ГОДИШНИК НА УНИВЕРСИТЕТА ПО АРХИТЕКТУРА, СТРОИТЕЛСТВО И ГЕОДЕЗИЯ
СОФИЯ

Том Volume 53 | 2020 | Брой Issue 1

ANNUAL OF THE UNIVERSITY OF ARCHITECTURE, CIVIL ENGINEERING AND GEODESY
SOFIA

Получена: 20.12.2019 г.
Приета: 22.01.2020 г.

RESULTS OF RECENT ACTUALIZATION OF BULGARIAN SIGNIFICANT RESERVOIRS INFLOW

I. Niagolov[1]

Keywords: *reservoir inflow, reservoir managementt*

ABSTRACT

There are about 50 significant reservoirs in Bulgaria, having more then 6,4 billion m^3 total water capacity. About the same quantity of Bulgarian fresh water resources are regulated in mentioned reservoirs – the sum of mean annual reservoir inflows is 6,5 billion m^3.

These reservoirs are important for the Bulgarian water economy and water authority pay a lot of attention on their management. Monthly the MOEW issues schedules for the reservoir releases. Reservoir inflows play an important role in this process.

The actualization of used reservoir inflow data was done two years ago. The final report contains the actualized data as well as some tendencies in temperature, precipitation and extreme event. An attempt is made to analyze tendencies in expected climate change and relevant scenarios.

The subject of this paper are some unpublished results from mentioned study. They are connected with observed quantitative characteristics and local inflows features.

Introduction

There are about 50 significant reservoirs in Bulgaria, having more than 6,4 billion m^3 total water capacity. About the same quantity of Bulgarian fresh water resources are regulated in mentioned reservoirs – the sum of mean annual reservoir inflows is 6,5 billion m^3. These reservoirs are important for the Bulgarian water economy and water authority pay a lot of attention on their management. Monthly the MOEW issues schedules for the reservoir releases. In this process an important role is given to reservoir inflows information and regardless of the permits issue system used [7], the water availability is very essential.

[1] Igor Niagolov, Prof. Dr. Eng., NCGI, NIGGG – BAS, Acad. G. Bontchev St. Bl. 3, Sofia 1113, e-mail: igorbg@mail.bg

The total volume [1] of registered surface runoff for the country in 2018 is 24,62 billion m^3. Compared to the previous one year 2017 this is 69,7% more watery year. A comparison with long term annual averages for the periods 1961 ÷ 1990, 1971 ÷ 2000 and 1981 ÷ 2010, show values increased with 33,4%, 51,7% and 58,1% respectively.

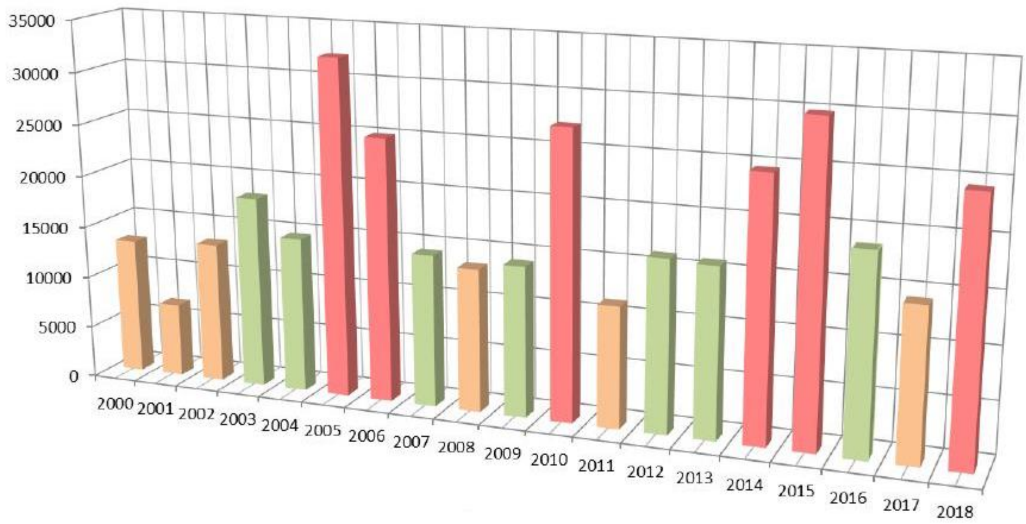

Figure 1. Annual surface water amount (mln m^3) for the 2000 ÷ 2018 [1]

For the period 2000 – 2018 the long-term average is more then 17,5 billion m^3/y and $C_V = 0,4$. There is an interesting coincidence – according to NIMH data for the period 1961 – 2008 the amount of fresh water resources formed on the Bulgarian territory and leaving it is 17,12 billion m^3/y.

The average annual rainfall in Bulgaria is 670 mm. Minimal and maximal anomalies are during years 2000 and 2005 respectively, reaching -40% and +42%. The rainfall information is contradictory. The information source is the same, but the following analyses are different.

According to [2] – "in 2021, the air temperature is expected to increase by 1,0 °C – 1,5 °C above the climatic norms compared to 1961 – 1990, and the average annual rainfall reduction by 4% – 7%. Rainfall is expected to continue in 2035, during which between 9% – 14% of rainfall will be lower than normal and warming may be higher than 2 °C (2,3 °C – 2,7 °C)".

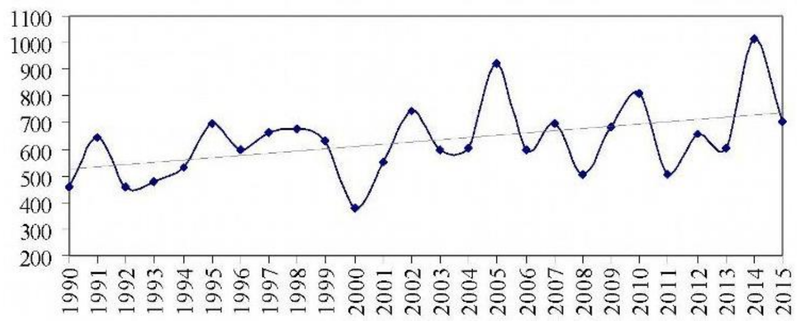

Figure 2. Mean annual precipitation sum (mm) for the 1990 ÷ 2015 (source [3])

An interesting information concerning precipitation in Bulgaria is given [3]. It is stressed that during 2014 in areas with altitude less then 800 m above sea level the annual precipitation sum is 1013 mm and 85% of the settlements are situated there. It is pointed out that during the period April – October 2014 intensive 24-hour rain that exceeded twice the average rainfall happened in some places. There is a conclusion that in the period 1990 – 2015 compared with the period 1961 – 1990 the amount of precipitation increased by 66%... An important feature is that the source is non-specialized.

This conclusion slightly mismatches the dynamics of some climatic element change, especially temperature and precipitation sum. For instance [4] points out that for the Bulgarian territory in the next decades it is expected warming and reducing precipitation amount, especially in the warm half-year. This situation is expected to reflect on the water resources of the country. The combination of high air temperature and precipitation deficit leads to higher summer transpiration and evapotranspiration. The risks of different drought events are rising. In the mentioned source a quantitative dependence is pointed out – mean annual precipitation reduction to 90% observed leads to 75% outflow reduction of long-term annual mean outflow. For example, according to RBMP2016 [5], the estimated two climate parameters for EASBD – average temperatures and rainfall for future periods of time (with 1976 ÷ 2005 being the reference period; ALADIN 5.2 model apply two IPCC AR5 RCP scenarios – “moderate” RCP4.5 and “pessimistic” RCP8.5). The results are summarized in the following table:

Parameter	**Period**	**RCP4.5**	**RCP8.5**
Temperature	2021 – 2050	Increase just over 1%	increase 1,3 – 1,5%
Mean precipitation	2021 – 2050	Increase 2,71%	n/a

If a simple technique of moving the average is used for the last more than 50 years, no long dry/wet subperiods are seen. The figure is as follows:

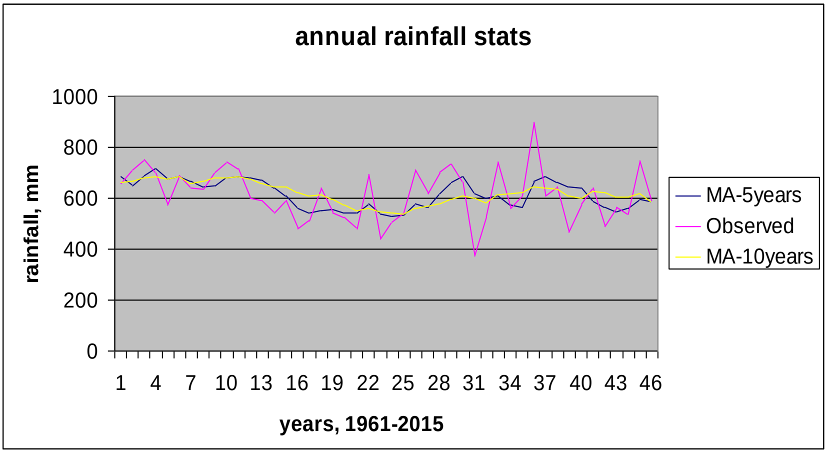

Figure 3. Simple stats for the annual rainfall – no long dry/wet subperiods

The more significant results comparing periods 1961 – 1990 and 2021 – 2050 are given in [8]. On the next Fig. 4 the “green” areas show places with expected increase of average annual rainfall. But the prevailing ones (half of the country in yellow) show expected decrease of the average annual rainfall.

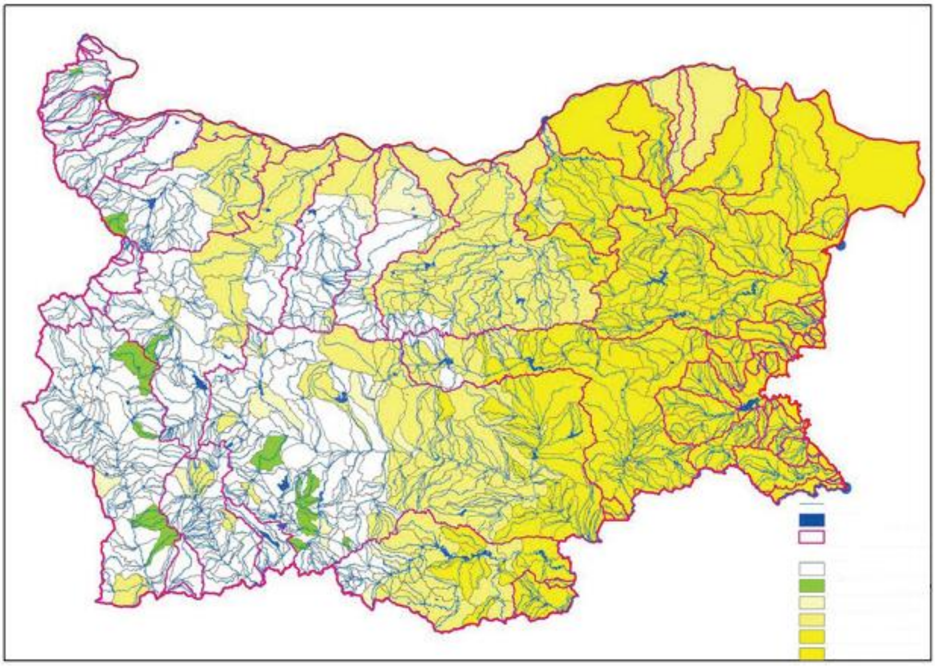

Figure 4. Percentage change in the period 2021 – 2050 [8] compared to the reference period for the average annual rainfall (rain and snow). Yellow shades represent decrease by 5, 10, 15 and 35%, respectively

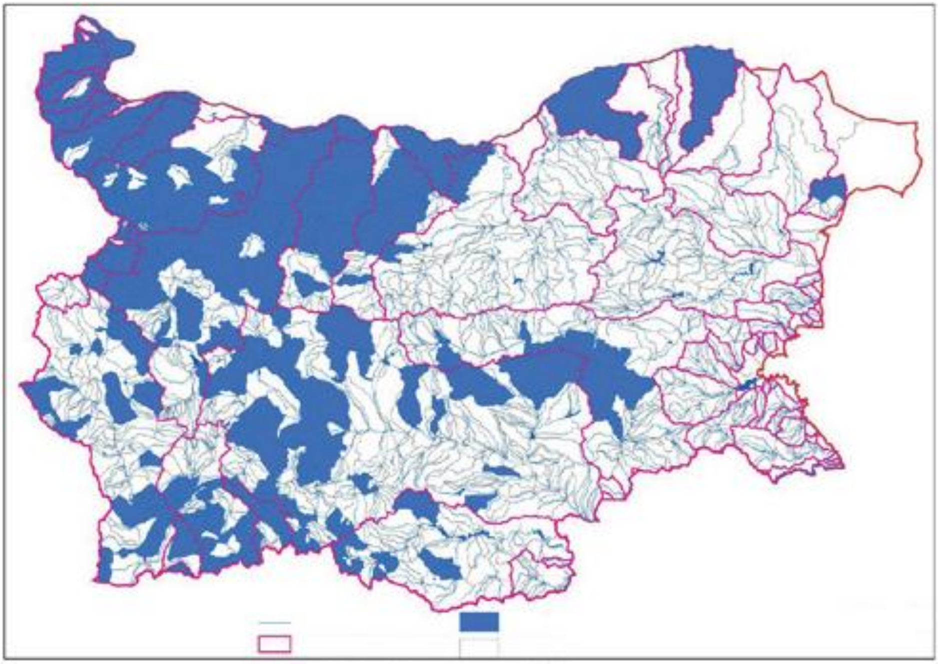

Figure 5. Watersheds where there is a 5% increase in the amount of precipitation with (6 h) intensity of above 10 l/m^2

Keeping in mind all of the above mentioned, the actualization of the used reservoir inflow data was done starting four years ago. The final report contains the actualized data [6], as well as some tendencies in temperature, precipitation and extreme event. An attempt is made to analyze tendencies in expected climate change and relevant scenarios.

Reservoir Inflows Series

As mentioned in the introduction, the sum of the mean annual reservoir inflows is about 6,5 billion m^3 for the significant reservoirs. For the period 2000 – 2018 the inflows variation is relatively high. The reservoir inflows sum coefficient of variation is smaller than this of the total resources. The value is C_V = 0,29. The inflows of the driest year 2001 are about 2,9 billion m^3 and in the wettest year 2005 – about 11,1 billion m^3.

The actualization of the used reservoir inflow data covers 45 reservoir series. The main purpose of the study is to point out the monthly and annual values for: mean inflow, inflows with 50%, 75% and 95% probability of exceedance (PE), as well as in addition the very important 5% PE.

A variant of the study results with the final table may be found at MOEW[1].

Annual inflow series

In this study 45 reservoir inflow series are used. The series length is different but usually about 50 years. One series is removed because the data period 1985 – 1994 is incomplete. For the rest 44 series 24 cases (~55%) where the means for the period 1985 – 1994 are the smallest among all 10-years periods (smallest value of the moving averages (MA)) may be found. This kind of results are stable. For shorter periods one may not find differences. If 5-yesrs periods are investigated there are 23 cases where minimal value of 5-years MA for the period 1985 – 1994 is the smallest among 5-years from all MA. For the two 5-years periods[2] the above mentioned cases logically decrease to 16. All this shows that the period 1985 – 1994 (as a whole and as a relatively long samples) is the driest in the reviewed inflow series.

During the last years single dry years or short sequences (2 – 3 year) of dry years are registered, but these are not parts of long dry periods (5 and more years).

For about half of the dams, period 1985 – 1994 remains the driest to date. These are mainly dams in the western part of the country. A few are in the Black Sea region.

There are homogeneity tests fulfilled. For half of the cases-series homogeneity tests are completed, for the rest series an anthropogenic influence is registered. These series are inflows to cascade dams (Batak, Jreb4evo), derivation dams (Belmeken, Goliam Beglik), and specific cases (Sretchenska bara, Mandra). This result is slightly surprising when climate changes are expected – clear nonhomogeneity only where anthropogenic influence takes place. If necessary, more detailed investigations have to be done.

Some important probabilities of exceedance (PE)[3] are calculated. These are the regulatory accepted PE of 5%, 50%, 75% and 95%. Again two cases are investigated – the actualized period (AP) and the period 1961 – 1990 years.

The comparisons are made for the different PE. The summarized results are as follows:

---

[1] http://www5.moew.government.bg/wp-content/uploads/filebase/Water/Povarhnostnivodi/Metodika/pritoci_NIMH.xls.

[2] years 1985 – 1989 or 1990 – 1994 are analized, i.e. first or last half of period 1985 – 1994

[3] probability of exceedance is calculated (New PE) and compared with PE in use until Actualization

- In half of the cases, the PE 5% for the AP to the period 1961 – 1990 is greater and vice versa;
- In almost all the cases the PE 95% for the AP is greater;
- A gradual change in the PE values is noticed (Fig. 5) for the intermediate cases (50% and 75%) – almost linear change.

These results point out that the separate dry years are observed recently. Regarding the regional location of reservoirs it may be stated that almost all of them are situated in south Bulgaria and Black Sea region.

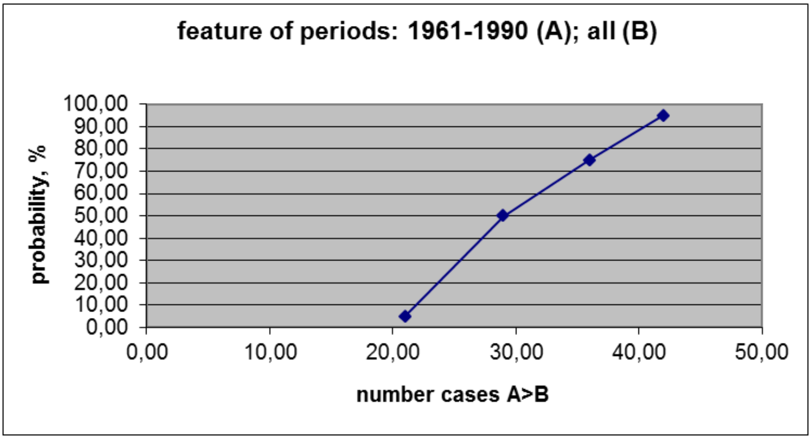

Figure 6. Cases of PE differences for periods 1961 – 1990 and final selection (AP)

The probability distribution remains practically stable and may be used for wide-ranging statistical analysis.

Monthly inflow series

For 1/3 of the reservoirs the adding of new inflow information causes no change for the average inflows. Where changes take place, the variety in the different cases is obvious:

- There are reservoirs (Beli Lom, Sopot) for which a decrease of monthly inflows during the whole year is observed;
- For the reservoirs as Vacha, G. Beglik, Dospat and others a decrease of the inflows is during high water months;
- Usually an inflows decrease is observed during 2 – 3 months (Conevo, Kamtcia, Jrebtchevo Arde dams);
- There are small inflow changes for Koprinka dam (increase in December), Sretchenska bara (decrease in high water months), Poroi dam (increase in low water months);
- An increase of inflows during the months at the beginning and at the end of the year appears for Iasna Poliana and Smirnenski dams.

There are reservoirs (Ognianovo, Topolnica, Malko Sharkovo) for which relatively high fluctuations are observed during the whole year and a detailed analysis should be done if needed.

There are no differences among monthly water quantities for many reservoirs – along the Balkan Mountains and in the southern part of the country (Yovkovci, Ticha, Topolnica, Iastrebino, Dospat, Jrebchevo, Ivailovgrad).

The differences among the calculated water quantities for PE 5% are greater than those for PE 95%. Small differences are available for less then half of the reservoirs, but the variety is relatively high: drier months for Saedinenie, Vacha, Traikov, Kardjali, Beli lom, wetter summer for Koprinka.and Beli Lom.

For separate characteristic probabilities (PE) the following generalizations may be given:

New PE 5% Usualy where differences take place the months are wetter. The reservoirs are situated in the Black Sea region (Poroi, Iasna poliana) and in the Danube plain (Kula, Rabisha, Sopot, Smirnenski, Stamboliiski). There are some exceptions as: Aheloi dam – drier first months and wetter last months; first months recently are drier for Malko Sharkovo and Ognianovo.

New PE 50% Usualy where differences take place the months are drier and during the first half of the year (Kula, Goliam Beglik), as well as – all year for Beli Lom.

New PE 75% Usualy first months recently are drier in nordwestern part – Kula, Ogosta, Sretchenska bara as well as all year for Beli Lom. For some reservoirs first high water months are drier (Goliam Beglik).

New PE 95% The variety for this part of results is in many manners: usualy first months recently are drier in nordwestern part. Kula, Ogosta, Sretchenska bara; There are small number of reservoirs Ognianovo, Saedinenie, Beli Lom for which all the months are drier. There are cases where the summer months are drier (Piasatchnik) or the first and last months are drier (Rabisha, Poroi, St. kladenetz).

Conclusions

During the last two decades are registered single dry years or short sequences (2 – 3 year) of dry years, but these are not parts of long dry periods. For about half of the dams under consideration the lond period 1985 – 1994 remains the driest to date. These are mainly dams in the western part of the country. A few are in the Black Sea region.

The differences among calculated water quantities for PE 5% are more than these for PE 95%. A gradual change in the PE values is noticed for all the cases (5%, 50%, 75% and 95%) – almost linear change.

Half of the series keep homogeneity, for the rest series an anthropogenic influence is registered. These series are inflows to cascade dams (Batak, Jreb4evo), derivation dams (Belmeken, Goliam Beglik), and specific (Sretchenska bara, Mandra). This result is slightly surprising when climate changes are expected – clear nonhomogeneity only where anthropogenic influence takes place.

For 1/3 of the reservoirs the adding of new inflow information causes no change for the average inflow.

Usually new PE 5% are wetter; new PE 50% are drier in first half of the year; for prevailing number of dams the new PE 75% are drier during the first months; new PE 95% are dominantly drier.

For improvement of reservoir management, a very useful action would be to slightly modify the wet and dry layers of the separate reservoirs (used in necessary dispatch schedules for management) according to the recent results obtained.

There are many cases with information “modified” from the source to the end user. The institutions obliged to gather and disseminate this information have to control the whole process instead of just only to collect profits at the beginning.

REFERENCES

1. http://www.hydro.bg/bg/data/reki2018.pdf.

2. National Strategy for Management and Development of the Water Sector in the R of Bulgaria. Annex 1. Analysis of Water Consumption and Future Water Needs., 2012. http://www5.moew.government.bg/wp-content/uploads/filebase/Water/IVodi/NSURVS/Analiz_1_Vodni_resursi.doc.

3. https://rus.bg/pogoda/pogoda/16445-za-poslednie-25-let-kolichestvo-osadkov-v-bolgarii-uvelichilos-na-66.

4. *Kolcheva, Kr.* Water Allocation and Climate Change – Character and Adaptation. “Vodno Delo”, 1/2, 2019 (in Bulgarian), https://www.stuwa.org/files/magazine/1-2.19_s1.pdf.

5. East Aegean region RBMPlan, 2016, https://earbd.bg/indexdetails.php?menu_id=609.

6. http://www5.moew.government.bg/wp-content/uploads/filebase/Water/Povarhnostnivodi/Metodika/pritoci_NIMH.xls.

7. *Kolcheva, Kr.* Water Use Right – Permits Issue. Vodno delo, 1-2, 2014, pp. 7-15 (in Bulgarian).

8. *Spiridonov, V., S. Balabanova*. Influence of Climate Change (by 2050) on the Intensive Rainfall on the Territory of Bulgaria. Bul. J. Meteo & Hydro 22/5 (2017) 26-37.

РЕЗУЛТАТИ ОТ АКТУАЛИЗАЦИЯТА НА ДАННИТЕ ЗА ПРИТОЦИТЕ КЪМ КОМПЛЕКСНИТЕ И ЗНАЧИМИ ЯЗОВИРИ В БЪЛГАРИЯ

И. Няголов[1]

Ключови думи: *приток в язовир, управпение на язовири*

РЕЗЮМЕ

Комплексните и значими язовири в България са над 50. Те имат общ обем над 6,4 млрд. m^3. Приблизително същото количество от водните ресурси на България се регулират в тях – сумата от средногодишните притоци регистрирани към тези язовири е около 6,5 млрд. m^3.

Тези язовири за важни за водното стопанство на страната и компетентните органи се грижат за доброто им управление. Ежамесечно МОСВ издава план-графици за изтакането им. В този процес важна роля има информацията за притоците в язовирите.

Актуализацията на използваните данни за притоците е извършена преди две години. Окончателният доклад включва актуализиваните данни, както и някои тенденции свързани с температурата, валежите и екстремни явления. Направен е опит за анализ на тенденции при очаквани климатични изменения и съответни сценарии.

Предмет на настоящият доклад са непубликувани резултати от споменатото изследване. Те са свързани с наблюдавани количествени характеристики на притоците, така и с тяхни регионални особености.

[1] Игор Няголов, проф. д-р инж., НИГГГ – БАН, ул. Акад. Г. Бончев, бл. 3, София 1113, e-mail: igorbg@mail.bg