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چکیده

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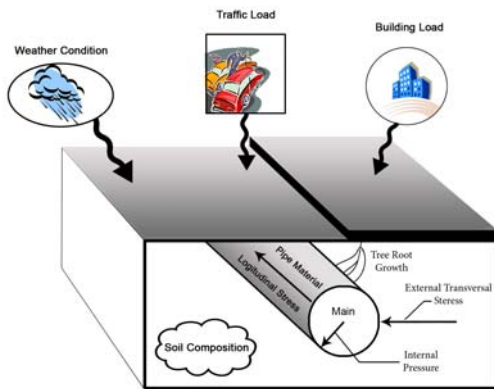
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واژه‌های کلیدی:

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[,]

Male .

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Shamir and Howard

(...

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

$N(t_0)$

$N(t)$

)

t

$N(t)$

(

A

g (

)

(1/Year)

[]

[,]

Kettler and Goulter

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$$N = K_0 \cdot Age \quad ()$$

K_0

N

McMullen

[-]

: []

$$Age = 65.78 + 0.028SR - 6.338pH - 0.049r_d \quad ()$$

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_{4x3}

(-)
()

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

:
()

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

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

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

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

: ()

$$Y = a_0 + a_1 \cdot Z_1 + a_2 \cdot Z_2 + a_3 \cdot Z_3 + a_4 \cdot Z_4 =$$

$$a_0 + a_1 \cdot X_1 + a_2 \cdot X_1 X_2 + a_3 \cdot X_3 / X_1 + a_4 \cdot X_2 / X_3$$

a_j

(LS)

j

ES

()

ES

EX

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ES

(...

GA

Matlab

(Ae) -

(De) -

(Lt) -

()

)

(

(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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[-]

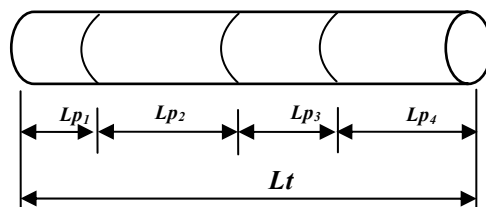
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(a_0)

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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	-

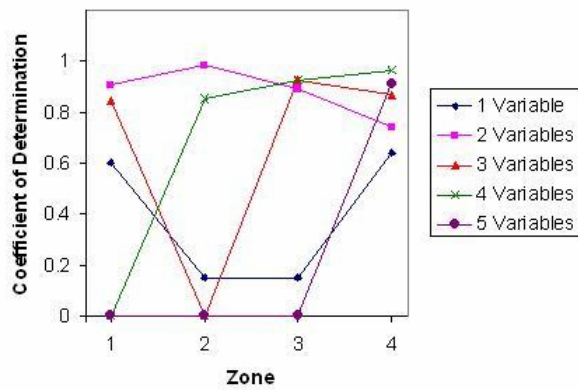
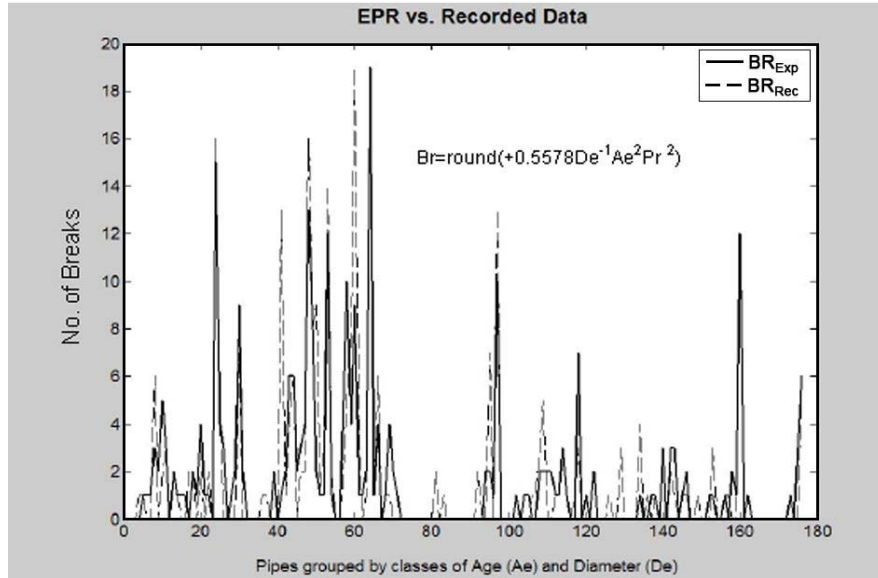


= P_{r_p}

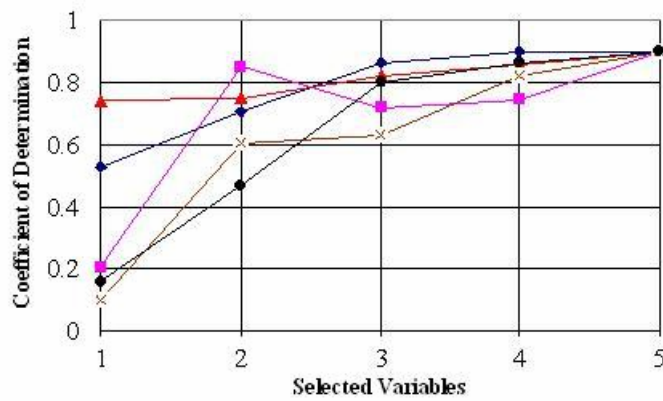
= L_p

= D_e

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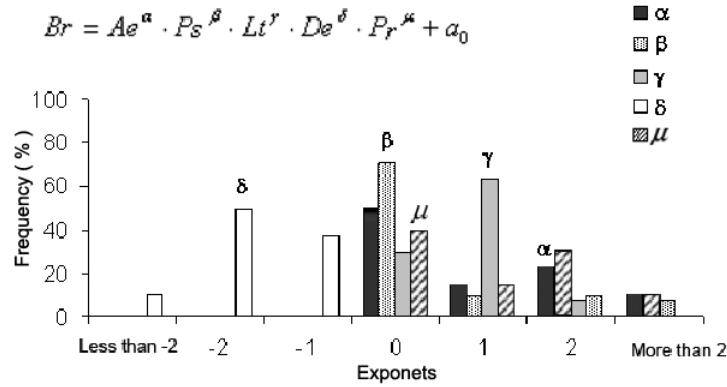
CoD



- ◆ 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

Zone	Burst Predicting Formulas in Pipes	CoD
1	$Br = round(6.385 \cdot 10^{-6} \cdot De^{-1} \cdot Lt^2 + 2.3024)$	0.992
2	$Br = round(36.221 \cdot 10^{-5} \cdot De^{-2} \cdot Lt^2 + 5.15)$	0.980
3	$Br = round(0.5578 \cdot De^{-1} \cdot Ae^2 \cdot Pr^2)$	0.978
4	$Br = round(0.097846 \cdot De^{-1} \cdot Lt + 0.0012545 \cdot Ae^2 \cdot Pr^2)$	0.987



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CoD

(Ae)

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% (De)

δ CoD

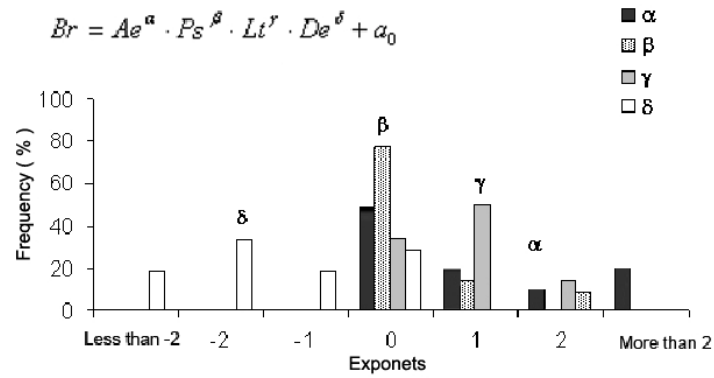
() CoD

()

CoD

%

μ



(Pr)

Ps

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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