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MBE NRMSE

.2004)

.(Glancey *et al.*, 1996)

.(Bukhari *et al.*, 1989)

(L) (M)

.(Upadhyaya *et al.*, 1984)

(w)

(T)

T

(g)

L

M

(ρ)

.(Al-Suhaibani & Al- Janobi, 1997; Macmillan, 2002)

L M T

:(Reaves *et al.*, 1968)

$$(L) = (w), (T) = \left(\frac{w}{g}\right)^{0.5}, (M) = \left(\frac{\rho}{w^{-3}}\right)$$

( )

.(Kuczewski & Piotrowska, 1998)

(R<sub>f</sub>)

$$\pi_1 = \frac{R_f}{\rho g w^3}$$

( )

(Kheiralla *et al.*,

, ( )

:

$$\frac{R_f}{\rho g w^3} = f \left( \frac{A}{\rho g w}, \frac{C}{\rho g w}, \frac{V}{\sqrt{g w}}, \varphi, \frac{d}{w}, \theta, \alpha, \dots \right) \quad ( )$$

(A) (C)

(d) (φ) (V)

(α) (θ)

$$\frac{R_f}{\rho g w^3}$$

:(Gee-Clough *et al.*, 1978)

.(Godwin & Dogherty, 2007)

$$\frac{R_f}{a w \sigma} = k_1 \left( \frac{\rho \cdot a}{\sigma} \right) + k_2 \left( \frac{\rho \cdot a}{\sigma} \right) \left( \frac{V^2}{g \cdot a} \right) \quad ( )$$

(a) (R<sub>f</sub>)

(k<sub>2</sub>, k<sub>1</sub>) (σ) (w)

(ρ)

(g) (v)

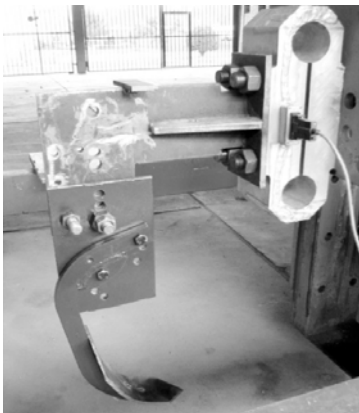
L

FD2

ASAE, S225.1

.( )

$$\frac{R_f}{a w} = 1.33 \rho \cdot a + 3.06 \left( \frac{\rho V^2}{g} \right) \quad ( )$$



± (kPa)

(Godwin, 1975)

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/ (kg/cm<sup>2</sup>)

(

06.15 Eijkelkamp

TGSS (MK3)

2. Extended octagonal ring transducer



1. Tool carriage



$$\pi_1 = \frac{d}{L} = \frac{d}{w} \quad ( )$$

$$\pi_2 = \frac{V}{LT^{-1}} = \frac{V}{g^{0.5}w^{0.5}} \quad ( )$$

$$\pi_3 = \frac{R_f}{MLT^{-2}} = \frac{R_f}{\rho g w^3} \quad ( )$$

$$\pi_4 = \frac{R_V}{MLT^{-2}} = \frac{R_V}{\rho g w^3} \quad ( )$$

$$\frac{R_f}{\rho g w^3} = F\left(\frac{d}{w}, \frac{V}{g^{0.5}w^{0.5}}, \alpha\right) \quad ( )$$

$$\frac{R_V}{\rho g w^3} = F'\left(\frac{d}{w}, \frac{V}{g^{0.5}w^{0.5}}, \alpha\right) \quad ( )$$

$$\left(\frac{R_f}{\rho g w^3}\right) = C \left[ F_1\left(\frac{v}{g^{0.5}w^{0.5}}\right) F_2\left(\frac{d}{w}\right) F_3(\alpha) \right]^n \quad ( )$$

$$\left(\frac{R_V}{\rho g w^3}\right) = C' \left[ F_1'\left(\frac{v}{g^{0.5}w^{0.5}}\right) F_2'\left(\frac{d}{w}\right) F_3'(\alpha) \right]^{n'} \quad ( )$$

( ) ( )

$\pi$   
 $n$   
 $m$   
 $n-m$

$$\log\left(\frac{R_f}{\rho g w^3}\right) = \log C + n \left[ \log F_1\left(\frac{v}{g^{0.5}w^{0.5}}\right) + \log F_2\left(\frac{d}{w}\right) + \log F_3(\alpha) \right] \quad ( )$$

$$R_f = f(d, v, w, \alpha, \rho, g) \quad ( )$$

$$\log\left(\frac{R_V}{\rho g w^3}\right) = \log C' + n' \left[ \log F_1'\left(\frac{v}{g^{0.5}w^{0.5}}\right) + \log F_2'\left(\frac{d}{w}\right) + \log F_3'(\alpha) \right] \quad ( )$$

$$R_V = f(d, v, w, \alpha, \rho, g) \quad ( )$$

( )

$d$                        $R_V$                        $R_f$   
 $\rho$                        $\alpha$                        $w$                        $v$

( )

$$n = n' = 1 \quad \log C = \log C' = 0$$

$g$   
 $w$                        $T$     $L$     $M$   
 $M$     $L$                        $T$                        $g$     $M$                        $\rho$     $L$   
 $T$

$$\log\left(\frac{R_f}{\rho g w^3}\right) = \log F_1\left(\frac{v}{g^{0.5}w^{0.5}}\right) + \log F_2\left(\frac{d}{w}\right) + \log F_3(\alpha) \quad ( )$$

$$(L) = (w) \quad ( )$$

$$(M) = (\rho/L^{-3}) \quad ( )$$

$$(T) = (w^{0.5}/g^{0.5}) \quad ( )$$

$$\log\left(\frac{R_V}{\rho g w^3}\right) = \log F_1'\left(\frac{v}{g^{0.5}w^{0.5}}\right) + \log F_2'\left(\frac{d}{w}\right) + \log F_3'(\alpha)$$

$\pi_4 \quad \pi_3 \quad \pi_2 \quad \pi_1$

$$\log\left(\frac{v}{g^{0.5}w^{0.5}}\right)$$

$$\left(\frac{v}{g^{0.5}w^{0.5}}\right)$$

w

( ) ( )

$$\log\left(\frac{v}{g^{0.5}w^{0.5}}\right)$$

R<sub>v</sub> R<sub>f</sub>

"n"

R<sub>v</sub> R<sub>f</sub>

n= /

$$F_1\left(\frac{v}{g^{0.5}w^{0.5}}\right)$$

n' = /

w

:

( )

$$\log F_1\left(\frac{v}{g^{0.5}w^{0.5}}\right) = 0.114 \text{Log}\left(\frac{v}{g^{0.5}w^{0.5}}\right)$$

( )

R<sub>v</sub> R<sub>f</sub>

$$\log F_1\left(\frac{v}{g^{0.5}w^{0.5}}\right) = \left(\frac{v}{g^{0.5}w^{0.5}}\right)^{0.114}$$

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$$\log\left(\frac{v}{g^{0.5}w^{0.5}}\right)$$

( )

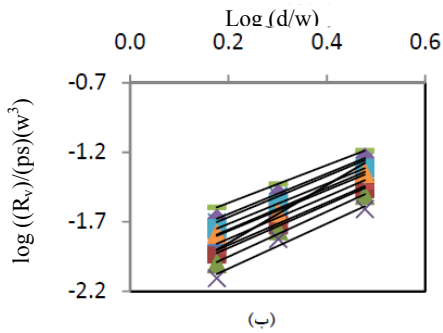
$$\log F_1\left(\frac{v}{g^{0.5}w^{0.5}}\right) = 0.142 \text{Log}\left(\frac{v}{g^{0.5}w^{0.5}}\right)$$

( )

$$\log\left(\frac{v}{g^{0.5}w^{0.5}}\right)$$

$$\log F_1\left(\frac{v}{g^{0.5}w^{0.5}}\right) = \left(\frac{v}{g^{0.5}w^{0.5}}\right)^{0.142}$$

( )

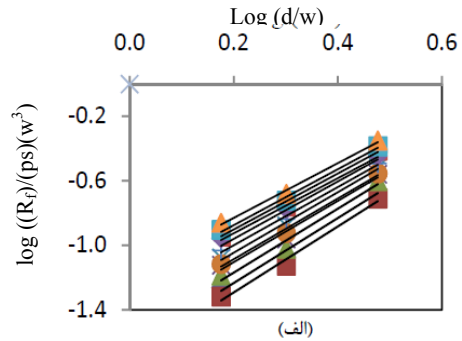


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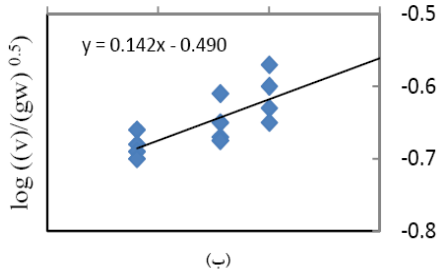
( )

log((R<sub>f</sub>)/(pg)(w<sup>3</sup>))

log (d/w)



log F<sub>1</sub> ((v)/(gw)<sup>0.5</sup>)

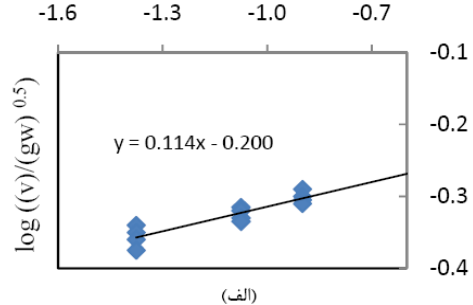


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log F((v)/(gw)<sup>0.5</sup>)

log F<sub>1</sub> ((v)/(gw)<sup>0.5</sup>)



(الف)

log ((v)/(gw)<sup>0.5</sup>)

( )

$$\left(\frac{v}{g^{0.5} w^{0.5}}\right)$$

$$F_2\left(\frac{d}{w}\right)$$

$$\text{Log}\left(\frac{d}{w}\right)$$

$$\log\left(\frac{R_f}{\rho g w^3}\right) - \log F_1\left(\frac{v}{g^{0.5} w^{0.5}}\right) = \log F_2\left(\frac{d}{w}\right) \quad ( )$$

n= /

( )

n= /

$$\log\left(\frac{R_V}{\rho g w^3}\right) - \log F_1'\left(\frac{v}{g^{0.5} w^{0.5}}\right) = \log F_2'\left(\frac{d}{w}\right) \quad ( )$$

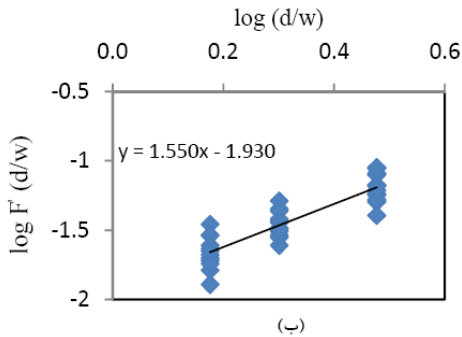
:

$$F_2\left(\frac{d}{w}\right) = \left(\frac{d}{w}\right)^{1.847} \quad ( )$$

( ) ( )

$$F_2'\left(\frac{d}{w}\right) = \left(\frac{d}{w}\right)^{1.55} \quad ( )$$

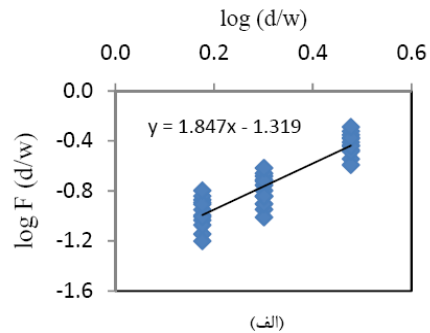
1 . First residuals



( )

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Log F (d/w)



(الف)

Log (d/w)

$F_3(\alpha)$

$$F_3(\alpha) = (10)^{(0.006)(\alpha)} \quad ( )$$

$$\log\left(\frac{R_f}{\rho g w^3}\right) \quad \log F_2\left(\frac{d}{w}\right)$$

$$F_3'(\alpha) = (10)^{(-0.013)(\alpha)} \quad ( )$$

$$\log\left(\frac{R_V}{\rho g w^3}\right)$$

( ) ( ) ( )

log F<sub>3</sub>(α) log F<sub>3</sub>(α)

$$\log\left(\frac{R_f}{\rho g w^3}\right) - \log F_2\left(\frac{v}{g^{0.5} w^{0.5}}\right) = \log F_3(\alpha) \quad ( )$$

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$$\log\left(\frac{R_V}{\rho g w^3}\right) - \log F_2'\left(\frac{v}{g^{0.5} w^{0.5}}\right) = \log F_3'(\alpha) \quad ( )$$

log (α)

n= /

n= /

( )

$$\left(\frac{R_f}{\rho g w^3}\right) = C \left[\left(\frac{v}{g^{0.5} w^{0.5}}\right)^{0.114} \times \left(\frac{d}{w}\right)^{1.847} \times (10)^{(0.006)(\alpha)}\right]^n$$

$$\log\left(\frac{R_f}{\rho g w^3}\right) = \log(C) + \log(F_1 \times F_2 \times F_3)^n \quad ( )$$

$$\left(\frac{R_f}{\rho g w^3}\right) \quad ( )$$

( )

n= /

log (c) = /

2 . Second residuals

$$\log\left(\frac{R_V}{\rho g w^3}\right) = \log(C') + \log(F'_1 \times F'_2 \times F'_3)^{n'} \quad ( )$$

( )

( )

$$n' = \frac{\log(c)}{\log\left(\frac{R_V}{\rho g w^3}\right)}$$

$$\frac{R_f}{\rho g w^3} = 10^{-1.447} \left[ \left( \frac{v}{g^{0.5} w^{0.5}} \right)^{0.114} \times \left( \frac{d}{w} \right)^{1.847} \times (10)^{(0.006)(\alpha)} \right]^{1.042}$$

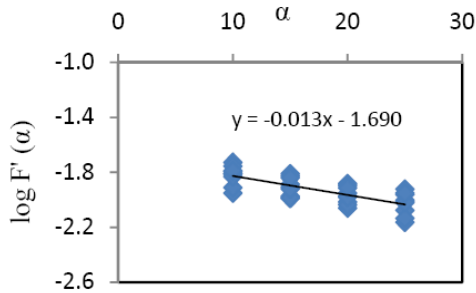
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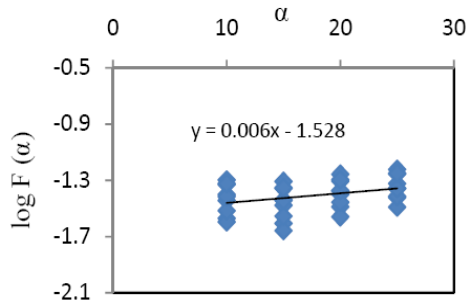
$$\frac{R_V}{\rho g w^3} = 10^{-1.707} \left[ \left( \frac{v}{g^{0.5} w^{0.5}} \right)^{0.142} \times \left( \frac{d}{w} \right)^{1.55} \times (10)^{(-0.013)(\alpha)} \right]^{1.05}$$

( )

$$\left( \frac{R_V}{\rho g w^3} \right) = C' \left[ \left( \frac{v}{g^{0.5} w^{0.5}} \right)^{0.142} \times \left( \frac{d}{w} \right)^{1.55} \times (10)^{(-0.013)(\alpha)} \right]^{n'}$$

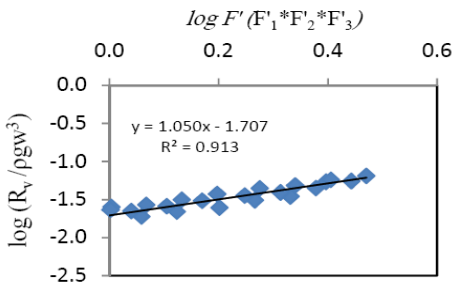


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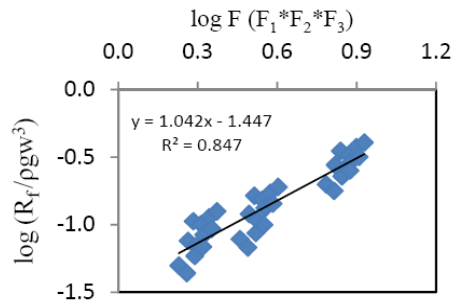


(الف)

( ) ( ) **log F (alpha)** **log (alpha)**



**log (Rv / rho g w^3)** **log F' (F1 \* F2 \* F3)**



**log (Rf / rho g w^3)** **log F (F1 \* F2 \* F3)**

( )

گروه های بدون بعد	محدوده تغییرات
$\frac{R_f}{\rho g w^3}$	$0.040 \leq \left( \frac{R_f}{\rho g w^3} \right) \leq 0.405$
$\frac{R_v}{\rho g w^3}$	$0.007 \leq \left( \frac{R_v}{\rho g w^3} \right) \leq 0.064$
$\frac{v}{g^{0.5} w^{0.5}}$	$0.042 \leq \left( \frac{v}{g^{0.5} w^{0.5}} \right) \leq 0.126$
$\frac{d}{w}$	$1.5 \leq \left( \frac{d}{w} \right) \leq 3$
$\alpha$	$10 \leq (\alpha) \leq 25$





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(ASAE (2006)0

(D497.5) ASAE

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MBE NRMSE

$$R_f = F_i \left( A + B(S) + C(S)^2 \right) Wd \quad ( )$$

$F_i$  (N)

$R_f$

ASAE

$W$  (km/h)

$S$  ( )

$C$

$B$

$A$

(cm)

$d$  (m)

$l$  (km/h)

( )

ASAE

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ASAE

$d$  (cm)

$g$  (m/s<sup>2</sup>)

$R_f$  (N)

( )

(Ashrafizade, 2006)

$R_v$  (N)

$V$  (m/s)

( )

$w$  (cm)

$\alpha$ (deg.)

$\rho$  (g/cm<sup>3</sup>)

NRMSE

ASAE

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