refers to profit as a specific form

of remuneration to a businessman for his taking initiative, risk and making the right decision. In the present paper, risk is referred to as a hazard of incurring a loss that results from taking a certain decision.

### **3. Methods to proceed in conditions of risk and uncertainty**

In terms of the conditions the works are carried out, for instance, in comparison with industrial processes (which are typical in the latter), the construction industry is a specific kind of business. Consequently, management in the construction industry requires special attention due to the diversity and complexity of situations that may possibly occur. As a rule, any of the following three basic groups of situations may occur [6]:

- Determined conditions,
- Random conditions,
- Indeterminacy conditions.

In business practice, determined conditions occur extremely rarely. They may only be assumed when the influence of random conditions is insignificant.

Construction processes are usually carried out at random conditions. Some of the typical random conditions are: project completion time, weather conditions, equipment failure frequency, etc. A diversity of management methods are applicable when acting under random conditions. As regards weather conditions, avoidance (or holding up the execution of construction works in adverse weather conditions) is a typical strategy. The influence of equipment failure frequency may be reduced by improving the quality of daily maintenance, providing a sufficient stock of machine parts, etc. Another option is to establish a reserve of equipment in any one of the two possible variants: the cold (or unloaded) reserve or the hot (or loaded) reserve. Improved supplies will result in keeping sufficient stock. It should be emphasized that, in management at random conditions, appropriate factors have to be minimized in the first place, followed by finding the most suitable strategy of management in the given situation. Indeterminacy conditions are ones that do not have the deterministic nature, while the extent of influence of random conditions is hard to assess due to the limited set (or even lack) of statistic data. Management at such conditions may be based on theory of games. In the

construction industry, the so-called 'games with nature' are especially useful ('nature' in this case is understood as the various conditions affecting the consequences of decisions taken; nature is perceived as a passive player, one not interested in winning the game at all). Solutions to the games with nature are based on the following decision-making criteria [6]:

- a) Wald criterion, also called the mini-max criterion, assumes the most cautious strategy of the decision maker; the choice of such strategy positively means avoiding risk;
- b) Hurwicz criterion, in which the decision-maker's pessimistic view of the anticipated natural conditions may be taken into account as the pessimism factor  $\alpha$  (ranging from 0 to 1);
- c) Bayes-Laplace criterion, which involves a degree of probability rather than complete uncertainty of the occurrence of natural conditions;
- d) Hodge-Lehmann criterion, based on the three criteria mentioned above, where: for  $\alpha=1$  it is identical with the Wald criterion, and for  $\alpha=0$  it is identical with the Bayes-Laplace criterion.

The choice of management methods should be based on the character of the specific situation in decision-making. Generally, there is a choice of applicable strategies of risk management [7]:

- impassive strategy – avoiding risk by failure to take actions burdened with risk;
- conservative strategy – taking risk cautiously, that is, acting up to certain level of risk only (for instance, holding up the implementation of a new process technology because of the risk inherent in it);
- expansive strategy – typical of taking risk in acting to win higher profits than usual.

The above strategies of risk management are connected with detailed strategies resulting from examining a specific situation in decision-making, taking into account the level of risk and the potential consequences of events (see Table).

Strategies of risk management [7, 8]

Level of risk	Potential consequences		
	Negligible	Medium	Significant
Low	Ignoring	Retention	Reduction
Medium	Retention	Transfer	Reduction
High	Retention	Reduction	Avoidance

Transfer of risk means the transfer to another object of the consequences of a situation burdened with risk (activities of insurance institutions are a typical example). Retention of risk means that risk is retained in an organization. Two variants are applicable to cover losses connected with risk retention:

- active retention – which means that a special fund (financial reserve) is established to cover losses;
- passive retention – which means that potential losses are covered from means other than such special fund.

The retention strategy may be applied provided that the following three conditions are satisfied [7]:

- the consequences and amount of potential loss are easily anticipated,
- the amount of a single loss is relatively low,
- the probability of loss accumulation to a significant amount is insignificant.

Risk reduction is made possible by implementing special safety devices, eg in the area of raw materials quality control or technological process control [9–11].

#### 4. Strategy risk management in concreting at low temperatures

In the light of the above considerations on various strategies of risk management, as regards the process of concreting at low temperatures, the potential risk factors inherent in such process should be taken into account. This analysis is focused on technological risk which seems the key factor in this case. The risk involved in concreting at low temperatures is characterized by the following typical elements:

- fluctuations in the prices of raw materials,
- accuracy with which various components are added to a concrete mix,
- failure frequency of equipment and facilities for making the concrete mix,
- variability of weather conditions during the transport and application of the concrete mix,
- requirement to provide transport of different duration and at various weather conditions,
- failure frequency of equipment and facilities for transporting the concrete mix from the plant to the construction site,
- fluctuations in the parameters of the process technology to apply the concrete mix,

- failure frequency of equipment and facilities for transporting the concrete mix within the construction site,
- failure frequency of equipment and facilities for consolidation of the concrete mix,
- suitability of the methods used for concrete curing,
- failure frequency of heating equipment,
- variability of weather conditions during the concrete curing, etc.

The above elements of risk may be classified in four basic categories, connected with the applicable strategy of risk management. The following basic strategies were used with regard to the above-mentioned potential elements of technological risk in the advisory system for concreting at low temperatures, named COLCON (after COLd CONcreting):

- a) ignoring strategy – applicable to failure of equipment and facilities for concrete mix production, transport and application;
- b) retention strategy – applicable to fluctuations in the prices of raw materials, accuracy of their addition to the concrete mix, variability of process parameters, and the requirement to provide transportation of different duration and at various weather conditions;
- c) reduction strategy – applicable to the variability of weather conditions;
- d) avoidance strategy – applicable under unusually bad weather conditions.

Such strategies were implemented in practice as follows:

- 1) failure to take action to modify the risk related to the situation in decision-making (for item a);
- 2) establishing a strength reserve to enable compensation of fluctuations in the prices of raw materials and their levels in the concrete mix, having to transport the concrete mix for periods of different duration at various weather conditions, and the variability of the process technology parameters (for item b);
- 3) establishing a cold reserve in the form of guards and hot air blowing facilities to heat the concrete in the case of a pessimistic scenario for weather conditions;
- 4) holding up the construction work in the case of unusually bad weather conditions (temperature of air below  $-5^{\circ}\text{C}$  or potential drop of temperature to below

$-15^{\circ}\text{C}$  the first night after the concrete mix application).

The aim of risk management in concreting, as discussed above, was to carry out the process while minimizing the influence of risk.

#### 4. Conclusions

The approach to risk management, as discussed in the present paper, has emerged as an element of the COLCON advisory system, developed in order to aid decision-making in traffic engineering (construction of engineering structures). It seems that decision-making in situations burdened with difficulties such as adverse weather conditions should be based on an analysis of the costs of holding up construction works (penalties for delays) versus the costs of going on with the construction works (which involve the risk of insufficient quality of work or unjustified high costs).

Obviously, there is also the question of providing the means to carry out the two basic strategies of risk management in the system (apart from the ignoring and the avoiding strategies), namely the following:

- Retention strategy – in the form of the strength reserve;
- Reduction strategy – by establishing a cold reserve (guards and hot air blowing equipment).

Although theoretically independent in the conditions the concreting works are carried out, such strategies have a similar function in minimizing the effect of risk, and the mutual relations between those strategies should be decisive for their contributions in the risk management system.

The validity of the accepted strategy has been shown in the construction works on the execution of the POZNAŃ BY-PASS A2 project in winter 1999/2000 – continued practically without any stoppages and with assured good quality of work.

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Įteikta 2000 11 06

## BETONAVIMO ŽEMOJE TEMPERATŪROJE RIZIKOS VALDYMO METODAI

J. Paslawski

Santrauka

Pirmiausia pateikiami rizikos valdymo teoriniai pagrindiniai. Antroje studijos dalyje analizuojamas sprendimų, susijusių su betonavimu žemoje temperatūroje, priėmimas. Pateikti tam tikri COLCON patiriamosios sistemos sprendimams priimti betonuojant žemoje temperatūroje elementai.

Pateiktas rizikos ir neapibrėžtumo – pagrindinių punktų, kurie įvairiais požiūriais yra analizuojami nurodytoje literatūroje, apibrėžimas. Siūlomi metodai ir jų taikymo, atsižvelgiant į riziką ir neapibrėžtumo sąlygas, galimybes. Tuo pagrįstos suformuluotos rizikos valdymo betonuojant žemoje temperatūroje strategijos. Daug dėmesio skiriama bendrai kompensuojančiajai dviejų pagrindinių strategijų: rizikos išvengimo ir jos mažinimo, charakteristikai. Kaip pagrindinis elementas priimant sprendimus, susijusius su rizikos valdymu pasirenkant bendrą strategiją, išskirta išlaidų analizė.

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