1. Dahlsveen T., Petráš D.: Energetický audit budov, Jaga group, s.r.o., Bratislava 2005. 2. STN EN ISO 12241 (730556): Tepelná izolácia technických zariadení budov a priemyselných prevádzok - Výpočtové pravidlá (apríl 2001). 3. Kapalo Peter: Výskum nestacionárnych procesov v systémoch distribúcie teplej vody za účelom zníženia energetickej náročnosti, Dizertačná práca, Stavebná fakulta, TU Košice, KTZB, 2005. 4. Kalaš Juraj, Kapalo Peter: Analýza efektívnosti realizácie decentralizovanej prípravy teplej úžitkovej vody v okruhu odovzdávacej stanice OST541, Stavebná fakulta, TU Košice, KTZB, Košice, 2002. 5. Vranayová Zuzana, Košičanová Danica: Hot Water from Hygienic and Energetic Point of View, Selected Scientific Papers, 10th Rseszow – Lviv – Košice Conference 2005, Supplementary Issue, ISBN 80-8073-411-9, Technical University of Košice, Faculty of Civil Engineering, Košice, Slovakia, 2005.

Kapelko A., Kapelko R.

Wrocław University of Technology,
Institute of Building Engineering
Poland, 50-370, Wrocław, Wybrzeże Wyspiańskiego 27.
E-mail: aleksander.kapelko@pwr.wroc.pl
rafal.kapelko@pwr.wroc.pl

THE OPTIMIZATION OF HYDROTECHNICAL CONCRETES' COMPOSITION

© Kapelko A., Kapelko R., 2007

This article reflect upon the problem of hydrotechnical concretes optimization basing on the authors' investigations including the determing of special concretes composition and the estimation of their quality. The issue of optimization is outlined, the objective function is formulated and preferred solution is calculated using STATISTICA (polynomial approximations) and MATHEMATICA (the least squares method) programmes.

Introduction. The concrete used in the construction of buildings for hydroengineering is exposed mainly to the destructive influence of water, atmospheric factors and other external elements of mechnical type. Concrete used in hydroengineering can be divided in the following way:

a) for massive constructions – in the internal and external construction zone,

b) for non-massive constructions.

The hydrotechnical concrete of external zone type can be divided into working:

a) constantly under water,

b) in changing water level zone

c) constantly above water.

Each of the variants of concrete used in hydroengineering meets different demands [1-3].

Special concretes are used in the construction of weirs, flood-gates, dams, sewage-treatment plants, reservoirs for water, and during reconstruction and modernization of those hydroengineering structures.

In order to meet the high quality parameters of hydrotechnical concretes, one uses aggregates and cements of appropriate quality and different admixtures and additives improving the quality of concrete exposed in the environment of water and temperatures' variability [1-5].

This article reflect upon the problem of hydrotechnical concretes optimization basing on the authors' investigations including the determing of special concretes composition and the estimation of their quality.

Lviv Polytechnic National University Institutional Repository http://ena.lp.edu.ua

Results of hydrotechnical concretes investigation. For the optimization we have chosen ten concretes used for the construction of weirs, flood-gates, reservoirs for water and sewage-treatment plants. The concretes contained the mineral or granitic aggregates with size up to 16mm, the Portland cements and the chemical admixtures of following types: waterproofing, water-reducing, air-entraining-plasticizing, accelerating the setting and hardening time, and superplasticizer.

The effects of admixtures used were similar in concrete mixtures and hardened concretes. Table 1 shows the desing demands refering to special hydrotechnical concretes.

Table I

Design demands of hydrotechnical concretes

No of concrete	Name of hydroengineering structure	Desing demands
1	sewage-treatment plant	C30/37 W8F150
2	sewage-treatment plant	C25/30 W6F150
3	sewage-treatment plant	C20/25 W6F150
4	sewage-treatment plant	C35/45 W12F150
5	weir	C20/25 W8F150
6	weir	C25/30 W8F150
7	flood-gate	C30/37 W8F150
8	repair of dam	C20/25 W6F150
9	reservoir for water	C15/20 W8F150
10	sewage-treatment plant	C15/20 W8F150

The issue of optimization formulation. The following optimization criteria were considered:

a) maximum compressive strength of concrete: $f_{cm}(x,y) = \max f_{cm}$,

b) maximum degree of resistance to water penetration: $W(x,y) = \max W$,

c) maximum resistance to water penetration (water penetration through concrete under pressure) – denoted as a minimum water penetration to specimen under pressure from 0,6 to 1,2MPa: $h_w(x,y) = \min h_w$.

d) maximum resistance to frost of concrete (denoted as a minimum percentage mass loss of specimens Δf_{cm} after 150 cyclic of freeze/thaw): $\Delta f_{cm}(x,y) = \min \Delta f_{cm}$,

Decision variables for above objective functions are following:

- x – ratio S/G as a proportion of sand amount to gravel amount in concrete mixture,
- y – ratio W/C as a proportion of water amount to cement amount in concrete mixture,

Decision variables x and y are within following ranges:

$$0{,}360 \le x \le 0{,}641$$
$$0{,}373 \le y \le 0{,}562.$$

Formulation of objective functions. The figures of function from Chapter 3 were obtained as the results of experimental investigations on the base described in Chapter 2. The analytic figures of function: f_{cm}, W, h_w and Δf_{cm} were received as the approximation of experimental results through polynomials of second degree in relation to variables x and y with use of STATISTICA programme [6].

The surface charts of these functions were presented on Fig. 1 ÷ 4. The extremes of considered functions were found with use of MATHEMATICA programme [7].

$$f_{cm}(x,y) = 150{,}105 – 203{,}937x – 235{,}823y - 286{,}282x^2 + 1156{,}564xy - 450{,}064y^2,$$

maximum $f_{cm}(x,y)$:

$$f_{cm} = 43{,}714 \text{ MPa}, \quad \text{for} \quad x = 0{,}641 \text{ and } y = 0{,}561625$$

$$W(x,y) = -7{,}434 + 0{,}749x + 36{,}327y - 15{,}648x^2 + 31{,}849xy - 56{,}732y^2,$$

maximum $W(x,y)$:

$$W = 1{,}06092 \text{ MPa}, \quad \text{for} \quad x = 0{,}489615 \text{ and } y = 0{,}457597$$

Lviv Polytechnic National University Institutional Repository http://ena.lp.edu.ua

$$h_w(x,y) = -225{,}387 + 100{,}509x - 899{,}891y + 29{,}98x^2 - 428{,}707xy - 564{,}892y^2,$$

minimum $h_w(x,y)$:

$$h_w = 5{,}92312 \text{ mm}, \quad \text{for} \quad x = 0{,}641 \text{ and } y = 0{,}373$$

$$\Delta f_{cm}(x,y) = -2{,}884 + 63{,}245x - 38{,}635y - 52{,}838x^2 - 42{,}555xy + 71{,}293y^2$$

minimum $\Delta f_{cm}(x,y)$:

$$\Delta f_{cm} = 0{,}71128\ \%, \quad \text{for} \quad x = 0{,}641 \text{ and } y = 0{,}462267$$

As the preferable solution the point from the set of compromise nearest to ideal point was obtained. Its coordinates fulfil the following condition (the least squares method):

$$\Phi(x,y) = [f_{cm}(x,y)/f_{cm}\max-1]^2 + [W(x,y)/W\max -1]^2 + [h_w(x,y)/h_w\min-1]^2 + [\Delta f_{cm}(x,y)/\ \Delta f_{cm}\min-1]^2 = \min \Phi$$

The solution of above problem was calculated with use of MATHEMATICA programme [7].

The following solution was obtained: $x = 0{,}641$; $y = 0{,}391$.

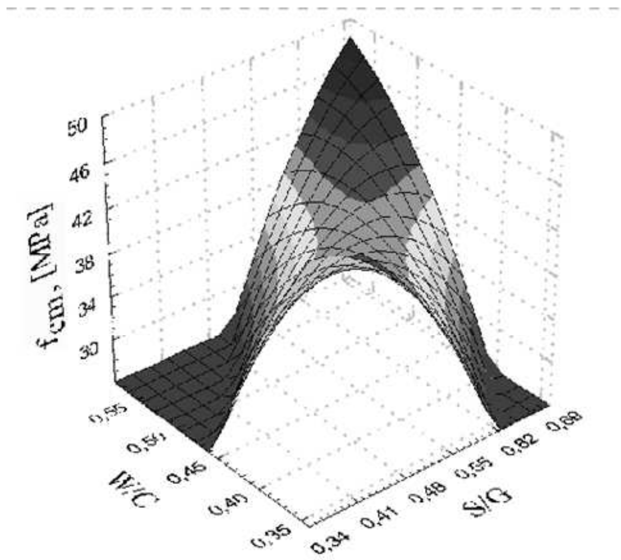

Fig. 1. Variation in compressive strength of concrete (f_{cm}) from ratio S/G and ratio W/C

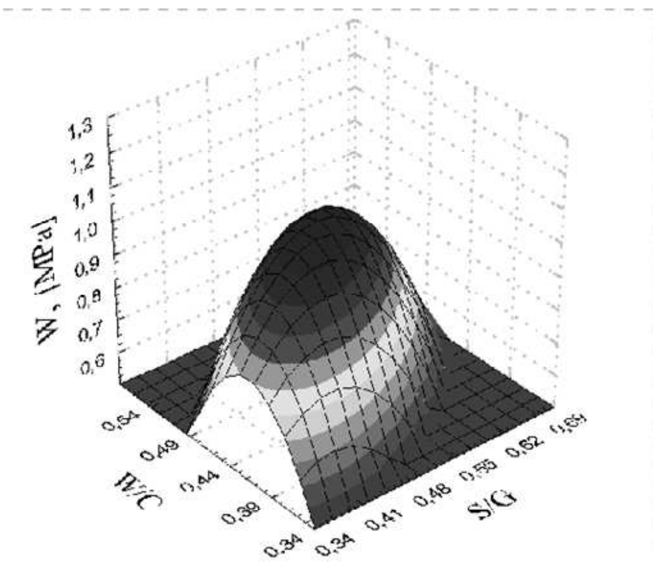

Fig. 2. Variation in degree of resistance to water penetration (W) from ratio S/G and ratio W/C

Lviv Polytechnic National University Institutional Repository http://ena.lp.edu.ua

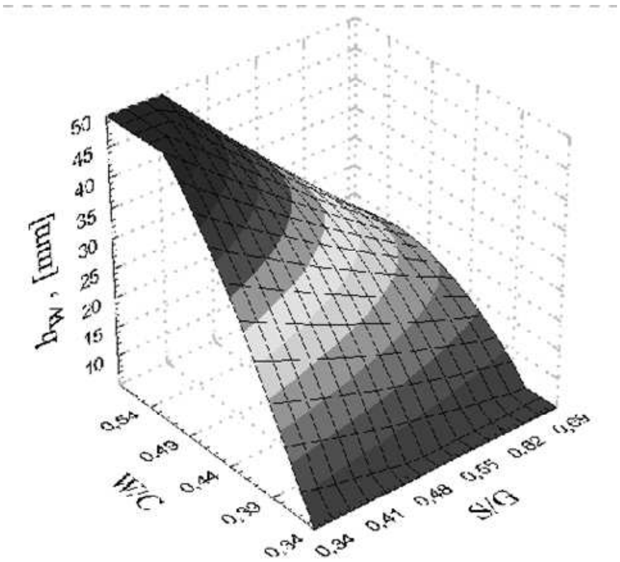

Fig. 3. Variation in depth of water penetration under pressure from 0,6 to 1,2MPa (h_w), from ratio S/G and ratio W/C

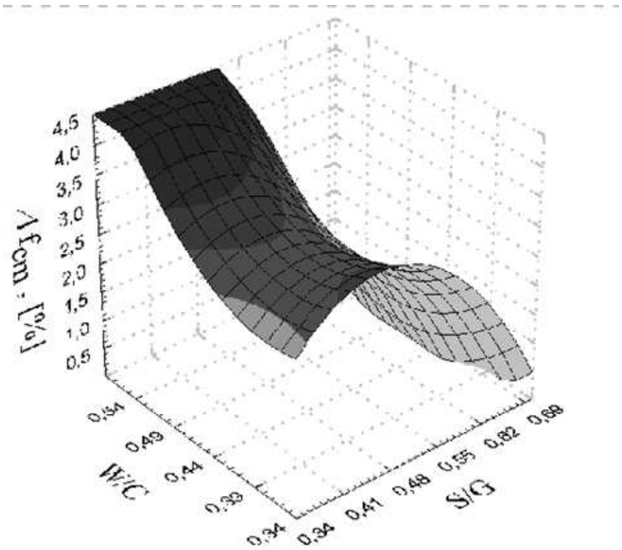

Fig. 4. Variation in mass loss after 150 cyclic of freeze/thaw (Δf_{cm}) from ratio S/G and ratio W/C

Conclusions. The solutions presented permit us to formulate the recipe for optimal hydrotechnical concrete made of mineral or granitic aggregates, Portland cements, water and different type of admixtures. Optimal hydrotechnical concrete implies the greatest compressive strength, resistance to cyclic freezeing/thawing and resistance to water penetration under pressure when the durability of concrete in the environment of water and temperatures' variability is taken into account.

The closest to optimal solution are the recipes of concretes No 1 and No 6, shown in the table 1.

This implies the following recipe for optimal hydrotechnical concrete:

- Portland cement CEM I 32,5 – 361 kg/m^3,
- tap water - 141 kg/m^3,
- gravel 8-16 mm - 625 kg/m^3,
- gravel 2-8 mm - 519 kg/m^3,
- sand - 733 kg/m^3,
- superplasticizer (1,64 %) - 5,87 kg/m^3,
- W/C=0,391,
- S/G= 0,641,

Lviv Polytechnic National University Institutional Repository http://ena.lp.edu.ua

- density of optimum concrete mixture - 2385 kg/m^3.

The solution seems to be fully reliable. It confirms intuitive, subjective opinion abort examination of many kinds of usual and special concretes and applied into the practice of working recipes.

Aggregates were experimentally combined into an optimum aggregate composition – characterized by maximum tightness and minimum water absorbability. The low W/C ratio of 0,391 results from the superplasticizer application into the concretes mixtures.

1. Kapelko A.: Production technology of concrete used in hydrotechnical buildings. Problems of Hydroengineering. 5-th Conference. Wrocław – Szklarska Poręba, 5-7 May 1994 Wrocław: Oficyna Wydawnicza Politechniki Wrocławskiej 1994. Prace Naukowe Instytutu Geotechniki I Hydrotechniki Politechniki Wrocławskiej nr 67, Konferencje nr 34, pp. 71-82 (In English). 2. Kapelko A.: The quality of concrete Works At the first stage of Lipki flap weir Construction. Problems of Hydroengineering 6-th Conference. Wrocław-Szklarska Poręba, May 6-8, 1996. Wrocław: Oficyna Wydawnicza Politechniki Wrocławskiej 1996. Prace Naukowe Instytutu Geotechniki I Hydrotechniki Politechniki Wrocławskiej nr 71, Konferencje nr 38, pp. 233-243. (In English). 3. Kapelko A.: Possibilities of retarding of concrete setting and hardening by the application of chemical admixtures. 7-th Conference Problems of Hydroengineering. Wrocław – Lądek Zdrój, 19-21 May 1999 Wrocław. Dolnośląskie Wydawnictwo Edukacyjne 1999, pp. 215-225. (In English). 4. Dodson V.: Concrete Admixtures, Van Nostrand Reinhold, New York, 1990. (In English). 5. Kapelko A., Kapelko R.: Optimization of composite materials with cement-fly ash matrix.. Archives of Civil and Mechanical Engineering, Vol. V, No.2, Wrocław 2005, pp. 25-34. (In English). 6. Stat Soft, Inc. (1997), STATISTICA for Windows [Computer program manual], Tulsa, USA, WEB: http://www.statsoft.com. (In English). 7. Mathematica 5.0 1988-2003 Wolfram Research WEB: http://www.wolfram.com. (In English).

УДК 624.074.04

Karas S., Slowik M., Demchyna B.*

Lublin University of Technology

*Lviv National Polytechnic University

Department of building structures and bridges

79013, Lviv, S. Bandery Street, 12

THE TENSION IN FLANGES OF FLEXURAL CONTINUOUS REINFORCED CONCRETE BEAM OF A T SECTION

© Karas S., Slowik M., Demchyna B., 2007

The purpose of the paper is to analyze what is the tension stress distribution and how to arrange longitudinal reinforcemenet in web and flanges in flexural beam of the cross section in the shape of a T. In continuous bridge girders it occurs that tension stresses are in flanges. The effective flange width in the case of compression zone is well elaborated and obvious. In the situation when the flanges are in tension there is no any rule in codes and technical literature to arrange the reinforcement in flanges. The observed damages in carry deck of Baranów Bridge over the Wieprz River direct authors to indicate the problem.

Introduction. The bending theory of reinforced concrete satisfies the three fundamental principles of the mechanics of deformable bodies:

– first, the stresses in the concrete and reinforcement satisfy the equilibrium condition,

– second, the linear strain distribution satisfies Bernoulli's hypothesis,

– third, the constitutive laws of concrete and reinforcing bar (as described below) are obeyed.

Lviv Polytechnic National University Institutional Repository http://ena.lp.edu.ua