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چکیده

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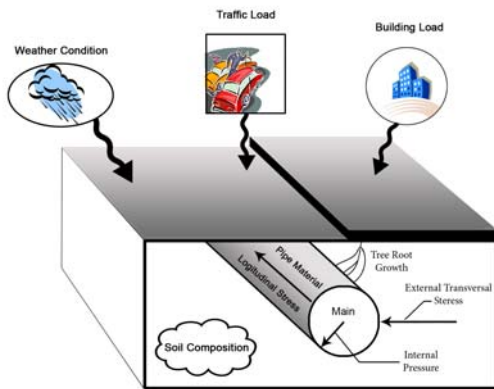
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واژه‌های کلیدی:

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Male .

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Shamir and Howard

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[ ]

$$N(t) = N(t_0) \cdot e^{A(t+g)}$$

$N(t_0)$

$N(t)$

t

$N(t)$

A

g (

)

(1/Year)

[ ]

[ , ]

Kettler and Goulter

[ ]

$$N = K_0 \cdot Age$$

$K_0$

$N$

McMullen

[ - ]

[ ]

$$Age = 65.78 + 0.028SR - 6.338pH - 0.049r_d$$

$SR$  ( )

$Age$

$pH$   $pH$  ( - )

$r_d$

Eisenbeis and Le Gat

$$[ ] \quad [ ] \quad ) \quad (T) \quad ($$

(EPR)

$$(X = [1, X_1, X_2, \dots, X_p]) X_j$$

$$Y = \ln T = X\beta + \sigma w \quad ( )$$

EPR  $X$   $Y$

Giustolisi & Savic

$$\sigma \quad \beta \quad w$$

EPR

[ ]

$$) X \quad (S) \quad ($$

$$S(t, \beta, X) = \exp[-\exp(\frac{\ln t - \mathbf{X}'\beta}{\sigma})] \quad ( )$$

$$= \exp[-t^{\frac{1}{\sigma}} \exp(\frac{-X'\beta}{\sigma})]$$

$$) \sigma \quad \beta \quad ($$

$$X' \quad X \quad ) t$$

(EPR)

$$t = (Ln(\frac{1}{S}) \exp(\frac{X'\beta}{\sigma}))^\sigma \quad ( )$$

$$( )$$



ES<sub>4x3</sub>

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$$ES_{m \times K = 4 \times 3} = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & -1 \end{bmatrix}$$

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$$Z_1 = (X_1)^1 \cdot (X_2)^0 \cdot (X_3)^0 = X_1$$

$$Z_2 = (X_1)^1 \cdot (X_2)^1 \cdot (X_3)^0 = X_1 \cdot X_2$$

$$Z_3 = (X_1)^{-1} \cdot (X_2)^0 \cdot (X_3)^1 = X_1^{-1} \cdot X_3$$

$$Z_4 = (X_1)^0 \cdot (X_2)^1 \cdot (X_3)^{-1} = X_2 \cdot X_3^{-1}$$

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$$Y = a_0 + a_1 \cdot Z_1 + a_2 \cdot Z_2 + a_3 \cdot Z_3 + a_4 \cdot Z_4 =$$
$$a_0 + a_1 \cdot X_1 + a_2 \cdot X_1 X_2 + a_3 \cdot X_3 / X_1 + a_4 \cdot X_2 / X_3$$

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a<sub>j</sub>

(LS)

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ES

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ES

EX

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ES

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GA

Matlab

(Ae) -

(De) -

(Lt) -

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(PS)

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( )

(CoD)

CoD

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$$CoD = 1 - \frac{N-1}{N} \cdot \frac{\sum (Br_{exp} - Br_{rec})^2}{\sum (Br_{rec} - \bar{Br}_{rec})^2} \quad ( )$$

( $N_p$ ) ( $L_t$ )

( $\frac{L_t}{N_p}$ )

[ ]

N

EPR

( )

$Br_{exp}$

$Br_{rec}$

$\bar{Br}_{rec}$

$Br = Ae^\alpha \cdot Ps^\beta \cdot Lt^\gamma \cdot De^\delta \cdot Pr^\mu + a_0$  ( )

$Br$

$Pr Ae De Lt Ps$

( )

( / ) CoD

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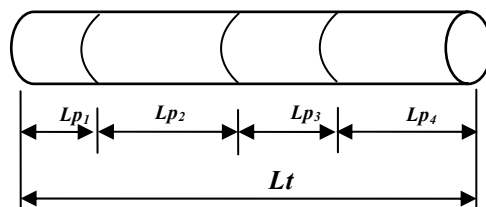
( $a_0$ )



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Diameter (mm) – Material Classes									
Parameters		63 PE	80 AC	90 PE	100 AC	150 AC	200 AC	250 AC	300 AC
Zone 1	Total Length (m)	1027	27169	4748	11716	12504	8668	2384	283
	Age (Year)	11	26	14	24	15	16	12	10
	Total Supplied Properties	22	998	137	92	105	81	20	1
	Mean Pressure (atm)	4	4.12	4.19	4.28	4.14	3.88	3.89	4.29
	No. of Breaks	2	61	6	13	7	7	1	0
Zone 2	Total Length (m)	22140	36263	20087	26651	22524	17101	3050	881
	Age (Year)	11	23	15	23	12	13	11	10
	Total Supplied Properties	476	1332	578	150	157	108	23	5
	Mean Pressure (atm)	4	4.12	4.19	4.28	4.14	3.88	3.89	4.29
	No. of Breaks	48	80	26	30	14	15	2	0
Zone 3	Total Length (m)	5228	26586	8366	34715	25235	4747	1892	1214
	Age (Year)	10	22	11	20	13	13	10	10
	Total Supplied Properties	112	976	241	93	147	35	7	5
	Mean Pressure (atm)	4	4.12	4.19	4.28	4.14	3.88	3.89	4.29
	No. of Breaks	12	59	11	40	14	4	1	1
Zone 4	Total Length (m)	1177	4619	8323	24230	9896	6209	930	-
	Age (Year)	8	16	9	14	10	11	7	-
	Total Supplied Properties	25	179	245	73	73	47	4	-
	Mean Pressure (atm)	4	4.12	4.19	4.28	4.14	3.88	3.89	-
	No. of Breaks	3	11	11	28	6	6	0	-

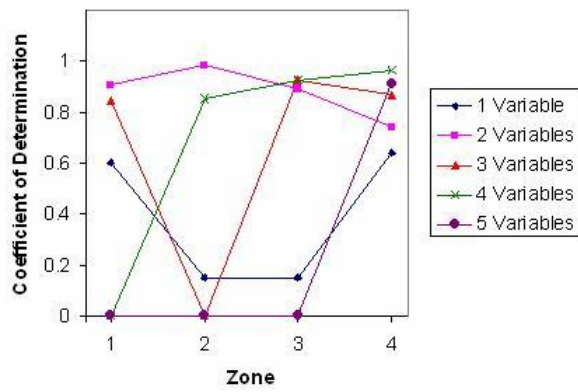
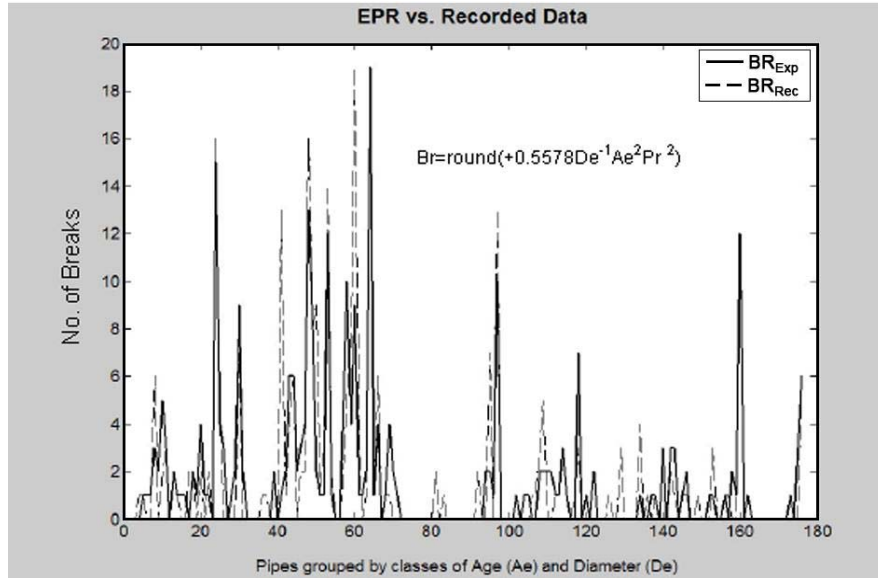


=  $Pr_p$

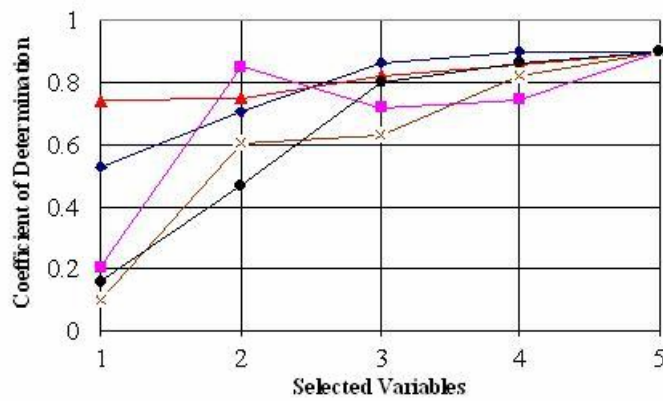
=  $L_p$

=  $De$

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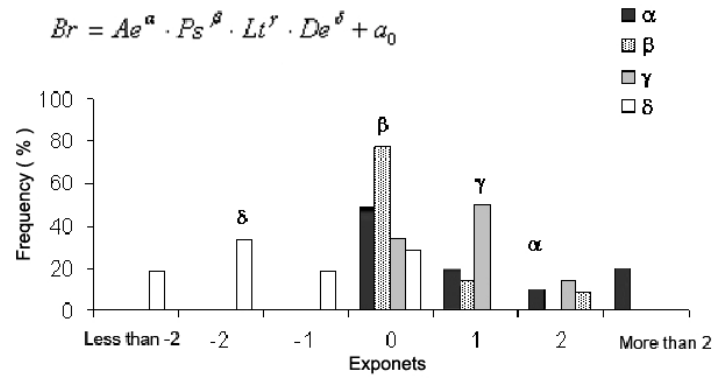
CoD



- ◆ Ae → Ae,De → Ae,De,Lt → Ae,De,Lt,Pr → Ae,De,Lt,Pr,Ps
- De → De,Lt → De,Ae,Pr → De,Ae,Pr,Ps → Ae,De,Lt,Pr,Ps
- ▲ Lt → Lt,Pr → Lt,De,Ps → Lt,Pr,De,Ps → Ae,De,Lt,Pr,Ps
- × Pr → Ae,Pr → Pr,Ae,Ps → Ar,Ae,Lt,Ps → Ae,De,Lt,Pr,Ps
- Ps → De,Ps → Ps,Lt,Ae → Ae,De,Lt,Ps → Ae,De,Lt,Pr,Ps

CoD





(Pr) %

Ps

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### جمع‌بندی و نتیجه‌گیری

- 1 - Kleiner, Y. and Rajani, B. B. (2001). "Comprehensive review of structural deterioration of water mains: statistical models." *Urban Water*, Vol. 3, No. 3, PP. 131-150.
- 2 - Kettler, A.J. and Goulter, I. C. (1985). "An analysis of pipe breakage in urban water distribution networks." *Canadian Journal of Civil Engineering*, Vol. 12, PP. 286-293.

- 3 - Pelletier, G., Mailhot, A. and Villeneuve, J. P. (2003). "Modeling water pipe breaks- three case study." *J. of Water Resource Planning and Management*, ASCE, Vol. 129, No. 2, PP. 115-123.
- 4 - Male, J. W., Walski, T. M. and Slutski, A. H. (1990). "Analyzing water main replacement Policies." *J. of Water Resource Planning and Management*, ASCE, Vol. 116, No. 3, PP. 363-374.
- 5 - Tabesh, M. and Abedini, A. A. (2005). "Analysis of pipe failure in water distribution networks." *J. Iran-Water Resources Research*, Vol. 1, No. 1, PP. 78-89, (in Farsi).
- 6 - Tabesh, M. and Honari, H. (2002). "Analysis of accidents and breaks in water distribution systems, results of a case study." *J. Water & Environment*, No. 50, PP. 17-23, (in Farsi).
- 7 - Skipworth, P. J., Saul, A. J. and Engelhardt, M. O. (2000). "Distribution network behavior-extracting knowledge from data." *International Symposium on Water Network Modeling for Optimal Design and Management (CWS 2000)*, Walters, Savic, eds., Woodbury Park, Exeter, UK, PP. 125-139.
- 8 - Shamir, U. and Howard, C. D. D. (1979). "An analytic approach to scheduling pipe replacement." *J. Am. Water Works Assoc.*, Vol. 71, PP. 248-258.
- 9 - McMullen, L. D. (1982). "Advanced concept in soil evaluation for exterior pipeline corrosion." *Proceedings of AWWA Annual Conference*, Miami, FL.
- 10 - Esenbeis, P. and Le Gat, Y. (1999). "Probabilistic forecast of failure occurrence in water networks with short maintenance records." *Water Industry System: Modeling and Optimization Application*, Savic, Walters (eds.), Research Studies Press Ltd., UK, PP. 191-198.
- 11 - Tabesh, M. and Soltani, J. (2007). "Optimal operational management of water supply systems by evaluation of mechanical reliability using Artificial Neural Networks (ANN)." *Proceedings of the 2nd National Conference on Iran Water Resources*, (2WRM 2007). Faculty of Engineering, Isfahan University of Technology, Iran, 23-24 Sep., 8 pages, (in Persian).
- 12 - Tabesh, M. and Soltani, J. (2007). "Modelling pipe failure in water distribution networks using neuro-fuzzy systems." *Proceedings of the 3<sup>rd</sup> National Congress on Civil Engineering*, University of Tabriz, Tabriz, Iran, 2-4 May.
- 13 - Aghaei, A. (2006). *Investigation of burst- prediction approach for water distribution systems by evolutionary computing*. MSc Thesis, Civil Engineering Department, Faculty of Engineering, Ferdowsi University of Mashhad.
- 14 - Tabesh, M., Abrishami, J. and Aghaei, A. (2007). "Pipe failure prediction in water distribution networks using evolutionary measures." *Proceedings of the 1st National Conference on Iran Water Resources*, (2WRM 2007), Faculty of Engineering, Isfahan University of Technology, Iran, 23-24 Jan., 8 pages, (in Farsi).
- 15 - Giustolosi, O., Savic, D. A. and Doglioni, A. (2004). "Data reconstruction and forecast by evolutionary polynomial regression." *6th International Conference on Hydroinformatics*, Liong, Phoon and Babovic (eds.), Singapore.
- 16 - Giustolosi, O. and Savic, D. A. (2004). "A novel genetic programming strategy: evolutionary polynomial regression." *6<sup>th</sup> International Conference on Hydroinformatics*, Liong, Phoon and Babovic (eds.), Singapore, Vol. 1, PP. 787-794.
- 17 - Sarv-Ab Consulting Engineers, (2004). *The Mashhad suburb wastewater collection and refinery project*. Summary of the first 6 volume reports.

1 - Log-Likelihood

3 - Gray Box

5 - Genetic Programming

7 - Rule-Based Genetic Programming

9 - Coefficient of Determination

2 - Evolutionary Polynomial Regression

4 - Data-Driven Modeling

6 - Genetic Algorithm

8 - Cost Function