Contributions to the determination of flooding levels using DUFLOW program for the river Mures in Arad

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Abstract :The study was conducted for Mures area located in Arad county, the area belonging to Arad Water Management System, which is designed to operate with two regional units, such as : the hydro system Lipova and hydro system Arad. There are four Key stations in this part of the hydrographic basin, which constant provide information on river Mures: Săvârşin, Radna, Arad and Nadlac.
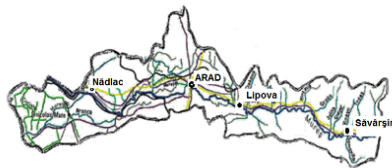
Fig.1 The studied area

1. DUFLOW PROGRAM

Defining a model for a particular situation requires some decisions that should be taken:
-the diagram;
-the origin/nature of the border conditions;
-digitization area and the time located for analysis;
-level of the required detail.

At the starting point of the program, the initial values of H and Q must be known. In addition to this, the effect of the wind and the rain conditions, must be given.

The branch points are selected at the border of the network, at junctions, at both sides of a structure. A more dense network is used for the areas with quick changes in the cross section. There are also some limitations in using the Duflow package.

One of them is that the equations are unidirectional. This means that the speed within a section is an average number on the width and the depth of that section. Not to mention that the stream must be, approximately, parallel on the axis of the river.

The values of some variables change over time. In Duflow the values are recorded in time sequences which can be: equidistant, not equidistant, constant or Fourier series. Some parameters may vary in time but they are constant for all the grid: the

wind speed, wind direction, the rain and the evaporation.

The files used in this paper are:
. PRJ. – the name of the project;
. CTR. – input data
. NET.,. NOD. - Contains the network and the geographical dispersion of points;
. BEG. - stored data concerning initial conditions;
. BND. –boundary conditions;
. RES. –the result of evaluation.

2. NECESSARY DATA

Duflow application was used for the river Mures area in Arad. This application was used beginning with Săvârşin key station and ended in Nadlac key station, next to the border with Hungary.

a. The axis of the thalweg is indicated on the lay-out plan;
b. The route is divided into sections. This division was made with the help of soma points called "branch points", which were numbered upwards so that sections between two subsequent branch points follow the plane bend of the axis of the thalweg;
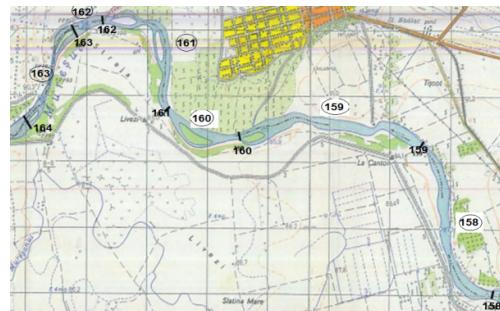

Fig.2 Sections 158-164

c. Sections were given integer;
d. In a system of axes of reference, when geographical north is known, the angle formed by this direction and the axis Oy is determined. The movement is being made clockwise;
e. The minimum elevation of the layer is determined, for all the points of digitization;
f. The profiles of the cross-section were built in each point of digitization;

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g. Using a set of numerical constants known for the water heights $h_1 = k \cdot \Delta H$ opposing the height of the thalweg, the widths of flowing at the surface were determined;

h. The coefficients of roughness were determined for each analyzed section;

i. The border conditions were mentioned;

j. The initial conditions at $t = t_0$ were mentioned in all points. These initial conditions have been given 0 value, so that it is necessary that the recording of the results should be made after a while. The levels in some points and the flow rate for some sections need some extra time to reach proper condition. This situation eraser the numerical constant of unrealistic beginning.

The program has several types of data processing, such as:
- Results related to time, where the fluctuation of level, flow rate and speed parameters is represented;
- Results related to time and position, where the fluctuation of parameters in time is presented; The latter option requires the defining of the route, indicating the selections where monitoring is needed. This way:
- Results related to the route are shown; the variation of parameters (level, flow rate and speed) on a route chosen at certain time (multiple time steps).

3. INTERPOINT APLICATION

In order to run a Duflow program in good conditions, we need good training prior to data entry. Input data must be calculated from cross sections of the points of digitization placed on the rout.

INTERPOINT is an auxiliary application which makes the automatic calculation of the basic elements needed in DUFLOW program. The principle of achieving this is getting information, strictly necessity, about some points of the route, needed for studying the level and the high water discharge.

The application has a pleasant graphic interface, being interactive and using Java formal programming language.

The theme proposed, faces the necessity encountered in engineering practice from hydrotehnics, that of a lot of data resulted from topographic and hydrometric measurements. These data must be filled in correctly to have a better view over the situation.

We don't have a proper knowledge of cross section profiles of the rods. The distance between these profiles is tens of km. It is necessary to know some intermediate sections in order to get accurate results concerning the levels of the water during the hight water discharge.

At the same time we need to calculate the elements of the cross sections, which are quite laborious and take a lot of time.

There are some conditions related to INTERPOINT application:

•The starting points which make up the cross sections were chosen so as to follow the bend of the river bed;
• The distance between two points that are given is a straight line and make up the sections in which the watercourse is divided, being bordered by the points of the digitization.

This application helps us get a representation of the points that follow the watercourse.
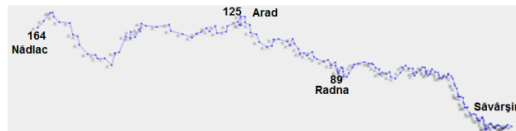

Fig.3 Representation of the points of the digitization of the network (river Mures)

If you access one of the points of the thalweg attached to the generated network, the application will present the cross section of the thalweg and at the same time, we will get information on the section area, the wetted perimeter and hydraulic radius, the width of the storage and the flow rate passing through the section, at different levels of water.
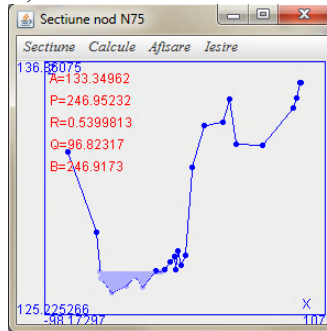

Fig.4 The generated cross section

Building the intermediate cross sections was achieved through mediation of the real sections, coordinates (x,y,z) of the intermediate sections resulting from the given conditions, according to the distance chosen on given circumstances. The application calculates the distance between the points, the alignment towards the direction of the point and the value of the thalweg points of the created sections.

Fig.5 The thalweg points calculation

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R = 1.222634
Q = 0.0
_____
Sectiune N14(278790.0,504178.0,0.0)
-----Calcule pentru 0.5:-----
A = 6.934446
P = 27.788462
B = 27.737783
R = 0.24954407
Q = 4.4274645
-----Calcule pentru 1.0:-----
A = 27.761314
P = 61.904053
B = 61.80216
R = 0.44845715
Q = 26.251114
-----Calcule pentru 1.5:-----
A = 264.7274
P = 741.21216
B = 741.02405
R = 0.35715467
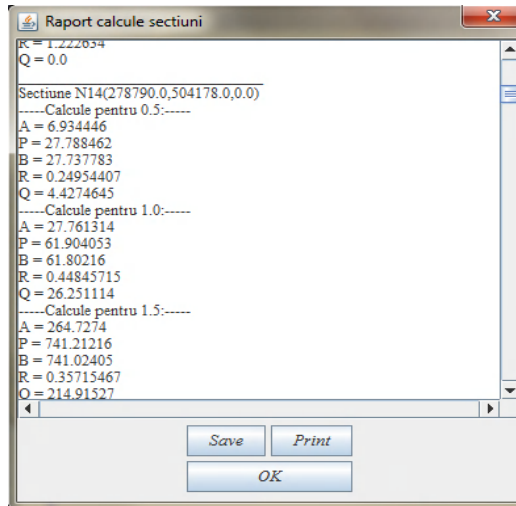Q = 214.91527

Save   Print
OK

Fig.6 Calculation of hydraulic components for the created sections

Knowing the cross section point, the Chezy roughness of the layer, the geometric average slope "i" of the section which includes this point(supposedly that "j" hydrodynamic slope of water is equal to "i" geometric slope, for different levels), we can identify the flow rate crosses the section, with the following formula:

$$Q = C * A * \sqrt{R * J} \quad (1)$$

where: $C = \dfrac{1}{n} R^{\frac{1}{6}}$ (2) and $R = \dfrac{A}{P}$ (3)

We get: $Q = \dfrac{1}{n} * A * R^{\frac{2}{3}} * J^{\frac{1}{2}}$ (4)

The principle used for calculating the plan area is to divide the section into schemes whose surface can calculated using common formulae. Then, me calculate the hydraulic radius and the flow rate for each elevation of water above the thalweg, according to the formula.

4. THE STUDY OF HIGH WATER DISCHARGE OF RIVER MURES IN ARAD REGION

The cross section located in the rod profile at the four key stations mentioned above were considered the starting points. The coordinates of the key stations, where the main sections are also located, are:

Săvârşin $22^013'$ east
$46^000'$ N
Radna $21^041'$ east
$46^005'$ N
Arad $21^019'$ east
$46^010'$ N
Nădlac $20^040'$ east
$46^008'$N

These coordinates were converted from UTM coordinates system into coordinate stereo 70, to be able to be represented in plan surface.

The following feature was obtained:
Săvârşin   x=284467 y=503767
Radna   x=243565 y=514605
Arad   x=215655 y=525107
Nădlac   x=165299 y=523936

Google Earth, Transdat and INTERPOINT applications, conveniently, helped ua thicken the thalweg points through which the cross sections have a proper length, so as to let us know the real fluctuation of the water level.

These points were considered points for digitization of the network; the number of the point, the number of the section, the first and the last point of each section until the last one, were all mentioned.

For the chosen area, 164 points which locate 163 sections were selected. Thus, the graphical plotting was obtained, which was similar to the representation obtained with INTERPOINT application.

5. CONCLUSIONS

This paper is a synthesis and an extension of hydrological data in the lower basin of the river Mures, in Arad county. This area, located in a region of hills and low mountains, is made of rivers with small basin areas.

Mures watershed area placed in the eastern part of the Tisza Plain, is an area where Mures river doesn't get any tributary streams. At the same time, the lower Mures is made of a part which is not impounded and another part which is impounded. The former lays between Savarsin and Lipova, and the latter lays between Lipova and the border.

Duflow application is adapted to the latest calculation procedures. It can:
-aim to the needs of hydraulic modeling by studying what can be done to manage the water quality and quantity.
-store the results in files to be accessed by other computer programs. For an immediate and suggestive analysis the results can be displayed graphically in time or space.
- handle large models, the calculation time being reduced.

The accuracy of the results depended on the way the data have been introduced. Thus, it was expected, given the initial conditions, that the level and the flow rate in all the points of the digitization was zero. That is why the output data have started to be recorded after some time from initiation the model, giving the network the proper time to reach the operational factors. Recording was carried out every second hour.

5.1 CASE 1

For the border conditions a constant flow rate was chosen, in point 1. This constant flow rate represents the flow rate with the probability of 1% and for the last point of digitization, point 164, the key curve was chosen as a margin condition. Following the analysis of the results we can conclude:

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-Point 1, which starts the modeling, is considered the cross section of the rod, at Savarsin key station, the section being given. At this point the recorded level was 153.68 m.
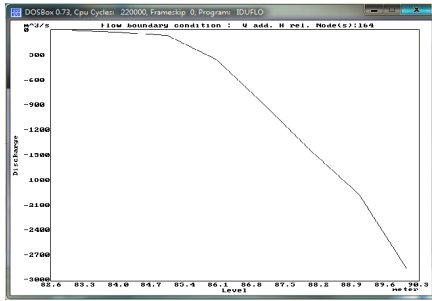

Fig.7 Key curve used in the final section

-In point 89, in the cross section of the rod, at Radna, the maximum height is 127.45 m. The flow rate in this section may vary between 2549.6 and 2550.6 m^3 / s.

-At Arad key station, the maximum height is 108.95 m and the flow rate slightly varies between 2549.4 and 2549.4 m^3 / s.

Fig.8 The diagram for Arad key station

-At the border of the county, in Nadlac, at the cross section of the rod, the level that was recorded was 89.70 m and the flow rate that which slightly varies between 2549.7 and 2550.3 m^3 / s.

-Studying the implications of the level increase on the areas crossed by Mures, we find that a flow rate with probability of 1% , may damage the area situated between points 86-122, 45 km, along the river. This is an area situated between Lipova and Arad, where a high water discharge with a flow rate of 1% may flood the ploughlands in the surroundings.

5.2 CASE 2

In this case, the constant flow rate with a probability 5%was considered the border condition for the point 1. For the final point the margin condition was the key curve.

The results obtained are as follows:
-At entry, in point 1, the level fluctuates between 153,045 and 153,195 m.
-At Radna key station level is between 125.975 and 126.02 m.
-At Arad key station changes the water level is between 107,475 and 107,495 m
-At Nadlac key station water level fluctuates between 89,204 and 89,211 m.
-Flooding occur between 102-122 points, 28.5 km along the river.

5.3 CASE 3

In this case, the entry flow rate at point 1, was considered the flow rate that was recorded by a hydrograph during a flooding, in 2004. In the final point it was considered the key curve.
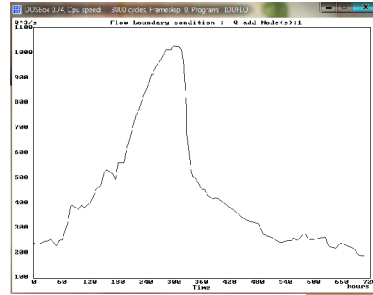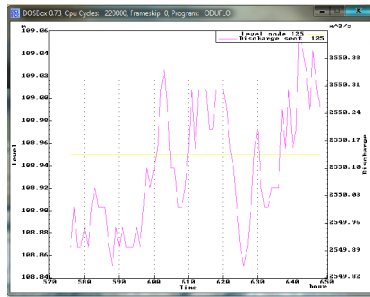

Fig.9 Flooding hydrograph

In the first part of the route, there is a significant variation of the flows rates and levels recorded, but not above the flood peak. Along the river bed, there is a slow variation of flow rates and levels. This variation can be represented graphically by a solid line.

Analyzing the diagrams, one may say that during such a flooding, the level of Mures exceeds the flood peaks between points 108 and 122, 22 km along the river.

A deep knowledge of territory aims at its development.

The Ways of fighting against flooding are both globally and locally. Some procedures could be: to reduce the global warning by diminishing the emission, a forestation, to build dams, barrages, to forbid building houses within the flooded area, to maintain the draw offs, to take care of the river beds.

REFERENCES

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