A METHOD TO FORECAST THE SEDIMENTATION-EROSION PHENOMENA IN SOME AREAS OF THE DAM LAKES ON RIVERS

BY

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Abstract. The paper presents the results of some researches on the riverbed morphology. These researches include the modeling of erosion-sedimentation processes, the measurements in situ over a long period of time and the verification of the model that was tested at the Chirita Reservoir of Iasi, for the mouth-river area of the two tributaries. A special conceived program was tested on the studied case.

Key words: sedimentation; erosion; lakes.

1. Introduction

The alluvial processes, which appear at the river mouth, have certain particular characteristics provided of the river waters interaction with the environment accepting them. These processes may be studied using the mathematical model of the liquid jet submerged into a liquid having the same

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density. Corrections concerning the density are necessary. The density varies with the length and height of the jet, because of the temperature and suspended load differences existing between the two liquids, which come into contact.

In our approach, we tried to study this complex process, by collecting data over a long period of time and processing them with the help of the Lagrange interpolation polynomial.

This investigation included three stages:

a) *in situ* data collecting;

b) mathematical modeling of the erosion/settling processes with Lagrange interpolation polynomial and conceiving the program;

c) running the program based on collected data and the validation of the mathematical model.

2. Data Collecting

The analysis of the morphological modifications which take place at the river mouth, (Mitroi, 1999), was realized on two tributaries of the Chiriţa Reservoir (Fig. 1). Observations and measurements on the river bad in this area exist since 1965. Some of the collected data were use to verify and run the program conceived by the team.

2. Mathematical Model

The Lagrange interpolation polynomial is a polynomial $L_m(x)$, designed as so to have the same values as the function $f(x_i)$ in the specified points $x_i$:

$$L_m(x_i) = f(x_i) = y_i, \quad (i = 1, 2, \ldots, n). \quad (1)$$

First, we shall find a polynomial $p_i(x)$, so that it might be annulled in all points, excepting $j = i$:

$$p_j(x_j) = \delta_{ij} = \begin{cases} 1 & \text{for } j = i; \\ 0 & \text{for } j \neq i. \end{cases} \quad (2)$$

The expression of such a polynomial is:

$$p_i(x) = C_i(x - x_1)(x - x_{i+1}) \ldots (x - x_n) = C_i \Pi_i(x) \quad (3)$$

in which: $\Pi_i(x) = \prod_{j \neq i} (x - x_j)$, $C_i$ - constant coefficient, determined by accepting that $x = x_i$. 
Fig. 1 – Investigated areas.
Consequently:

\[ p_i(x) = 1 \text{ and } C_i = 1/\Pi_i(x_j) . \quad (4) \]

From eqs. (3) and (4), the polynomial we are looking for shall have the following form:

\[ p_i(x) = \frac{\Pi_i(x)}{\Pi_i(x_j)} . \quad (5) \]

As for the polynomial \( L_m(x) \) and the condition (1), the former shall have the following form:

\[ L_m(x) = \sum_{i=1}^{n} y_i p_i(x) . \quad (6) \]

Really, since the polynomials \( p_i(x) \) are of the \((n - 1)\) order, \( L_m(x) \) is of the same order and it meets the condition (1):

\[ L_{n-1}(x) = \sum_{i=1}^{n} y_i p_i(x) = \sum_{i=1}^{n} y_i \delta_{ij} = y_j, \quad (j = 1,2,...,n). \quad (7) \]

After the necessary substitutions, we get to a Lagrange interpolation polynomial whose form is (Mitroi, 1999; Popescu, 1999):

\[ L_{n-1}(x) = \sum_{i=1}^{n} y_i \frac{\Pi_j(x)}{\Pi_j(x_i)} = \sum_{i=1}^{n} y_i \prod_{j \neq i} \frac{x - x_j}{x_i - x_j} . \quad (8) \]

Particular cases:

a) When \( n = 2 \), there are just two tabular points so that the eq. (8) is reduced to the equation of the line \( y = L_1(x) \), which passes through the above-mentioned points:

\[ y = \frac{x - x_2}{x_1 - x_2} y_1 + \frac{x - x_1}{x_2 - x_1} y_2 . \quad (9) \]

b) When \( n = 3 \), there are three tabular points. The eq. (8) represents the parabola \( y = L_2(x) \), which passes through these three points and whose expression is:
The Conceived Program

The program can forecast the evolution of the river bad in the river/lake contact area for the $y = L_i(x)$ equation line particular case, which, for the purpose of this research, proved to be sufficient. The core lines of program below can be easily converted for any newer version of Visual Basic for a better graphical interface.

\[
y = \frac{(x-x_2)(x-x_3)}{(x_1-x_2)(x_1-x_3)}y_1 + \frac{(x-x_3)(x-x_1)}{(x_2-x_3)(x_2-x_1)}y_2 + \frac{(x-x_1)(x-x_2)}{(x_3-x_1)(x_3-x_2)}y_3.
\]

(10)

2.1. The Conceived Program

The program can forecast the evolution of the river bad in the river/lake contact area for the $y = L_i(x)$ equation line particular case, which, for the purpose of this research, proved to be sufficient. The core lines of program below can be easily converted for any newer version of Visual Basic for a better graphical interface.
'FS = "profile"
1 IF D$ = "D" OR D$ = "d" THEN INPUT "Nume fisier "; FS
   INPUT "Calculul se face la timpul "; X: PRINT
   OPEN "i", #1, FS
   INPUT #1, NI, NP, NT
   'NI numarul de masuratori, NP numar verticale, NT numar de profile
   IF D$ = "d" OR D$ = "D" THEN DIM T(NI), XI(NI), YI(NI), XO(NP, NI), YO(NP, NI)
   OPEN "o", #2, LEFT$(FS, 6) + "PR"
   PRINT #2, NI; NP; NT
   XMAX = 0; YMAX = 0; XMIN = 1E+07; YMIN = 1E+07
   FOR U = 1 TO NT
     FOR V = 1 TO NP
       GOSUB 4
     NEXT V
     PRINT "---------------------------------------------"
   NEXT U
   IF XMAX < X THEN XMAX = X
   PRINT xmin, xmax, ymin, ymax
   CLOSE
   INPUT "Desen D/N "; D$
   IF D$ = "d" OR D$ = "D" THEN GOSUB 5
   END
4 'Sub CALCUL
   FOR K = 1 TO NI
     INPUT #1, D, YI(K), XI(K)
     IF XMAX < D THEN XMAX = D
     IF YMAX < YI(K) THEN YMAX = YI(K)
     IF XMIN > D THEN XMIN = D
     IF YMIN > YI(K) THEN YMIN = YI(K)
   NEXT K
   Y = 0!
   FOR I = 1 TO NI
     P = 1!
     FOR J = 1 TO NI
       IF J <> I THEN P = P * (X - XI(J)) / (XI(I) - XI(J))
     NEXT J
     Y = Y + P * YI(I)
   NEXT I
   PRINT "Pentru profilul "; U; " si verticala "; V; " y="; Y
   PRINT #2, D; Y
   RETURN
5 'Sub DESEN
   DEF FNO (U) = (U - XMIN) * 620 / (XMAX - XMIN)
   DEF FNP (V) = 400 - ((V - YMIN) * 400 / (YMAX - YMIN))
   SCREEN 12
   LINE (0, 0)-(640, 640), 0, BF
   OPEN "i"; #1, LEFT$(FS, 6) + "PR"; 'curba prognozata
   INPUT #1, C, NP, D
   FOR I = 1 TO NP
     INPUT #1, A, B
     X = 10 + FNO(A)
Fig. 2 – Prognosis of the alluvial phenomena evolution in the tributary – lake area: 1 – *in situ* measurements for 1965; 2 – *in situ* measurements for 1987; 3 – results of the program confirmed by measurements in 1998; 4 – program’s forecast for 2015.
REFERENCES


O METODĂ DE PROGNOZĂ A FENOMENELOR DE SEDIMENTARE-EROZIUNE ÎN UNELE ZONE ALE LACURILOR DE ACUMULARE

(Rezumat)

Se prezintă rezultatele unor cercetări asupra morfologiei albiei. Aceste cercetări cuprinde modelarea proceselor de eroziune-sedimentare, măsurătorile in situ pe o perioadă lungă de timp şi verificarea modelului, care a fost testat la acumularea Chiriţa din Iaşi, pentru zona gurii de râu a celor doi afluenţi. Un program conceput special a fost testat pe cazul studiat.