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THE HIERARCHY OF DECISION-MAKING CRITERIA IN CONCRETING AT LOW TEMPERATURES

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1. Introduction

Special procedures are required in concreting at low temperatures [1]. Most commonly, it is the objective to reach sufficient freezing resistance as soon as possible. On the other hand, what should be another objective in making technology related decisions, specifically in the case of traffic engineering (bridges, viaducts, etc), is the durability of the concrete layer [2]. Over the past several years, durability has become more and more important as a criterion in selecting materials and technologies in the building industry [3]. Owing to economic changes taking place, the issues of quality and long-term guarantees have become the key to effective management. Selection of appropriate materials based on such criteria as their strength and durability will inevitably influence the service life of a building structure as well its maintenance costs [4].

In this paper, the author deals with the problem of making technology related decisions in concreting at low temperatures, considering the freezing resistance of concrete (*conditio sine qua non*) and durability related criteria such as loss of strength and loss of weight.

2. The problem

Concreting at low temperatures is not a novelty. A number of methods are known in the art that enable the process despite natural obstacles. A few of them will now be indicated:

• hot components (building in portions of hot concrete);

• thermal insulation of concrete mixes from weather conditions upon application;

• heating (using a variety of heating devices to heat the concrete in the maturing step);

• modification of concrete with admixtures to enable concreting at low temperatures.

Specifically, modification of concrete has become an unusually attractive technology due to the extraordinary progress observed in the building chemistry. One of the factors behind is lowered costs of modification thanks to the admixtures having become less expensive while the costs of energy are becoming higher and higher, which accounts for the growing popularity of the technology.

The problem to be considered in this paper pertains to making technology related decisions in building highways of concrete, at conditions that are generally regarded as disadvantageous (below +5°C) but not during long periods of freezing temperatures. It is of greatest importance at such conditions to obtain concretes with sufficient compression strength, enabling freezing resistance to be obtained. It is a *conditio sine qua non* for accepting the technology and, while being widely discussed in other sources, this technology need not be explained in detail in this paper [5].

It will do to briefly discuss a few examples, showing the findings of studies on the efficiency of concrete modification with an admixture, enabling application at low temperatures. For example, in the graph shown in Fig 1, compression strength of a concrete mix was compared during the initial period of its maturation (24 to 48 hours), showing differences enabling the modifier dosage to be established at a certain level.

What remains to be done is to evaluate the modification technology in respect of durability properties of the concrete, expected to provide a concrete structure with long service life, without adding to its operating costs.

3. Standards for durability of concrete

The limiting value of durability is the time when the limit of a given operating quality has been achieved. In the example for concrete [6], two elements were selected for consideration in respect of their changes following a period of simulated operation in laboratory conditions

- compression strength of concrete (Fig 2);
- changes in weight (Fig 3).

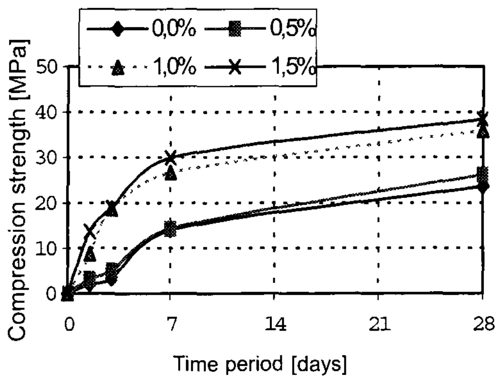

Fig 1. Compression strength of modified concrete

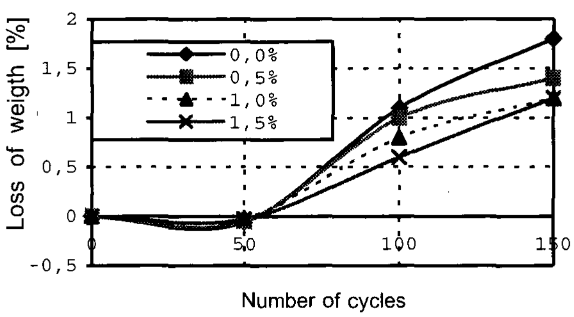

Fig 2. Weight loss of modified concrete (accelerated ageing)

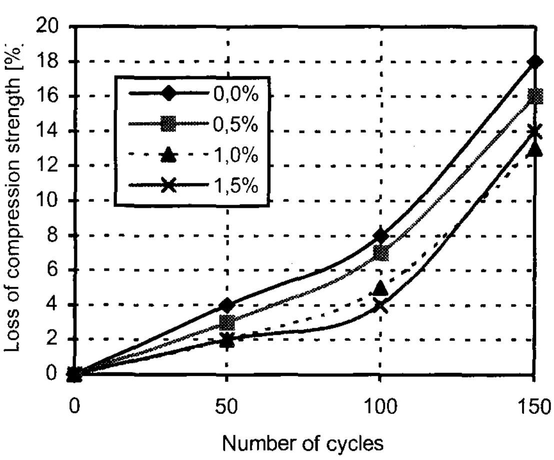

Fig 3. Loss of compression strength of a modified concrete

According to Polish Standard [6], loss of compression strength of concrete following a given number of freeze-thaw cycles, compared to the same parameter for a sample matured at natural conditions may be a maximum of 20%; the weight loss for the same two samples of concrete as above may be a maximum of 5%. In the light of the above considerations on determination of durability properties of concrete, it seems that a certain procedure should be adopted for comparison of the durability of modified concretes. Such procedure is proposed in the following:

1. Assumptions:
   - user's requirements;
   - operating conditions of the material in the structure;
   - application properties of material;
   - criteria of application properties;
   - application properties.
2. Analysis of degradation mechanism:
   - identification of a degradation mechanism;
   - identification of the type and extent of degradation;
   - determination of degradation indicators;
   - selection of a technique to include application properties in ageing tests.
3. Laboratory tests:
   - studies to determine the predicted service life of concrete and characterize the dependence of its degradation range on environmental conditions;
   - determination of the type and extent of degradation indicators.
4. Interpretation of results:
   - determination of the usefulness of material in specific conditions;
   - attempt to evaluate the predicted limiting number of cycles, based on developed mathematical models.

While attempting to predict the service life of concrete, enough attention should be paid to considerable differences in exposures of concrete to temperature fluctuation cycles around 0°C. It is estimated that, while more than 50 freeze-thaw cycles occur annually in the USA, just a single freeze-thaw cycle per year is observed in the Far North [7]. Consequently, it seems that concrete is a material with unusually wide range of application and the resulting variability of its operating conditions practically prevent the possibility of expressing durability of concrete in units of time such as months or years, as suggested in documents where procedures for determination of expected service life of materials are provided [1, 3]. Requirements regarding durability of concrete should be defined in technical specifications, based on analysis of operating conditions by design engineers.

4. Hierarchical model of decision-making

While analyzing a variety of decision-making models, applicable in this case of technology related decisions [2] in concreting, it seems that typical decision-making models, such as decision tree analysis, linear programming, game theory or multi-criterion analysis, are in their classical forms based on an automatic decision-making scenario. What seems more desirable under the circumstances, is a procedure of hierarchical decision analysis, which is based on a dialogue scenario, enabling decisions to be immediately tracked on the specific levels of decision-making analysis.

What is particularly important in hierarchical decision analysis is the criterion of reaching sufficient freeze resistance in a relatively short period of time. Criteria typically connected with durability, such as loss of weight and loss of compression strength, both related to freeze resistance, and such criteria as water permeability and absorbability should be considered as a next step. Among the criteria mentioned above, freeze resistance alone has an element related to passage of time (simulation of ageing process).

The next level of decision-making includes analysis of economic criteria, that is not only the costs of reaching freeze resistance and the selected durability properties but also maintenance costs in the context of using the material (concrete) in specific application conditions. In traffic engineering, it seems specifically desirable to use surface protection techniques to improve durability of concrete.

5. Conclusions

The following conclusions are arrived at from the models of technology related decision-making, as presented in this paper:

- It is advisable to employ a hierarchical model in making technology related decisions in concreting;
- The following elements should be included in the hierarchical model for making technology related decisions in concreting:
  - freeze resistance criterion (related to reaching high enough freeze resistance at an early stage),
  - durability in terms of freeze resistance (loss of weight and loss of compression strength, as well as water permeability and absorbability);
  - criterion of maintenance costs, in connection with the use of surface protection products.

In considering the durability of concretes, the requirement for having to predict the service life of concrete in units of time such as months or years can hardly be accepted. On the other hand, the proposed procedure enables comparison of various samples of modified concretes, while changing just a single parameter, for instance, the level of admixture dosage.

References

1. Systematic methodology for service life prediction of building materials and components // Rilem Recommendations. Materials and Structures, 1989, 22, p. 385-392.
2. O. Kapliński. Modelling of construction process. A managerial approach. Komitet Inżynierii Lądowej i Wodnej PAN, Warszawa 1997. 175 s.
3. Z. Ściślewski. Zasady projektowania budynków i budowli z uwzględnieniem trwałości. Wydawnictwa Instytutu Techniki Budowlanej, Warszawa, 1994. 47 s.
4. G. Fagerlund. Trwałość konstrukcji betonowych. Arkady Warszawa, 1997. 93 s.
5. J. Pasławski. Some aspects of risk management in construction // 1-ers Ateliers de recherche "Precevoir, identifier et gerer les risques en marketing". Universite Paris 1 – Pantheon-Sorbonne. Paris 2000, p. 29–42.
6. PN-88/B-06250 Beton zwykły.
7. A. M.Neville. Właściwości betonu. Polski Cement, Kraków, 2000. 499 s.

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SPRENDIMŲ PRIĖMIMO KRITERIJŲ HIERARCHIJA ATLIEKANT BETONAVIMO DARBUS ŽEMOSE TEMPERATŪROSE

J. Pasławski

Santrauka

Betonuojant žemose temperatūrose būtina naudoti specialias priemones. Svarbu yra parinkti medžiagas ir technologijas.

Nagrinėjami sprendimai, susiję su betonavimo darbais žemose temperatūrose. Reikia įvertinti ne tik betono pasipriešinimą užšalimui, bet ir daugybę kitų veiksnių. Statyboje svarbiausia yra ilgaamžiškumas. Lenkijos standartuose reikalaujama atlikti betono svorio nuostolių ir betono atsparumo gniuždymui sumažėjimo testus. Straipsnyje pateikti testų, atliekamų su betono bandiniais, pagamintais su modifikatoriais ir be jų, pavyzdžiai.

Racionaliai betono sudėčiai ir betonavimo technologijai nustatyti gali būti taikoma sintezės analizė, linijinis programavimas, lošimo teorija. Efektyvesnė yra hierarchinių sprendimų analizė. Aprašyti pagrindiniai sintezės analizės realizavimo etapai.

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