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HYDROTECHNICS

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ASPECTS REGARDING THE PUBLISHING AND LISTING OF CADASTRAL DATA FOR VERIFICATION BY OWNERS

BY

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Abstract. On the basis of cadastral data collection from the sectors of the administrative territory, the surveyed data is then uploaded into the Database, in the form of graphic and non-graphic/textual representation, corresponding to the Land Register, with a transient or indefinite character. Subsequently, the activity of setting up the final or real cadastre is carried out. Thus, the pattern of the informational flux switching from the data of the declarative cadastre to the data of the final cadastre is presented. This implies the obligation to inform the owners by written letter or by public listings about the land surveying and mapping in places agreed by the Municipality. This action will compare the data held by land owners in ownership documents, with the data of mapping and measurements. This will help them fill in the interview form, it will assist in solving and analysing appeals, and it will update the data by registering and tabulating the latest integrated information in the Land Register, in a realistic and correct manner. The cadastral documentation is prepared on the basis of a framework Protocol of cooperation between ANCPI (The National Agency for Cadastre and Real Estate) and Iaşi Municipality.

This paper presents a series of issues which surfaced at this working stage.

Key words: cadastre; real estate; database; land register; mapping.

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1. Introduction

According to Law nr.7/1996, the general cadastre is a unitary and mandatory system of technical, economic and legal land registration, with the overall objective of identifying and recording on maps and cadastral plans of all land and other properties throughout country, irrespective of their ownership. Basic entities of this system are the plot, the construction and the owner. The general cadastre is organized at the level of each administrative-territorial unit: village, town, city, county and entire country.

The derivative objectives of the Informational System of General Cadastre at municipal level are of great importance, the data and the information serving to a multitude of activities namely

a) presenting in real time of detail data necessary to legal, fiscal and administrative institutions;

b) transmitting synthesized data to directions of statistics and legal authorities on the status and evolution of the land register on counties and the entire country;

c) providing material elements necessary to real estate advertizing materials for the establishing and security of property rights, protection of state public and private domain, reduction of litigations and solving legal conflicts;

d) elaborating studies on land use, environment protection, land resources and other activities extended to large areas;

e) support of political, technical and economic decisions;

f) supporting the development of land market;

g) ensuring transparency through publication of cadastral data;

h) integration of general cadastre in the land register, etc.

The set up of a modern Integrated Informational System of General Cadastre at the level of Iaşi municipality contains a set of procedures and methods grouped within an information flow. It comprises the development of cadastral data collection, data sources, data processing and storage, publication of results for consultation by shareholders and compensation calculation areas, solving/handling appeals, the inclusion in the Land Register as well as web-site publishing.

This model can be implemented as such or it can be adapted to the specific requirements of the administrative units.

2. Stages of the General Cadastre Information System

The most important stages of setting up the informational system of general cadastre at the level of a municipality are presented in Table 1.

Table 1

Nr.	Stage works	Specific operations
1	Preparatory works	Requirements establishing, financing ensuring, permits obtaining, preparing specifications, tendering, signing contracts, etc.
2	Analysis of the actual situation	Analysis of the situation in terms of geodetic and cartographic data base, of the executed works.
3	Preparing overall technical and execution design for the entire activity, based on the field analysis, on the analysis of the existent works and of the size and complexity of the territory	Setting up options in relation to the analysis of the existent status and the technical standards and financial resources. Field and office work
4	Designing, setting up and determining the municipal geospatial geodetic network to integrate in the national system, offset block, in ETRS 89 system and Stereo 70	a) Planimetry 1° basic GPS network; 2° main polygonometric/polygonal network; 3° secondary polygonal network; b) Levelling rehabilitations, modernization and thickening of precision levelling network
5	Delineation of borders and territory marking of administrative territory, the perimeters inside, terrain and other destinations that occupy large areas	a) Outside the city boundary cadastral administrative delineation of the municipality and the neighbouring villages according to Law: *7*/96 and *2*/68 on delineation of each administrative unit b) Inner boundary determining the perimeter of built city
6	Flight project to obtain orthophotoplan at the scale 1:500	Flight designing plan Approval Flight obtaining permits Flight
7	Determining geodetic thickening points to support network, necessary for the topographic survey and photogrammetric determination	Field work and calculations
8	Processing photogrammetric image	
8.1	Photogrammetric determining activity	Photogrammetric mapping
8.2	Aero triangulation	Aerotriangulation. Creating aerotriangular bands or blocks of aerotriangulation by binding patterns or adjacent bands
8.3	Designing orthophotoplan on scale 1:500	Processing specific to design of orthophotoplan on scale 1:500

Table 1
Continuation

8.4	Designing restored plan on scale 1:500	Vectorization based on orthophotoplan and designing restored plan on scale 1:500
9	Zoning and cadastre sectori-zation	Zoning and sectorisation of administrative territory, according to norms. Thus, 28 traditional zones are obtained (Copou, Ciric, Păcurari, etc.) and 303 cadastre sectors, arondated to the 5 city hall's neighbourhood centres and GIS headquarters
10	Cadastral numbering and marking the types of actual land use with symbols	Manual and/or automatic procedures
11	Field measurements to design the basic topographic plan, by completing the restored plan	a) Integration by classic measurements with or without automatic devices (electro-optical) b) Repers and photogrammetric decryptions for new plans
12	Drawing up field original plans based on new measurement or by deriving them from the basic topographic plan	a) Drawing up field originals based on measure-ments b) Based on copies after field originals and, whe-never possible, of photogrammes
13	Gathering textual and descriptive data for real estate fund. Identifying owners and use categories of the land	a) Based on printed copies of derived cadastre plans b) Based on copies of the field original and, if possible, of photogrammes c) Based on ownership documents d) Registering in specific forms
14	Downloading data files and organising the data base of the general cadastre for the municipality	a) Offline b) Online
15	Calculation and compen-sation of areas	a) By coordinates obtained through classic and/or automatic measurements b) By coordinates obtained through analytic photogrammetric measurements
16	Publication of cadastre data	a) Notifying the owners through media b) Drawing up lot plan on sectors c) Drawing up lists of owners on sectors d) Publication of cadastre data on sectors in established locations e) Validating documents of the owners. Desig-ning an Interview Form f) Writing appeals by the owners g) Finding solutions and sending them to the commission h) Ensuring transparency of data. SCADIF ap-plications and file of real estate

Table 1
Continuation

17	Cadastre documentation up-dating	a) Checking the closure of areas on cadastre quarters/sectors b) Checking closure of inside border areas c) Checking closure of outside border areas
18	Presenting data to Real Estate Office (OCPI, Iaşi)	Finishing data processing and presenting data to Real Estate Office: a) Setting up the collective land register b) Setting up the individual land register c) Upgrading Urban Data Bank
19	Verifying information cohe-rence of data. Importing data in GIS system	Verifying information coherence of data
20	Writing cadastre registries using data automatic processing and printing devices of output data	a) File of real estate units b) Land register of owners c) Land register of lots d) Land register of real estate e) Alphabetical index of owners
21	Mapping and editing general cadastre plan of the administrative unit and multiplying it in the necessary number of copies	a) Drawing up the trapeze grid b) Editing. Automatic procedures
22	Control, reception and approval of introducing general cadastre	Order of ANCPI President

At the end, after the necessary verifications and approvals, the documentation follows the formalities of real estate publicity, that is registering the buildings in the permanent Land Register. Only in this way the system can and will effectively become the guarantee of the ownership rights according to the Constitution.

3. Publishing Cadastral Data in Order to Check and Complete Information on Real Estate and Owners

The stage of publishing cadastral data contains two types of activities, developed at the same time.

3.1 Activities to Complete the Temporary Cadastre Plan

Gathering cadastral data must be finalized by elaborating some temporary cadastre documentations. This attribute of temporary is owed to the fact that for some of the buildings, the data will be gathered from temporary documentations at the Real Estate Office, and for others these are gathered from the Economic and Local Public Finance Direction, the Agricultural Registre, the property laws and from statements of the owners.

Thus, the stage of gathering data for cadastre sectors and uploading them in the Urban Data Bank, as graphic and non-graphic registration, represents the stage of setting up the temporary Land Register. This stage is necessary as the owner of the real estate gains and retains ownership rights on the real estate.

The temporary registration, by which a real estate ownership right is aquired, modified and erased, is done under condition and to the extent that it is justified, representing a conditioned or imperfect tabulation. The aim is to confer the attribute of real when it will be changed to permanent registration.

3.2 Activities to Set Up the Permanent Cadastre Plan

Completion of gathering cadastre data on various sectors grouped in one area and processing them lead to the beginning of activities in relation to the set up of real/permanent cadastre. All these activities start by publication of cadastre data and have as objective the comparison of declarative cadastre data to the real cadastre data, based on authentic ownership documents, data which will be the base of registring the real estate in the permanent Land Register.

This stage implies the following activities:

a) Informing real estate owners on the publication of cadastre data. This is done by mass-media and the official site of the City Hall, in a simple and easy to understand language concerning the purpose and importance of this activity, as well as the expected advantages at the level of each owner and at the level of the municipality.

b) Publication of lot plans for the processed sectors was already done at the neighbourhood centre of the city hall, in a large room with a good visibility of documentations.

c) Identifying real estate by the owners. The Protocol between ANCPI and the City Hall provides that the publishing of cadastre data for verification and approval of owners is done in compact groups of 10…12 cadastre sectors. The information flow is shown in Fig. 1.

d) comparison of data obtained through measurement and declarative data, with the data in the authentic ownership documents. After identifying the lot and identification elements of the lot and the owner, the borders and neighbourhoods will be checked. In case of differences between the existence, location, area, land category, ownership documentation, legal status of real estate, then the owners will fill in the Interview Form, without filling in data on the measured surface.

In case owners do not possess the temporary cadastral documentation or ownership documents they will fill in the Interview Form even if they are not on the list. Their appeal will be done by filling in a special form.

e) Analysis of appeal and answers from the commission.

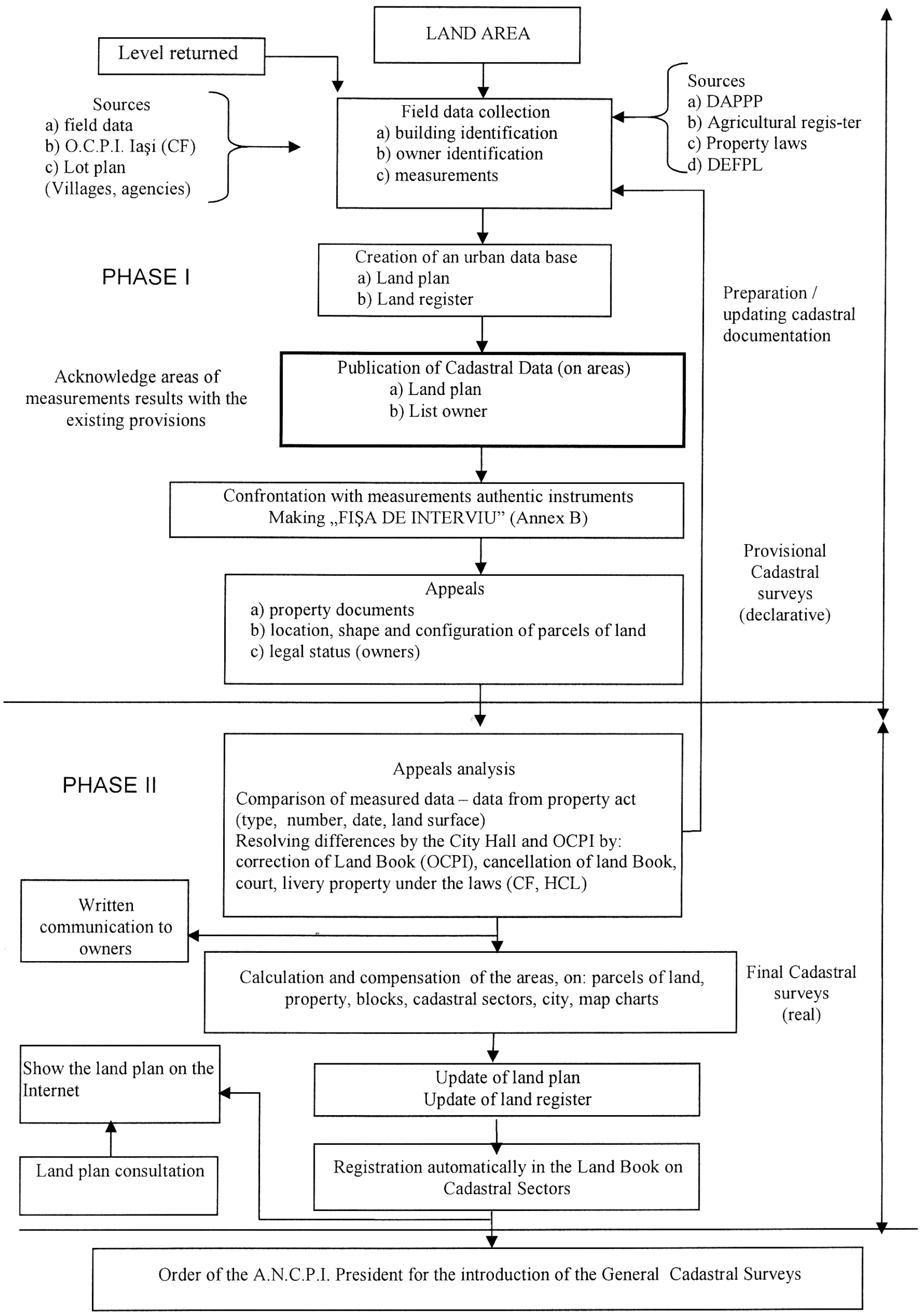
LAND AREA
Level returned
Sources
a) field data
b) O.C.P.I. Iaşi (CF)
c) Lot plan
(Villages, agencies)
Field data collection
a) building identification
b) owner identification
c) measurements
Sources
a) DAPPP
b) Agricultural regis-ter
c) Property laws
d) DEFPL
PHASE I
Creation of an urban data base
a) Land plan
b) Land register
Preparation / updating cadastral documentation
Acknowledge areas of measurements results with the existing provisions
Publication of Cadastral Data (on areas)
a) Land plan
b) List owner
Confrontation with measurements authentic instruments
Making „FIŞA DE INTERVIU" (Annex B)
Provisional Cadastral surveys (declarative)
Appeals
a) property documents
b) location, shape and configuration of parcels of land
c) legal status (owners)
PHASE II
Appeals analysis
Comparison of measured data – data from property act (type, number, date, land surface)
Resolving differences by the City Hall and OCPI by:
correction of Land Book (OCPI), cancellation of land Book, court, livery property under the laws (CF, HCL)
Written communication to owners
Calculation and compensation of the areas, on: parcels of land, property, blocks, cadastral sectors, city, map charts
Final Cadastral surveys (real)
Show the land plan on the Internet
Update of land plan
Update of land register
Land plan consultation
Registration automatically in the Land Book on Cadastral Sectors
Order of the A.N.C.P.I. President for the introduction of the General Cadastral Surveys

Fig. 1

The commission is made up and approved by the territorial office, according to legal provisions. The appeals, according to art. 1, align. (6) of Law 7/1996, republished, will be solved in 60 days. After solving the appeals and correcting the lot plans and the Urban Data Bank, it will inform those interested that that lot plan is updated.

f) Verifying inclusion of land areas on cadastral sectors. The calculation of areas is performed analytically, by coordinating the points of the borders of the administrative territorial unit (perimeter of outborder and inborder domain, subdivided on cadastral sectors), of real estate units and lots after processing field and office data. The values of areas registered in the general cadastre documents are measured in square meters.

The calculated and registered areas in the general cadastre can differ from the areas registered in ownership documents. The owners will be informed on potential differences and can contest them, according to legal provisions.

To control areas the following aspects will be considered:

a) the sum of lot areas in ownership documents equals the calculated sum of areas of lots, constraints;

b) the sum of real estate areas equals the calculated sum of cadastre sectors;

c) the sum of cadastre areas equals the calculated sum of inborder and outborder domain.

4. Presenting Data to OCPI to Complete the Permanent Land Register

The documentation will be presented in two stages:

1° The technical documentation on the whole administrative territory, constituted by namely

a) the general technical project and the execution project;

b) the delimitation of administrative territory;

c) the geodetic data (point networks, descriptions, processed data, etc.);

d) photogrammetic data.

2° Cadastre technical documentations on cadastre sectors, according to the project of finalising the stage, constituted by

a) technical descriptive documents;

b) cadastre plan of the sector, drawn up according to the pre-established specifications;

c) printed registers;

d) alphabetic index of owners;

e) files of the graphic and text data bases, in the required format and organisation;

f) list of ownership documents unregistered correctly;

g) the external checking file of the paper.

The new Land Registers will open on stages, on cadastre sectors, after solving all the appeals, according to Law of Cadastre and Real Estate nr.

7/1996, republished. After the technical reception of the general cadastre on a certain cadastre sector, the new buildings will receive cadastre numbers, continued from the numbers registered in the general cadastre.

The final documentations will be the collective Land Register and the individual land register.

In case the properties are common or in severalty, all the owners will be registered, indicating the individual property of each owner.

The GIS municipality real estate can be accessed by all those concerned, using an application designed by Iaşi municipality, SCADIF – Informational Cadastre System, online, according to legal provisions.

The application has as main objective the presentation of the information plan of the municipality to obtain cadastre data, with reference to real estate, which can be temporarily accessed on www.5psolutions.eu/gis. The web presentation site, designed in GML, is characterized by the following conceptual characteristics:

a) it uses a map server which generates the images of the plan;
b) an interactive plan loading images generated by mapserver;
c) conversion from .dmg, .dxf in .shp, .dbf;
d) interrogation using various fields;
e) manages three graphic levels (artery, lot, building);
f) user interface, etc.

The functions presentation is done in submenus within a horizontal bar, and can be accessed by clicking on each: home, about application, FAQ, Plan of Iaşi. After visualizing the informational plan of Iasi municipality the building can be accessed, searching after address or unique cadastre code, and can be visualized in location, geometric configuration and type of ownership.

The main console comprises the informational cadastre plan, the thematic levels and work options for those; the area can be identified by a red rectangle delineating it. The main area presents work options with the functions: search building (street, building, cadastre entity, selecting number in the updated address plan of the municipality, cadastre number). The scale of the plan has two options: zoom and plan editing on standard scale, 1:500. At printing, there are printing options to introduce elements refering to scale, projection system (Stereo 70 or UTM), format (A3 or A4), type of printer, etc.

The edited document is official, bears the header of the City Hall, GIS Direction – Cadastre, electronic signature of the director, editing date and address.

Taking into account that the set up of a national cadastre presupposes an important number of activities, on a relatively large time expanse, the cadastre works cannot be finalized at the same time and in a short period of time, especially in the case of large administrative units, cities and municipalities; Law 7/1996 makes provisions for a gradual and progressive introduction of the new system of real estate publicity. Thus, this system is based on the final Land Registers, at the finalizing of cadastre activities in each administrative unit.

Until the Land Registers are finalized they will become functional on cadastral areas/sectors, along with the traditional publicity and registration system, respectively the temporary Land Registers.

The paper presents the stages and concrete activities to set up the Informational System on the procedures and methods, grouped within an informational flux on gathering cadastre data, data sources, processing and stocking the data, results publication to be consulted by real estate owners, calculation and compensation of areas, solving appeals. Thus, the data will be registered in the final Land Register and cadastral data will be published on the internet.

The application SCADIF (Informational CADastral System), a specialized web application, permits online consultation of information on own real estate from each owner. The model can be implemented as such or can be adapted to concrete requirements of the administrative territorial units intending to implement the system.

5. Conclusions

The publication of cadastre data to be consulted by real estate owners allowed the following aspects to be noticed:

1. The publicity and data display at the City Hall's neighbourhood centres was done in local mass-media, informing on the numbers of cadastral sectors, quarters, streets etc., as well as the working agenda (calendaristic period, consultation hours, interview forms, authentic ownership documents, etc.).

2. The activity started on 20.05.2009, at present being in the 5th stage (18.03.2010…18.05.2010), the area representing approximately 4,000 ha. The last two stages will take place during June – August 2010, the remained area summing up to 1,200 ha.

3. Within each stage, the owners had a legal time span of 60 days to check the data accuracy and write down complaints.

4. Data publication was done, simultaneously, on sectors from inside border and outside border areas, starting from the west side of the city, each sector conforming to the specific location.

5. All real estate owners, after consulting the lists and the lot plan, with technical assistance, filled in the interview form, in the presence of specialists from the City Hall. An important percentage was noticed in absence of authentic ownership documents.

6. The presence at the accuracy checking of cadastral data of the owners was in general low, of approx. 20%. Though, a part of the absent owners later presented at the City Hall, at the GIS Direction, to fill in the interview form and the complaints.

7. The commissions analysing the complaints met only once, due to lack of personnel. Moreover, the land register office did not elaborate permanent tabulations.

8. Some of the most severe difficulties are the differences between the areas as appear in documents and areas measured and represented on the cadastral plan, overlapping of real estate in case of different owners, lack of concordance of neighbours of real estate, absence of real estate in the lot plan, although there was a formal sheet possession, absence of percentage of severalty for each owner, lack of concordance of addresses, etc.

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ASPECTE PRIVIND PUBLICAREA ŞI AFIŞAREA DATELOR CADASTRALE, ÎN VEDEREA VERIFICĂRII ACESTORA DE CĂTRE DEȚINĂTORI

(Rezumat)

Pe baza culegerii datelor cadastrale pe sectoare ale teritoriului administrativ, se face încărcarea lor în Baza de Date, sub formă de înregistrări grafice şi nongrafice/textuale, care corespund Cărții Funciare cu caracter nedefinitiv. În continuare, se desfăşoară activitatea de realizare a cadastrului definitiv/real. Se prezintă modelul fluxului informațional pentru trecerea de la datele cadastrului declarativ la datele cadastrului definitiv. Aceasta presupune obligația aducerii la cunoştința deținătorilor, prin înştiințare scrisă şi prin afişare la locațiile stabilite de către Primărie. Prin această acțiune, se realizează confruntarea de către deținători a datelor din măsurători şi a celor declarative, cu datele din actele de proprietate, completarea fişei de interviu, analiza şi rezolvarea contestaților, actualizarea cu datele rezultate şi înscrierea/intabularea în Cartea Funciară cu caracter definitiv. Documentația cadastrală definitivă se întocmeşte pe baza Protocolului cadru de colaborare intervenit între ANCPI şi Primăria Municipiului.

În lucrare sunt prezentate o serie de probleme ce apar în această etapă de lucru.

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DETERMINATION AND MONITORING OF THE INCLINATION OF TALL BUILDINGS OF CIRCULAR CROSS SECTION USING HIGH PRECISION GEODESIC MEASUREMENTS

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Abstract. Tower-type tall buildings undergo geometrical axis tilts from the vertical due to differential settlements of foundations and grounds, uneven heating by sunlight, strong winds action, earthquakes, etc. Regarding this problem, during execution and after commissioning, observations and measurements of the tall buildings geometrical axes verticality should be done, aiming to ensure fitness in use. The way to determine the tilt axis of circular cross section tall buildings by high precision cyclic measurements of geometrical leveling is shown.

Key words: geometric leveling; monitoring; deformations; inclination; landmarks.

1. Introduction

The activity of tracking *in situ* the behaviour of buildings in execution and in operation, is in fact a special type of attempt, generated by the need to ensure safety in operation, the basic requirement being often fulfilled for scientific purposes. In this case, the building loading is just the real operation loading, but the loading time is much longer.

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It comes out that *in situ* behaviour monitoring of buildings merges together the behaviour tracking, discovering the discrepancies with the expectations and the eliminating interventions, in order to ensure the operation fitness (Hann, 2008).

Since geodetic, trigonometric and leveling methods only allow to analyse the buildings behaviour depending on the nature and size of deformations and tilts, they should be also, compulsorily, corroborated with other other data such as the study of groundwater regime, land mechanics, operating conditions, etc., in order to discover the causes of evolutive phenomena occurence and establish possibilities to mitigate, stop or remove these.

The paper shows the way to determine a chimney axis tilt in the industrial platform of a company.

2. Presentation of the Method and Technology for Data Measuring and Processing

Monitoring of the behaviour of concrete industrial exhaust towers was made as based on a special tracking project using high precision cyclic measurements of geometrical leveling. The study was made at the occurrence of a settlement of the ground adjacent to the chimney, due to floods in the neighboring hall. It is mentioned that the objective was founded at –9 m in the layer of ballast.

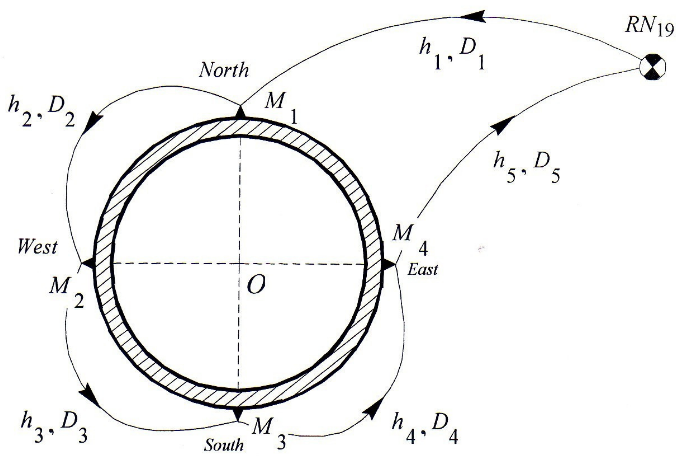

Fig. 1 – Layout sketch of the settlement marks and of the fixed landmark, including the track of the geometrical leveling sections.

Based on the project, the site was chosen and a number of four settlement marks, labelled M_1, M_2, M_3 and M_4, were attached to the chimney on the perpendicular directions as well as a fixed depth landmark, labelled RN_{19} (Fig. 1).

The settlement marks have been built in at about 0.70 m soil depth, representing bracket wall marks.

The fixed depth landmark was made by drilling with the role of achieving and maintaining the horizontal comparison / reference plane against which marks rates are determined in each cycle.

In each cycle of observations high precision measurements of geometrical leveling were made, by obeying the execution prescriptions of the geometrical leveling – State geodetic, of the orders *I* and *II*. The measurements were done using a Zeiss Dini 10 Digital level and the staff with a 1.75 m invar band, with barcode, ensuring a readings accuracy of 0.10 mm on the staff. In each measurement cycle, from the zero/initial cycle, settlement marks rates were calculated, depending on the fixed mark rate and average level differences, measured on each section, as obtained by two horizons of the device.

The balanced rates of the *j* settlement mark, obtained in two cycles of measurements, initial and current, are expressed by the relations (Nistor, 1993; Nistor & Nistor, 2007)

$$H_j^0 = H_{19} + \sum_{i=1}^{n} (h_i^0 + k_{h_o} D_i), \tag{1}$$

$$H_j^t = H_{19} + \sum_{i=1}^{n} (h_i^t + k_{h_t} D_i), \tag{2}$$

where: $i = \overline{1,n}$ – the number of measurements; $j = \overline{1,n-1}$ – the number of settlement marks; $t = \overline{1,N}$ – the number of cycle of observations.

In the relations (1) and (2) the following entries were made:

a) temporary level differences on each section, obtained as the arithmetical mean of the measured values with the two horizons

$$h_i^0 = \frac{1}{2}(h_i^{0,I} + h_i^{0,II}),\ h_i^t = \frac{1}{2}(h_i^{t,I} + h_i^{t,II}); \tag{3}$$

b) section lengths, D_i, [m];

c) closing errors on the fixed landmark rate

$$f_{h_0} = \sum_{i=1}^{n} h_i^0\ ;\ f_{ht} = \sum_{i=1}^{n} h_i^t\ ; \tag{4}$$

d) unitary corrections sizes, corresponding to the two cycles

$$k_{h_0} = -\frac{f_{h_0}}{\sum_{i=1}^{n} D_i}\ ;\ k_{h_t} = -\frac{f_{h_t}}{\sum_{i=1}^{n} D_i}\ . \tag{5}$$

By means of the settlement marks rates, *the partial vertical deformation sizes*, produced between two conjugated cycles have been calculated using relation

$$\Delta H_j^t = H_j^t - H_j^{t-1} \ , \tag{6}$$

where j is the settlement mark number ($j = \overline{1,4}$); t – the current measurement cycle number; $(t - 1)$ – the previous cycle number.

At the same time, *the total vertical deformation sizes* have been calculated as the difference between the current cycle rates and the zero/initial cycle ones, with the relationship

$$\Delta H_j^t = H_j^t - H_j^0 \ , \tag{7}$$

The vertical deformations, called *settlements* for the negative values and *raisings* for the positive ones, have been included in the settlement charts beginning with the current cycle. It should be emphasized that the vertical deformations sizes, expressed in millimeters, include two components: a component due to the chimney behaviour, which is bigger, and a a component due to random errors, inherent to the measuring process having a lesser size.

Corresponding to each cycle, based on the vertical deformations of the settlement marks, on the two perpendicular directions, $M_3 - M_1$ and $M_4 - M_2$, differential settlements are calculated with the relations

$$\Delta H_{31}^t = \Delta H_1^t - \Delta H_3^t \ , \ \Delta H_{42}^t = \Delta H_2^t - \Delta H_4^t \ . \tag{8}$$

At this stage, on the chimney height, H, and the distance between the settlement marks, D (the outer diameter of the chimney on the marks level), *the perpendicular components of the axis tilt* from the vertical (Fig. 2) are calculated with the relationships

$$q_1^t = \frac{H}{D}\Delta H_{31}^t \ , \ q_2^t = \frac{H}{D}\Delta H_{42}^t \ . \tag{9}$$

It is worth mentioning that H and D sizes will be determined by the method shown by Nistor & Nistor (2007) and Onu (2009).

Finally, based on components (9) in each cycle of observations, *the tilt resulting vector sizes*, at the top of the chimney, and orientation in the plane, are calculated (Figs. 2 and 3):

$$L^t = \sqrt{\left(q_1^t\right)^2 + \left(q_2^t\right)^2} \ , \ \theta_{L^t} = \arctan\left(\frac{q_2^t}{q_1^t}\right). \tag{10}$$

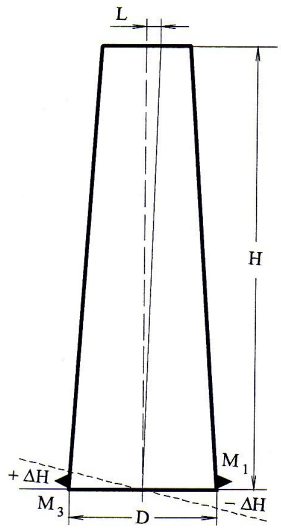

Fig. 2 – Tilt vector (elevation).

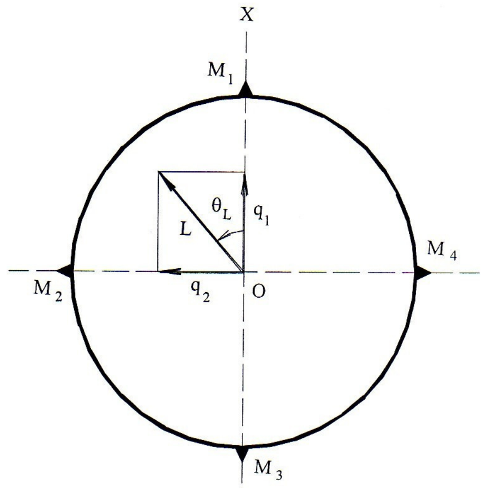

Fig. 3 – Components, tilt vector and plane orientation.

3. Results Accuracy Assessment

Correct evaluation of results is possible based on the mean square error of the chimney vector tilt. With this view, it is proceeded as follows:

The mean square errors of the vertical deformations in the settlement marks, expressed by (7) are calculated with the relation established by Nistor & Nistor (2007)

$$s_{\Delta H_j^t} = \pm\frac{1}{2}\sqrt{n_j(n-n_j)\sum_{i=1}^{n}(d_{0i}^2 + d_{ti}^2)}\ , \tag{11}$$

where: n is the total number of the leveling stations; n_j – the total number of stations from the fixed landmark to the envisaged settlement mark, $j=\overline{1,n-1}$; d_{0i} and d_{ti} – the deviations between the level difference sizes measured with the two horizons of the device in the station points i, ($i=\overline{1,n}$), expressed by:

$$d_{0i} = h_i^{0,I} - h_i^{0,II};\ d_{ti} = h_i^{t,I} - h_i^{t,II}. \tag{12}$$

The mean square errors of the differential setlements (8), for each cycle, for the direction $M_3 - M_1$, will be

$$s_{\Delta H_{31}^t} = \pm\sqrt{s_{\Delta H_1^t}^2 + s_{\Delta H_3^t}^2} \approx \sqrt{2}s_{\Delta H_1^t}, \tag{13}$$

and for direction $M_4 - M_2$

$$s_{\Delta H_{42}^t} = \pm\sqrt{s_{\Delta H_2^t}^2 + s_{\Delta H_4^t}^2} \approx \sqrt{2}s_{\Delta H_2^t}. \tag{14}$$

The mean square errors of the tilt vector components, (9), will be:

$$s_{q_1^t} = \frac{H}{D}s_{\Delta H_{31}^t};\ s_{q_2^t} = \frac{H}{D}s_{\Delta H_{42}^t}. \tag{15}$$

Consequently, *the mean square error of the tilt vector* is calculated. For the observations cycle *t*, ($t = \overline{1,T}$), the error will be

$$s_{L^t} = \pm\sqrt{s_{q_1^t}^2 + s_{q_2^t}^2} \approx \sqrt{2}s_{q_1^t}. \tag{16}$$

The confidence interval within which the real value of the tilt vector will be found, with the probability P = 68.3%, corresponding to the mean square error, will be expressed by the double inequality

$$L^t - s_{L^t} \le \overline{L^t} \le L^t + s_{L^t}. \tag{17}$$

4. Case Study

Tracking the behaviour of a chimney, having the height H = 65 m, and the length of the outer diameter, D = 9 m, on the level of the settlement marks is shown. The settlement marks M_1, M_2, M_3 and M_4 have been materialized by cast-iron bracket parts, on two perpendicular directions (Fig. 1). The reference plane, against which the level differences were cyclically measured by middle geometrical leveling with two horizons of the device was considered the fixed depth landmark, RN_{19}, built about 50 years ago.

Tracking has imposed, as important settlements occurred in the ground adjacent to the chimney, near a rolling mill, as a result of a flood produced in the neighboring hall. It was estimated that the important settlement of the ground would have been produced by the chimney

The study presented includes only the results obtained between cycles no. 6 (7/30/2002) and no. 10 (18/06/2004). Based on settlement marks rates the vertical deformations, settlements or raisings, of the five measurement cycles were calculated, as shown in Table 1, columns 2...5.

Based on the vertical deformation in each mark, in each cycle were calculated, first of all, the differential settlements (8), between the marks placed on the two perpendicular directions, $M_3 - M_1$ and $M_4 - M_2$, shown in Table 2, columns 2 and 3.

By their means, height H and the outer diameter D on the marks level, the component sizes (9), columns 4 and 5, the sizes of the tilt vectors tilt of the geometrical axis from the vertical and their orientation in plane, columns 6 and 7, were calculated (Table 2).

Table 1

Cycle No.	Date	Vertical deformations ΔH_i^t, [mm]			
		Settlement marks			
		M_1	M_2	M_3	M_4
0	1	2	3	4	5
6	30.07.2002	–2.40	–1.50	+1.46	+0.75
7	30.01.2003	–7.29	–8.17	–2.91	–3.72
8	01.07.2003	–6.68	–8.24	–2.92	–4.99
9	21.01.2004	–9.04	–7.10	–4.28	–3.18
10	18.06.2004	–8.10	–7.85	–2.64	–3.17

Table 2

Cycle No.	Date	Differential settlements		Vector components		Vector tilt	Vector tilt orientation
		ΔH_{31} mm	ΔH_{42} mm	q_1 mm	q_2 mm	L mm	θ_{L_t}, [g,c]
0	1	2	3	4	5	6	7
6	30.07.2002	–3.86	–2.25	–27.45	–16.00	31.77	33.60
7	30.01.2003	–4.38	–4.45	–31.15	–31.64	44.40	50.50
8	01.07.2003	–3.76	–3.25	–26.74	–23.11	35.34	45.37
9	21.01.2004	–4.76	–3.92	–34.31	–28.31	44.48	43.92
10	18.06.2004	–5.46	–4.68	–38.83	–33.28	51.14	45.11

Fig. 3 graphically shows the tilt vector and its plane orientation, on a 1:2 scale, corresponding to cycle 10 of observations. A rectangular system of axes was chosen, in which the X-axis coincides with the $M_3 – M_1$ direction.

5. Conclusions

Based on the results, it was found that the size of vertical deformation (settlements) are small, as well as those of the tilt vectors, including keeping the direction of tilt. These lead to a fair appreciation of chimney no. 2 behaviour, from the rolling mill 16", in the two years in which the behaviour study continued. In such situations, after nearly 50 years of operation, it can be said that its vertical position was stabilized. It is therefore advisable to check the verticality of the chimney by a trigonometric method, for example by performing cyclic measuring of horizontal and vertical angles, from the end points of a fixed length base (Nistor, 1993).

Also, provided that only the leveling method is used, it is necessary to carry out two fixed reference points, especially when both are fixed surface reference points. This will allow permanent, cyclical monitoring of the reference plane stability on the vertical, against which measurements are made.

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DETERMINAREA ŞI MONITORIZAREA ÎNCLINĂRII CONSTRUCŢIILOR ÎNALTE, CU SECŢIUNI CIRCULARE, PRIN MĂSURĂTORI GEODEZICE DE ÎNALTĂ PRECIZIE

(Rezumat)

Construcţiile înalte de tip turn suferă înclinări ale axelor geometrice faţă de verticală, datorate tasărilor diferenţiate ale fundaţiilor şi terenurilor, încălzirii neuniforme de către razele solare, acţiunii vânturilor puternice, seismelor etc. În acest sens, în timpul execuţiei şi după darea lor în exploatare se impune executarea de observaţii şi măsurători asupra verticalităţii axelor geometrice ale construcţiilor înalte, având ca scop asigurarea aptitudinii pentru exploatare. Se prezintă modul de determinare a înclinării axelor construcţiilor înalte cu secţiuni circulare prin măsurători ciclice de nivelment geometric de înaltă precizie.

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NEW AUTOMATION AND MONITORING TRENDS OF CONSTRUCTIONS *IN SITU* BEHAVIOUR

BY

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Abstract. Monitoring constructions' *in situ* behaviour includes the tracking and analysis of their technical and functional evolution and the interventions on them in order to rectify the determined behaviour deficiencies. Safety in exploitation is a prerequisite and imperative aiming at performances such as physical and chemical resistance of materials and constructions structure, the shape and position stability, deformability, elasticity, etc. An important part in this complex process has the high precision geodetic methods.

The present paper features an automation and monitoring system of the *in situ* behaviour of massive constructions, where the geodetic measurements become the components of a type of informatic technology, as part of the Artificial Intelligence developed in recent years all over the world.

Key words: monitoring; behavior; geodetic; measurements.

1. Introduction

In situ behaviour of construction is a phrase defining the manifestation of physical and chemical transformations which they undergo in the processes of interaction with the ambient, natural and technologic environment. Knowing the causal and conditional laws of occurrence and development of the

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constructions' behavioural phenomena allowed and still allow defining some behavioural features. These features can be defined qualitatively by attributes or quantitatively through sizes and parameters; if it refers to existent constructions they are considered as being completed. Thus the settlement, cracking, deformation, state of effort, etc., are used to define some behavioural properties such as physical and chemical resistance, stability, the motion, hydrothermic and acoustic comfort.

Knowing the behaviour of *in situ* constructions provides the possibility to assess the attitude towards constructions' exploitation.

By definition, the monitoring of *in situ* behaviour of constructions comprises the following and evolution of their technical and functional condition and interventions on them in order to rectify the determined behaviour deficiencies.

Organizing the follow-up of *in situ* constructions is made in two ways: a *current follow-up* with simple, usual observation and measurement technical means and a *special follow-up* based on certain risk criteria performed by qualified and competent individuals or companies using specialized techniques after a special monitoring project. In these complex and important operations, the National Commission has a very special place. *In situ* behaviour of constructions, professional non-profit association that supports the need to preserve the built fund based on knowing the *in situ* behaviour of constructions and their monitoring in order to assure their suitability for exploitation.

Within the monitoring methods of *in situ* behavior of construction the geodetic measurements are widely used. The high precision of performed measurements, data processing methods and estimation of results' accuracy represent a basic system in the extensive process of studying the constructions, in many ways being irreplaceable. In the same time, geodetic measures do not exclude the physical methods of studying the constructions but are closely linked and interconnected.

In this paper we have presented some aspects of automation, monitoring and *in situ* behaviour of massive constructions using expert systems in which the data of the geodetic measurements, along with the measurements made by devices installed on the construction or inside it, become the components of a type of informatics, as part of the artificial intelligence.

2. The Presentation of the Expert Systems for the Automation and Monitoring of Constructions *in situ* Behaviour

Monitoring *in situ* behaviour of construction represents a special test generated firstly by the need of assuring safety in exploitation, this basic desideratum being completed by specific purposes. Monitoring the behaviour refers to the cyclic determination of position and shape changes of the construction but also to take notice if some progressive phenomena which may affect the safety of the construction occur. This allows taking immediate measures to prevent accidents, disasters and loss of human lives. That is why monitoring of *in situ* behavior of technical constructions should be well organized, made by specialists with a solid scientific and technical training using devices and methods that assure an adequate precision according to the requirements imposed by such works

Until now, the data regarding *in situ* behaviour of constructions were obtained either permanently in the case of physical methods, using measurements and control devices set on massive construction or inside it (weight dams), or in observation cycles, the intervals between them increasing according to time of operation, as the construction is stabilized. Based on the processed data, periodical analyses regarding the numerical values of the parameters that characterize the construction in certain conditions of stress were carried out.

In recent decades, Artificial Intelligence has developed as a distinct field of computer era. Part of it, the expert systems have polarized the interest of specialists especially because of the important perspectives for application in various fields.

Regardless of whether the final option in making a choice and implement the decision will be up for an expert, covering some previous sequences of the decisional process in due time and with minimum costs as well as the evaluation of thousands of possible combinations between the variables of a problem are not possible without the help of a computer. Contrary to the initial concepts which considered that the development of expert systems could replace the experts in various fields, for example in supervising massive hydrotechnical constructions, it paws proved that without the best experts is not possible to develop expert systems. Moreover, it was found that even if the expert is assisted in making strategic or valuable decisions, using this type of informatic technology provides the employee who has a general training the possibility of performing activities specific for some distinct specializations.

The question is how can a program assist a specialist in the field to interpret the resulting data in order to make a decision? In this respect, there are two ways of approach, namely

a) It is possible to create a program to choose the most plausible decision from several variants, all data being derived from measurements? This decision can be verified through evolved methods and if it is invalidated the program can suggest another variant, the final decision belonging exclusively to the specialist. This model has no mathematical foundation being a matrix which comprises theoretical knowledge and personal experiences. It is rarely used.

b) A second possibility is to approach the program which assists an expert by simulating the specialist's reasoning. The program will incorporate knowledge pieces needed for reasoning and which through inference mechanisms will infer the decision. This type of programs was called Knowledge Based System (KBS), a name used in Great Britain or Expert Systems in the U.S.

Data structure used in this case is an orientated graph over which is applied a chain logical evaluation mechanism (branch chain logic). The graph nodes may contain pieces of knowledge (symbols, sentences) and/or logic operations. A node may have one or more entries (arcs oriented towards that node) and one "exit" which can be multiplied (Fig. 1).

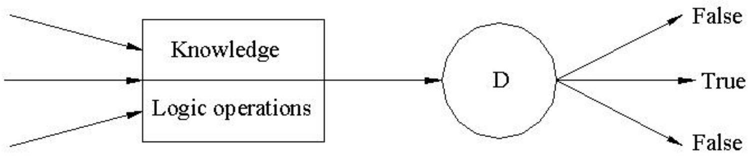

Fig. 1 – The scheme of an orientated graph node.

Through arcs the nodes transmit to each other the truth values (True/False). The presented system works properly only if the output will show a single True value and the rest will be False, in all cases of use (possible sets of assumptions). The disadvantage of this model lies in the complexity that the graph can reach for a larger set of pieces of knowledge. Inevitably, this complexity leads to errors in operation.

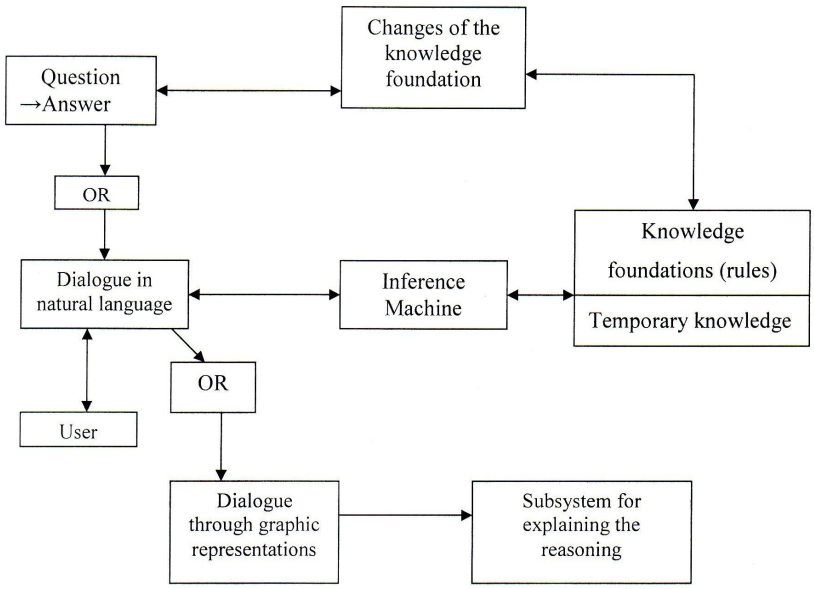

Fig. 2 – The Structure of an Expert System.

An Expert System (ES) is a program that provides solutions at the quality offered by a specialist for problems from a narrow field. Building such programs involves extracting information from specialists in the field and codifying them into a language compatible with the computer.

The Structure of an ES is presented in Fig. 2.

An ES has two important features namely

a) Gives the user the possibility to follow the performed reasoning, and allows him to intervene for choosing a favorite route.

b) The possibility of simple knowledge foundation updating and the use of the same nucleus for different knowledge foundations which, however, have the same structure.

The architecture of the system consists in separating the machine from the information that it processes enabling the core of the expert system to be used for knowledge in different fields.

ESs work faster than human experts, making faster decisions; contain consistent information (structured in the same way) about an environment subject to hazard; they make the distribution of information to more people at different places possible; they can be integrated with other systems and can provide stored data anytime, and also increase the quality of decision making process.

Unlike the presented advantages, the ES has a series of limitations: data collection from experts is difficult, experts may often have different values, then the time is short, the difficulty of assessing the situation occurs, conclusions can not be verified in terms of fairness.

3. Expert Systems for the Automation and Monitoring, Collecting, Processing and Determining the Deformation and Displacement Vectors of Weight Dams

Over time, the thorough knowledge of the changes in geometric shapes and constructions' space positions during the exploitation of massive constructions (dams, power plants, nuclear power plants, sluices, etc.) has led to finding and studying the methods so these changes can be determined, anticipated and analysed.

Determining the changes occurred during the exploitation of a construction is essential for both its safe operation, and for the design of other constructions using the experience we have in terms of *in situ* behaviour. Currently, the technological developments enables the use of some high precision devices and instruments which allow to periodically obtain accurate field data which then are processed according to rigorous methods leading to parameters that characterize the state of stress and deformation of exploited constructions.

Nowadays, combining GPS technology with the accurate observations of total stations and high precision electronic levels, of gradient sensor, devices for transmitting information *via* radio waves has led to the emergence of some automatic, powerful, flexible and interactive monitoring systems for massive constructions, reducing the time for observations and increasing their accuracy**.**

Such an ES was implemented for the automation and monitoring of deformations and displacements occurred within weight dam permanently subjected to a large number of static and dynamic stress. These systems were developed and improved by companies producing geodetic measurement equipment.

The monitoring system consists of software for data acquisition and processing, geodetic equipment (GPS receivers with two frequencies, total stations, advanced electronic levels) and Measuring and Control Devices (MCD).

Such a system is based on software that retrieves and processes data from both the MCD installed within and around the dam and from the geodetic robotic instruments. Mainly, the software must meet the following requirements:

a) to run under the most common operating system;

b) to store data in a relational database;

c) to support operations automatically, semi-automatically or on demand;

d) to be compatible with data from a variety of sensors;

e) to be remotely accesible both in terms of commands and collected data;

f) to be able to automatically restart in case of a blackout;

g) to be able to automatically start and stop the sensors and devices that it controls at the beginning and end of each measurements series;

h) to be able to retrieve video images in real time from the monitored location.

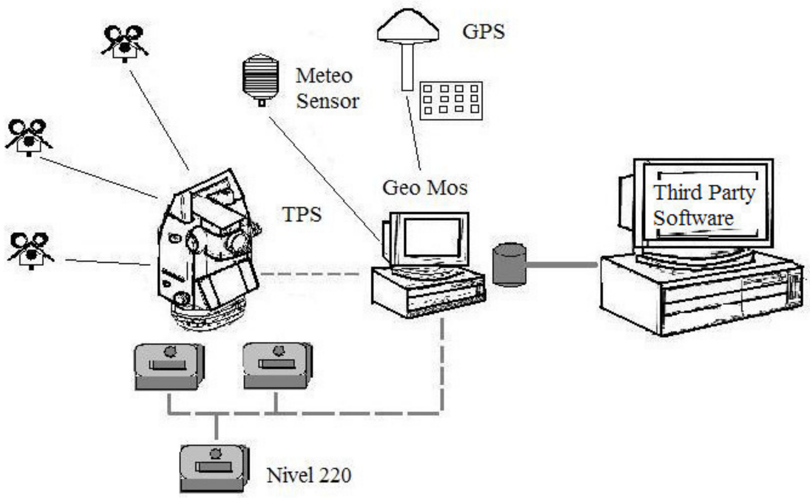

Fig. 3 – The scheme of automatic control system.

In each measurement cycle data is represented by directions and horizontal and vertical angles provided by automatic total stations installed on fixed pilasters materializing the micro-triangulation network for monitoring the dam (Fig. 3). Temperature, atmospheric pressure and humidity are also collected and used for the correction of measurements. Intervals at which the automatic measurements are performed are defined by the administrator of the monitoring system established during the following-up project.

Within the calculation program, the first step is to check the stability of the pilasters of the follow-up network, excluding from the beginning the possibility of obtaining inaccurate coordinates due to the movement of points considered fixed. After correcting the data measured in displacement points we move to calculate the deformations and displacements from the considered observations cycle.

Measuring the angles and distances is made with robotic total stations, by automatic recognition of the prisms mounted on the concrete pilasters. They are protected by "shelters" with special glass walls allowing the observations; the power supply necessary for the functioning is made from photo-voltaic panels. The commands towards the total station but also the measured data are transmitted *via* radio waves using modems specially designed for this purpose.

In the monitoring points on the dam's body are embedded prisms which are sighted by total stations automatically commanded by data collection software. For measuring the deformation and vertical displacements, settlements or elevations, digital electronic levels are used, as the total stations, they perform measurements preset in the software for data collecting and processing. Within the monitoring system GPS receivers can also be used; at least one of those must be placed at a greater distance from the dam, but, for a more precisely calculation, not more than three kilometers. The role of GPS receivers is to "awaken" the monitoring system if major movements are detected. The signal from the GPS receiver will command one or more measurement cycles from which will result the actual deformations and displacements of the dam.

All data provided from the geodetic equipments and MCD devices is transmitted in numerical/digital format.

The results are provided in the form of graphs in which are represented the last cycles of measurements, in terms of vertical and horizontal movements of the studied construction/ dam (Fig. 4). The monitoring system is also able to provide information on real time movements of the dam when it is required by the construction's administrator (Fig. 5). For example, this may be necessary during the drainage/ filling the accumulation lake.

Corroborating the information provided by all sensors installed on the monitored construction, the monitoring software can generate three levels of warning by comparing the data obtained with the limitations imposed for each type of construction. Thus, if the first warning level is exceeded, a text message can be sent to the person in charge of the system. If the second warning level is exceeded, the optical and acoustic warning systems can be switched on, and the person in charge of the system must decide what measures should be taken. If the third warning level is exceeded, an alarm siren will be operated, the area will be evacuated and, after verifying the data again, the person in charge of the system may inform other authorized agents responsible for the safety of the local population.

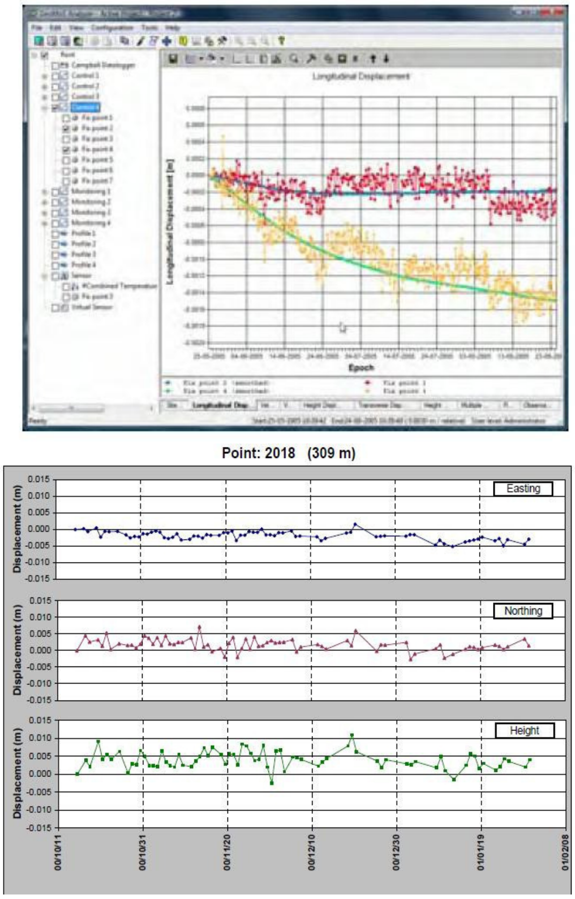

Fig. 4 – Graphical representation of horizontal and vertical movements.

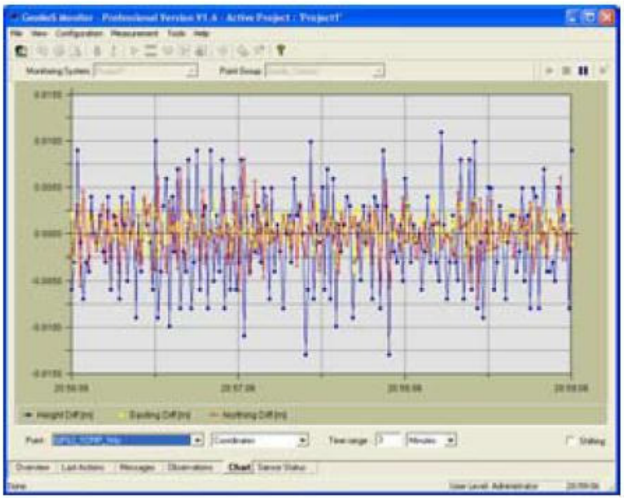

Fig. 5 – Graphical representation of movements in real time.

4. Conclusions

All geodetic and MCD along with the monitoring software form a complex system that has many advantages compared with traditional methods of monitoring *in situ* behaviour of massive constructions. These advantages are the following:

a) Obtaining a high accuracy by eliminating human errors.

b) Accessing the system from great distance.

c) Carrying out cycles of observations at shorter intervals than in the case of the classical method, and also in any unexpected moment.

d) Determining the displacements and horizontal and vertical deformation in a shorter time and immediate warning in case of danger.

e) Correlating the geodetic measurements with data provided by the MCD installed inside the construction.

f) Obtaining and processing data in real time, with the help of graphs.

g) Decreasing the time for collecting, processing, graphic representation, storage and remote transmission of data and reducing the costs of the monitoring activity of *in situ* behaviour of constructions.

It is believed that the automatic monitoring system for *in situ* behaviour of massive constructions is the viable alternative, technically and economically speaking, of the traditional system of monitoring constructions' behaviour, being recommended for massive and complex constructions with a high level of danger in case they yield.

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TENDINŢE NOI DE AUTOMATIZARE ŞI MONITORIZARE A COMPORTĂRII *IN SITU* A CONSTRUCŢIILOR

(Rezumat)

Monitorizarea comportării *in situ* a construcţiilor cuprinde urmărirea şi analiza evoluţiei tehnice şi funcţionale a acestora şi intervenţiile pe ele, în vederea remedierii deficienţelor de comportament constatate. Siguranţa în exploatare este o cerinţă primordială şi imperativă, ea vizând performanţe precum rezistenţa fizică şi chimică a materialelor şi structurilor de construcţii, stabilitatea de formă şi de poziţie, deformabilitatea, elasticitatea, etc. În cadrul acestui proces complex, un rol important îl joacă metodele geodezice de înaltă precizie.

Se prezintă un sistem de automatizare şi de monitorizare a comportării în sistem a construcţiilor masive, în care măsurătorile geodezice devin componente ale unui tip de tehnologie informatică, ca parte a Inteligenţei Artificiale, dezvoltate în ultimele decenii în lume.

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PERFORMANCE OF GPS SUPPORT GEODETICAL NETWORK FOR DIGITAL CADASTRAL PLAN OF A ROAD

BY

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Abstract. In order to achieve the topographical and cadastral plans necessary for designing works of rehabilitation and modernization of an existing road, or for a Roads Cadastral Information System, it is necessary the designing and achievement on the field of a geodetical supporting network. The compliance with the precision and density of network points are provided in "Design Theme". When choosing the points location there are taken into account the regulations relating to stability, preservation, measurements efficiency, direct and quick accessibility. The manner to perform a support geodetical network for a digital cadastral plan of a road is presented in this work.

Key words: digital plan; cadastre; network; road.

1. Introduction

Since the preliminary stage of topographical surveys, required for a new road designing or for an existing road rehabilitation by modernization, as also for a digital cadastral plan development, within the design theme are established the locations of the points that will form a support geodetic network of the planimetric and level measurements, indicating the requirements/accuracy

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tolerances in plan and vertical determination. Support and detail points coordinates will be determined in Projection System Stereo 70, respectively in 1975 Black Sea Quota System Currently, the support network achievement is made by using the Global Navigation Satellite System (GNSS) satellite technology, in the ETRS 89 European geodetic datum, adopted also in our country in 2009, under the RO_ETRS 89 code. But cartographic representations, plans and maps shall be drawn in Stereo 70 System which represents the Krasovski 42 local/regional geodetic datum. Therefore, after calculating the support network coordinates in the European global datum, the transformation to locally Krasovski datum is needed, respectively their conversion in the Stereo 70 Projection. Finally, the topographical/cadastral plan is the technical documentation for the design to be made, respectivelly the Cadastral Information System of the Road.

This work presents the implementation technology of the GPS support geodetical network for the digital cadastral plan of a road.

2. Presentation of GPS Support Geodetical Network for the Digital Cadastral Plan of a Road

2.1. Implementation of Support Geodetical Networks for Cadastral and Topographical Measurements

Within roads cadastral works, the possible application of Romanian Position Determination System (ROMPOS) dedicated to surveyors owning GNSS technology are

a) surveying networks implementation;

b) establishing of the points coordinates defining the buildings limits;

c) detailed survey for roads cadaster.

Support geodetic networks are defined according Ord.*534*/2001 and classiffied in *support geodetic networks of densification and survey*. They are made according to hierarchical and density principle, from higher to lower (Fig.1).

The points classes represented in Fig. 1 are: *A* – base stations (real) – A Class (70…100 km); *a* – base stations (virtual) (hundreds of meters); *B* – densification markers – B Class (about 40 km); *C* – densification markers – C Class (about 10 km); *R* – surveying network points (hundreds of m ... 1 km); *1,2,3,4,5,6* – detail points (tens...hundreds of m).

Based ROMPOS services, the coordinates of the *surveying networks* points can be determined using ROMPOS-GEO (postprocessing static positioning service). Users of this service can take data collected from GNSS Stations Reference and are able to fit the surveying network in the ETRS89 System of Reference and Coordinates (SRC) from Romania (RO_ETRS 89 – Romanian Terrestrial Reference System 1989). In the same time with the satellite data at the desired recording interval (enough 5s, 10s, 15s, 30s), the coordinates of these stations are also transmitted.

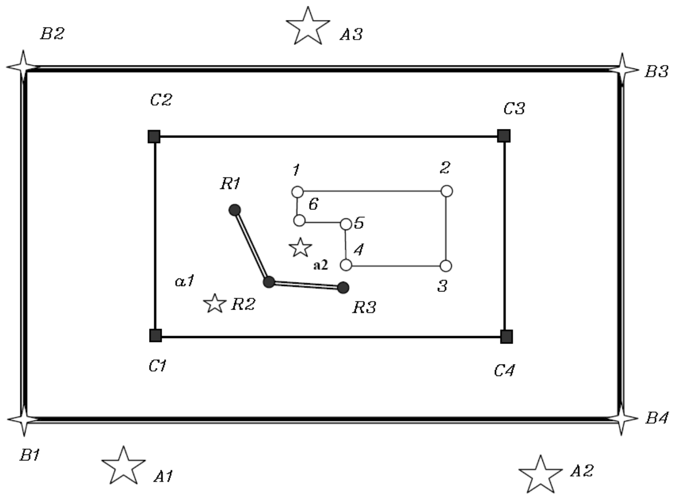

Fig. 1 – Scenario concerning the GNSS geodetical networks from working area.

Surveying network, consisting of at least two points on the field, will be stationed with Global Navigation Satellite System (GNSS) receivers and will collect in static/rapid-static way. Surveying duration depends mainly on the distance to the station/stations and/or terminal/reference terminal, having the coordinates in the RO_ETRS 89 Coordinates on the number of receivers' frequencies and also on the number and geometric distribution of satellites in surveying time. Internal accuracies of 3-D coordinates determination can easily reach values below 5 cm, specific to this type of network.

An operator of surveying networks and detailed survey, holder of GNSS technology, will have to take the following steps according to legal norms in force:

a) To carry out the *surveying network* by *static/rapid static* measurements; will make the connection to the hierarchic superior GNSS networks in the area (Class *A, B, C*). For the connection to the base stations (reals), the corresponding satellite records are taken. Through this network constraining, on at least two points of higher class, will be generated closed polygons (triangles) in which the primary results can be verified by unclosings calculation.

b) To *carry out the detailed survey* by *static/rapid static or kinematic* measurement method. Kinematic method can be carried out by measurements in *postprocessing* manner or in *real time*. For kinematic measurements in postprocessing it will be used at least one reference station located in the working area, or a permanent reference station of RGN-GSP. For kinematic measurements made in real time, it can be used

a) reference stations, at least one, located in working area and short distance radio communication;

b) real permanent reference stations from RGN-SGP and GPRS remote communications - ROMPOS-RTK service (real stations version);

c) *virtual* reference stations, generated on data collected at real reference stations from RGN-SGP-ROMPOS-RTK VRS service (*virtual reference station version*).

Due to the fact that these determinations of detail, in kinematic way, will be made taking into account the *principle of redundancy* (more measurements than strictly necessary), the position's determination in RTK (Kinematic in Real Time) will include two coordinates determinations at each point of detail, similar to the method of double eraser, by making *two survey activations* at short time intervals (seconds, minutes). Surveying network points will have a description and a set of coordinates in SRC ETRS89 and in national SRC (Stereo70).

The *points performance* is the operation of fixing landsurveying and geodetic points. The marking operation is necessary, in order to be easily the points identified both on their determination and also when determining other points. The points marked on land make the connection between plan/map and land. *The marking of the GPS support geodetic network points* is made for a long time, with concrete markers and underground marking (SR 3446-1/1996). The *marking of of the survey points / traverses points*, is made by hobs, metal bolts/pickets or concrete markers small shape, without underground marking.

2.2. Measurement Methods, Measurement Sessions and Duration, Imposed Conditions

The measurement method chosen for road section survey is the static method, with base and rover. A receiver is placed on a point, whose coordinates are precisely known, in RO_ETRS 89 system. This is known as the *base receiver*. The other receiver is placed at the other end of the base and is known as *mobile* (*rover*).

The data is then recorded by both stations simultaneously. It is important that data to be recorded at the same time by each station. The length of time between data records can be set at intervals of 15, 30 or 60 s.

The receivers must collect data for a specific period of time. This period is influenced by the length of the base, by the number of observed satellites and satellites geometry. As a basic rule, the time of observation is at least one hour for a base length of 20 km, with five satellites and Geometric Dilution of Precision (GDOP) (precision a point is determined) predominantly of eoght. Longer basis require a longer observation time. Once sufficient data have been collected, the receivers can be stopped. The mobile device (the Rover) can then be moved on the following basis and measurements can begin again. It is very important to introduce the redundancy in the measured network. This involves to measure points at least twice, and that creates safety checks against problems that might otherwise go unnoticed. An increase in productivity can be achieved by adding an additional wireless receiver. Good coordination is needed between teams carrying out measurements, in order to maximize the effect of using three receivers.

As an empirical estimate of the relative precision of measurements it can be considered ±5 mm ±1 ppm of the base length.

A substantial reduction in the duration of working sessions to 5…20 min per session is achieved with fast static method , being used to estimate the ambiguities. The method gives good results in determination of short basis (max. 5 to 10 km), with very good satellite constellations and with receivers measuring both frequencies. Potential accuracy is estimated at ±5 mm ±1 ppm. The method is often used in support network densification. The GPS satellite measurements, for the support geodetic network densification in the interested area, are made by the static method. Thus, for the *A,B,C,D* and *E* networks, the coordinates of point *A* are known in RO_ETRS89 system, the others needed to be determined. In the situation of a three receivers measurement, in the working stages *1*,…,*5*, the proceeding is as follows:

The receivers are placed in points *A, B* and *E*, the GPS data for the established period of time being recorded. After the required stationary period, the receiver placed in point *E* moves to *D*, and that from *B* moves to *C*. Thus, the triangle *ACD* is measured (steps *1* and *2* – Fig. 2). Next, the receiver *A* moves to *E*, and that from *C* moves to *B*, measuring the *BDE* triangle.

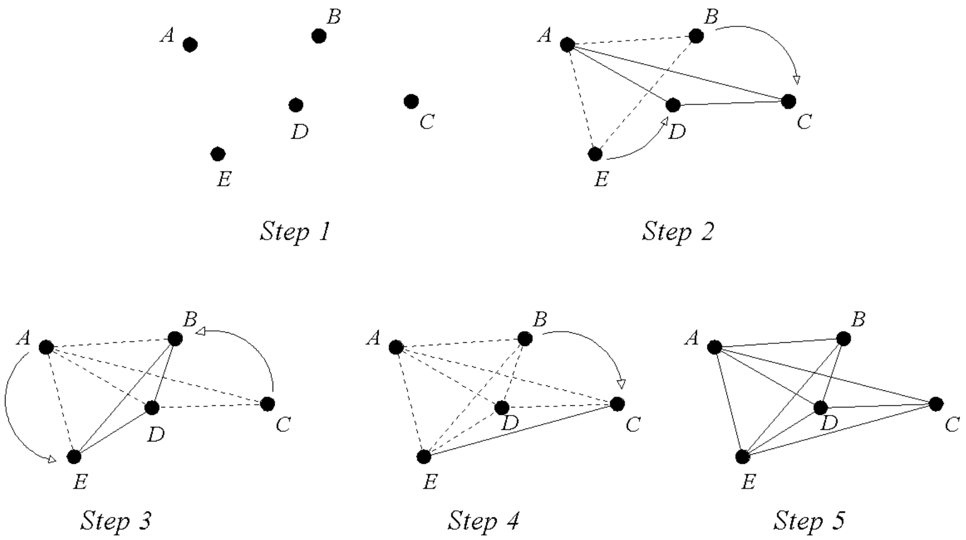

Fig. 2 – GPS measurements by static method; steps *1*,…,*5*.

Finally, the receiver *B* will move back to *C*, measuring the *EC* line (steps *3* and *4* – Fig. 2). The final result will be the measured network. One of the points is three times measured and the others of at least twice. This introduces the redundancy, any gross error will be highlighted and the wrong measurement can be removed (step *5* – Fig. 2).

2.3. Measured Data Processing and Coordinates Calculation

After measurements processing, are obtained the cartesian coordinates (X, Y, Z) and/or spatial geographical coordinates (B, L, h), and also their determination accuracies. However usually, there are requested the coordinates X, Y in projection stereo 70, Krasovsky ellipsoid, normal H elevations refered to the Black Sea 1975, and their determination accuracies.

The results obtained by GPS technology, are influenced by certain factors, among which can be listed: *network geometry*, *satellites geometry*, *receiver's type*, *working method and GPS data processing*, *the works organization*.

For a GPS measurement, the WGS 84 (World Geodetic System) system closed to RO_ETRS 89, has: the origin defined by the vector of datum point coordinates (if obtained from a point positioning with pseudo-distances (navigation solution), it can be false by more than 100 m); the system scale can vary depending on the modeling accuracy of the phase observations, for example, single-frequency results can be affected by systematic errors if are not taken into account the ionospheric effects and, therefore, different GPS measurements networks may have different scales; the axes orientation of the coordinates system for new created points of GPS network, will be implicitly defined by linking to the WGS 84 system, and may have a few seconds of deviation of arch.

Depending on the correct choose of a datum station, of a GPS network to WGS 84, this point will affect the GPS results reported to WGS 84. For this reason, there may be a *corresponding set of transformation parameter officially published*, in order to link accurately the GPS results to a local datum, or a *set of relative transformation parameters*, to a GPS measurement, in a local datum. The 3-D similarity transformation, known as *Helmert transformation with seven parameters*, is ideal for connecting 3-D GPS networks to other GPS or terrestrial networks.

Considering the *Helmert transformation*

$$r^G = (1+m)R(r_x, r_y, r_z)r^C + t^C , \tag{1}$$

where

$$r^G = (X^G, Y^G, Z^G)^T , \tag{2}$$

$$r^C = (X^C, Y^C, Z^C)^T , \tag{3}$$

$$R(r_x, r_y, r_z) = R_Z(r_z) + R_Y(r_y) + R_X(r_x) , \tag{4}$$

the last being the rotation matrix around axis X, Y, Z; r_x – rotation angle around axis X; r_y – rotation angle around axis Y; r_z – rotation angle around axis Z;

$$R(r_z)=\begin{pmatrix}\cos r_z & \sin r_z & 0\\ -\sin r_z & \cos r_z & 0\\ 0 & 0 & 1\end{pmatrix},\ R_y(r_y)=\begin{pmatrix}\cos r_y & 0 & -\sin r_y\\ 0 & 1 & 0\\ \sin r_y & 0 & \cos r_y\end{pmatrix},$$

$$R_x(r_x)=\begin{pmatrix}1 & 0 & 0\\ 0 & \cos r_x & \sin r_x\\ 0 & -\sin r_x & \cos r_x\end{pmatrix}; \tag{5}$$

m – the scale factor; $t^C=(\Delta X,\Delta Y,\Delta Z)^T$ – the position vector of ***C*** system in relation to system ***G***. For small rotations r_x, r_y, r_z, around 10 the relations (4) become

$$R(r_x,r_y,r_z)=\begin{pmatrix}1 & r_z & -r_y\\ -r_z & 1 & r_x\\ r_y & -r_z & 1\end{pmatrix}\cdot, \tag{6}$$

In geodesy, the general transformation pattern (1) is known as *Bursa-Wolf model*.

When this model is applicable to small networks, the rotation parameters are correlated with translation parameters. This correlation problem is addressed with the *Molodensky-Badekas* model, expressed with the relation

$$r^G=r_m+(1+m)R(r^C-r_m)+t, \tag{7}$$

where

$$r_m=(X_m,Y_m,Z_m)\ \text{and}\ X_m=\frac{\sum_{i=1}^{n}X_i^C}{n},\ Y_m=\frac{\sum_{i=1}^{n}Y_i^C}{n},\ X_m=\frac{\sum_{i=1}^{n}Z_i^C}{n} \tag{8}$$

are the coordinates of centroid network; n is the number of points common to the two networks, 1 + m – the scale factor.

Rotation angles depend on the linear basis associated vectors and not on the absolute coordinates from their ends. For this reason it doesn't matter where the origins of coordinate systems are, as estimated rotation angles are the same. Also, multiplication of a set of points with Cartesian coordinates with a scale factor is equivalent to multiplying the corresponding linear bases lengths with the same scale factor. Scale factor can be determined either from 3-D coordinates or from the corresponding linear bases lenghts.

As for the rotation angles, the origin of the coordinates system does not affect the obtained results for the scale factor.

2.4. Support Network Densification and Surveying Network

Coordinates of geodetic networks are calculated in projection system Stereo 70 and the Black Sea 1975 reference system. The support geodetic network for carring out roads surveying works consists of all points determined in the unitary systems of reference.

Densification geodetic network is made in order to ensure the density of points needed within working area and adjacent area, for roads surveying works. Within the configuration of densification geodetic network will be included at least four points of support geodetic network, so that the formed polygon to enclose all densification network points. The densification geodetic network is carried out through geodetic technologies based on satellite records.

For the network design it will be taken into account the following measures:

a) densification and surveying network must be based on at least four points of support geodetic network;

b) support points will be uniformly distributed, both within the network and at its edge;

c) all new points will be determined by a minimum of three vectors;

d) it will be provided the determination of the double-stationed connecting points, in different sessions.

The minimum number of sessions, s, in a network with p points, and with the use of r receivers is calculated with the relation

$$s = \frac{p-n}{r-n}, \text{ for } n \geq 1, \tag{9}$$

where n is the number of contact points between sessions. If a point is stationed of m times , than sessions number is calculated with the relation

$$s = \frac{mxp}{r}. \tag{10}$$

Densification geodetic networks compensates as free networks, by enclosing in their configuration at least four points of the support geodetic network. Average standard deviation for determination of the densification geodetic network points, in planimetric position, is calculated with the relation

$$s_r = s_0 \sqrt{\frac{\sum_{i=1}^{n} \left(Q_{XX_i} + Q_{YY_i} \right)}{2n}}, \tag{11}$$

with a tolerance $s_p \leq \pm 5$ cm.

After compensation as free network, the plane coordinates of densification and surveying network points in projection system Stereo 70 will be determined, by a Helmert transformation, with a minimum of four points of the triangulation support geodetic network.

The points of densification network should provide a density of 1 point/5 km^2 outside built-up areas and 1 point /km^2 in built-up areas.

Surveying geodetic networks are created in order to ensure the number of points necessary to topographical and cadastral detailed measurements.

The density of a surveying geodetic network is determined in relation to the surface where the works are performed and their purpose. Surveying geodetic networks are designed as to provide the points which separate the administrative-territorial units, as well as those that define the studied road. It will be provided a density of at least 1 point/km^2 in the plain area, 1 point/ /2 km^2 in hilly areas and 1 point/5 km^2 in mountain areas.

The surveying geodetic network is compensated as constrained network on the points of the support and densification network. Standard deviation for the determination of a point should not exceed ±10 cm, in the city and ±20 cm in outside built-up area, lowland ±30 cm, hillyland ±50 cm in mountain areas. Errors along the coordinates axes and the total error are calculated with the relations

$$s_x = s_0\sqrt{Q_{XX}}\,,\; s_y = s_0\sqrt{Q_{YY}}\,,\; s_p = \sqrt{s_x^2 + s_y^2} \tag{12}$$

Technical documentation, developed after carring out the support, densification and surveying geodetic networks, subject to acceptance, will include

a) the technical memorandum, including a general description of work, working methods, used tools, data processing (method of network compensation, standard deviations, error ellipse for each new geodetic determined point), obtained accuracies, etc.;

b) old and new points arrangement scheme, with visibilities marking (visas draft), accomplished measurements scheme (visas draft);

c) ASCII files magnetic support, with data from field measurements;

d) topographical descriptions and bearing sketches of old and new points, as coordinates inventory, including magnetic support;

e) table indicating the differences between the old coordinates (point of *I, II, III, IV* order) and the new coordinates of the same points, resulted from the compensation network.

3. Case Study

The current work is related to the territory of Oşeşti Commune, Vaslui County. The support and surveying network is accomplished by FENO markers and hobs. The traverses are compensated on points from support network using GPS devices, supported on the national geodetic network in Stereo

70 system and Black Sea 1975 quota system. GPS measurements were made homogeneous, in one campaign for all the work, ensuring the continuity and consistency of measurements.

In order to obtain the transcalculation parameters, the permanent stations IASI, VASL (Vaslui) and BACA (Bacău) were used.

Then, the coordinates of S 120, S 119, S 109, S 108, S 101, S 100, S 025, S 024,S 013 points were determined, using a Trimble R8 GPS, in RTK, by ROMPOS system. Were determined the following sets points: three points at the beginning of the route, three points in the middle and three points at the end of the studied road section.

The nine points were determined in stationary sessions with 30 min. on each point, X, Y, Z Cartesian system, with a deviation of 3 cm altimetric and 2 cm planimetric. The RTK abreviation comes from kinematic in real-time. It is an On the Fly (OTF) kinematic measurement method, which runs in real time.

Fixed station has attached a radio link and sends the data received from the satellites. And the mobile has also, a radio link and receives the transmission from the fixed station. Mobile receives data also directly, from satellites through its own GPS antenna.

These two data sets can be processed together with the rover, in order to solve the ambiguity, and therefore will achieve a high accuracy relative to the fixed receiver. Once the fixed receiver has been installed and sends data through radio communication, the rover can be activated. When seeks the satellites and receives data from fixed, the activation process can begin.

Table 1

Point denomination	North (X)	East (Y)	Elevation (Z)
S 013	586878.979	689642.500	218.93
S 024	586931.532	689637.455	221.59
S 025	586837.698	689671.079	217.81
S 100	588107.430	687947.862	152.45
S 101	588071.565	687908.530	150.21
S 108	588169.654	687942.792	154.01
S 109	590247.738	686252.107	214.62
S 119	590298.095	686284.656	213.57
S 120	590138.998	686262.835	209.16

This is similar to the activation made in the case of an OTF kinematic measurement, the main difference being the fact that is brought to an end, in real time. Once activation is complete, the ambiguities are solved and the rover can record points and coordinates. At this point, the determination accuracy of the base is in the range of 1…5 cm.

It is important to maintain contact with fixed receiver, otherwise, the mobile could lose the ambiguity.

Table 1 presents an inventory of the GPS points coordinates.

In Fig. 3 are presented the GPS points with their plan layout, in part.

The GPS measurements compensation is automatically made. The traverses were made with Leica 1203 total station, with a measurement accuracy of the angles of ±3".

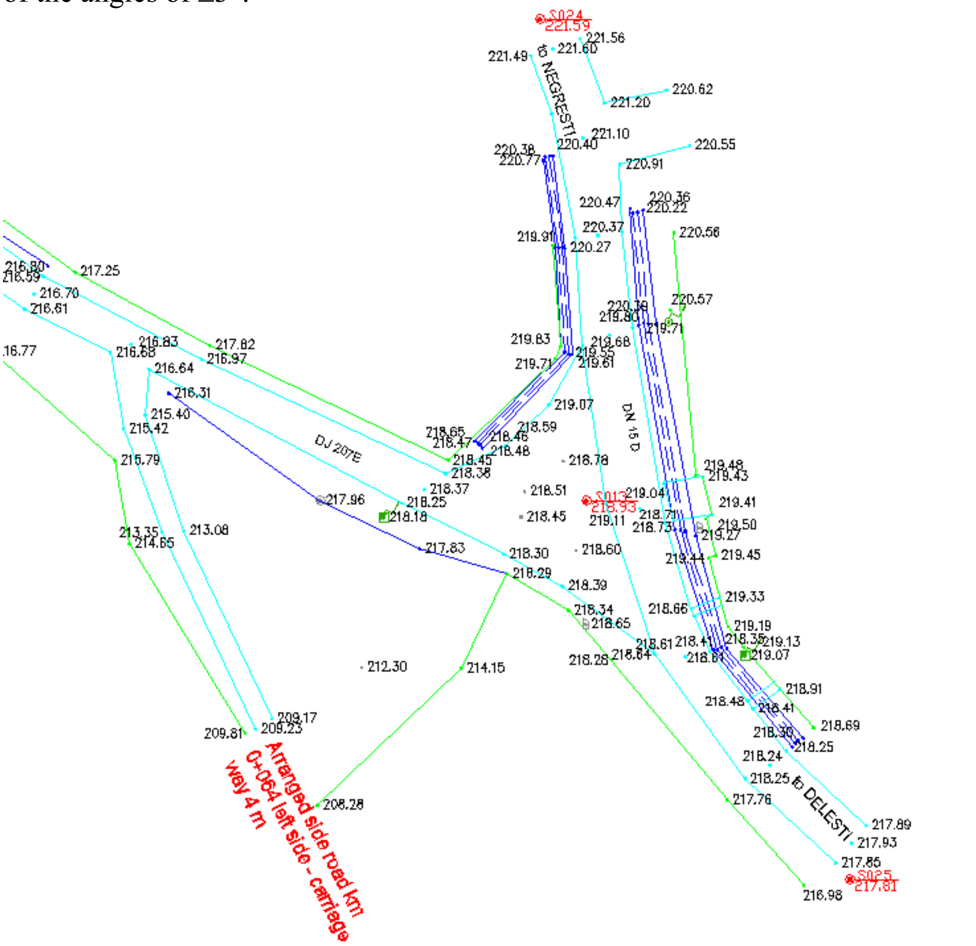

Fig. 3 – GPS points layout on the field (partially).

4. Conclusions

Following the obtained results to carry out the GPS support network as the basis for the digital cadastral plan of a road, the following conclusions may be drawn:

1. The densification points placement on field is done by maps designing, and is completed with on-site visits.

2. The obtained results with the GPS system are depending on the network geometry, on GPS stations number and distribution, including the database setup, on configuration of the satellite position, receiver type, surveying and processing manner.

3. Verification and identification of old points is made either with a GPS pocket or by comparing the distance measured with total stations with those deduced from the coordinates.

4. Avoiding the proximity to large power plants, and reflective surfaces.

5. The RTK measurement method proved to be a good way of obtaining high precision, high accuracy GPS measurements.

6. GPS technology use has great flexibility, doubled by the posibility of coupling to other means of determining the support networks.

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REALIZAREA REŢELEI GEODEZICE DE SPRIJIN GPS PENTRU PLANUL CADASTRAL DIGITAL AL UNUI DRUM

(Rezumat)

Pentru realizarea planurilor topografice şi cadastrale, necesare lucrărilor de proiectare, de reabilitare şi modernizare a unui drum existent, sau pentru un Sistem Informaţional Cadastral al drumurilor, este necesară proiectarea şi materealizarea pe teren a unei reţele geodezice de sprijin. Respectarea cerinţelor de precizie şi densitate a punctelor reţelei sunt prevăzute în *Tema de proiectare*. La alegerea amplasamentului punctelor se au în vedere prescripţiile normativelor referitoare la stabilitate, conservare, eficienţă pentru măsurători, accesibilitate directă şi rapidă.Se prezintă modul de realizare al reţelei geodezice de sprijin, pentru planul cadastral digital al unui drum.

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ERRORS AND CALCULUS OF DEVICES FOR PREIMPOSED ACCURACY OF LIQUID FLOW MEASUREMENTS

BY

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Abstract. The conditions and possibilities for discharge measurement are presented. In hydraulic schemes sometimes the discharge claimed with given accuracy and there, for this purpose, calibrated hydraulic constructions may be used. Based on the claimed accuracy of measurement number of repetition of direct measured amounts is presented.

Key words: flow measurement; errors; devices calculus; measurement accuracy.

1. Measurement Errors

Measurements of physical amounts are direct (when by comparison operation the quantity claimed is obtained); or indirect (another is measured directly and by relationship of the two will furnish the claimed physical quantity).

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1.1. Errors of Direct Measurement

The direct measurement of a physical dimension by n repetition is performed with respect to the claimed accuracy. The most probable value of the measurement is the arithmetic mean

$$a_m = \frac{\sum_i a_i}{n}. \tag{1}$$

Sometimes this value is given by the weighted average, if for individual measurement, a_i, the weights, p, can be attached

$$a_m = \frac{\sum_i a_i p_i}{\sum_i p_i}. \tag{2}$$

Weight of individual measurements is difficult to determine, criterions are delicate and partial. For length there are no criterions for weight attachment to measurements for a given device. Volumetric flow measurements (volumes, V_i, and times, t_i, are direct measured) each measurements can be time weighted

$$p_i = \frac{t_i}{\sum_i t}; \; Q_i = \frac{V_i}{t_i}; \; Q_m = \frac{\sum_i p_i Q_i}{\sum_i p_i}. \tag{3}$$

Physical dimensions measurements are affected by errors, that can have systematic or casual nature.

Systematic errors due to disadjustment of the used measurement devices, values of measurements with a fix quantity with respect to the real value are deviated.

Casual errors due to human subjective happens; they are positives or negatives with respect to the real value of the measurement, and gross and small errors they can be: sometimes gross casual errors may ferret out and correct or eliminate.

The absolute error of the measurement, a_i, is

$$\varepsilon a_i = a_i - a_m. \tag{4}$$

Sum of small casual errors is null.

The relative error of the measurement is

$$\delta a_i = \frac{\varepsilon a_i}{a_m} = 1 - \frac{a_i}{a_m}. \tag{5}$$

Errors are characterized by *root-mean square error*, when the real value of the measurement is known:

$$\sigma a = \sqrt{\frac{\sum_i (\varepsilon a_i)^2}{n}} \tag{6}$$

and by *standard errors*, when the real value of the measured amount is unknown

$$sa = \sqrt{\frac{\sum_i (\varepsilon a_i)^2}{n-1}}. \tag{7}$$

The probable error with respect to statistics is smaller than the standard one,

$$r_a = \pm 0.7645 sa. \tag{8}$$

Value of the measured physical amount will be

$$a = a_m \pm ra, \tag{9}$$

with a probable relative error

$$\delta a = \frac{ra}{a_m}. \tag{10}$$

1.2. Errors of Indirect Measurements

A relationship of the physical amounts is

$$A = f(B). \tag{11}$$

These can be written

$$A + \mathrm{d}A = f\left(B + \mathrm{d}B\right) \tag{12}$$

or

$$A + \varepsilon A = f\left(B + \varepsilon B\right) \tag{13}$$

From differential definition it results

$$\mathrm{d}A = \frac{\mathrm{d}\left[f(B)\right]}{\mathrm{d}B}\mathrm{d}B. \tag{14}$$

The relative error, δA, for an amount A is

$$\delta A = \frac{\mathrm{d}A}{A} = \frac{\mathrm{d}\left[f(B)\right]}{f(B)} = \mathrm{d}\left\{\ln\left[f(B)\right]\right\}. \tag{15}$$

For function

$$A = f\left(B_1, B_2, ..., B_n\right), \tag{16}$$

analogically it results

$$\delta A = \frac{\mathrm{d}A}{A} = \mathrm{d}\left\{\ln\left[f\left(B_1, B_2, ..., B_n\right)\right]\right\}. \tag{17}$$

The maximum relative error, δA, for the amount A by summing modules of partial derivatives of the function $\ln\left[f\left(B_1, B_2, ..., B_n\right)\right]$ has the expression

$$\delta A = \frac{\mathrm{d}A}{A} = \sum_i \left|\frac{\mathrm{d}B_i}{B_i}\right|. \tag{18}$$

Fluid discharge measurement uses indirect amounts measurement theory, both for pressurized and free surface flow.

2. Discharge Measurement by Classic Devices and Methods

Discharge measurements use volumetric, gravimetric methods or hydraulic phenomena, like: orifices, tubes, diminution of the cross sections, bents for suppressed flow, orifices under low head, weirs, modification of the cross section on channels (Venturi, Parshal, de Marchi), falls on channels in lower stage flow. For all mentioned discharge measurements theory of errors for indirect measurements are applied. Direct measurements errors define accuracy of indirect measurements.

2.1. Volumetric Flow Measurement

Relationship of direct measurement amounts and discharges is $Q = f(V,t)$ or explicately $Q = V/t$, where V is the direct measured volume during t period and Q – the discharge. For considered variable, V, it results $\delta Q_V = \mathrm{d}Q/Q = \varepsilon v/V$, than for variable t resulting $\delta Q_t = \mathrm{d}Q/\mathrm{d}t = -\varepsilon t/t$. The total probable relative error of the volumetric discharge measurement will be

$$\delta Q = \left|\delta Q_V\right| + \left|\delta Q_t\right|. \tag{19}$$

Small casual errors appear for measuring time and volume. There may appear systematic errors like: errors of the chronometer, capillary ascension of the liquid column in a depth measuring tube, or horizontal cross section measurement errors, or errors due to the tank and liquid dilatation under temperature variation.

2.2. Gravimetric Flow Measurement

Relationship of direct measured amounts and discharge is $Q = f(G, t, \gamma)$, with $Q = G/\gamma t$, G being the weight of the liquid, t – measurement period and γ – unit weight of the liquid. Applying theory of indirect measurements the probable relative errors results, respectively, $\delta Q_G = \varepsilon G/G$; $\delta Q_t = -\varepsilon t/t$; $\delta\gamma = -\mathrm{d}\gamma/\gamma$ and the probable relative error for the discharge is

$$\delta Q = \left|\delta Q_G\right| + \left|\delta Q_t\right| + \left|\delta Q_\gamma\right|. \tag{20}$$

This relation is applied in laboratories and calibrating installations.

2.3. Flow Measurement by Orifices and Tubes

A given orifice or tube working under the head, H, and having the diameter, d, and discharge coefficient, μ, for flow measurement leads to relationship

$$Q = \mu \frac{\pi d_2}{4}\sqrt{2gH}, \tag{21}$$

or $Q = f(\mu, d, H)$.

Applying the direct flow measurement theory (§**1.2**) partial relative errors of the flow measurement are

a) For head (H being the variable):

$$\delta Q_H = \frac{\mathrm{d}Q}{Q} = \frac{\mathrm{d}\left(\mu \frac{\pi d^2}{4}\sqrt{2gH}\right)}{\mu \frac{\pi d^2}{4}\sqrt{2gH}} = \frac{1}{2}\cdot\frac{\varepsilon H}{H} = \frac{1}{2}\delta H;$$

this partial relative error can be systematic or casual.

b) For diameter (d being the variable)

$$\delta Q_H = \frac{\mathrm{d}(d^2)}{d^2} = 2\frac{\varepsilon d}{d} = 2\delta D;$$

the orifice or tube being realized, this partial relative error will be a systematic one.

c) Relative partial error flow measurements due to coefficient of discharge, μ, results from indirect determination of its value namely

$$\delta_\mu = \frac{\pm 0.6745 s\mu}{\mu_m}.$$

The total relative error of flow measurement by orifices and tubes is

$$\delta Q = |\delta\mu| + 2|\delta d| + \frac{1}{2}|\delta H|. \tag{22}$$

Relative partial error of amounts that define the discharge will be multiplied by their power in the relationship (ex.: head relative error by 1/2 and diameter error is double in discharge relative error).

These devices for small liquid discharge (order of magnitude l/s) of drains, springs, and brooklets are used.

Utilization of a set of changeable orifices or tubes is recommended to obtain a given accuracy of the measurements (Fig. 1).

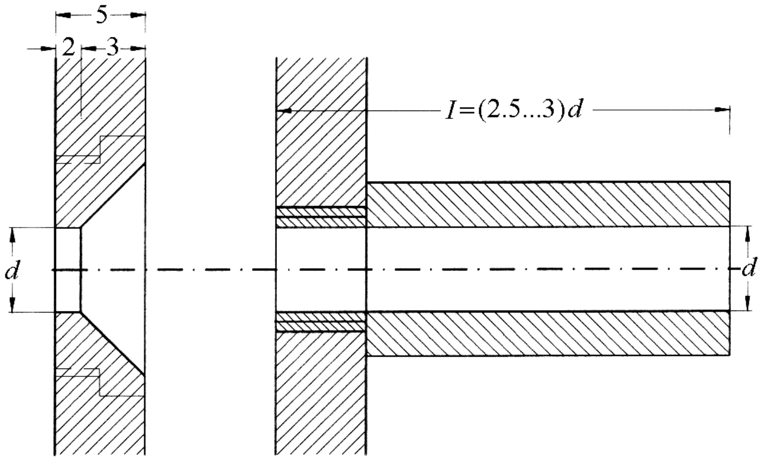


Fig. 1 – Interchangeable orifices or tubes.

Relative errors, $\delta\mu$ and δd, being known by construction, for a given relative error of the discharge, δQ, for absolute error, εH, of the head, knowing the minimum head it results:

$$H_{\min} = \frac{1}{2} \cdot \frac{\varepsilon H}{\delta Q}$$

and the diameter, *d*, from the set.

2.4. Flow Measurement Using Orifices under Low Head

These orifices are realized by plane or cylindrical gates having a complete contraction, or gates in a continuous bed canal where the bottom contraction is removed (Fig. 2).

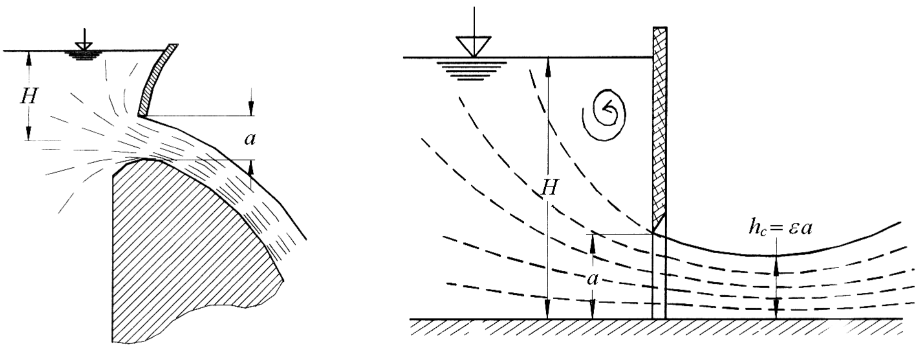


Fig. 2 – Orifices under low head: *a* – with complete contraction; *b* – bottom contraction removed.

For big orifices with complete contraction (Fig. 2 *a*) the relationship for the discharge is

$$Q = f\left(\mu, b;\ a, H\right),$$

b being the width of the orifice, so

$$Q \cong \frac{2}{3}\mu ba\sqrt{2gH}. \tag{23}$$

For orifices from Fig. 2 *b*

$$Q = f\left(\mu, \varepsilon, a, b, H\right)$$

or

$$Q \cong \mu ab\sqrt{2g\left(H - \varepsilon a\right)}. \tag{24}$$

Discharge and contraction coefficients by discharge measurement obtained by other ways can be established by statistical calculus of relative error resulting

$$\delta Q_\mu = \frac{\varepsilon\mu}{\mu} = \delta\mu \quad \text{and} \quad \delta Q_\varepsilon = \frac{\varepsilon(\varepsilon)}{2\varepsilon} = \frac{1}{2}\delta\varepsilon.$$

For gate width measurements it results

$$\delta Q_b = \frac{\varepsilon b}{b} = \delta b,$$

and for gate opening

$$\delta Q_a = \frac{\varepsilon a}{a} = \delta a.$$

All these relative errors are systematic for a given gate and opening.

Discharge relative errors due to head measurements are

$$\delta Q_H = \frac{1}{2}\cdot\frac{\varepsilon H}{H} = \frac{1}{2}\delta H.$$

The total relative error of discharge measurement by orifices under low head will be

$$\delta Q = |\delta\mu| + \frac{1}{2}|\delta\varepsilon| + |\delta b| + |\delta a| + \frac{1}{2}|\delta H|. \tag{25}$$

A pre-imposed accuracy of discharge measurements needs the minimum head on the orifice

$$H_{\min} = \frac{1}{2}\cdot\frac{\varepsilon H}{\delta Q_H}. \tag{26}$$

2.5. Flow Measurement in Closed Hydraulic Systems by Diminution of the Cross Section

Flow measurements in closed hydraulic systems (pipe systems) by circular or segment orifices (diaphragms), conical or conoid tubes, venturi-meters or devices with generalized diminution of the cross section (by plane or curve surfaces) can be undertaken (Fig. 3).

Aspects of the movement within circular orifices and conoidal tubes are illustrated in Fig.4.

For all these devices the relationship

$$Q = f\left(\mu, As, H\right)$$

or

$$Q = \mu As\sqrt{2gH} \qquad (27)$$

is characteristic, with $\mu = f(As/A)$, As/A being the ratio of the throttle and the total cross section.

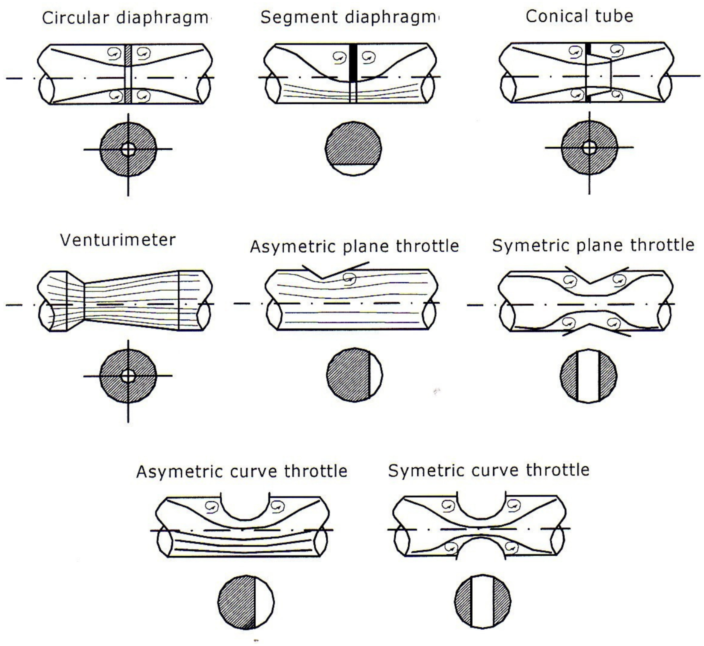
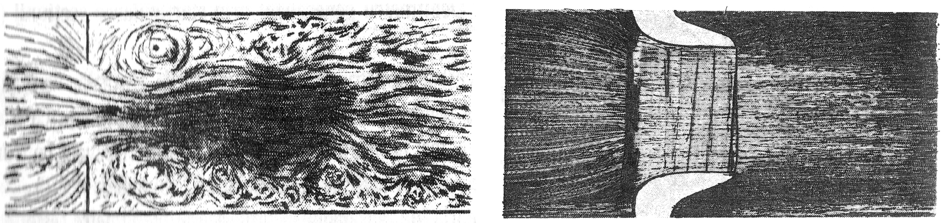


Fig. 3 – Different shapes of the diminution of the cross section.



a *b*

Fig. 4 – Movement aspects through diaphragms (*a*) and conoid tubes (*b*).

The following relative partial errors are characteristic in this case:

a) for coefficient of discharge, μ, that have to be determined by other way

$$\delta Q_{\mu} = \frac{\varepsilon\mu}{\mu} = \delta\mu;$$

b) for the throttle cross section

$$\delta Q_{As} = \frac{\varepsilon As}{As} = \delta As \ .$$

These partial relative errors are systematic for a given device.

Relative partial error for head measurement is

$$\delta Q_H = \frac{1}{2} \cdot \frac{\varepsilon H}{H} = \frac{1}{2} \delta H \ .$$

The total relative error for the discharge is

$$\delta Q = \left|\delta \mu\right| + \left|\delta As\right| + \frac{1}{2}\left|\delta H\right| .$$

The needed accuracy of the measurement for a given δQ_H determines the minimum head of the device

$$H_{\min} = \frac{1}{2} \cdot \frac{\varepsilon H}{\delta Q_H}$$

and, consequently, the reduction of the cross section.

2.6. Flow Measurements by Weirs

Open flow discharge measurement frequently uses weirs.

Sharp crested weirs – rectangle, triangle, trapezoidal, proportional – in labs as a rule are used, but if there exist possibilities they are set in open flow (mostly on canals).

a) *Rectangle standard weir* (*Bazin type*)

The characteristic relationship is

$$Q = f\left(m, b, H\right)$$

or

$$Q = mb\sqrt{2g}H^{3/2} , \tag{28}$$

where m is the discharge coefficient; b – the weir width, and H – the head on the weir (Fig. 5).

Relative partial errors are

a) For discharge coefficient

$$\delta Q = \frac{\varepsilon m}{m} = \frac{\pm 0.6745 sm}{m} = \delta m;$$

which may be determined by discharge comparative measurements;

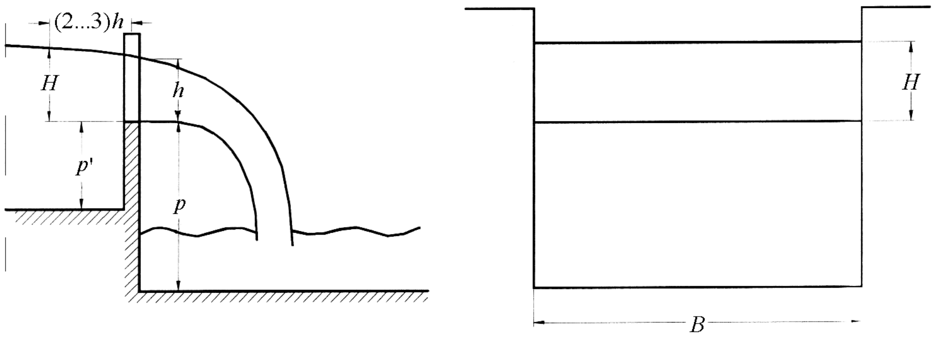


Fig. 5 – Standard weir.

b) For weir width

$$\delta Q_b = \frac{\varepsilon b}{b} = \delta b;$$

these two partial relative errors once determined will constitute systematic errors;

c) For head

$$\delta Q_H = \frac{3}{2} \cdot \frac{\varepsilon H}{H} = \frac{3}{2} \delta H.$$

The total relative error for the standard weir will be

$$\delta Q = |\delta m| + |\delta b| + \frac{3}{2} |\delta H|. \quad (29)$$

Calculus of the weir for a given condition of head measurements, and flow interval, δQ_H, for the minimum discharge, $Q_{\min}$, assumed, being known εH, leads to

$$H = \frac{3}{2} \cdot \frac{\varepsilon H}{\delta Q_H} \quad \text{and} \quad b = \frac{Q_{\min}}{m\sqrt{2g} H^{3/2}}. \quad (30)$$

The relative partial error of head measurement will be amplified 3/2 times in dishrage measurements.

b) *Triangle sharp crested weir (Thompson weir)*
Analogously to the standard weir, the characteristic relationship is:

$$Q = f(\mu, Q, h) \quad \text{and} \quad Q = \frac{8}{15}\mu \mathrm{tg}\frac{\theta}{2}\sqrt{2g}H^{5/2} \tag{31}$$

and relative partial errors are

$$\delta Q_\mu = \delta\mu; \quad \delta Q_\theta = \frac{2\varepsilon\theta/2}{\sin\theta} \quad \text{and} \quad \delta Q_H = \frac{5}{2}\cdot\frac{\varepsilon H}{H} = \frac{5}{2}\delta H.$$

The total relative error of the flow measurement is

$$\delta Q = |\delta\mu| + \frac{2}{\sin\theta}\left|\frac{\varepsilon\theta}{2}\right| + \frac{5}{2}|\delta H|. \tag{32}$$

For a realized weir δQ_μ and δQ_θ represent relative systematic errors. The weir can be calculated in an analogous may like the standard one in view to obtain the claimed accuracy.

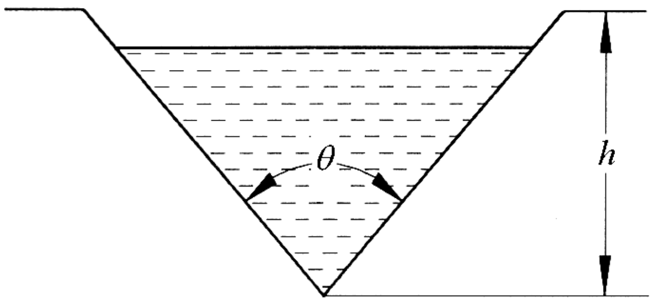


Fig. 6 – Triangle (Thompson) weir.

Trapezoidal (Cipoletti) and proportional weirs discharge measurements accuracy may be determined using a same methodology.

3. Accuracy of Measurements and the Minimum Number of Repetitions for Direct Measurements

Amounts of primary measurements are affected by errors, and small casual errors could not be detected or eliminated.

Imposed accuracy reaching for measurements, with a given reliance, P, for imposed tolerance by n repetitions of the measurement, will be obtained

$$n \geq \left[\frac{t(P)}{\varepsilon} s \right], \tag{33}$$

where $t(P)$ is the probability argument, ε – the tolerance and s – the standard error.

For a normal (Gauss) error distribution, for a reliance degree $P = 0.99$ and a tolerance at the level $\varepsilon = (0.4....2)s$ imposed, the delimiting criterion for gross and small errors will be obtained.

The probability argument

$$t = \frac{a_i - a_n}{s\sqrt{(n-1)/n}}, \tag{34}$$

for each repetition, will be determined, than $1 - 2\phi(t)$, with $\phi(t)$ – the integrated probability

$$\phi(t) = \frac{1}{\sqrt{2\pi}} \int_0^1 \mathrm{e}^{-t/2} \mathrm{d}t; \tag{35}$$

$\phi(t)$ and $1 - 2\phi(t)$, determined by Hasting approximation, are given in tables (Rumşiski, 1974).

For a given apparition probability, α, of gross errors, if:

$$1 - 2\phi(t) \leq \alpha \tag{36}$$

the measured value, a_i, is affected by gross error and will be eliminated.

Before experimentations, each type of direct measurements by n repetition will be realized. After the mean value, a_m, and standard errors, s, computation level of the tolerance, ε, will be established.

For each type of direct measurements the level of reliance, P, results, and $t(P)$ is determined from tables; finally the minimum repetition of measurement (from eq. (33)) is obtained.

4. Conclusions

In hydraulic engineering practice discharge measurement is very important. In hydraulic schemes, and sometimes in labs, there are no certified devices or instruments for discharge measurements and some hydraulic structures are used for this purpose. They are analysed and calibrated for discharge measurements.

With respect to characteristics of these structures, dependences of the discharge *vs.* other direct measurable variables are defined.

Based on direct measured variables accuracy relative error of discharge measurement and number of repetition of direct variables measurement is possible to be determined.

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* * * *Îndrumător tehnic pentru măsurarea debitelor de apă*. CNA, Bucureşti, 1981.

ERORI ŞI CALCULUL PENTRU PRECIZII PREIMPUSE A MIJLOACELOR DE MĂSURARE A DEBITELOR

(Rezumat)

Se studiază condiţiile şi posibilităţile de măsurare a debitelor. În amenajări hidrotehnice debitul se cere a fi cunoscut cu anumită precizie, iar în acest scop pot fi utilizate construcţii calibrate. Bazat pe precizia cerută se determină numărul minim de repetiţii ale mărimilor directe.

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BIOGAS - CLEAN ENERGY FOR SUSTAINABLE DEVELOPMENT

BY

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Abstract. There is an increased recognition worldwide of the need for conservation, efficient and sustainable usage of the resources and a better control of pollution and waste management for mitigating the environmental and energy crisis facing today’s world. In this context, biogas has become an attractive alternative source of energy as the renewable fuel serves several policy priorities, ranging from increased domestic energy production to the reduction of greenhouse gases and more efficient waste treatment.

In this paper, the authors will highlight the main aspects of environmental protection assured by using clean energy from biomass and modern technologies for obtaining biogas, which besides green energy offers a way for hygienization the areas inhabited by humans and animals, bringing environmental benefits and supporting the sustainable development.

Key words: environment protection; hygienization; technologies; biogas; sustainable development.

1. Introduction

The rapid growth of the world population, economy and industry in the last century has resulted in a series of factors that are particularly relevant in the

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context of the current environmental crisis: pollution of all four environment components, the main reason for the manifestation of global warming, increased quantity of wastes, intensification of agriculture and not at least shortage of water resources.

In accordance with the fast growing population and the technological development the world is facing an increased demand for energy and the dependence of consumption on fossil fuels, particularly natural gas, oil, and coal.

Overcoming the energy crisis, mitigating the environmental problems and tackling waste disposal problems led to a global recognition of the need for technical and economic efficiency in the allocation and exploitation of resources and also linking human activities with measures to protect natural factors by adopting cleaner technology to prevent and minimize the negative effects on the environment.

Cleaner technology can be achieved by promotion renewable energy sources, which also gives the guarantee of real prerequisites for achieving the strategic objectives for increasing security of energy supply based on sources diversification and reducing the share of imports of energy, namely sustainable energy sector development and environment protection.

The EU policy concerning renewable energy (RES) has set forward a fixed goal of supplying 20% (GD, 2004) of the European energy demands from RES until 2020. It is without doubt that a major part of the renewable energy will originate from European farming, forestry and wastes: by biomass conversion to gaseous, liquid and solid biofuels. At least 25% of all bioenergy in the future can originate from biogas, produced from wet organic materials, like animal manure, whole crop silages, wet organic food/feed wastes, etc.

The approached subject is a topical one, joining the current line of innovative demands on the conversion of wastes to harmless and useful products that can provide at least a partial answer to pollution and energy problem.

2. Agricultural Biomass and Biogas Potential in European Union

The most common kinds of waste can be classified into four types: agricultural, industrial, municipal and nuclear. Agricultural wastes include a wide range of organic materials (often containing pesticides), animal wastes, and timber by-products. Many of these, such as plant residues and livestock manure, are very beneficial processed as renewable energy.

The animal production sector is responsible for 18% of the green house gas emission, measured in CO_2 equivalent and for 37% of the anthropogenic methane, which has 23 times the global warming potential of CO_2. Furthermore, 65% of anthropogenic nitrous oxide and 64% of anthropogenic ammonia emission originates from the same animal production sector (Alloway, 1990).

In the EU-27 more than 1,500 mill tonnes of animal manure is produced every year. When untreated or managed poorly, manure becomes a major source of ground and fresh water pollution, pathogen emission, nutrient leaching, and ammonia release. If handled properly, it turns out to be renewable energy feedstock and an efficient source of nutrients for crop cultivation.

Table 1 shows the biogas and energy potential of pig and cattle manure produced every year in the European Union.

Table 1
Estimated Amounts of Areas of Interest for Biomass Production from Agriculture and Animal Manure for Each Member of European Union (Nielsen-Holm *et al*., 2008)

Country	Arable area (106 Ha)	Agricultural area (106 Ha)	Cattle manure (106 tons)	Pig manure (106 tons)	Total manure (106 tons)
Austria	1.4	3.4	29	6	35
Belgium	0.8	1.4	38	12	49
Bulgaria	3.3	5.3	9	2	11
Cyprus	0.1	0.1	1	1	2
Czech Republic	3.1	4.3	20	5	25
Denmark	2.3	2.7	22	24	46
Estonia	0.5	0.8	3	1	4
Finland	2.2	2.2	13	3	16
France	18.5	29.7	272	28	300
Germany	11.8	17.0	183	49	232
Greece	2.7	8.4	8	2	10
Hungary	4.6	5.9	10	8	18
Ireland	1.2	4.4	98	4	102
Italy	8.0	15.1	89	17	106
Latvia	1.8	2.5	5	1	6
Lithuania	2.9	3.5	11	2	13
Luxemburg	0.06	0.1	3	0	3
Malta	0.01	0.01	0	0	0
Netherlands	0.9	1.9	54	21	75
Poland	12.6	16.2	77	33	110
Portugal	1.6	3.7	20	5	25
Romania	9.4	14.7	40	12	52
Slovakia	1.4	2.4	8	3	11
Slovenia	0.2	0.5	6	1	7
Spain	13.7	30.2	94	46	140
Sweden	2.7	3.2	23	3	26
U.K	5.7	17.0	146	9	155
EU Total	196.6	113.5	1,284	295	1,578

Total manure (106 tons) = 1,578; for realistic implementation level and utilization al 40...70%; methane heat of combustion 40.3 MJ / m^3; Mtoe = 44.8 Pj; assumed methane content of biogas 65%.

Total Manure (106 tons)	Biogas (106 m^3)	Methane (106 m^3)	Potential PJ	Potential Mtoe
1578	31.568	20.519	827	18.5

Table 1 presents areas of specific interests for biomass production conditions. The calculation of biogas potential was taken into consideration only for manure. Based on the data from Table 1, the possible energy crops potential was calculated. The results in PJ and Mtoe are presented in Table 2. The countries with good potential to produce biomass for energy are the ones with high ratio hectares of agricultural land per capita.

Table 2

Energy Crop Potential in EU, Depending on the Percentage of Utilized Arable Land and Achieved Crop Yield (Nielsen-Holm *et al*., 2008)

Yield	10% arable land in EU		20% arable land in EU		30% arable land in EU		CH_4	
	PJ	Mtoe	PJ	Mtoe	PJ	Mtoe	m^3	Mtoe
10 t TS/ha	2.042	46	4.084	91	6.127	137	25.3 billion	22.8
20 t TS/ha	4.084	91	8.169	182	12.253	274	50.7 billion	45.5
30 t TS/ha	6.127	137	12.253	274	18.380	410	76.0 billion	68.5

L e g e n d: TS – total solid = dry matter-biomass; Mtoe – million tons of oil equivalents.

The estimated biogas production in the European Union can be seen in the Table 3. This Table shows amounts of exploited biogas, and not biogas burnt in flares.

Table 3

Biogas Production in European Union, [ktoe] []

Country	Landfill gas	Sewage sludge gas[1]	Other biogases[2]	Total
Germany	416.4	270.2	1,696.5	2,383.1
United Kingdom	1,433.1	191.1	–	1,624.2
Italy	357.7	1.0	47.5	406.2
Spain	259.6	49.1	21.3	329.9
France	161.3	144.2	3.7	309.2
The Netherlands	43.2	48.0	82.8	174.0
Austria	10.7	2.0	126.4	139.1
Denmark	14.3	21.0	62.6	97.9
Belgium	48.1	18.0	12.5	78.6
Czech Republic	29.4	32.1	17.0	78.5
Poland	19.1	43.0	0.5	62.6
Greece	38.0	9.8	–	47.8
Finland	26.4	10.3	–	36.7
Ireland	23.9	7.9	1.7	33.5
Sweden3	19.1	52.4	19.1	90.6
Hungary	2.1	12.4	5.7	20.2
Portugal	–	–	15.4	15.4
Slovenia	7.6	0.6	3.8	11.9
Luxembourg	–	–	10.0	10.0
Slovakia	0.5	7.6	0.5	8.6
Estonia	3.1	1.1	–	4.2
Lithuania	1.6	0.8	–	2.5
Cyprus	–	–	0.2	0.2
Total	2,905.2	887.2	2,108.0	5,901.2

L e g e n d: [1]Urban and industrial. [2]Decentralized agricultural plants, municipal solid waste methanisation plants, centralized codigestion plants.

Biodegradable organic waste produces – in undirected way – large quantities of biogas with methane content that produces a greenhouse effect over 20 times bigger than carbon dioxide.

Table 4
Biogas Production, Electricity and Thermal Energy Potential for Different Wastes
(Biogas Barometer, 2008)

Product	Volume m^3	Weight t	Biogas m^3	Electricity kWh	Thermal energy kWh
Liquid bovine dejection	1	1	15	27	54
Solid bovine dejection	1	0.3	10.1	18	36
Liquid swine dejection	1	1	15.6	28	56
Solid swine dejection	1	0.3	23.5	42	84.6
Liquid poultry droppings	1	1	44.5	80	160
Solid poultry droppings	1	0.3	29.3	52	105
Solid sheep droppings	1	0.3	21.1	38	76
Solid horse droppings	1	0.3	18.9	34	68
Corn Silo	1	0.625	67.6	121	243
Grass crop	1	0.5	89	160	320
Fan	1	0.35	137.8	248	496
Clover	1	0.3	64	115	230
Straw	1	0.04	12	21	49
Corn cobs	1	0.4	123.8	222	445
Apple scraps	1	0.3	2.6	4.6	9.4
Molasses	1	0.3	68.4	123	246
Whey	1	1	15.3	28	56
Vegetable scraps	1	0.4	14.5	26	52
Tomatoes peel	1	0.4	29.8	53.6	107
Scraps from the mold	1	0.5	357	642.6	1285
Citrus pasta	1	0.3	36.8	65.8	131.7

Energy component that calls for action of producing biogas is becoming more important under current energy crisis. Of course there are also other components: ecological, social, and pedological but the share of the first one tends to increase especially after the increasingly obvious crisis of fossil fuel and resources and the threat of global warming as a result of human activities.

3. Wastewater Treatment and Biogas

The scientific and technical development of the last two centuries has created the conditions for lifting the material quality of people's life, but the contemporary world is facing major problems with the management of resources and environmental protection.

The consumption of water, their contamination with large amounts of pollutants has adverse effects on the environment, producing a lock of balance with a particular emphasis on life.

Therefore the attention of many countries is moving toward more rigorous management of waste water treatment technologies, as well as upon of capitalize their organic potential as a non-conventional energy source.

Municipal sewage contains organic biomass solids, and many wastewater treatment plants use anaerobic digestion to reduce the volume of these solids. Anaerobic digestion stabilizes sewage sludge and destroys pathogens.

3.1. Principles of Anaerobic Treatment

Methane fermentation of organic solid and liquid waste is an anaerobic process through which is achieved the progressive mineralization of organic matter due to biochemical oxidation–reduction processes and leads to the formation, on the one hand, of carbon dioxide by oxidation, and secondly, of methane by reduction.

In this fermentation process, the gas mixture is known as fermentation gas methane, swamp gas or biogas. Chemically speaking, biogas is a mixture of methane gas, carbon dioxide and very small proportions, carbon monoxide, nitrogen, hydrogen sulfide, water vapor, etc.

Underlying processes of anaerobic digestion are classified into three main categories:

a) hydrolysis;

b) formation of acids and acetogenesis;

c) methanogenesis.

The main products of anaerobic digestion are: biogas, stabilized effluent and sludge with improved properties.

Biogas is a gaseous mixture consisting mainly of methane, carbon dioxide, and in small proportion gases like: H_2S, H_2, NH_3, etc.

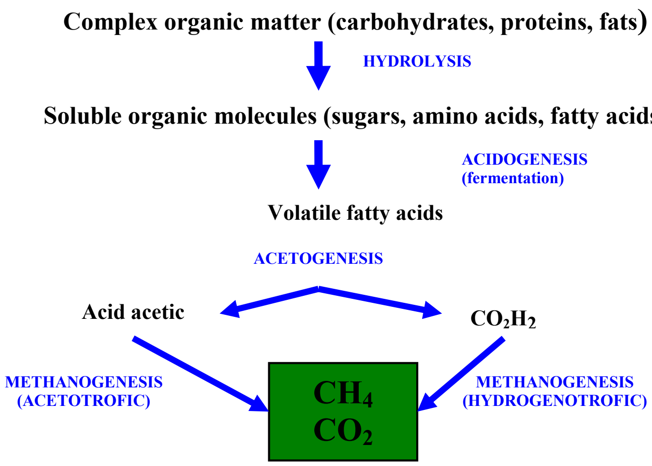

Fig. 1 – Anaerobic digestion biochemical conversion pathways (www.rotaguido.it)

The quantity and composition of the fermentation gas (biogas) depend on the composition of organic material degradation and the continued functioning of the process.

In Table 5 are presented the average values of biogas composition depending on substrate used. Lower heat potential of biogas is about 5,250 kcal/m^3 for a methane content of 60%.

Table 5

Biogas Composition Depending on the Type of Substrate Used (Pantea, 2010)

Components	Agricultural residues	Sewage sludge	Industrial Waste	Landfills
Methane	50...80%	50...80%	50...70%	45...65%
Carbon dioxide	30...50%	20...50%	30...50%	34...55%
Water	saturated	saturated	saturated	saturated
Hydrogen	0...2%	0...5%	0...2%	0...1%
Hydrogen sulfide	100-700 ppm	0...1%	0...8%	0.5...100 ppm
Ammonia	insignificant	insignificant	insignificant	insignificant
Carbon monoxide	0...1%	0...1%	0...1%	insignificant
Nitrogen	0...1%	0...3%	0...1%	0...20%
Oxygen	0...1%	0...1%	0...1%	0...5%

The anaerobic decomposition of carbohydrates is formed with a composition of biogas $CH_4/CO_2 = 1/1$. This report can cover up to $CH_4/CO_2 =$ $= 2/1$, with higher volume of protein and carbon-rich fat.

From an economic perspective, the specific quantity and quality of biogas produced as a result of anaerobic processing of waste water and sludge are important parameters of the process.

Table 6

Production and Composition of Gas for Different Groups of Organic Substances (Pantea, 2010)

Group	Gas production and composition cm^3/g substance
Carbohydrates	790 (50 CH_4 + 50 CO_2)
Fats	1,250 (68 CH_4 + 32 CO_2)
Proteins	704 (71 CH_4 + 29 CO_2)

According to B u s w e l l's equation for anaerobic treatment of wastewater unpurified with carbohydrate the theretical composition of biogas is 50% CH_4 and 50% CO_2,

$$C_6H_{12}O_6 \rightarrow 3\ CH_4 + 3\ CO_2 \qquad (1)$$

Whereas CO_2 is more soluble in water, with decreasing temperature and the increasing of pH, CO_2 reacts and forms bycarbonate/carbonate and biogas can contain more than 80% methane.

The total quantity of gas is reduced by the amount of CO_2 that is absorbed and dissolved in the liquid. Waste water containing protein and fatty acids can generate more than 50% methane.

Effluent characteristic depends on the effluent treatment system adopted for waste water treatment and organic water. During the anaerobic process a part of organic matter turns into methane and another part is digested and reflected in the effluent.

Anaerobic sludge digestion provides a small amount of sludge compared with aerobic treatment, with good qualities that can be capitalized by using it as fertilizer for agriculture, because it contains nutrients (N, P, Mg, etc.).

a) *Hydrolysis*

Hydrolysis is the first step required for anaerobic degradation of complex organic substrate. The types of organic polymers commonly founded in waste water, especially ones from food industry are: carbohydrates, proteins and lipids.

Organic polymer materials can not be used as it is by microorganisms so it must be hydrolyzed to compounds with smaller molecules able to cross the cell membrane.

At this stage, microorganisms in combination with extra cellular enzymes (cellulases, hemi-cellulases, proteases, etc.) decompose the complex organic substances in organic acids, amino acids, hydrogen and carbon dioxide. The degree of hydrolysis depends on several factors including: pH, temperature, biomass concentration, type of organic material anaerobic treated.

b) *Formation of acids and acetogenesis*

Hydrolysis products are converted into organic acids by acidogenic fermentation bacteria. Acidogenic and hydrogen producing bacteria microorganisms decompose substances resulting from the preceding stage of hydrogen, acetate and carbon dioxide, which is the substrate for methanogenesis.

This phase is called *the BOD's constant phase* because it makes a chemical rearrangement of the structure of organic molecules and takes place in two stages: acetic acid is formed and alcohols, hydrogen reducing equivalents that may be achieved only when molecular hydrogen is removed immediately after training.

The presence of large quantities of hydrogen causes the formation of volatile fatty acids (especially propionic acid, butyric acid and alcohols).

Acetogenesis is the phase in which acids (propionic, butyric) and alcohols produced in the first stage are converted to acetate, bicarbonate, and molecular hydrogen reducing equivalents under the influence of acetogenesis microorganisms.

Non-methanogen state microorganism population is composed of anaerobic bacteria. Acetogenesis bacteria produce hydrogen, carbon dioxide and acetate. The species of microorganisms encountered in the acetogenesis degradation are Syntrophomonas wolfei and Syntrophobacter wolini.

c) *Methanogenesis*

During methanogenesis stage microorganisms break down the products of acetogenesis phase and after the process results methane and carbon dioxide. Methanogenic bacteria are responsible for the formation of methane, all studied methanogenic microorganisms possessing special coenzymes, coenzyme *M*, which participates in the final stage in the formation of methane. For the microorganisms responsible for methanogenesis, the anaerobic environment should be mandatory.

Among the organisms involved in the anaerobic processes anaerobic are: *Clostridiumsp*, *Anaerobus Peptococcus*, *Bifidobacterium* sp. *Desulphovibrio* sp., *Corynebacterium* sp., & *Lactobacillus*, *Actinomyces*, *Staphylococcus* and *Escherichia coli*.

The main methanogenic reactions are

1. The hidro-genotropic reactions (Pantea, 2010)

$$4\ H_2 + H^+ + 2\ HCO_3^- \rightarrow \text{acetat} + 4\ H_2O \tag{2}$$

$$4H_2 + 4S^\circ \rightarrow 4\ HS^- + 4\ H^+ \tag{3}$$

$$4H_2 + 2HCO_3^- + H^+ \rightarrow CH_4 + 3H_2O \tag{4}$$

$$4H_2 + 4SO_4^{2-} + H^+ \rightarrow HS^- + 4H_2O \tag{5}$$

$$4H_2 + NO_3^- + 2H^+ \rightarrow NH_4^+ + 3H_2O \tag{6}$$

2. Acetoclastic methanogenesis

$$CH_3COO^- + H_2O \rightarrow HCO_3^- + CH_4 \tag{7}$$

3. Other substrates metanogenesis

$$4HCOOH \rightarrow CH_4 + 3CO_2 + 2H_2O \tag{8}$$

$$4CH_3COOH \rightarrow 3CH_4 + CO_2 + 2H_2O \tag{9}$$

$$4\left(CH_3\right)_3 N + 6\ H_2O \rightarrow 9CH_4 + 3CO_2 + 4NH_3 \tag{10}$$

$$2\left(CH_3\right)_2 NH + 2H_2O \rightarrow 3CH_4 + CO_2 + 2NH \tag{11}$$

$$4\left(CH_3\right) NH_2 + 2H_2O \rightarrow 3CH_4 + CO_2 + 4NH_3 \tag{12}$$

4. Biogas Utilization

Biogas can be used for the same applications as natural gas. The energy content of biogas and landfill gas depends on its content of methane. The energy content for biogas with methane content of 65%, and for biogas upgraded to 97% methane, and for other fuels is:

a) 1 Nm^3 biogas (65% methane) = 6.5;
b) 1 Nm^3 biogas (97% methane) = 9.7;
c) 1 liter petrol = 9.1;
d) 1 liter diesel = 9.8.

All gas appliances can be adjusted to the lower heating value of biogas. It is demonstrated that biogas can be applied for the production of heat, *e.g.* in hot water and steam boilers; for the production of electricity and heat in combined heat and power plants (CHP), in micro turbines or in hot fuel cells (solid oxide fuel cells, molten carbonate fuel cells) (McCahey, 2007).

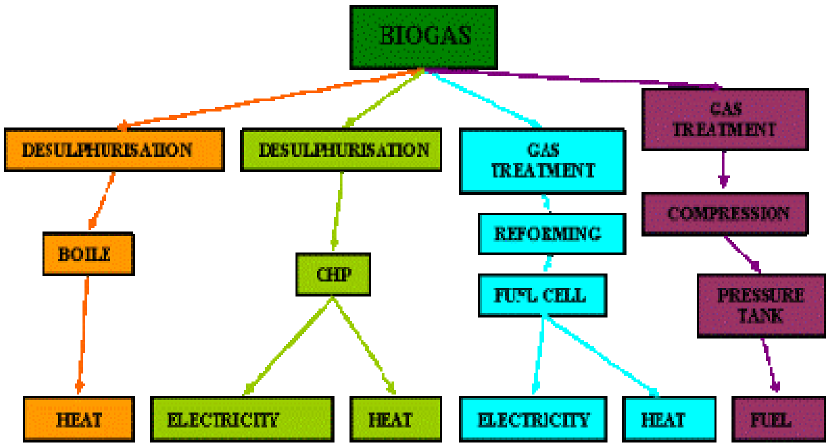

Fig. 2. – Biogas utilization yield (Holm-Nielsen *et al.*, 2009).

Biogas can also be used as a vehicle fuel. Natural gas used as a vehicle fuel gives 20...30% lower CO_2 emissions. For biogas the reduction of green house gas emissions can be as much as 100%. In fact, a reduction above 100% can be achieved when biogas produced from manure is utilized as a vehicle fuel.

Methane, which is a strong green house gas, is released into the atmosphere from manure in traditional manure storage. Biogas as a vehicle fuel can thus both decrease the leakage of methane from manure and decrease the emissions of fossil carbon dioxide. Another advantage is that vehicles running on upgraded biogas or natural gas have lower emissions of particles of NO_x and SO_x.

Biogas can be used in a number of applications including fuel for natural gas vehicles. The main environmental benefit is that fossil fuels like petrol and diesel can be replaced.

Nowadays biogas is widely used for energy efficiency of the processes that takes place in waste water treatment plants (WWTP).

Due to the large number of equipment operating in a WWTP, electricity consumption is high. In the operation of a waste water treatment plant energy consumption is necessary for pumping mechanisms movement, lighting, signals, technological heating.

Biogas is sludge fermentation gas, a by-product of biological sludge stabilization process. Following fermentation process the gas resulted requires collection, processing and storage until use. It is usually passed through special separators, where methane gas is separated from the rest. Using raw biogas can lead to poisoning, because it contains toxic gases.

An example of an operating plant of biogas is the biological reactor or metantank, a concrete construction, waterproofed and thermal insulated. Inside the metantank must be maintained a completely anaerobic environment for the process to take place. Anaerobic digester is a large energy consumer. By using biogas is possible to increase energy efficiency and lower energy consumption. A plant can use 2...4 biological reactors having the heating system of the thermophilic regime sludge posed in the center.

Biogas can be used in cogeneration plants located in the waste water treatment plant. On the sludge line, at low power, under 1MW, can be used internal combustion engines that operate with diesel purified biogas, clean. For powers greater than 1 MW gas turbines which are coupled to electrical generators will be used (Dima, 1999).

Methane within biogas can be concentrated *via* a biogas up grader to the same standards as fossil natural gas (which itself has had to go through a cleaning process), and becomes biomethane. If the local gas network allows for this, the producer of the biogas may utilize the local gas distribution networks. Gas must be very clean to reach pipeline quality, and must be of the correct composition for the local distribution network to accept. Carbon dioxide, water, hydrogen sulfide and particulates must be removed if present. If concentrated and compressed it can also be used in vehicle transportation. Compressed biogas is becoming widely used in Sweden, Switzerland, and Germany.

A biogas-powered train has been in service in Sweden since 2005.

5. Conclusions

At present the European Union has some of the strictest legislation regarding waste management and landfill sites called The Landfill Directive (Council Directive, 1979) which aim is “to prevent or reduce as far as possible negative effects on the environment, in particular the pollution of surface water, groundwater, soil and air, and on the global environment, including the greenhouse effect, as well as any resulting risk to human health, from the land filling of waste, during the whole life-cycle of the landfill”.

Biogas has become an attractive alternative source of energy in Europe as the renewable fuel serves several policy priorities, ranging from increased domestic energy production to the reduction of greenhouse gases and more efficient waste treatment.

In the current global environmental crisis and the limited degree of supportability of the environment, the authors of this paper, highlights the importance of promoting environmental protection, by using renewable energy – biogas, as a component of sustainable development of human society in a clean environment free from environmental risks.

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BIOGAZ – ENERGIE CURATĂ PENTRU ASIGURAREA DEZVOLTĂRII DURABILE

(Rezumat)

Este recunoscută la nivel mondial necesitatea de conservare, utilizarea eficientă şi durabilă a resurselor şi un mai bun control al poluării şi gestionarii deşeurilor în vederea atenuării crizei energetice şi de mediu cu care se confruntă lumea de astăzi. În acest context biogazul, a devenit o sursă de energie alternativă atractivă în calitate de combustibil regenerabil, servind mai multe priorităţi de acţiune, variind de la creşterea producţiei interne de energie la reducerea emisiilor de gaze cu efect de seră şi tratarea mai eficientă a deşeurilor.

Se evidenţiază unele aspecte ale protecţiei mediului asigurată prin utilizarea energiei curate din biomasă şi tehnologii moderne de obţinere a biogazului, care, pe lângă energie verde oferă o modalitate pentru igienizarea zonelor locuite de oameni şi animale, aducând beneficii de mediu şi sprijinind dezvoltarea durabilă.

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STUDY CONCERNING ON THE INFLUENCE OF FRICTION COEFFICIENT OVER GRAVITY DAMS – PPC APPLICATION

BY

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Abstract. In recent years, the use of small computers in various fields of activities took an increasing scale. This is mainly due to the convenience of their small size and similar performance with an average power computer. Moreover, they offer the ability to connect remotely *via* the built-in modem to any other computer or data base storage place. Shortly, they have the necessary facilities for land use activities. The aim of the authors is to write a program for Pocket PC and to use it mainly for demonstration purposes and study the development of characteristic parameters of gravity dams based on variation of friction coefficient, f. The research results are presented in the form of charts and tables accompanied by an interpretation of them.

Key words: friction coefficient; gravity dam; pocket PC.

1. Introduction

The influence of friction coefficient, *f*, and negative pressure coefficient, *m*, over the upstream and downstream-side slope of dams is well known for triangular profiles. In the present study we aim to illustrate this influence using a computer tool came recently in the use of engineers and researchers, the Pocket PC. For now, the software available for these computers

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is limited to operating systems, incompatible with those on regular computers and other specific applications focused mainly on networking, internet, mobile telephony and GPS (Global Positioning System). These computers have a great advantage for field research because they are powerful computing machines while very small. We have tried to compensate this shortfall due to lack of specific software for studied issues. So, we have purchased at an affordable price a programming language used on this mini-computers: *Visual Basic for Pocket PC*. The only downside of this programming language is the limited number of characters allowed for line program (see the extract of program code below).

We have designed a computer program especially for teaching purposes, able to calculate the overturning and sliding stability coefficients, the efforts in horizontal sections for the following circumstances: construction or operating, taking into account or not the earthquake. The research results were represented as charts and tables accompanied by a discussion over them.

2. Experiment Description

The program has two working screens

a) An input screen for entering the following data (Fig. 1): the height of the dam, *Hb*, [m]; width of the coping, *BC*, [m]; coping height, *hc*, [m]; negative pressure coefficient, *m*; reduction coefficient of pore water pressure; the concrete – rock friction coefficient, *f*; calculation section *Z*, [m], and some option boxes for taking into account or not the loads according to a specific loading scheme (self weight, water, earthquake); three other buttons are designed for running (ENTER,) reset screen (RESET) and an exit button.

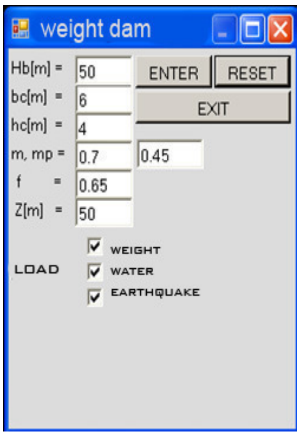

Fig. 1 – The input screen.

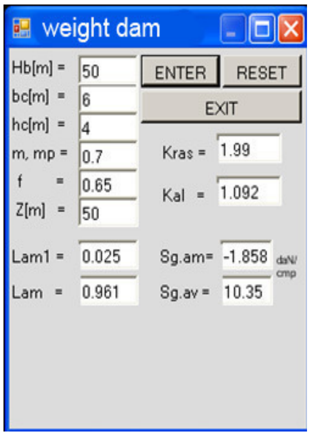

Fig. 2 – The result screen.

b) The second screen (Fig. 2) contains additional windows for displaying results: upstream and downstream slope: $1/\lambda_1$ respectively $1/\lambda$; the coefficient of sliding stability, k_{al}; the overturning stability coefficient, K_{ras}; efforts at the upstream side σ_{am} and at the downstream-side, and σ_{av} [daN/cm^2]. The screen becomes available after hitting the *run* button (ENTER) of the first screen. Both screens have a standard form for Pocket PC computers, leaving space at the bottom of each screen for the on-screen keyboard.

In what follows are given some of the code lines written in Visual Basic for Pocket PC, presented for demonstration purposes only (just a sample of the whole code). It is necessary to mention the limited number of characters allowed for a statement of the code and the fact that we had to split the long formulas to fit within 120 characters for each statement:

```
Sub Button1_Click
label1.Visible=True
label2.Visible=True
textbox1.visible=True
textbox2.Visible=True
label6.Visible=True
label7.Visible=True
textbox6.visible=True
textbox7.Visible=True
label11.Visible=True
label12.Visible=True
textbox11.visible=True
textbox12.Visible=True
label16.Visible=False
textbox13.Visible=False
textbox14.Visible=False
label15.Visible=False
checkbox1.visible=False
checkbox2.Visible=False
checkbox3.Visible=False
label13.Visible=True
...
mg=bc*hc*(B-bc/2)+bc^2/2*H/B*(B-2/3*bc)+B^2*H/3+x*H/2*(B+x/3)
mr=((B+x)*H/2+(2*hc+bc*H/B)*bc/2)*(B+x)*2/3
...
'Text6.Visible=-1
'Text7.Visible=-1
TextBox6.Text=kr
TextBox7.Text=kal
...
er=(bc*hc*(l*z-bc/2)+bc^2/2/l*(l*z-
2/3*bc)+l*z^2/2*2/3*l*z+l1*z^2/2*(l*z+l1*z/3))
er=er/(bc*hc+bc^2/2/l+l*z^2/2+l1*z^2/2)
...
'Remcalc.ef.seismG
erg=(bc*hc*(z+hc/2)+bc/2*bc/l*(x-
bc/l/3)+(l1+l)*z*z/2*z/3)/(bc*hc+bc/2*bc/l+(l1+l)*z*z/2)
```

```
ssga=6*0.1*2300*(bc*hc+bc/2*bc/l+(l1+l)*z*z/2)*erg/((l1+l)*z)^2
ssgv=-6*0.1*2300*(bc*hc+bc/2*bc/l+(l1+l)*z*z/2)*erg/((l1+l)*z)^2
ssga=Int(ssga/10000*1000)/1000 'transf in daN/cmp,3zec
ssgv=Int(ssgv/10000*1000)/1000
If CheckBox1.Checked=True Then
kg=1
Else
kg=0
End If
If CheckBox2.Checked=True Then
ka=1
ksemn=-1
Else
ka=0
ksemn=1
End If
If CheckBox3.Checked=True Then
ks=1
Else
ks=0
End If
If z<H-ha Then
m=TextBox14.Text
ha=0
Else
m=TextBox8.Text
'ha=3
ha=z-(H-ha)
End If
bz=(l1+l)*z
saa=(500*l1*z^2-m*500*(z-ha)*bz+1000*ha*bz+500*l*ha^2)/bz
saam=500*l1*z^2*(bz/2-l1*z/3)-500*z^3/3-m*500*(z-ha)*bz*(bz/2-
(l1+l)/3)+500*ha^3/3-500*l*ha^2*(bz/2-l*ha/3)
saam=saam*6/bz^2
saa=saa+saam
saa=Int(saa/10000*100)/100
sav=(500*l1*z^2-m*500*(z-ha)*bz+1000*ha*bz+500*l*ha^2)/bz
av=sav-saam
sav=Int(sav/10000*100)/100
sta=sa*kg+saa*ka+ssga*ksemn*kg*ks+ssaa*ka*ks
stv=sv*kg+sav*ka+ssgv*ksemn*kg*ks+ssav*ka*ks
TextBox11.Text=sta
TextBox12.Text=stv
End Sub
End Sub
Sub Button3_Click
AppClose
End Sub
Sub CheckBox2_Click
```

```
    label16.Visible=True
    textbox13.Visible=True
  End Sub
```

The research team has analyzed the influence of two parameters over the characteristics of a gravity dam. They are the negative pressure coefficient, m, ranging between 0.5 and 1 for a constant friction coefficient of 0.65 and coefficient of friction, f, ranging between 0.5 and 0.8 for a constant value of the negative pressure coefficient of 0.7. Based on the results obtained by running the program we have been prepared the following tables and graphs to showing the evolution of the following parameters: λ_1, λ, K_{ras}, k_{al}, σ_{am}, σ_{av} in the construction and operating hypothesis, with and without earthquake. Because of luck of space, for now, we shall only discuss the influence of the *f* parameter.

Table 1

Changes in the Characteristics of the Dam According to the Friction Coefficient, f

Nr.	*Hb*	*m*	*f*	b_c	h_c	λ_1	λ	σ_{am} (G+W)	σ_{av} (G+W)	σ_{am} (G+W+ +EQ)	σ_{av} (G+W+ +EQ)	K_{ras}	K_{al}
1	50	0.7	0.5	8	4	0.033	1.25	2.18	6.34	0.826	7.694	2.411	1.095
2	50	0.7	0.55	8	4	0.033	1.136	1.64	6.95	0.105	8.485	2.285	1.107
3	50	0.7	0.6	8	4	0.033	1.041	1.06	7.61	–0.664	9.334	2.163	1.12
4	50	0.7	0.65	8	4	0.033	0.961	0.42	8.33	–1.498	10.24	2.046	1.133
5	50	0.7	0.7	8	4	0.033	0.892	–0.27	9.11	–2.392	11.23	1.935	1.146
6	50	0.7	0.75	8	4	0.032	0.833	–1.01	9.93	–3.343	12.26	1.829	1.159
7	50	0.7	0.8	8	4	0.032	0.79	–1.66	10.65	–4.17	13.16	1.748	1.184
8	50	0.7	0.85	8	4	0.032	0.79	–1.66	10.65	–4.17	13.16	1.748	1.258
9	50	0.7	0.9	8	4	0.032	0.79	–1.66	10.65	–4.17	13.16	1.748	1.332
10	50	0.7	0.95	8	4	0.032	0.79	–1.66	10.65	–4.17	13.16	1.748	1.406
11	50	0.7	1	8	4	0.032	0.79	–1.66	10.65	–4.17	13.16	1.748	1.48

3. Results and Significances

The results (represented in Fig. 3 show that the values of λ are quite strongly influenced by the variation of *f* whiles the values of λ_1 (the upstream tilt) remain almost constant. We need to mention that upstream and downstream tilt were calculated by the program as follows: λ, the downstream tilt, results from the conditions of stability whiles λ_1, the upstream tilt results from the condition that the resultant of all forces acting on the dam is located at the upstream limit of the central core. We also have to remember that all the assumptions are made for teaching purposes and this sample is as simple as possible so the students will easily understand it and learn to use it.

Analysing Fig. 4, one can observe that the variation of *f*, affects both the stability coefficient of the structure. While overturning stability coefficient, K_{ras}, is strongly influenced (reduced) by values of the friction coefficient between 0.5 and 0.8 (the most common situation in practice), slip-rate stability, K_{al}, is stronger influenced (increased) by values of $f > 0.8$.

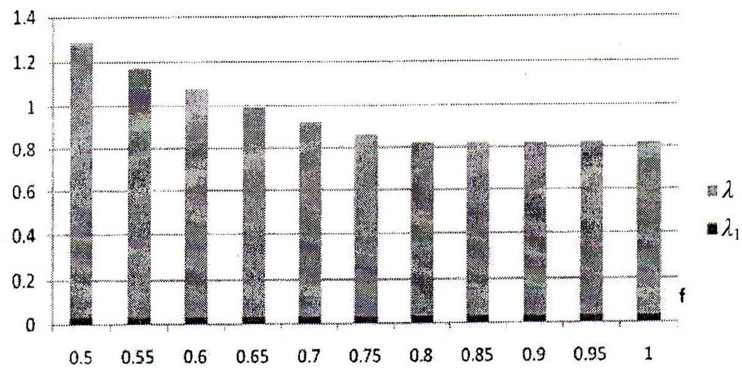

Fig 3 – Variation of λ and λ_1 *vs*. *f*.

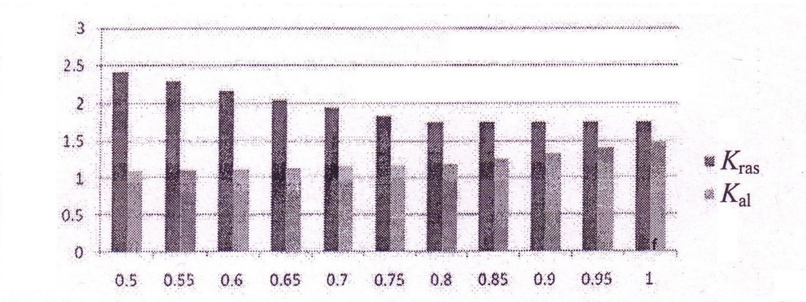

Fig 4 – Variation of K_{ras} and K_{al} *vs*. *f*.

The variation of σ_{am} respectively σ_{av} efforts, *versus* friction coefficient, *f*, is represented in Fig. 5. It is noted that σ_{am} has positive and negative values, with value 0 for *f* ; 0.68. The σ_{av} values are always positive, ranging between the 0…10.8 daN/cm2.

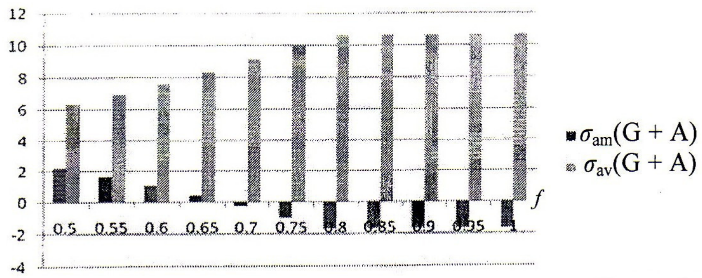

Fig 5 – Variation of σ_{am} and σ_{av}, if lake is full, depending on *f*.

As expected the values of σ_{am}, respectively σ_{av}, are small compared to the resilience of the concrete, emphasizing the lack of these types of dam construction: inefficient use of the strength capacity of the concrete.

Similarly, the Fig. 6 shows the concrete efforts for the two sides, when lake if full and earthquake occurs. Efforts are higher at both sides; the upstream values are mostly negative not exceeding 4 daN/cm^2. In this case too, the resilience of the concrete is not rationally used especially for the compression stresses σ_{av} .

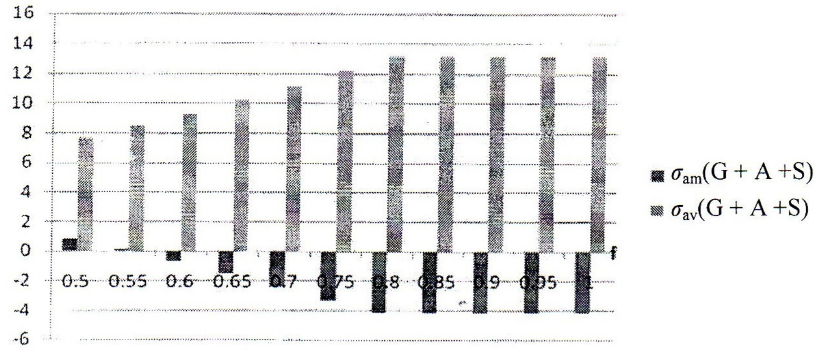

Fig 6 – Variation of σ_{am} and σ_{av} *vs. f*, if lake is full and earthquake occurs.

4. Conclusions

The use of Pocket PC proves to be a handy alternative for various on site studies. Our example is mainly a didactical example and incite for engineers and researchers with programming abilities to start writing programs for scientific use of these devices. This small study aims to give students a much more interesting and affordable way to perform scientific studies with the help of a device which mainly use for communication or fun but most likely to be quickly and easily available in any circumstances. The graphic presentation of the results is suggestive for the studied influence of the friction coefficient over the assumed way of dimensioning a gravity dam.

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* * * Basic for PPC, language website: http://www.basic4ppc.com/Documentation

STUDIU PRIVIND INFLUENŢA COEFICIENTULUI DE FRECARE ASUPRA GRAVITĂŢII BARAJELOR – APLICAŢIE PPC

(Rezumat)

În ultimii ani, utilizarea calculatoarelor mici în diverse domenii de activitate s-a făcut la o scară mai largă. Acest lucru se datorează în principal confortului de dimensiuni reduse şi de performanţă similară cu un calculator de putere medie. Mai mult decât atât, acestea oferă posibilitatea de conectare de la distanţă prin intermediul built-in modem la orice alt computer sau bază de date. Pe scurt, ele au facilităţile necesare pentru activităţile de utilizare pe teren. Scopul autorilor este de a scrie un program pentru Pocket PC şi de a-l utiliza în principal pentru scopuri demonstrative şi de studiu de dezvoltare a parametrilor caracteristici ai barajelor gravitaţionale bazat pe variaţia coeficientului de frecare, *f*. Rezultatele cercetării sunt prezentate sub formă de grafice şi tabele, însoţite de o interpretare a acestora.

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INFLUENCE OF ENVIRONMENTAL FACTORS ON MECHANICAL RESISTANCE OF STONE BUILDINGS AND THEIR QUANTIFICATION IN TECHNICAL EXPERTISE

BY

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Abstract. The main factors leading to deteriorating of mechanical properties of stone masonry are presented. The paper is based on research studies and investigations carried out during time on buildings made of natural stone and their interaction with the environment. As part of technical expertise, structural engineers must determine how to calculate more realistic parameters for the constituent materials. In the qualitative analysis, the identification of factors and destructive effects represents an important element of investigative activity. Based on some case studies solved by the authors, destructive factors are synthesized, and so as the parameters of behavior and pathology degradation. The effect of destructive factors from marine environment upon stone buildings is studied too.

Key words: stone; environmental factors; mechanical strength.

1. Introduction

The activity of technical expertise of buildings, structural intervention measures in order to ensure their strength and stability and, in particular, the

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work of conservation and restoration of historic buildings is based on knowledge of constituent material behavior phenomena, structural engineers can interpret the whole building response towards the environment. Any building material degradation is the result of a process that takes place in very different time evolutions depending on the particular materials and construction processes on one hand, depending on the nature, intensity and frequency of causes, on the other hand.

2. General Causes of Degradation

The general causes of degradation in the interaction of building materials - environment, can be grouped as follows:

a) Congenital factors: evidenced by hidden defects and potential defects of materials caused by the use of improper construction materials and methods of operating conditions, errors in design or execution.

b) Cyclical factors: manifested by aggressive agents presence in the environment due to geoclimatic phenomena (rain, snow, wind, solar radiation, relative humidity, temperature variations, according to seasonal and daily cycles); work intermittently, with different intensity and frequency.

c) Acyclic factors: manifested by pollution, vibration, biological attacks, etc.

d) Operating factors: operating materialized loads, wear, aging, about the functional requirements.

e) Accidental factors: manifested through strokes, liquid or gas leaks, hard body impact caused by negligence, misuse, inappropriate interventions.

f) Catastrophic factors: seismic action, landslides and land subsidence, floods, explosions, fire, lightning, hurricanes, etc.

These factors, quantified in the literature as pathogenic factors of the degradation process, have the effect of various forms of degenerative phenomena, most of which several will often simultaneously or in time with the actions of several factors. Most phenomena of degradation – the whole building and particularly of utilized materials – originate from the presence of water. Almost all the utilized traditional materials are porous and susceptible to moisture. Humidity present in the material, cyclical, permanent or accidentally generates and amplifies the complex change processes.

The presence of water binds a series of physical, chemical and biological processes leading to important degradation material.

Using stone commonly characterize the oldest residential buildings in certain regions. The local origin (including previous building), stone, in the form of raw or carved-stone, are mainly used to achieve mass builders, but also the structural elements or as a finishing material (floors, frames, etc.). Sometimes they are mixed masonry: brick – stone, rough stone – carved stone.

Current stones used in Romania are the limestone, in different varieties, and the silicate (marble, granite, conglomerates).

Traditional stone masonry have often plastered parament, are made of stones of different sizes and nature, lime mortar, usually hydraulic, and sand grains. Sometimes the stones are relatively homogeneous in nature and scale, are sometimes heterogeneous masonry or become heterogeneous as a result of subsequent interventions (Fig.1).

Fig. 1 – Transylvania historic monument.

The used stones come from rock origin, mineralogical composition and structure varied, and shows different characteristics and behaviors, which is why it is necessary to identify them. An approximate identification is usually possible with a visual examination of colour, texture and stone structure, which allows inclusion in one or other of the categories of specialized handbook rocks described with such physical, chemical and mechanical. In case of doubt and for precision measurements of various characteristics (composition, structure, texture) are required sampling and laboratory analysis of them.

3. Degradation Processes

Stone degradation processes are very complex, depending on one hand on the physical, chemical and mineralogical characteristics specific to each type of stone, on the other hand on the nature, intensity and frequencies of aggressive factors and their possible interactions.

Long regarded as a key to aggressive factors involved in the degradation processes are the physical ones (temperature variations, frost, etc.). Recent studies tend to give priority to explain the phenomena of degradation by the actions of chemical and even biological nature.

3.1. Physical Processes

The main physical phenomena that contribute to the degradation of building materials are

a) Successive expansions and contractions in situations where they are affected by temperature variations.

b) Mechanical action of water, the changing of aggregation state (freeze – thaw, evaporation) generate tensions that produce lift off, surface weathering, porosity, cracks and sometimes fractures.

c) Mechanical actions produced by crystallization of salts in aqueous solution by increasing the volume associated with the process, induce voltages that produce similar alterations in the frost.

d) Wind action produces progressive erosion of the exposed surfaces.

e) Physical wear normal or premature from the operating conditions.

f) Natural aging, resulting in slow changes of the structure and properties of certain materials.

Physical processes associated with natural chemical processes are dangerous.

3.2. Chemical Processes

Chemical processes are based on chemical reactions that occur between the compounds present in the utilized materials, various compounds in water and pollutants contained in water or atmosphere, reactions leading to formation of salts with various features and effects in masonry: changes solubility, crystallization mode, colour, volume changes related to frost, all effects leading to significant changes in strength of materials and consequently decreasing the bearing capacity of structures.

A fundamental characteristic of the salts, with implications for reclamation work, is the hygroscopicity, namely the ability of salts to absorb atmospheric vapour and transform them into the water.

The sulfates presence in stone masonry is related to

a) composition of the utilized materials: sulphates are commonly found in the raw material for construction materials (representing approx. 6% of Earth's crust), including water used for mortar;

b) capillary rise of groundwater containing sulfate;

c) air pollutant;

d) Black Sea is near the coast (usually magnesium sulfate);

e) presence of microorganisms (especially on calcareous or lime mortars exposed), able to metabolize sulfur into sulfate.

Typical degradation caused by these salts is erosion, efflorescence produced due to increased volume crystallization.

Sulphates are extremely dangerous because of their ability to crystallize with varying amounts of water, which produces variable volume changes depending on relative humidity, respective water quantity, and therefore voltage variations within the wall or plaster affected. For example, if a sodium sulphate 75% relative humidity causes an increase in volume of up to 40%.

The sulfates are easily identified by the following typical symptoms: superficial decomposition (friable) of the material, separation of paint and coatings, corrosion surface.

Affected areas do not always show signs of moisture, because water that promotes sulfation process is eliminated in the form of vapour.

In combination with water, anhydrous sulfuric can cause erosion of masonry SO_3 by sulfuric acid attack on calcium carbonate

$$SO_3 + H_2O \rightarrow H_2SO_4 \quad (1)$$

$$H_2SO_4 + CaCO_3 \rightarrow H_2CO_3 + CaSO_4 \quad (2)$$

Calcium sulfate can be easily "washed" with water.

An important destructive factor for building located in marine areas is mainly sodium chloride (NaCl). Chlorides are transported by capillary rise of sea wind, condensing quickly on contact with walls of stone.

In their natural state are not hygroscopic, but they are combining with other salts, especially sulphates.

Chlorides are harmful if present in water used for mortar: if at mortar preparation the calcium hydroxide comes in contact with magnesium chloride, calcium chloride is formed ($MgCl_2$), hygroscopic and soluble in water:

$$Ca(OH)_2 + MgCl_2 \rightarrow CaCl_2 + Mg(OH)_2 \quad (3)$$

In hygroscopic state, chlorides have a great capacity to absorb water and steam. In contrast, crystallization need a very low relative humidity, which is rare for the destructive effects of these salts by varying the volume.

Carbonation is a phenomenon of hydrogen and oxygen loss, the constituent material is enriched with carbon. This process occurs through the action of carbonic anhydride (a typical example is "fat" lime mortar).

Carbon dioxide reacts with water to form carbonic acid (CO_2) forms carbonic anhydrous by live burning of organic substances or by their decomposition. Major damage in buildings are caused by altered carbonate karst-type events as a result of "laundering" of calcium bicarbonate (acid calcium carbonate) from the processing of calcium carbonate formed by the action of water and carbonic anhydride, that is carbonic acid

$$CO_2 + H_2O \rightarrow H_2CO_3 \quad (4)$$

$$CaCO_3 + H_2CO_3 \rightarrow Ca(HCO_3)_2 \quad (5)$$

Another destructive factor is the hygroscopic and very soluble salts in water.

The nitrate is usually linked to the phenomenon of decomposition of organic materials and the use of nitric acid (HNO_3) as fertilizer. They are generally present in soil in the form of sodium nitrate ($NaNO_3$). Most damaging to buildings of limestone are calcium nitrate ($Ca(NO_3)_2$), resulting from the reaction between nitric acid and calcium carbonate (Figs. 2 and 3).

$$2HNO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + H_2CO_3 \quad (6)$$

Fig. 2 – Stone masonry subjected to salt attack.

Fig. 3 – Limestone masonry – marine attack.

Calcium nitrate has the capacity to absorb large amounts of water vapour. In soluble state may crystallize at a temperature of 25°C and a relative humidity of about 50%, producing aggression against masonry components in contact with that solution. Corrosion may occur if, through the action of carbonic acid, calcium nitrate is transformed into calcium carbonate and then in calcium bicarbonate

$$Ca(NO_3)_2 + H_2CO_3 \rightarrow 2HNO_3 + CaCO_3 \quad (7)$$

$$Ca(NO_3)_2 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2 \quad (8)$$

A visible alteration producted by salts on stone masonry is the formation of “black crusts” and efflorescence. “Efflorescence” salt stain appears as white, crystalline or amorphous, often located in dry areas, protected from rain, which helps to facilitate the formation of evaporation of crystal deposits. “Efflorescence” is formed by contact with moisture in the ground or the coming ascension of direct infiltration from the outside. Sometimes salt water comes from ground water, in which it tends to migrate to the free surface of the wall, dry sun or wind. Under these conditions two phenomena are manifesting: storage evaporation: salt crystals on the surface and filling superficial capillaries. It produces thus a surface crust in elevation located at the base of masonry. This crust prevents evaporation of successively contribution of moisture that takes place through the capillaries located immediately to the next level. Consequently, the newly-formed large crystals appear behind the precedents, the latter being pushed to the outside surface and the layer separates from the initial disaggregation phenomenon that continues similarly (Fig. 4).

Fig. 4 – "Efflorescence" on natural stone masonry (sediment blocks salts brought to the surface).

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INFLUENŢA FACTORILOR DE MEDIU ASUPRA REZISTENŢELOR MECANICE LA CONSTRUCŢIILE DIN PIATRĂ ŞI CUANTIFICAREA ACESTORA ÎN EXPERTIZA TEHNICĂ

(Rezumat)

Se prezintă principalii factori care conduc la deprecierea proprietăţilor mecanice ale zidăriei din piatră. Lucrarea are la bază studii şi cercetări/investigaţii efectuate pe parcursul timpului la construcţii realizate din piatră naturală supuse interacţiunii cu mediul inconjurător. În cadrul activităţii de expertiză tehnică, inginerul structurist trebuie să aprecieze cât mai real parametrii de calcul pentru materialele constitutive fapt pentru care în cadrul analizei calitative identificarea factorilor distructivi şi a efectelor produse reprezintă un element important al activităţii.

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THE EUTROPHICATION OF WETLANDS

BY

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Abstract. The paper uses as an interest point the study of eutrophication with the better understanding of flood risk and help to reduce the flood risk more effectively, especially in vulnerable areas like eutrophication risk sites. The eutrophication analysis of Bârzava hydrographic basin is presented through a computation model which takes into account the nitrogen and phosphorus concentrations, influenced by factors like temperature, transparency, biomass, biochemical consumption of oxygen. The obtained results reflect the need to apply certain measures for sediment reduction.

Key words: eutrophication; flood; floodplain; nutrients; wetland.

1. Introduction

Wetlands are considered by many authors (Durand *et al*., 2000; Datta, 2000; Sanchez-Carrillo & Alavarez-Cobelas, 2001; Song *et al*., 2007) to be unique ecosystems, different from other aquatic systems by geological, hydrological and chemical properties. In this study, the term wetland is used as ”area of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters”(Ramsar Convention…, 1971).

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Riparian wetlands exist in proximity of water courses and are usually supplied by them and have the transfer ability between the slope and water table with storing capacity for high water periods.

Due to low water speed and high content in nutrients present in wetlands, the eutrophication process is imminent. Eutrophication is defined as the water enrichment with nutritive substances for plants – first of all with nitrogen and phosphorus (the other tens of compounds needed for development being very limited) – which leads to a strong growth of the algae and macrophits („efflorescence”) which then die and produce serious consequences: water quality decrease (colour, taste, scent, disturbance, oxygen decrease, increasing concentration for iron, manganese, carbon dioxide, ammonium, methane, sulphuretted hydrogen, etc.) (Husaru, 2008). The floods play an important role in determining the eutrophication processes by modifying the water retention parameters: temperature, discharge, transparency, nutrients supply (Husaru, 2010). This issue is frequently present because of the high content of pollutants in water coming from treatment plants, agriculture and industry.

2. Experimental

The integrated water resources management requires a thorough analysis of the water resources quantitative and qualitative evolution.

2.1. Technical Indicators

β retention coefficient is defined as the ration between the water retention efficient volume, V_u, and the annual storage volume, V,

$$\beta = \frac{V_u}{V} = \frac{V_u}{31.56}106Q_m \qquad (1)$$

where Q_m is the multianual mean affluent discharge.

When the retention discharge is supplemented through derivations, this inflow has to be taken into account for the retention coefficient computation. Also, in order to determine coefficient it should be subtracted the upstream user’s discharges.

The retention coefficient is a synthetic indicator of the water retention regularization type. For the rough characterization of the regularization type taking into account this indicator, A. F i l o t t i proposes certain values. The regularization type realized for a water retention function of the retention coefficient is indicated in Table 1.

Table 1
Retention Coefficients

Regularization type	Retention coefficient	
	Minimum	Maximum
Hourly – daily	0	0.0006…0.001
Weekly	0.0006…0.001	0.003…0.006
Seasonal	0.003…0.006	0.003…0.006
Annual	0.05…0.10	0.25…0.35
Super annual	0.25…0.35	1.00…5.00

The flood retention coefficient, β_v , is defined as the ratio between the water retention's non permanent volume, V_{np}, and the flood volume, V_v,

$$\beta_v = \frac{V_{np}}{V_v}. \tag{2}$$

As the high waters are linked to different return probabilities, it becomes of high interest the computation of this coefficient for different waves. For each wave is taken into account the volume up to the extraordinary maximal level with the proper return probability. Because the extraordinary maximal level corresponding to different flood waves depends of the outlet shape, the comparison of the high waters retention coefficients for different return probabilities can provide important indications regarding the construction of the high waters waste ways.

The quality index of the retention, α, is defined as the ratio between the total volume, V_t , of the retention and the volume, W_b , of the dam's body

$$\alpha = \frac{V_t}{W_b}. \tag{3}$$

According to this index, the bigger is the value, the favourable is the location.

The quality index has a rough value, because it does not include elements concerning the retention basin development. It applicability is limited to classic water retentions with frontal dams, it usage for plain water retention with lateral dykes being questionable.

The regularization degree, γ, is defined as the ratio between the minimum discharge, Q_r , insured through the retention exploitation and the multiannual mean affluent discharge, Q_m,

$$\gamma = \frac{Q_r}{Q_m}. \tag{4}$$

The regularization degree can be determinate for different probabilities of the discharge, Q_r. Function of the probability it can be drawn a variation curve of the γ coefficient. It's important to know that this regularization degree does not take into account exclusively the retention's size and the hydrological regime, but also depends largely of the exploitation mean of the water retention.

For the water uses with variable consumption the interpretation indicator could be utilized namely

$$\gamma = \frac{Q_f}{Q_m}, \tag{5}$$

where Q_f is the multiannual mean of the a variable discharges insured by the water uses demands. Such interpretation raises difficulties if the retention satisfies the water demands for the water uses by sampling the water from different sections.

The flood wave attenuation degree is defined as the report between the maximum effluent discharge, $Q_{\max d}$, and the maximum affluent discharge $Q_{\max a}$

$$\beta_v = \frac{Q_{\max a}}{Q_{\max d}}. \tag{6}$$

This indicator varies in function of the flood return probability, Function of this probability it can be drawn a variation curve. For the retentions with controlled waste ways, this indicator depends, normally, on the dam gates exploitation rules (Popa, 1998).

The water retention usability indexed are ratios of some water retention effects specific to different water uses, referring to the volume unit. In this case the most frequent indexis are

a) the insured power for the downstream hydropower plants, related to the retention's effective volume;

b) the insured irrigated surface related to the retention's effective volume.

The indexes which characterize the implications of the retention basin represent the ratios between the different implications size of the retention basin expressed in physical scales and the retention's total volume. The most usual are:

a) the specific agricultural or arable which no longer belongs to the productive circuit and related to the effective volume unit, [ha/m^3];

b) the specific number of relocated inhabitants from the retention basin related to the effective volume unit plus non permanent, [inh/m^3].

These indicators highlight the amplitude of the social and economical implications of the water retentions' construction.

The influence of each environmental element over the future ecosystem is difficult to asses. The present studies allowed only a qualitative and incomplete assessment of these influences. Therefore is important when studying water retentions to pursue the development of the processes through the measurement of a series of characteristic parameters. These parameters can be grouped in two large categories:

1° Parameters which characterize environmental elements and highlight the influences exercised on the system.

2° Parameters which characterize the qualitative processes evolution within the system.

From this point of view, the parameters related to the water quantities in the system or the dependent values (water volumes, surfaces, levels, etc.) and the variation of these values, have to be considerate also as parameters which characterize environmental elements.

The mathematic model for the computation of the N and P concentrations in the studied water retentions uses a method based on multiple correlations between the N and P concentrations and temperature (*T*), transparency (Tr), biomass (*B*) and CBO_5.

The ratio (1) has the form of a multiple non linear correlation. The *α*, *b*, *c*, *d* and *e* parameters will be deduced through the least squares method, transforming non linear correlation into a multiple through the logarithm of the ratio (1). In what follows is presented the theoretical part of the N concentration method

$$N = aT^b \mathrm{Tr}^c B^d C^e, \tag{7}$$

$$\lg N = \lg a + b \lg T + c \lg \mathrm{Tr} + d \lg B + e \lg C. \tag{8}$$

The following notations are made:

$$y_i^e = \lg N; \alpha = \lg a; x_1 = \lg T; x_2 = \lg \mathrm{Tr}; x_3 = \lg B; x_4 = \lg C. \tag{9}$$

Is used, also, the notation

$$\overline{Y}_{x_1,x_2,x_3,x_4} = \alpha + bx_1 + cx_2 + dx_3 + ex_4. \tag{10}$$

Applying the least squares method,

$$F = \sum_{i=1}^{n} \left(\overline{Y}_{x_1,x_2,x_3,x_4} - y_i^e\right)^2 \to \text{minimum}, \tag{11}$$

which is realized for

$$\frac{\partial F}{\partial \alpha} = 0; \frac{\partial F}{\partial b} = 0; \frac{\partial F}{\partial c} = 0; \frac{\partial F}{\partial d} = 0; \frac{\partial F}{\partial e} = 0, \tag{12}$$

$$F=\sum_{i=1}^{n}\left(\alpha+bx_1+cx_2+dx_3+ex_4-\lg N\right)^2\rightarrow \text{minimum.} \quad (13)$$

It results the following equations system from which it will be calculated the α, b, c, d and e parameters:

$$\begin{cases} n\alpha+b\sum_{i=1}^{n}x_1+c\sum_{i=1}^{n}x_2+d\sum_{i=1}^{n}x_1+e\sum_{i=1}^{n}x_4-\sum_{i=1}^{n}\lg N=0,\\ \alpha\sum_{i=1}^{n}x_1+b\sum_{i=1}^{n}x_1^2+c\sum_{i=1}^{n}x_1x_2+d\sum_{i=1}^{n}x_1x_3+e\sum_{i=1}^{n}x_1x_4-\sum_{i=1}^{n}x_1\lg N=0,\\ \alpha\sum_{i=1}^{n}x_2+b\sum_{i=1}^{n}x_1x_2+c\sum_{i=1}^{n}x_2^2+d\sum_{i=1}^{n}x_2x_3+e\sum_{i=1}^{n}x_2x_4-\sum_{i=1}^{n}x_2\lg N=0,\\ \alpha\sum_{i=1}^{n}x_3+b\sum_{i=1}^{n}x_1x_3+c\sum_{i=1}^{n}x_2x_3+d\sum_{i=1}^{n}x_3^2+e\sum_{i=1}^{n}x_3x_4-\sum_{i=1}^{n}x_3\lg N=0,\\ \alpha\sum_{i=1}^{n}x_4+b\sum_{i=1}^{n}x_1x_4+c\sum_{i=1}^{n}x_2x_4+d\sum_{i=1}^{n}x_3x_4+e\sum_{i=1}^{n}x_4^2-\sum_{i=1}^{n}x_4\lg N=0. \end{cases} \quad (14)$$

3. Results and Conclusions

The parameters which characterize the qualitative processes evolution have to be forecasted before the water retention construction by studying the influence of the different possible uses regarding to this evolution.

For analysing the Barzava drainage area degree of eutrophication is used this model with data collected before entering two important lakes: Gozna and Secu, at the entrance, where the slow water speed and sediments make the area similar with the conditions of a riparian wetland.

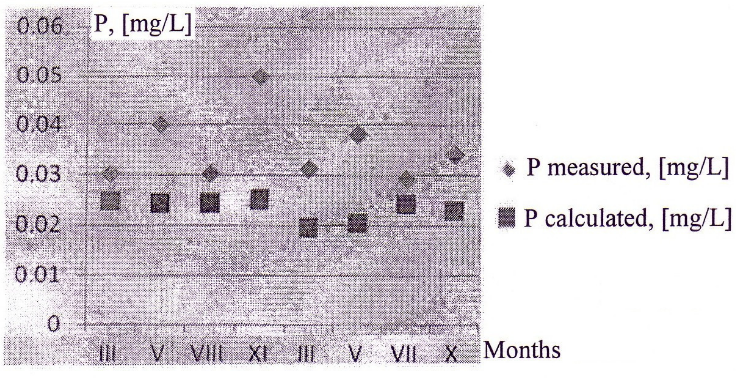

Fig. 1 – Levels of measured and calculated concentration for phosphorus, Secu Lake.

From the charts (Figs. 1 and 2) can be observed that there are no big differences between the measured and the calculated values for N and P concentrations. The significant differences are due to rainy periods when the floods contributed to the parameters modification (temperature, transparency, biomass and CBO_5).

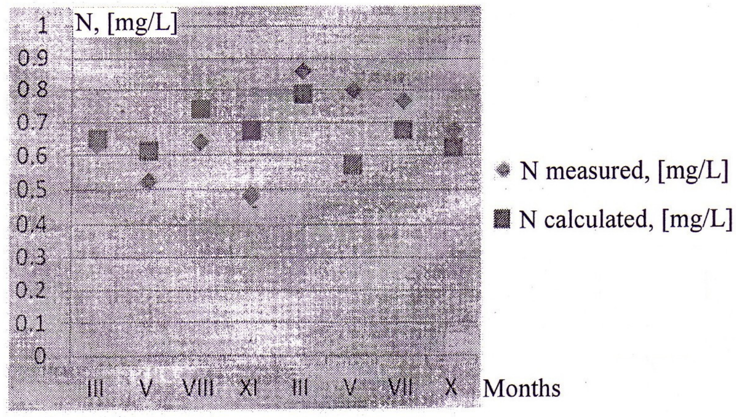

Fig. 2 – Levels of measured and calculated concentration for nitrogen, Gozna Lake.

This kind of forecast is very important because the possibility of influencing the processes development responsible to avoid serious errors. Until present the parameters regarding the water quality of the retentions do not have a prescriptive character, thus they are just a project parameter.

As fighting measures to prevent the eutrophication is necessary to take some external measures applied to the water mass which target the nitrogen and phosphorus reduction and the flood risk mitigation for the intake discharge area.

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EUTROFIZAREA ZONELOR UMEDE

(Rezumat)

Se urmăreşte studiul eutrofizării în scopul înțelegerii riscului la inundații şi reducerea acestuia cu o eficiență crescută în zonele cu risc de eutrofizare. Analiza stadiului de eutrofizare a bazinul hidrografic Bârzava este prezentată printr-un model de calcul ce utilizează ca puncte de intrare concentrațiile de N şi P, influențat de factori ca temperatura, transparența, biomasa, consumul biochimic de oxigen. Rezultatele reflectă necesitatea aplicării unor măsuri de reducere a aportului de aluviuni.

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FLOOD RISK ASSESSMENT

BY

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Abstract. This paper makes an assessment of the risk failure of the defense works against flooding located along and perpendicular on rivers, including areas with natural riparian wetlands. Highlighting these areas allow us to make complex studies about the possibilities amplified by the flood mitigation, considering the surfaces and lowering the flood risk. Explanations about the "hazard risk" scheme are made with flood analyses in many case studies to propose a computation model for risk and management assessment accordingly with the risk and hazard maps. One details the risk and safety in different water management systems.

Key words: risk, hazard; probability; defense works and wetland.

1. Introduction

The problem of risks regarding constructions and river works systems is essential because of the great values of material damages and consequences over the environment, the socio-economical structures, and over the human being. The risks result from an insufficient data base, from an imperfection of

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theoretical and experimental methods and technologies, from approximate evaluations of the future exploitation conditions, from forecasts of environment conditions that cannot include phenomena, such as: extraordinary precipitations, volcanic eruptions, landslides, meteorites. The *risk* is defined as the probability of river works structures or its functionality to be affected during its existence. Usually, the risk is estimated by event probability multiplications, with its consequences. The risk is characterized by three elements: hazard, vulnerability and exposure (Bădăluță-Minda, 2008).

If one of these three factors increases or decreases, the risk will be higher or lower. Salvano Briceno, Director of UN/ISDR Secretary: „Investigation in disaster risks mitigation decreases human vulnerability at hazards and helps to interrupt the vicious circle of poverty". The hazard is an unpredictable event, which influences life, properties and human activities leading to disasters. Vulnerability represents the susceptibility of objects to be affected by the hazard. Exposure refers to human activities and hazard potential dangers.

To make a better distinction between these two notions, „hazard" and „risk" it useful to follow the scheme represented in Fig. 1.

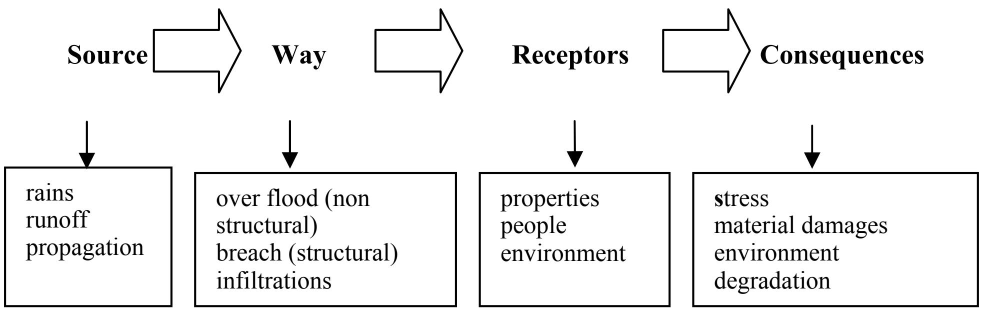

Fig. 1 – The "hazard – risk" scheme.

The receptors are represented by entities that can be affected and can suffer damages (population, material goods, etc).

In order to appear a risk there must be a hazard generated by an event or a source (precipitation for long time), a receptor (flooded area properties) and a way between source and receptor (flood way, defenses against flood, slope surface flow and landslides).

Risk evaluation is the quantifying process of human losses potential, total or partial destruction of houses, economical objectives, infrastructure, etc.

2. Flood Risk

The unsteadily use of the concept of probability–insurance, risk *r*-safety *A*, in water management, in general, and high water management, in particular, it is necessary to give a few definitions.

High waters are phenomena governed by statistics legislation. These water works cannot be done in order to present an absolute safety.

In practice there is an improper use of the hydrologic notion of maximum discharge assurance inserted in computations, although here it is about the probability of accomplishment of some effect for water management.

The degree of protection (safety) or the degree of defense against flooding is given by the probability of not-exceeding the allowed maximum discharges or the not-flooding probability, given by the relation:

$$F = \text{prob}\,(Q_{\text{flood}} \le Q_{\text{max. admitted}}). \quad (1)$$

The flooding risk is given by the probability of exceeding of allowed maximum discharges or the flooding probability, namely:

$$P = \text{prob}(Q_{\text{flood}} > Q_{\text{max.admitted}}). \quad (2)$$

It is obvious that $F + P = 1$. That is why the maximum discharge, with P-assurance, for example P = 1%, for which is dimensioned a river work cannot express symbolically the defense against flooding degree (safety degree), although, the practice use these in a conventionally way. This is given by the value F = 99%. The probability that maximum discharges with the assurance (annual) P to appear at least once in the n years of the river work existence (flooding risk) is (Crețu, 1986)

$$P_n = 1-(1-P)^n = 1-(1-1/T)^n, \quad (3)$$

where: T is the repetition period, without the implication of some successive regularity in the appearance of the phenomenon.

The probability that a flood doesn't appear at all in the n years of river work existence (defense degree, protection, safety) is:

$$F_n = (1-P)^n \cong \mathrm{e}^{-nP} \quad (4)$$

Establishing satisfactiory probabilities for the requirements of defense against natural flood can be done by two types of methods, different like principles namely

a) Normalized defense degree method is function of the importance class of defense objective (Table 1).

Table 1
Computation Probability

Importance class	I	II	III	IV	V
Probability of computation	0.1	1.0	2.0	5.0	10.0
Probability of verification	0.01	0.1	0.5	1.0	3.0

b) Comparative and technical-economical analyses method, for which the flooding probability is justified by increasing the medium incomes or by elimination of intensive damages.

Regarding the first method, the prescriptions refers to maximum discharge that is formed only on rivers with natural conditions, not on the rivers modified by river works for high water management, although may be applied, by extension also for the modified flow regime. Making a difference between the two values of computation probability, the sizing one and the verification one, is done only regarding the safety of construction and does not refer to fighting against flood effect.

Thereby, taking in consideration the hypothesis of some defense against flood scheme through high water wave's attenuation, dam design takes in consideration the probabilities of sizing and verification, for the fighting against flood effect for protected areas, is indicated only the computation probability.

High water management refers especially to the problem of river works safety, included in the management scheme. Unlike other water management areas/disciplines, for which the computation probabilities exceeding affects exclusive the utilities, in high water management exceeding some probability affects the safety of the construction itself.

The computation for high water management in order to fight against the harming effects of flood stays at the basis of river basin or sub-river basin management scheme. High water management computations in order to ensure the safety of river works are necessary for the study of hydrotechnical scheme for different works mentioned in the management scheme (especially for dischargers).

Regarding the establishing of satisfactory probabilities for the defense against flood requirements using the technical-economical analyse method it is mentioned the fact that this probabilities are the result of an analyse, it isn't imposed apriority by prescriptions (as in the case of the first method, the one for the normative degree for defense).

The technical-economical analyses may indicate also, theoretically, different requirements for defense, therefore can indicate different computation probabilities for the objectives, which, according to the prescription it frames in the same class of importance. In the case of accidental floods we cannot speak about some repetition probability, which is characteristic to natural flood.

Accidental floods are not taken in consideration in the process of river works dimensioning and verifications. Studies regarding the management of accidental high water must have to contain an evaluation of risk failure for river works and also, for the appearance way and propagation of flood waves.

Between precaution measures that are taken states the pursuit of time behavior of retentions and river works, those for warning – alarming, but also that constructive measures and adequate exploitation (limited functioning dischargers, partially controlled diversions of flood waves). If it is defined the safety degree (rel. (1)) and the flood risk for accidental floods by the probability of not exceeding, respectively discharge exceeding (eqs. (2)), than

$$Q_{\text{flood}} = Q_{\text{failure}} \,. \tag{5}$$

These relations must to be correlated with the river works safety. In what follows the methods for establishing risk and defence against accidental floods probabilities are studied namely

1. Technical-economical analyze method follows to optimize the decider strategies (adequate appliance of games theory). The computation algorithm is the following:

a) The costs corresponding to decider strategies are calculated for different safety degrees of the dam for different expenses; the costs programs are including the safety of the dams and/or program of different nature for damage reduction and life savings

$$C_{j,i} = \sum_{n=1}^{n=3} P_{i,n} + C_j, \tag{6}$$

where: n = 1, 2, 3 is the destroyed area, partially flooded; $P_{i,n}$ – the damage for the *I*-program from the accidental affected area; C_j – the cost value for planning, corresponding to the *J*-strategy.

b) The matrix

M =

Strategies of the decider \ Outgo programs	N_1 ... N_i ... N_N
S_1	C_{11} ... C_{1i} ... C_{1N}
:	:
S_j	C_{j1} ... C_{ji} ... C_{jN}
:	:
S_M	C_{M1} ... C_{Mi} ... C_{MN}

is being build.

c) The acceptance of the strategy with minimum costs ($C_{j,i}$ – min).

2. The river works safety method, $P, F = f(P_c)$, where P_c is the probability of dam failure.

3. The Case Study. Discussion

Serious accidents and failures that generated risk acceptance and assessment as a common procedure in river works design, are aiming to achieve a rational balance between safety and economy. Situations are analysed for three kinds of systems: transversal river works, longitudinal systems and natural riparian wetlands.

3.1. Transversal River Works

In case of the probabilistic models (the determinist ones, where the failure risk cannot be determined – taking in consideration the minimum investment criterion, $I_{\min}$) quantitative risk measurement is the probability of failure, and the criteria for the selection of the optimal variant is given by minimizing the overall cost. (Priscu, 1994; Stematiu, 1978)

$$C_g = C_i + \sum_i P_{c,i} C_{p,i}, \tag{7}$$

where: C_i is the cost of the dam building from the investment value and the maintenance cost; $P_{c,i}$ – the probability of failure corresponding to the failure mechanism; $C_{p,i}$ – the damage costs, including the cost of restoration.

Based on this observation we can determine the value of calculated overflow discharge

$$\begin{array}{c}[c_{g,i}]_{\min} \to [P_{c,i}]_{\text{accept.}} \Rightarrow Q_{\text{tear.–calc.}}(t);\\ \downarrow \\ F,P = f(P_c).\end{array} \tag{8}$$

During the working accumulation of the relationship (3) leads to:

$$\left[c_{\text{expl. exp.}} + \sum P_{c,i} C_{p,i}\right]_{\min} \to Q_{\text{tear.-calc.}}(t). \tag{9}$$

In the case of the river works, the overall security degree of the defence system, representing the so-called *viability* (meaning the safety maintenance in operation), depends on the arrangement of the elements in the systems.

In the main connection the elements are serial disposed. (Fig.2).

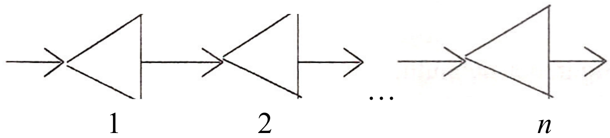

Fig. 2 – The main connection.

The safety of the system decreases in this case once with the increasing of elements number. In the alternative connection the elements are disposed parallel (Fig.3).

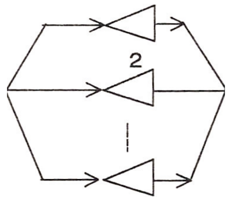

Fig. 3 – The alternative connection.

The safety of the system increases when the number of elements is higher.

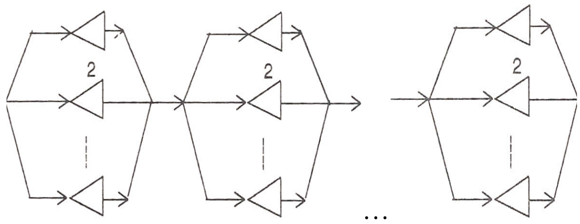

Fig. 4 – The mixed connections.

3.2. The Longitudinal Systems

Flood risk may be defined as the probability that the natural discharge of the high water to exceed the maximum allowed level (the one corresponding to the minimum flood limits in a natural or modified habitat) namely

$$R = P(Q_{\max}^{p\%} \geq Q_{\max\,\text{adm.}}). \tag{10}$$

In case of river works regime has to be taken into consideration also the discharger, modified by derivation ($\pm Q_{\text{deriv.}}$), upstream retention ($\pm Q_{\text{lake}}$), so that the flood risks in some areas are

$$R = P(Q_{\max}^{'p\%} \geq Q_{\max\,\text{adm.}}), \tag{11}$$

where

$$Q_{\max}^{'p\%} = Q_{\max}^{p\%} \pm Q_{\text{deriv.}} \pm \Delta Q. \tag{12}$$

Calculating the flood risk it is necessary to take in consideration, beside the natural discharge from precipitations (rain, snow), the discharge (±) from the high water and volume diversions (±) from the filing in or emptying retentions. The flood risk can be defined simply and correctly in the case of longitudinal river works, in case of natural or modified regime (with embankments), considering the probability of exceeding the dikes level (over this level the floods occur).

Theoretically

$$R = P(H_{\max}^{'p\%} > H_{\text{dike}}). \quad (13)$$

Of course, in the case of embankments (Figs. 5 and 6), we have to take in consideration that there are local differences of the dike crest along the river, independent of the water level

$$H_{\max}^{'p\%} = f(Q_{\max}^{'p\%}, S'). \quad (14)$$

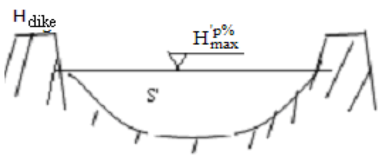

Fig. 5 – Cross section in an embanked river.

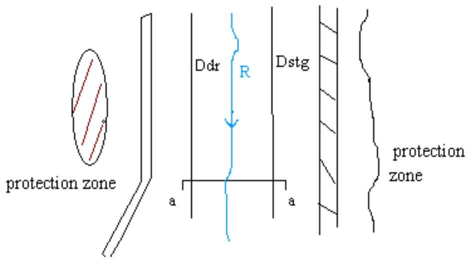

Fig. 6 - The top view of an embanked rive.

The risk management in the designed system supposes the intervention on the maximum level of river bed ($H'_{\max}$), corresponding to a certain exceeding probability (p%) through the derivatives of flow and/or discharged volumes or withdrawn in retentions. For reducing the risk there is necessary that the sum

$$\sum (Q_{\max} \pm Q_{\text{deriv.}} \pm \Delta Q)_{\min} \quad (15)$$

be minimum.

In case of defense against flooding river works (dikes), (through overflowing and infiltration), in the definition of risk must interfere also the overflowing/infiltration duration until the beginning of failure, Δt,

$$R = P(H_{\max}^{p\%} > H_{\text{dike}}; \Delta t \geq \Delta t_{\min}), \quad (16)$$

where $\Delta t_{\min} = f(H_s) = (1\ldots6)\ h$, appreciated as depending on dike material consistency, from a personal research done on all failure cases (approximately 100) in the last two years in Romania.

In case of breaches analysed for all river basins from Romania, the forecast anticipation, excluding the prediction time, varies from 2…3 hours to 4 days. At a closer analyse these can be taken in consideration in risk management diminishing.

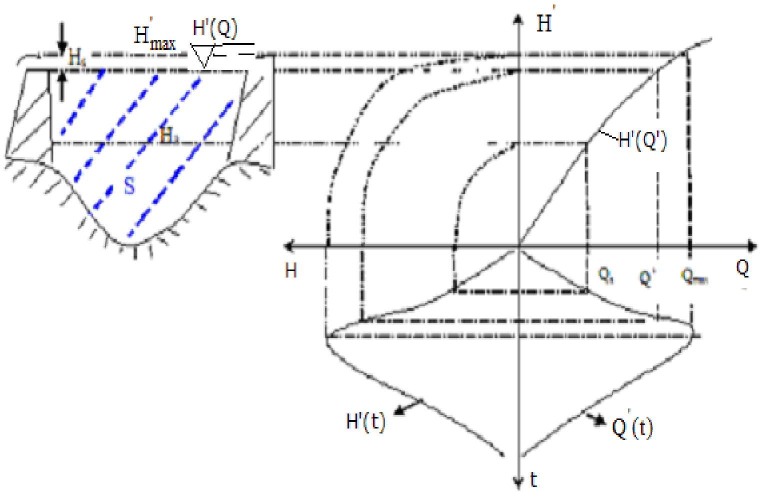

Fig. 7 – The level hydrograph.

Corresponding to relations $H' = f(Q')$ and $Q(t)$ it results the level hydrographs, $H' = f(t)$ (Fig. 7)

In comparison with all mentioned above, the algorithm for computation flood risks to dike failure is the following:

a) the embankment area is separated in different sectors with the same characteristics of dike structure (materials, consistency, time behavior, etc);

b) there are established the computation section with risk in “weak points” established through dike monitoring (low degree of compaction - aeration, holes made by martens, badgers and foxes, etc.);

c) inequalities along dikes length can determine high time for over-flowing;

d) it is designated the effective discharge hydrograph, $Q'(t)$, from the computation sections for some flood forecasted with t_a or for the flood with the computation probability, $p\% = 1\%, 5\%$, etc.

3.3. Riparian Wetlands

The characteristics and the current state of riparian wetlands are mainly due to the various hydrological factors like the water regime and the flow situation that are characterized by complex elements (precipitation, evaporation, transpiration, geology, relief, soils, vegetation, land use) linked to ensure the conditions that make this particular land suitable for specific fauna and vegetation.

The difference between Figs. 6 and 8 represents a non-structural measure to fight against floods by using natural wetlands without the intervention of dikes.

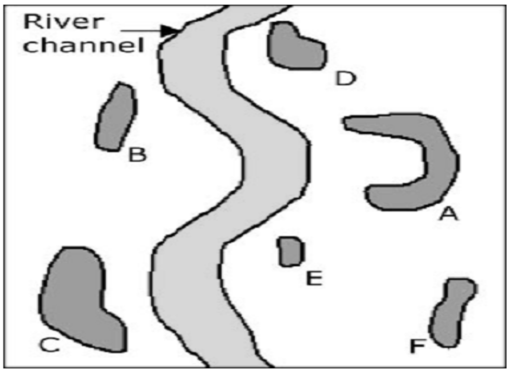

Fig. 8 – The river and different sized wetlands (Frazier & Page, 2009).

Promoting the new concept, *living with floods*, for flood risk reduction can interfere once with discharge decrease and it can also interfere over the flowing surface, *S*, from eq. 14.

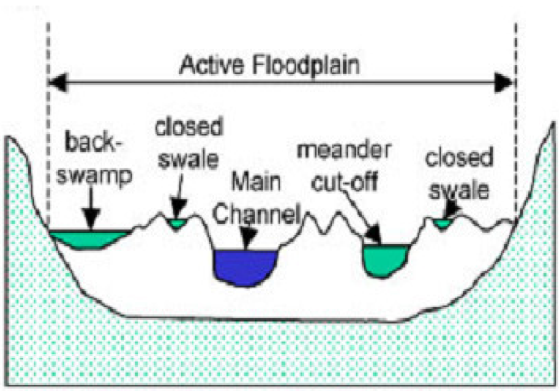

Fig. 9 – Theoretical relationship between wetland inundation and river discharge.

The increasing of the flowing surfaces represented in Fig. 9 as the active floodplain can be done through the local defense dikes, the revitalization of wetlands, decreasing with predilection the pressure on the embankment that occurs in the current arrangement schemes.

4. Conclusions

The analysed situations are extreme and over the top of the natural floods, amplified by failure of transversal and longitudinal defense works.

The management of extreme situations analysed in this paperwork makes reference on forecasting accidental floods and takes notice on the non-structural measures rather than the structural ones.

In the situation of producing these events, repairing the defense works must take notice the priority of the new concepts regarding the defense against flooding, "living with floods".

With the help of a good management and wise use of proposed systems the accepted risk can be diminished from a maximum to a medium and even minimum level.

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EVALUAREA RISCULUI LA INUNDAŢII

(Rezumat)

Se face o evaluare a riscului de cedare a lucrărilor de apărare împotriva inundaţiilor amplasate de-a lungul şi perpendicular pe râuri, inclusive în zonele umede

naturale riverane. Evidenţierea aceste zone permite să se efectueze studii complexe despre posibilităţile marite de atenuare a inundaţiilor, ţinând cont de suprafeţe şi de reducerea riscului la inundaţii.

Explicaţii despre schema "hazard–risc" sunt realizate cu analize ale inundaţiilor în mai multe studii de caz pentru a propune un model de calcul pentru evaluarea riscurilor şi de management conform cu hărţile de risc şi hazard.

Se detaliază riscul şi siguranţa în diferite sisteme de gospodărire a apelor.

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FLOW ANALYSIS MODELS AND TRANSPORT IN SATURATED SOILS

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Abstract. The results of a study for modeling flow and transport processes in soil are presented. After an analysis of the most used models in this area, it is presented the program BIOF&T, which allows the simulation of groundwater flow and dissemination of chemical compounds in porous media with variable saturation. This program has been used in a case study to simulate the process of transport in a heterogeneous porous medium in two-dimensional system.

Key words: flow; transport; saturated soil; 3-D models; BIOF&T.

1. Introduction

The soil's pollution, due especially to the industrial activities, is nowadays a major problem. The distribution of pollutants into the soil has pretty serious implications as regards the good state of natural biotic systems and against the health of human beings.

The prognosis of the quality of soil and subterranean waters implies the

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realization of some mathematic models for the flowing and dispersal of chemical compounds. These models consist in the integration of equations that describe the flowing and course of the pollutant front in the porous mediums.

The parameters that interfere in these equations have to be estimated on the basis of some measurements performed *in situ* (the model's calibration).The modeling's results can be used in practice under the conditions that the model was calibrated and validated.

The physical phenomena that happen in the flowing hydraulics through porous mediums are very complex, and that's why their mathematic modeling has to take into account the fact that the processes they study are coupled between them, aren't linear and the studied medium is and not homogeneous, this being composed of three different materials: water, air, soil. These three materials can be named *phases* and between them it happens both a phenomenon of mutual deformation thanks to the action of one against the other and a phenomenon of mass transfer due to the chemical reactions that may happen between these phases.

Taking into account these facts, a mathematic model for the flowing and transport into porous soils may be represented using the general formula

$$Y = F\,(X, A) + \varepsilon, \tag{1}$$

where: X is the vector of entrance variables; Y – the vector of exit variables; A – vector of the parameters taken into study; ε – the error committed by the approximation through modeling.

Mathematic modeling means, in fact, the art of determining in what measure the mathematic model has small values for ε, if these are comparable to the values obtained by experimental data. Besides, a mathematic model has to be exact, adaptable and easy-to-use as much as possible.

Another problem taken into account into the mathematic modeling of flowing through porous mediums is that of modeling scale which is not always an easy process. In this type of flowing there is the possibility of modeling at macroscopic scale which takes care of the study of the phenomena at the level of soil's pores.

The physical quantities taken into account are defined into a point that is situated in an infinitesimal volume. The continuity of the studied field comes out from the geometry of the soils pores. This modeling prevails the writing of phenomena's equations in the most rigorous manner, but this is not enough realistic because the soils are very complex and heterogeneous mediums. It is said that the appropriate scale to the soils` description is the macroscopic one.

If we analyse the present stage of international knowledge in the field, we can say that there are important results in the field, an impressive number of studies (mathematic models and experiments), models of the flowing prognosis into subterranean waters and even pollution models. Unfortunately, the acquisition of such calculation programs is very expensive. The application of such programs requires a serious knowledge of the output quantities, the phenomenon and the used field.

We presents, in what follows, the next models for flow and transport in porous media:

a) MODFLOW, simulates steady and nonsteady flow in an irregularly shaped flow system in which aquifer layers can be confined, unconfined, or a combination of confined and unconfined. Flow from external stresses, such as flow to wells, areal recharge, evapotranspiration, flow to drains, and flow through river beds, can be simulated. Hydraulic conductivities or transmissivities for any layer may differ spatially and be anisotropic (restricted to having the principal directions aligned with the grid axes), and the storage coefficient may be heterogeneous.

Specified head and specified flux boundaries can be simulated as can a head dependent flux across the model's outer boundary that allows water to be supplied to a boundary block in the modeled area at a rate proportional to the current head difference between a "source" of water outside the modeled area and the boundary block. MODFLOW is currently the most used numerical model in the U.S. Geological Survey for ground-water flow problems.

b) MODFLOW-SURFACT is a powerful three-dimensional finite-difference flow and transport program containing many advancements and improvements over the standard public-domain versions of MODFLOW. With more robust solution methods and enhanced simulation capabilities for handling complex saturated/unsaturated subsurface flow and transport processes, MODFLOW-SURFACT is specifically designed to address the many limitations and short-comings of the standard MODFLOW codes. MODFLOW-SURFACT is used to simulate: multiple water tables, or perched water table systems, steep water table gradients crossing multiple model layers, over-pumped wells screened across multiple model layers, surface water infiltration through the vadose zone to the water table, large water table fluctuations causing desaturation or resaturation (drying/wetting) of grid cells, soil vapour flow through the unsaturated zone.

c) Visual MODFLOW Premium is a three-dimensional groundwater flow and contaminant transport modeling application that includes well head capture zone delineation, pumping well optimization, aquifer storage and recovery, groundwater remediation design, natural attenuation simulation, and saltwater intrusion.

The model creates contour/colour maps of model properties and simulation results, presents graphical summaries of global and local mass budgets, creates model calibration plots and statistical summaries including mean error, absolute mean error, standard deviation, and many more, full control of map overlays – save your overlay configurations and view only the overlays you require, displays 3-D pumping wells and observation wells, represents soil property zones and boundary conditions in 3-D, renders high resolution 3-D volumetric contaminant plumes, creates irregular shaped cross-sections, 3-D pathlines with time markers, defines 3-D cut-away regions, animates sequential degradation of contaminant plumes and saves into AVI file format for use in Microsoft PowerPoint presentations.

Visual MODFLOW Premium creates detailed contour maps of modeling results including: heads, drawdown, concentration, water table elevation, head difference between layers, flux between layers, layer elevations (bottom, top, and thickness) and net recharge.

Visual MODFLOW Premium produces detailed tabular and graphical reports of the mass balances for both the flow and mass transport simulations. These reports provide global and local summaries of the mass inflows and outflow from the system, or from a localized region of the model.

Visual MODFLOW Premium displays flow velocity vectors and flow pathlines. Flow velocity vectors can be used to effectively illustrate the direction and magnitude of groundwater flow velocity throughout the model domain.

d) MODPATH should simulate the transport of pollutants in the aquifer and to model the dynamic evolution of pollution in time and space.

The model can be used to identify the sources of pollution and its degree of contribution. A modular three-dimensional finite-difference groundwater model is used in order to describe and predict the behavior of the groundwater system. MODFLOW application can use the finite difference transport models to simulate systems for water supply, containment remediation, mine dewatering. Ground-water flow within the aquifer is simulated in MODFLOW using a block-centered finite-difference approach. Layers can be simulated as confined, unconfined, or a combination of both. Flows from external stresses such as flow to wells, areal recharge, evapotranspiration, flow to drains, and flow through riverbeds can also be simulated.

MODPATH is a particle-tracking post-processing package that was developed to compute three-dimensional flow paths using output from steady-state or transient ground-water flow simulations by MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model. The particle tracking package consists of two Fortran computer codes: (1) MODPATH, which calculates particle paths, and (2) MODPATH-PLOT, which displays results graphically (Pollock, 1994).

e) MT3D is a new version of the Modular 3-D Transport model, where MS denotes the Multi-Species structure for accommodating add-on reaction packages. MT3DMS has a comprehensive set of options and capabilities for simulating advection, dispersion/diffusion, and chemical reactions of contaminants in groundwater flow systems under general hydrogeological conditions. The key features of MT3DMS are summarized below.

MT3DMS is unique since it includes three major classes of transport solution techniques in a single code, *i.e.*, the standard finite difference method; the particle-tracking-based Eulerian-Lagrangean methods; and the higher-order finite-volume TVD method. Since no single numerical technique has been shown to be effective for all transport conditions, the combination of these solution techniques, each having its own strengths and limitations, is believed to offer the best approach for solving the most wide-ranging transport problems with desired efficiency and accuracy.

MT3DMS is implemented with an optional, dual-domain formulation for modeling mass transport. With this formulation, the porous medium is regarded as consisting of two distinct domains, a mobile domain where transport is predominantely by advection and an immobile domain where transport is predominantely by molecular diffusion. Instead of a single "effective" porosity for each model cell, two porosities, one for the mobile domain and the other for the immobile domain, are used to characterize the porous medium. The exchange between the mobile and immobile domains is specified by a mass transfer coefficient. The dual-domain advective-diffusive model may be more appropriate for modeling transport in fractured media or extremely heterogeneous porous media than the single porosity advective-dispersive model, provided that the porosities and mass transfer coefficients can be properly characterized.

MT3DMS can be used to simulate changes in concentrations of miscible contaminants in groundwater considering advection, dispersion, diffusion and some basic chemical reactions, with various types of boundary conditions and external sources or sinks. The chemical reactions included in the model, are equilibrium-controlled or rate-limited linear or non-linear sorption, and first-order irreversible or reversible kinetic reactions (Zeng Chinmiao & Patrick Wang, 1999).

f) FEMWATER is a three-dimensional finite element water flow formed by the two older models, 3DFEMWATER (flow) and 3DLEWASTE (transport). It can be used to simulate flow and transport in both the saturated and unsaturated zone. Furthermore, the flow and transport can be coupled to simulate density dependent problems such as salinity intrusion.

g) SEAM3D is a reactive transport model used to simulate complex biodegradation problems involving multiple substrates and multiple electron acceptors. It consist of a series of modules for simulating the flow and transport of multiple constituents in a three-dimensional anisotropic, heterogeneous domain (Widdsowson, 2002).

h) RT3D is a Fortran 90-based software package for simulating three-dimensional, multi-species, reactive transport in groundwater. With the growing popularity of natural attenuation solutions for contaminated sites around the world, RT3D is quickly emerging as a very powerful tool for demonstrating the effectiveness of biodegradation processes for treating dissolved groundwater contamination. With a variety of pre-programmed reaction packages can be applied to scenarios involving contaminants such as heavy metals, explosives, petroleum hydrocarbons, and/or chlorinated solvents. RT3D can also be used to simulate active groundwater treatment processes including air-sparging, biosparging and reactive walls.

i) MIKE SHE is an integrated hydrological modeling system for building and simulating surface water flow and groundwater flow. MIKE SHE can simulate the entire land phase of the hydrologic cycle and allows components to be used independently and customized to local needs. MIKE SHE can be used for the analysis, planning and management of a wide range of water resources and environmental problems related to surface water and groundwater, especially surface water impact from groundwater withdrawal, conjunctive use of groundwater and surface water, wetland management and restoration, river basin management and planning, impact studies for changes in land use and climate.

j) MARTHE was originally developed as a three-dimensional ground-water model designed to compute water flow and solute transport in saturated porous media (Thiery,1995). MARTHE also solves the Richards' equation numerically using a fully implicit scheme with a three-dimensional finite difference discretization. For the vadose zone, the Richard's equation is solved using prescribed retention and relative hydraulic conductivity functions (van Genuchten,1980; Gardner,1958). Advective, diffusive and dispersive transport is computed simultaneously with the hydraulic calculation. Mass transport is simulated using a total variation diminishing (TVD) scheme. Calculations for energy, temperature, mass and water fluxes are performed in a fully coupled manner within the model.

For modeling the flow in the soil (unsaturated) remember UnSat Suite WHI program that combines VLEACH programs, PESTAN, VS2DT, HELP in a specific graphical environment, to simulate one-dimensional flow and contaminant transport in unsaturated zone.

2. Modeling Bidimensional Flow and Transport in a Multicomponent Saturated Soils

In literature still exist many other models for simulating transport but in the present study we use the model BIOF&T. This BIOF&T models describes a three (two) dimensional finite element (2-D/3-D) for water flow and multi-component aqueous phase transport in variably saturated porous media. BIOF&T has capabilities to model contaminated sites that have complex heterogeneous and/or anisotropic hydrogeology. BIOF&T models variably saturated fractured media or unfractured granular porous media based on a dual porosity approach.

The flow and transport in the unsaturated zone is modeled either in 1-D vertical or in 2-D planar or radial symmetric vertical sections or in full 3-D.

The flow and dissolved phase transport in the saturated zone are modeled as 2-D areal or a 3-D phenomenon.

BIOF&T allows uncoupled solution of the unsaturated and the saturated zones. During the solution of the unsaturated zone, the time series of the spatially distributed contaminant effluent rate is computed and subsequently used to define loading to the groundwater.

BIOF&T -3D has options for coupled three dimensional solutions of the unsaturated and saturated zones for complicated problems. 2-D rectangular or isoparametric quadrilateral or 3-D rectangular prism or isoparametric hexahedral elements are permissible to accuretely model irregular domain and material boundaries. BIOF&T incorporates convection, dispersion, diffusion, adsorption, desorption and biodegradation based on oxygen limited, anaerobic, first order, or monod type biodegradation kinetics as well sequential anaerobic or first order biodegradation involving multiple daughter products. Given the initial conditions, temporal and spatial variations in the sources (*i.e.*, nonaqueous phase liquid) is computed and updated internally by the model. Spatially variably recharge rates accounting for different hydrogeologics can be specified.

Biof&T allows use of two constitutive models for relating permeability, saturation and pressure namely

1. van Genuchten constitutive model;
2. linear constitutive model.

2.1. van Genuchten Model

Relationship between head, saturation, and relative permeability can be expressed as

$$\overline{S_w} = [1 + (\alpha\psi)^n]^{-m}, \tag{2}$$

$$k_{rw} = \overline{S_w}^{0.5}[1 - (1 - \overline{S_w})^{1/m}]^2, \tag{3}$$

where

$$\overline{S_w} = \frac{S_w - S_m}{1 - S_m}$$

is the effective water saturation, S_m – the irreducible water saturations, α, [L^{-1}], and n are porous medium parameters and $m = 1 - 1/n$.

2.2. Linear Constitutive Model

Water saturations, head and relative permeability are linearly related namely

$$k_{rw} = \frac{S_w - S_m}{1 - S_m}, \tag{4}$$

$$\frac{\psi - \psi_a}{\psi_m - \psi_a} = \frac{1 - S_w}{1 - S_m}, \tag{5}$$

where: ψ_a is the air entry pressure, [L]; ψ_m – the head, [L], corresponding to the irreducible water saturation, S_m .

BIOF&T models aqueous phase transport of up to five species in variably saturated porous media. The unsaturated zone and the groundwater aquifers are considered to be consisting of fractured and/or granular porous media.

BIOF&T – 3-D allows computationally efficient uncoupled or coupled solution of the unsaturated and the saturated zones. When solutions are uncoupled, the flow and transport in the unsaturated zone is modeled either in 1-D vertical direction or in 2-D planar or radial symmetric vertical sections.

The flow and dissolved phase transport in the saturated zone are modeled as 2-D areal or a 3-D phenomenon. The solutions of the unsaturated zone implies the computation of the temporal ad spatial distribution of the contaminant effluent rates.

These are used to define contaminant ladings to groundwater during simulation of aqueous phase transport in the saturated zone. An option for coupled three dimensional solution of the unsaturated and saturated zones can be selected for complicated problems.

A typical subsurface transport media has five distinct regions:

1. Voids filled with air.
2. Mobile water located inside the larger inter-aggregate pores or fractures.
3. Immobile water located mainly in the intra-aggregate pores or in the porous media surrounding fractures.
4. A dynamic soil region, in equilibrium with the mobile phase.
5. A stagnant soil region where mass transfer is diffusion limited.

Van Genuchten and Wierenga (1976) expressed the general transport equation as

$$\frac{\partial}{\partial t}(\theta_m C_{wm}) + \frac{\partial}{\partial t}(\theta_{im} C_{wim}) + \frac{\partial}{\partial t}(f \rho P_{wm}) + \frac{\partial}{\partial t}\left[(1-f)\rho P_{wim}\right] =$$

$$= \frac{\partial}{\partial x_i}\left(\theta_m D_{ij} \frac{\partial}{\partial x_i}\right) - \frac{\partial}{\partial x_i}(q_i C_{wm}) - q_s C_{ws}, \tag{6}$$

where: θ_m and θ_{im} are the fraction of the soil filled with mobile and immobile water, respectively, C_{wm} and C_{wim} – the concentrations, [ML^{-3}], of species ω in the mobile and immobile water respectively, q_i – the Darcy velocity, [LT^{-1}], P_{wm}

and P_{wim} – adsorbed phase concentration of species ω in the mobile and immobile phase, [M/M], respectively, f – the fraction of the sorption sites which is in direct contact with the mobile liquid, ρ – soil bulk density, [ML^{-3}], ρ_s – the volumetric flow rate of fluid injection (or withdrawal) per unit volume of the porous medium and C_{ws} – the concentration of species ω in the injected fluid; D_{ij} is the hydrodynamic dispersion tensor having the components

$$\theta_m D_{ij} = d_L \left|q\right| \delta_{ij} + (d_L - d_T)\frac{q_i q_j}{\left|q\right|} + \theta_m \tau D_c \delta_{ij}, \tag{7}$$

where d_L and d_T are the longitudinal and the transverse dispersivities, respectively, δ_{ij} – the Kronecker delta, τ – tortuosity, D_c – the coefficient of molecular diffusion and $|q|$ – the absolute value of the Darcy velocity.

Using the continuity equation for water flow

$$-\frac{\partial q_i}{\partial x_i} = \frac{\partial \theta_m}{\partial t} - q_s \tag{8}$$

and assuming a linear adsorption, ($P = K_d C$), eq. (2) can be written as

$$\begin{aligned}&\frac{\partial C_{wm}}{\partial t}[\theta_m + f\rho k_d] + \frac{\partial C_{wim}}{\partial t}[\theta_{im} + (1-f)\rho k_d] = \\ &= \frac{\partial}{\partial x_i}(\theta_m D_{ij}\frac{\partial C_{wm}}{\partial x_i}) - q_i \frac{\partial C_{wm}}{\partial x_i} - q(C_{ws} - C_{wm}).\end{aligned} \tag{9}$$

The mobile and immobile phases concentrations are related as:

$$\frac{\partial C_{wim}}{\partial t}[\theta_{im} + (1-f)\rho k_d] = x(C_{wm} - C_{wim}), \tag{10}$$

where: x is a mass transfer coefficient, [T^{-1}], for diffusive mass exchange between the mobile and immobile phases.

Incorporating decay losses, λ_{wm}, and contaminant loading from a hydrocarbon source to the mobile phase, H_w , in eqs. (9) and (10), it results:

$$\begin{aligned}&\frac{\partial C_{wm}}{\partial t}[\theta_m + f\rho k_d] + \frac{\partial C_{wim}}{\partial t}[\theta_{im} + (1-f)\rho k_d] = \\ &= \frac{\partial}{\partial x}(\theta_m D_{ij}\frac{\partial C_{wm}}{\partial x_i}) - q_i \frac{\partial C_{wm}}{\partial x_i} - q(C_{ws} - C_{wm}) - \lambda_{wm} + H_w,\end{aligned} \tag{11}$$

$$\frac{\partial C_{wim}}{\partial t}[\theta_{im}+(1-f)\rho k_d]=x(C_{wm}-C_{wim})-\lambda_{wim} \quad (12)$$

Soil properties needed for BIOF&T flow simulation are: saturated hydraulic conductivity, K_{ij}, in principal flow directions, anisotropy angle, Ω, of the main principal flow direction in the areal plane with the x-direction of the model domain, soil porosity, Φ, irreducible water saturation, S_m, van Genuchten retention parameters, α and n. SOILPARA 1995 a proprietary computer model developed by DAEM, provides an easy way to use tool for estimating soil hydraulic parameters from soil texture based on

1. The public domain model RETC, developed by M. Th. Van Genuchten.
2. The work of Shirazi and Boersma (1984) and Campbell (1985) and
3. A selection of USDA recommended typical parameter values for various texture classes available in the SOILPARA database.

Campbell (1985) method incorporates the effects of bulk density and texture on saturated hydraulic conductivity. Due to the large uncertainty associated with estimation of hydraulic conductivity, it is desirable to estimate its value from field and laboratory data (Technical Documentation,..., 1995).

BIOF&T 3-D INPUT

- Mesh discretization data
- Initial conditions for flow: water
- Boundary conditions for flow: specified head boundaries, flux boundaries, and sources and sinks
- Soil hydraulic properties: van Genuchten parameters, hydraulic conductivity distribution and porosity
- Initial conditions for transport: species concentration
- Boundary conditions for transport: specified concentration boundary, specified mass flux, and spatial distribution of contaminant loading
- Dispersivities
- Mass transfer rate coefficient between oil and water phase
- Distribution coefficient
- Bulk density
- Diffusion coefficient for species
- Biodegradation parameters for each species
- Fraction of the mobile phase

BIOF&T 3-D OUTPUT

Flow

- Spatial distribution of water pressure with time
- Spatial distribution of water saturation with time
- Velocity distribution with time
- Pumping/injection rates and volume *vs*. time

Transport (for each species)

- Spatial distribution of concentration with time
- Mass dissolved in water *vs*. time
- Mass remaining in NAPL phase *vs*. time
- Mass adsorbed on the solid phase *vs*. time

Biof&T simulate the transport in two-dimensional heretogeneous porous media. Al-Niami and Rushton (1979) developed an analytical solution for dispersion in stratified porous media. In this example the domain consists of two layers. Groundwater flow is parallel to the direction of the stratification. (Fig.1)

Initial concentration	= 0 ppm
Groundwater velocity in layer #2	= 0.0008 cm/day
Dispersivity layer #2	= 125 cms
(Dispersion coeff	= 0.1 cm^2/day)
Groundwater velocity in layer #1	= 0.0004 m/day
(Dispersivity layer #1	= 0.25 cms)
(Dispersion coeff	= 0.0001 cm^2/day)
Concentration at the inlet boundary	= 1 ppm
Length of the domain in x-direction	= 1,000 cm
Width of the domain (z-direction)	= 500 cm

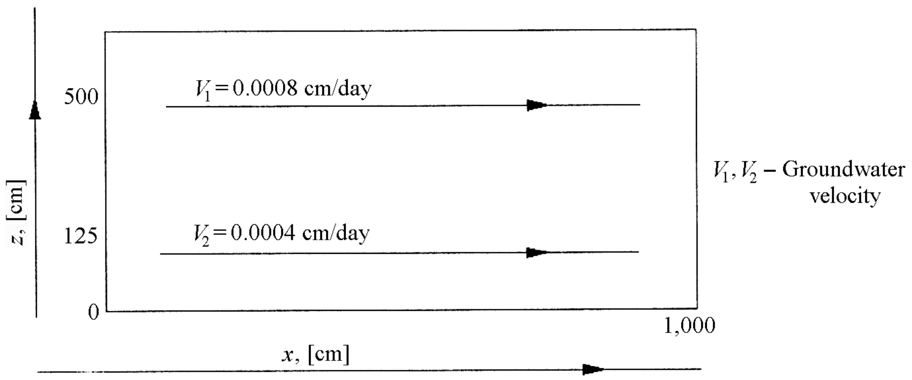

Fig. 1 – Two-layered porous medium.

Uniform nodal spacings of 100 cm and 25 cm were used along the *x*- and *z*- directions, respectively. The results of the BIOF&T simulation can be reasonably compare with the analytical solution (Fig. 2). There is some differences in these solutions at the lower right corner of layer #1. This could be due to an extremely hight Peclet number (100/0.25 = 400) in the lower layer which may have caused an instability in the numerical solution.

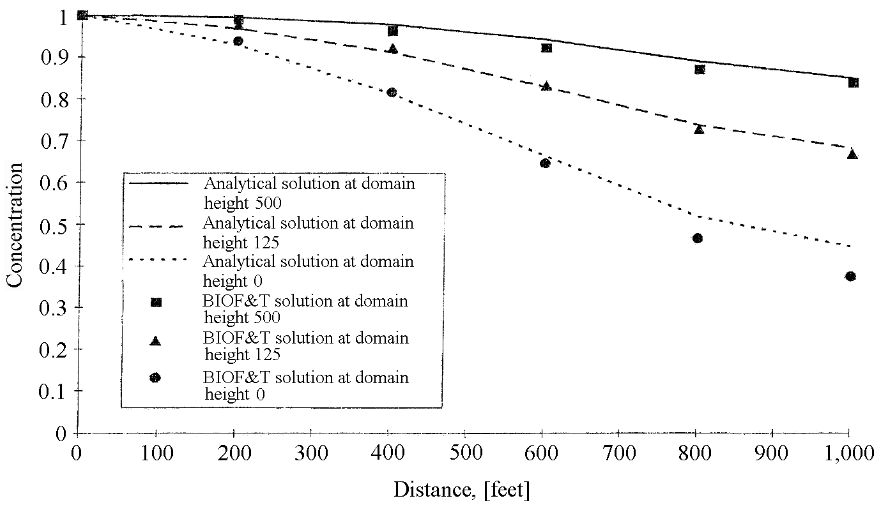

Fig. 2 – Two-dimensional transport in heterogeneous porous media.

3. Conclusions

Computational cost of a typical 3-D flow and transport problem can be enormous. In BIOF&T a computationally efficient solution is obtained by discretizing the solution domain into horizontal slices. This slices are solved in sequence individually to reduce the matrix size. An iterative approach is implemented to perform solution among slices. This results in considerable performing time saving, enabling solution of large problems.

Required input for flow analyses consists of initial conditions, soil hydraulic properties, time integration parameters, boundary conditions and mesh parameters. The van Genuchten constitutive model is used to define the moisture retention properties for the unsaturated zone. For transport analyses, additional input data are the porous media dispersivities, fraction of the porous media as mobile phase (needed only for fractured media), species solubility, biodecay parameters, diffusion coefficient, distribution coefficient, mass transfer coefficients (needed only for fractured media analysis).

For the use of the modeling program BIOF&T there are necessary, both qualitative mathematic investigations and numeric investigations. From the qualitative point of view is aimed, both the study of the existence of the equations results which configure the interest phenomena and their properties which present physical relevance.

As for the development of this model is to analyse the models accuracy, the algorithms convergence, the validation of numeric methods (by soft – the comparison of the results obtained by classical methods – or experimental – by comparison of the numeric values calculated with experimental data).

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MODELE DE ANALIZĂ A CURGERII ŞI TRANSPORTULUI ÎN SOLURI SATURATE

(Rezumat)

Se prezintă rezultatele unui studiu privind modelarea proceselor de curgere şi transport în sol. După o analiză a celor mai utilizate modele în acest domeniu se expune programul BIOF&T, care permite simularea curgerii apei subterane şi propagarea compuşilor chimici în medii poroase cu saturaţie variabilă. Acest program a fost utilizat într-un studiu de caz, pentru a simula transportul într-un mediu poros heterogen, în sistem bidimensional.

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ICE JAM ON BISTRITA RIVER – CAUSES AND POSSIBLE SOLUTIONS

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Abstract. The present work provides both description of the ice jam phenomena along the Bistriţa river in the upstream of the Izvoru Muntelui lake and applied or ignored solutions. Most applied solution is breaking ice with explosives (inefficient by reason of material type and boundary condition). Appropriate solution (increase of water temperature) still need to be proved.

Key words: frazil ice; ice jam; blasting.

1. Introduction

An ice jam is a stationary accumulation of ice that restricts flow. Ice jams can cause considerable increases in upstream water levels, while at the same time downstream water levels may drop, exposing water intakes for power plants or municipal water supplies. Types of ice jams include freezeup jams, made primarily of *frazil* ice; breakup jams, made primarily of fragmented ice pieces, and combinations of both.

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Freezeup jams are composed primarily of *frazil* ice, with some fragmented ice included and occurs during early winter to midwinter. The floating *frazil* may slow or stop due to a change in water slope from steep to mild because it reaches an obstruction to movement such as a sheet ice cover, or because some other hydraulic occurrence, slows the movement of the *frazil*. Jams are formed when floating *frazil* ice stops moving downstream, forms an “arch” across the river channel and begins to accumulate. Freezeup jams are characterized by low air and water temperatures, fairly steady water and ice discharges, and a consolidated top layer.

Breakup jams occur during periods of thaw, generally in late winter and early spring, and are composed primarily of fragmented ice formed by the breakup of an ice cover or freezeup jam. The ice cover breakup is usually associated with a rapid increase in runoff and corresponding river discharge due to a significant rainfall event or snowmelt. Late season breakup is often accelerated by increased air temperatures and solar radiation.

This paper refers to specific problems which are created by *frazil* in Bistrița river.

Frazil ice is formed in turbulent, supercooled water. Supercooled water has a temperature below its equilibrium freezing point; for pure water the freezing point is, by definition, 0°C (32°F) at atmospheric pressure. Supercooling takes place in rivers at locations where the water is turbulent, where the water surface is not covered by ice, and when the air temperature is less than 0°C (32°F) by a significant amount (usually an air temperature of –8°C (18°F) or lower is required). If the water surface is covered with ice, the temperature at the ice/water interface must be at the equilibrium freezing point, and all heat transfer from the water would stop when the water cooled to 0°C (32°F). As a result, the formation of *frazil* is always associated with open water.

The level of supercooling should be not overestimated; it will usually not exceed several hundredths of a Celsius degree and in not one case will exceed 0.1°C (0.18°F). As a result, supercooling is detectable only with laboratory-grade thermometers. *Frazil* ice appears first as small crystals (0.1 mm to several millimeters) that are distributed more or less uniformly throughout the region of turbulence. In rivers, for example, this is likely to be throughout the entire depth. Each crystal starts out as a perfect disk, whose major diameter is of 10...12 times its thickness. This disk shape is the form by which *frazil* is chiefly known, but, with time, *frazil* ice evolves through a number of processes to form larger and larger ice masses. Eventually, it will become a stationary, floating ice cover that may be many kilometers long.

2. *Frazil* Ice Formation

During the formation stage, the initial *frazil* ice crystals are created. Formation is characterized by supercooled water, turbulent flow, the rapid growth of diskshaped crystals, and the creation of new crystals by secondary nucleation (explained below).

The length scales of the ice associated with this stage range from several micrometers to perhaps a few millimeters. This stage usually takes place during cold periods when the heat loss from the open water surface is intense.

2.1. Nucleation

It is now known that the *frazil* crystals do not "spontaneously" appear through nucleation in the water column. Nucleation is a general term, referring to the formation of a new phase of a substance from a parent phase. In our case, the parent phase is obviously water, and the new phase that is appearing is, of course, ice. We know now that *frazil* ice crystals are formed from s*eed crystals*, which are ice crystals introduced from outside the natural water body. Seed crystals can be produced by a number of different sources: vapour evaporating from the water surface, which, encountering cold air, can sublimate into ice crystals, which falls back onto the water surface and are entrained by the turbulent motion of the flow; small water droplets generated by breaking waves, bubbles bursting at the water surface, and splashing; snow and sleet. But seed crystals are not the whole story.

2.2. Secondary Nucleation

It is observed that once a very few seed crystals are introduced into turbulent supercooled water, very quickly many new crystals are created through *secondary nucleation*. Collisions of existing crystals with hard surfaces (including other crystals) is thought to be the main mechanism through which new *frazil* ice crystals are formed. These new crystals can then further increase the rate of secondary nucleation with a multiplication effect. Because the *frazil* ice crystals are suspended in supercooled water they are also growing in size. The water temperature will dynamically reflect the balance of the latent heat released by the growing crystals and the heat transfer from the water surface. Eventually, the rate of latent heat released is enough to return the water temperature to the ice–water equilibrium temperature (0°C (32°F)).

3. *Frazil* Ice Evolution and Transport

Frazil ice evolves and is transported after it is formed. *Frazil* evolves largely from the individual crystals joining together to form larger masses. The evolution of *frazil* is characterized by water more or less at the equilibrium temperature, and *frazil* in the form of *flocs*, *anchor ice,* and *floes*. The length scales of the ice associated with this stage range from several millimeters to many meters.

The *frazil* is largely moving under the influence of the flow velocity of the river or stream, generally at the surface. After cold nights, it is typical to see *frazil slush*, formed of *frazil* flocs, moving along at the water surface of northern rivers and streams. This ice may travel long distances, moving for many days and may eventually form large moving floes. Eventually, *frazil* can form stationary, floating ice covers that may be quite large and last for the entire winter season. These ice covers are formed by a variety of mechanisms, depending on what form the *frazil* ice takes when it arrives at the stationary ice cover, and on the hydraulic conditions at the cover's leading edge. These floating covers can become very thick, especially in the (relatively rare) cases where a *hanging dam* forms. *Frazil* ice may be deposited on or eroded from the underside of the cover throughout the winter. The crystal structure of ice covers formed from *frazil* ice reflects its origin, and the ice crystals tend to be small and randomly oriented.

4. Problems Caused by *Frazil* Ice in Bistrița River

There are a number of problems that can be caused by *frazil* ice. If areas of streams or channels remain open for long periods during cold weather, large amounts of *frazil* ice can be formed, carried downstream by the flow velocity, and eventually deposited in a relatively slow velocity reach of the river to form a *freezeup ice jam*.

Freezeup ice jams can block substantial portions of the river cross section. This blockage may raise upstream water levels enough to cause flooding, or may serve as the site of a *breakup ice jam* later in the winter season. Upstream water levels may also be raised if large amounts of *frazil* ice are deposited on the channel bottom as *anchor ice* to form *anchor ice dams*. Anchor ice dams are relatively rare and usually occur in steep, shallow rivers and streams. Water intakes can experience significant problems with *frazil* ice if they are operated when the water is supercooled. The crystals in the supercooled water will be growing in size and will stick to any object they contact – including intake trash racks, as long as these objects are at a temperature below freezing point. Given the effective heat transfer rates provided by flowing water, any object in the water that is not heated will quickly be at the temperature of the supercooled water and will accumulate *frazil*. Sufficient *frazil* can accumulate on the trash rack to effectively block it and completely stop the flow of water into the intake, often with severe consequences.

5. Specific Problem Upstream Izvorul Muntelui Lake

Freeze up ice jams block all the river cross section and river flow continue as a seepage trough *frazil* ice and river bank. It is obvious that flow capacity decreases and all water and *frazil* ice are deposited in stream channel. The raise of upstream level depends on water discharge and air temperature. Maximum upstream long ice jam was of 25…30 km and 5…7 m depth.

There are many structural or nonstructural methods for reducing the frequency and severity of damages from ice jams. This paper refers to blasting for remouve the ice jam.

5.1. Breaking Ice with Explosives

When explosives are used to break a semi-infinite solid medium, detonation of charges on the surface is very inefficient. Experience suggests that the same is true of charges fired in air on top of a floating ice sheet.

The detonation produces gas at high temperature and pressure and this creates a bubble in the water. The gas bubble expands against hydrostatic *pressure,* but because of inertial effects the expansion does not cease until the bubble pressure has dropped well below the external water pressure. Eventually it collapses, again with inertial over-run, until the bubble pressure is well in excess of water pressure. This process gives rise to successive bubble pulsations. While these pulsations are occurring, a bubble in deep water rises by virtue of its buoyancy.

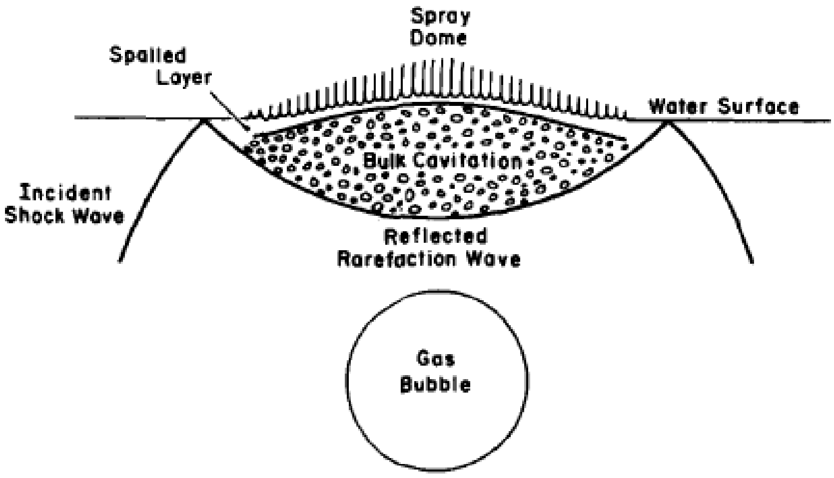

Fig. 1– Spalling of the water surface by an underwater explosion.
(after Malcolm Mellor *apud* Young, 1973).

To maximize the damage from a blast, the user must plan on firing the charge directly beneath the ice cover. In order to calculate the optimum charge weight, W, it can be assumed that the greatest efficiency will be achieved when

$$W=\left(\frac{t}{0.347}\right)^3,\ [\text{kg}],$$

where t is expressed in metres and W in kg**.** The procedure can be illustrated by a numerical example.

When the ice thickness is of 1 m,

$$W = \left(\frac{1}{0.347}\right)^3 = 23.9 \text{ kg}$$

The predicted value of the crater radius is

$R = 6.57W^{1/3}$, (W, [lb] and R, [ft]).

Consequently

$$R = 6.57\left(\frac{23.9}{0.453}\right)^{1/3} = 24.6 \text{ ft} = 7.5 \text{ m}.$$

When the ice thickness is of 2 m

$$W = \left(\frac{2}{0.347}\right)^3 = 191.5 \text{ kg}.$$

The predicted value of the crater radius is

$$R = 6.57\left(\frac{191.5}{0.453}\right)^{1/3} = 49.3 \text{ ft} = 15 \text{ m}.$$

Blasting ice jams requires consideration of several factors that are not present when breaking level ice. Firstly, in the few hours after a jam has gone into place, it is usually not stable enough to hold personnel or equipment. However, *these first few hours, while the hydrograph is still on the rising limb*, *is the time that the blasting operation will have the greatest chance of success*, as there *is still sufficient flow to clear the jam*. Thus, charges have been placed by helicopter or by throwing them from shore. The blasting should proceed from the toe upstream into the jam. Secondly, for maximum effectiveness, the charges should be placed *below the water*, but this may not be possible if the personnel cannot be put on the jam. If the charges cannot be placed under the jam, they should be placed as deep into the jam as is practical by putting them in naturally occurring holes and crevasses. Once the charges are placed, the best results are obtained when they are detonated simultaneously. In general the charge size should be about the same as given above, though the charge size might be slightly larger or spacing reduced to compensate for not being able to set the charge under the ice. Furthermore, *the broken ice in the jam will also act* *to absorb much more energy* than an unbroken cover, so spacing may need to be adjusted during the course of the operation to assure that the craters overlap.

In Bistriţa river neither condition for sccesfully blasting are present.

In Fig. 2 are presented ice jam *inception* in Bistriţa river upstream, Izvorul Muntelui lake.

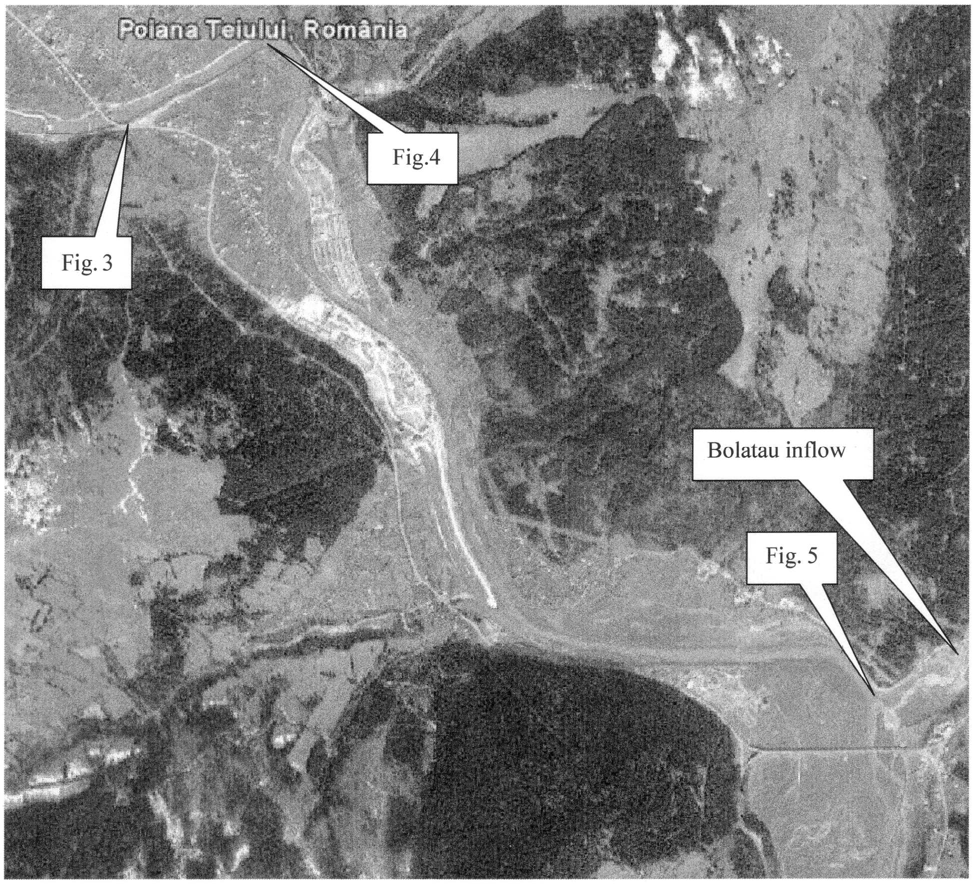

Fig. 2 – Sector of Bistriţa river where observation was done.

Observation was maded in January 27, 2011.

Between point Figs. 4 and 5 ice jam was already fitted several days before. *Frazil* ice shown in Fig. 3 comes from far upstream river. Bolatău river melts ice jam downstream its inflow but have not activates ice breakup because upstream ice jam blocks all the river cross section and there is no flow herein.

Fig. 3 – *Frazil* ice inflow on Bistrița river.

Fig. 4 – Ice jam formation.

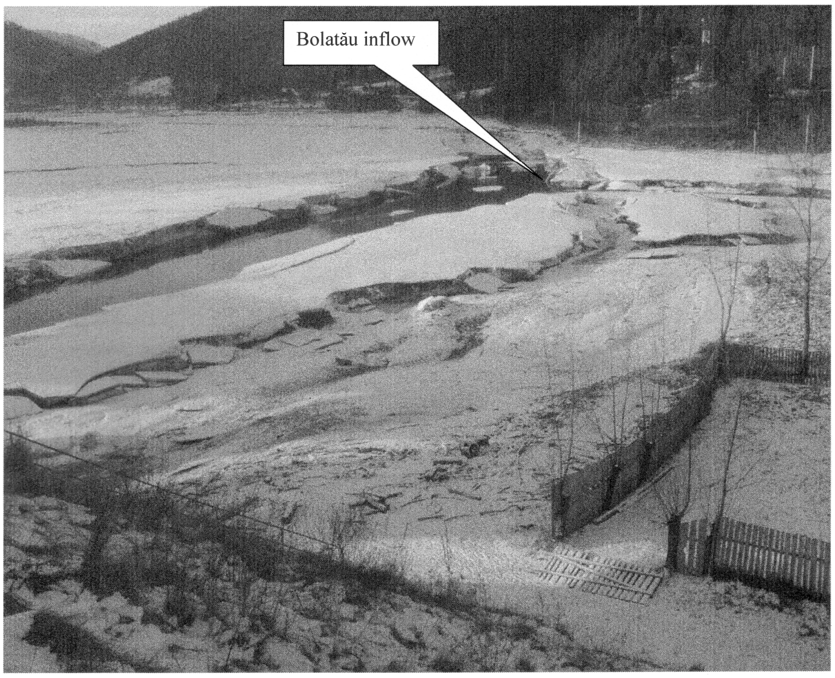

Fig. 5 – Ice jam melting by warm water inflow from Bolatău river.

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BLOCAJE DE GHIAŢĂ PE BISTRIŢA – CAUZE ŞI SOLUŢII POSIBILE

(Rezumat)

Blocajele de ghiaţă de pe râul Bistriţa, amonte de lacul de acumulare Izvorul Muntelui, au specific faptul că obturează intreaga albie. Una din metodele utilizate pentru deblocarea albiei de ghiaţă este utilizarea explozivilor. În articolul de faţă se arată că din cauza mecanismului de formare şi a blocării integrale a albiei folosirea exploziilor pentru deblocare este inutilă.