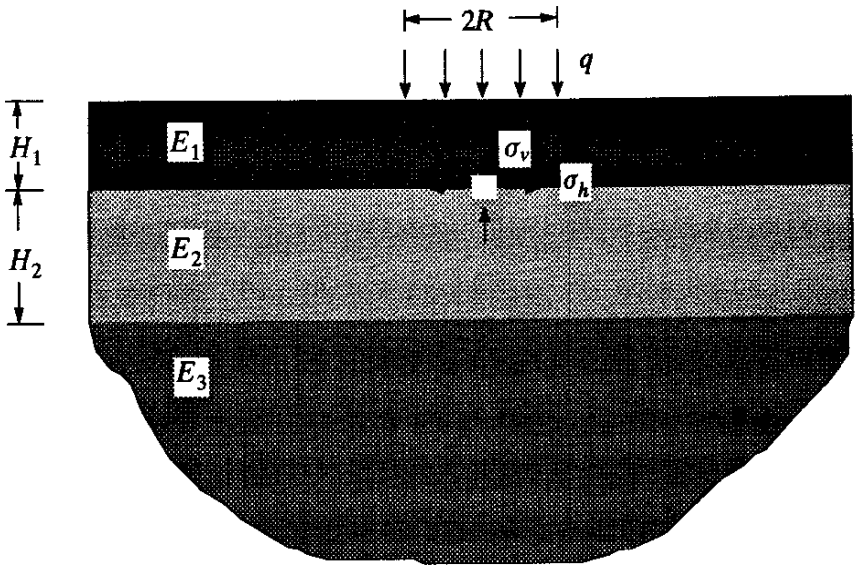
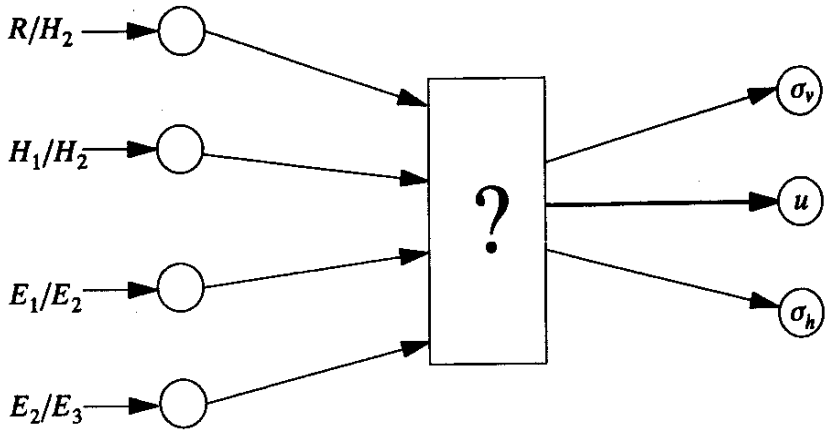
THREE LAYER ELASTIC HALF SPACE





SUMMARY OF DATA

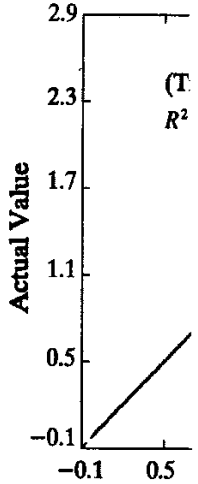
	DISPLACEMENT			HORIZONTAL STRESS			VERTICAL STRESS			
	Average	SS	SD	Average	SS	SD	Average	SS	SD	No. of Data
Train	0.1767	321.27	0.299	213.66	1017057500	531.52	–12.53	1323848	19.18	3600
Test	0.0092	22.50	0.114	239.17	309618240	423.29	–7.73	334846	13.92	1728
Total	0.1493	352.14	0.257	221.93	1327434400	499.14	–10.97	1685653	17.79	5328

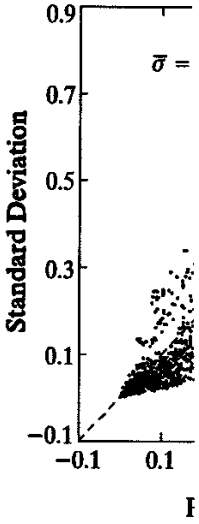
R/H_2 : 0.2, 0.4, 0.8, 1.2, 1.8, 2.4

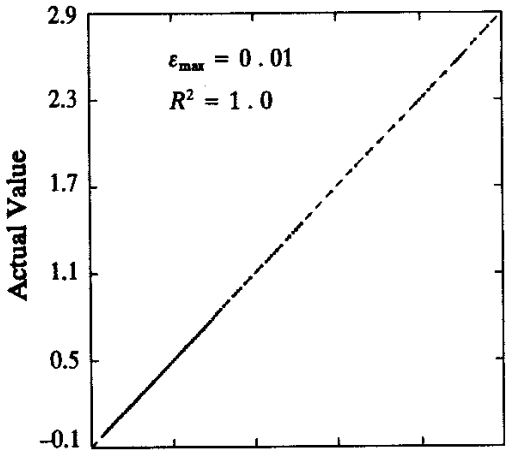
H_1/H_2 : 0.5, 1.0, 1.5, 2.0, 4.0, 5.0

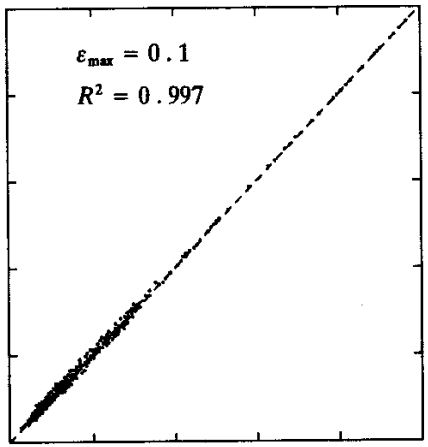
E_2/E_3 , E_1/E_2 : 0.5, 1.0, 2.0, 5.0, 10., 30., 50., 90., 140., 170.

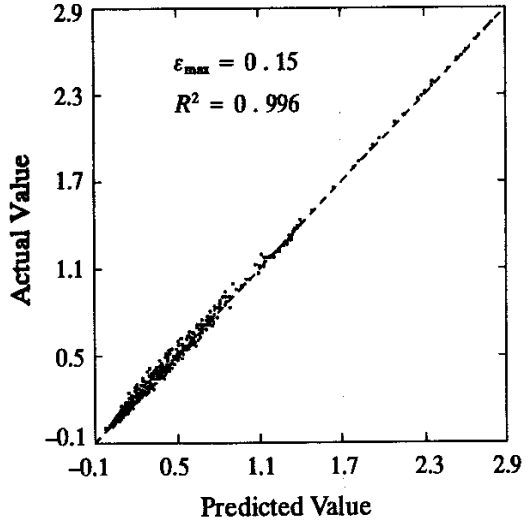
DISPLACEMENT (TRAINING)

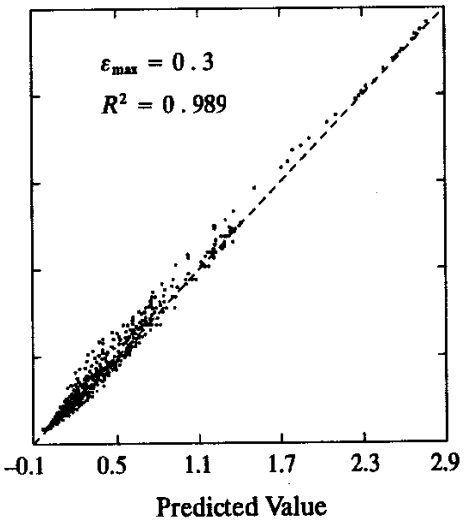












DISPLACEMENT

ε_{max}	**CPU / 20** *(Sec)*	**RMS** *(Train)*	R^2 *(Train)*	$\overline{\sigma}$ *(Train)*	**Subdomain**	**Parameters**	**RMS** *(Test)*	R^2 *(Test)*	$\overline{\sigma}$ *(Test)*	R^2 *(Total)*
0.01	85	0.0015	1.000	0.002	1290	2935	0.063	0.695	0.093	0.980
0.10	15	0.0150	0.997	0.016	335	1220	0.058	0.742	0.084	0.981
0.15	12	0.0200	0.996	0.021	268	1012	0.055	0.768	0.078	0.982
0.30	9	0.0320	0.989	0.031	170	700	0.060	0.724	0.088	0.972

A. 3-Layer System Data Generated from Mutliple BISAR Runs

There are two files:
bsr.dat is the data to be used for data fitting.
bsr.tes is the data to be used for testing after the model is developed.

This is a 3 layer system with E1, E2, E3, h1, h2, and r (radius of loaded area)
An standard load was considered. There are seevn columns in each data set.

The first 4 columns are inputs as follows:

1 - K1: (E1/E2) from .5 to 170
2 - K2: (E2/E3) from .5 to 170
3 - H : (h1/h2) from .2 to 2.4
4 - A : (r/h2) from .5 to 5

Columns 5 to 7 are outputs as follows

5 - D0: Deflection at the center of load
6 - H : Horizontal strain at the bottom of layer 1
7 - V : Vertical strain at the bottomn of layer 1

B. AASHO Road Test Data

There are three files:
pav.dat is the data to be used for data fitting. (7592 records, about 80%)
pav.tes is the data to be used for testing after the model is developed.
         (1872 records, about 20%)
pavall.dat contains all the data in the above files and also sorted by
         section number and indexday. This file can also be used for data
         fitting and then sensitivity analysis afterwards.

There are eleven columns in each data set.

The first 10 columns are inputs as follows:

1 - loopnum: loop number from 1 to 6
2 - lane: 1 for inner lane, 2 for outer lane
3 - thick: surface thickness in inches
4 - basethk: base thickness in inches
5 - subasthk: subbase thickness in inches
6 - sect: test section number
7 - indexday: indexday for the AASHO Road test from 1 to 55
8 - wtappl: total number of weighted application
9 - load: axle load in kips
10- l2t: 0 for no load, 1 for single-axle, 2 for tandem-axle

Column 11 is the response, PSI

"loess1.5"

```
Call:
loess(formula = D0 ~ K1 * K2 * H * A, span = 0.5, degree = 2, normalize = F)

 Number of Observations:          3600
 Equivalent Number of Parameters: 42.7
 Residual Standard Error:         0.2055
 Multiple R-squared:              0.54
 Residuals:
     min     1st Q   median   3rd Q   max
 -0.4068 -0.02105 0.005336 0.03958 2.132
```

pav.loess

```
Call:
loess(formula = D0 ~ K1 * K2 * H * A, span = 0.1, degree = 2, normalize = F)

 Number of Observations:          3600
 Equivalent Number of Parameters: 16.1
 Residual Standard Error:         0.07764
 Multiple R-squared:              0.96
 Residuals:
     min     1st Q    median   3rd Q    max
 -0.5723 -0.01265 -0.001217 0.01181 0.3155
```

pav.loess2

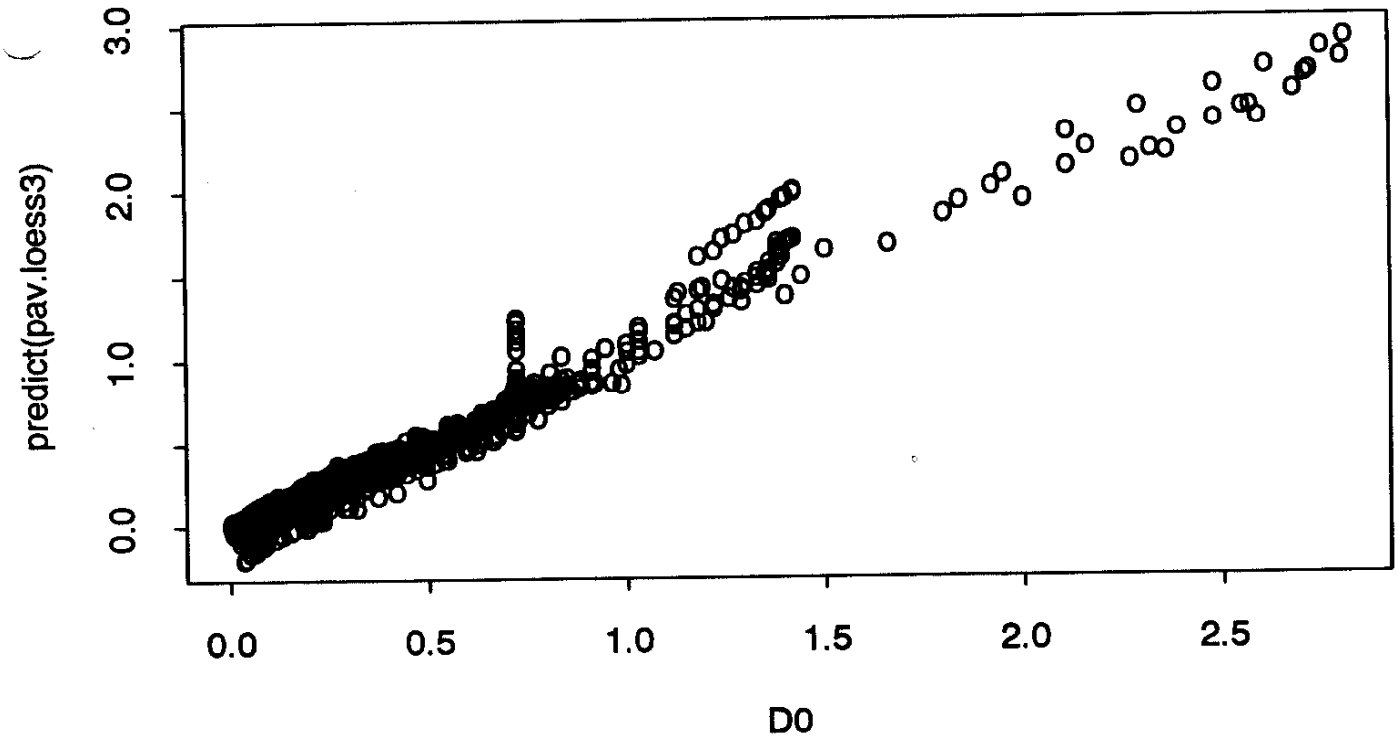
```
Call:
loess(formula = D0 ~ K1 * K2 * H * A, span = 0.05, degree = 2, normalize = F,
      trace.hat = "approximate")

 Number of Observations:          3600
 Equivalent Number of Parameters: 14.9
 Residual Standard Error:         0.05245
 Multiple R-squared:              0.98
 Residuals:
     min     1st Q     median   3rd Q    max
 -0.5722 -0.01015 0.00004293 0.01118 0.2342
```

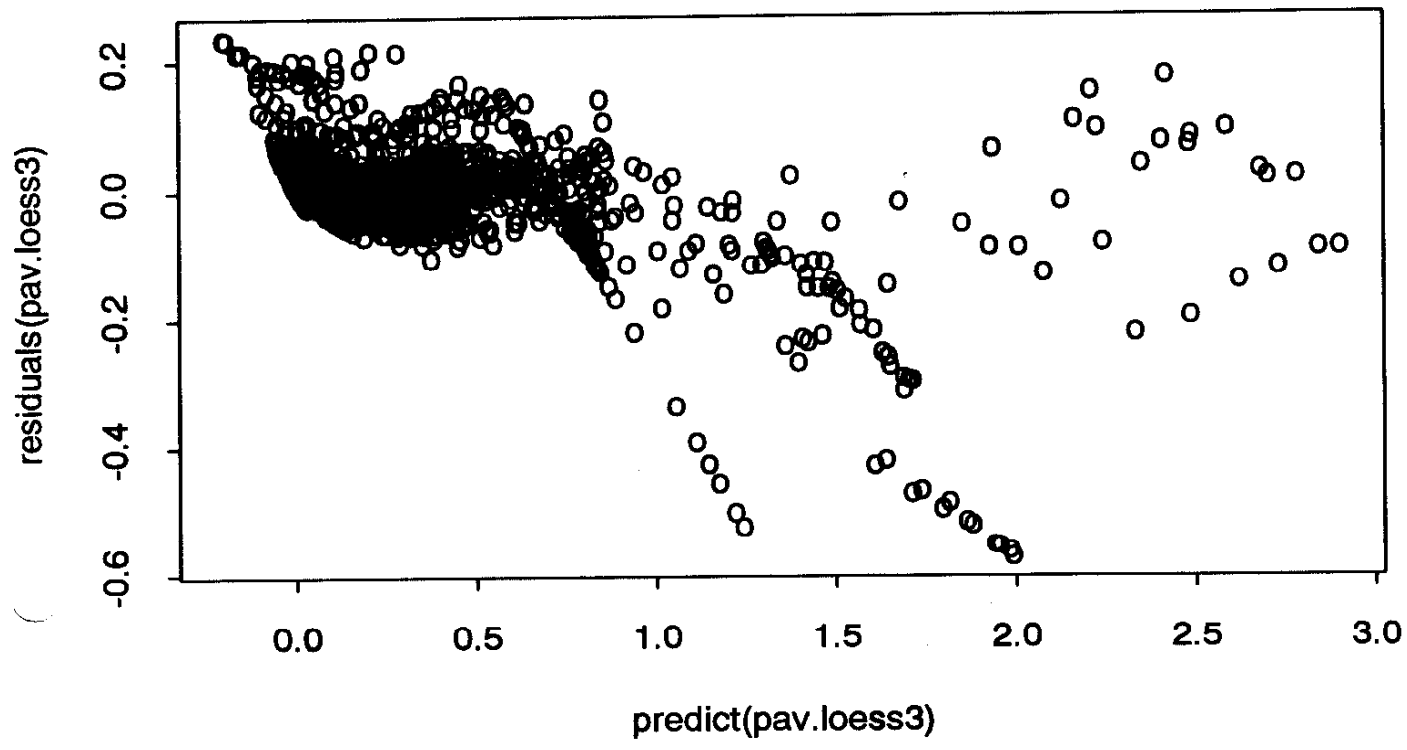
pav.loess3

```
Call: lm(formula = D0 ~ predict(pav.loess3))
Residuals:
     Min       1Q    Median       3Q    Max
 -0.4452 -0.01553 -0.006186 0.008473 0.3369

Coefficients:
                     Value Std. Error  t value Pr(>|t|)
       (Intercept)  0.0121    0.0009   13.5345   0.0000
predict(pav.loess3)  0.9274    0.0025  376.7569   0.0000

Residual standard error: 0.04698 on 3598 degrees of freedom
Multiple R-Squared: 0.9753

Correlation of Coefficients:
                    (Intercept)
predict(pav.loess3) -0.4872
```

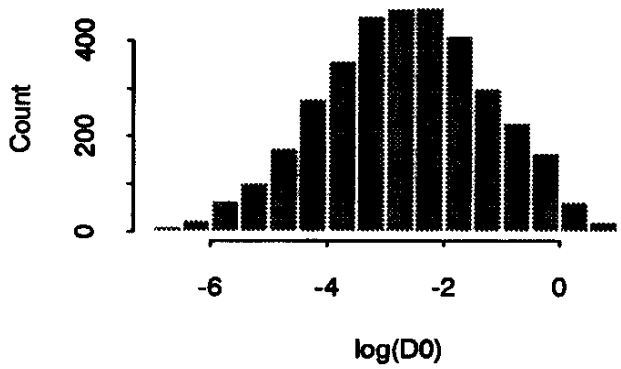
LOESS Algorithm:

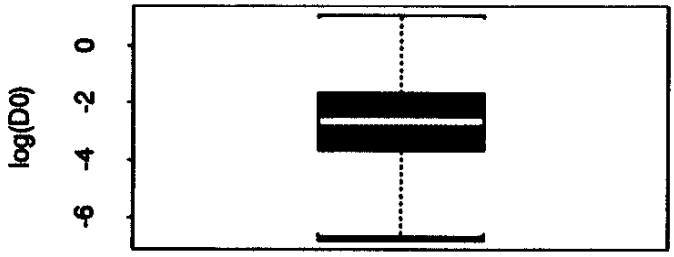
Prediction Based On Original DB (3600 pts)

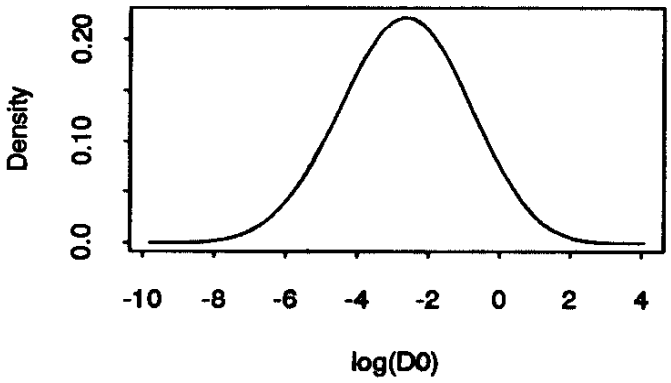

predict(pav.loess3)
3.0
2.0
1.0
0.0
0.0
0.5
1.0
1.5
2.0
2.5
D0

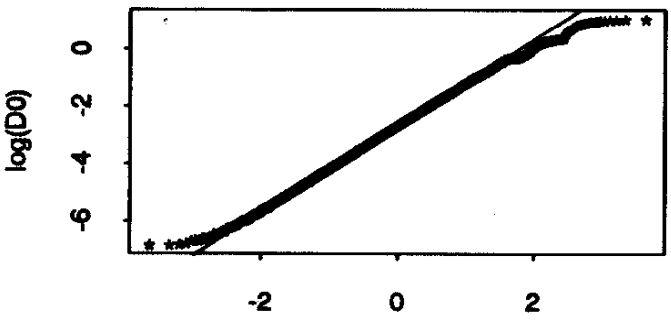

residuals(pav.loess3)
0.2
0.0
-0.2
-0.4
-0.6
0.0
0.5
1.0
1.5
2.0
2.5
3.0
predict(pav.loess3)

For Reflection



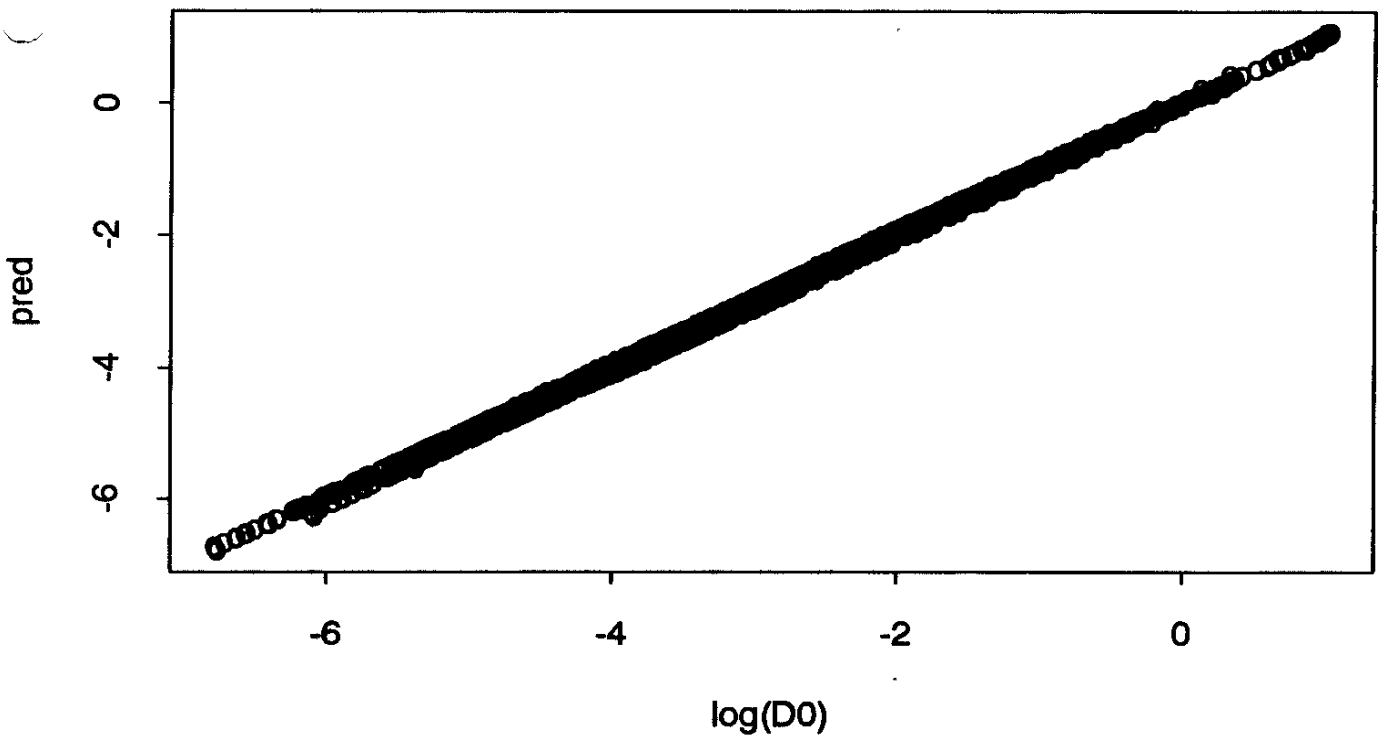


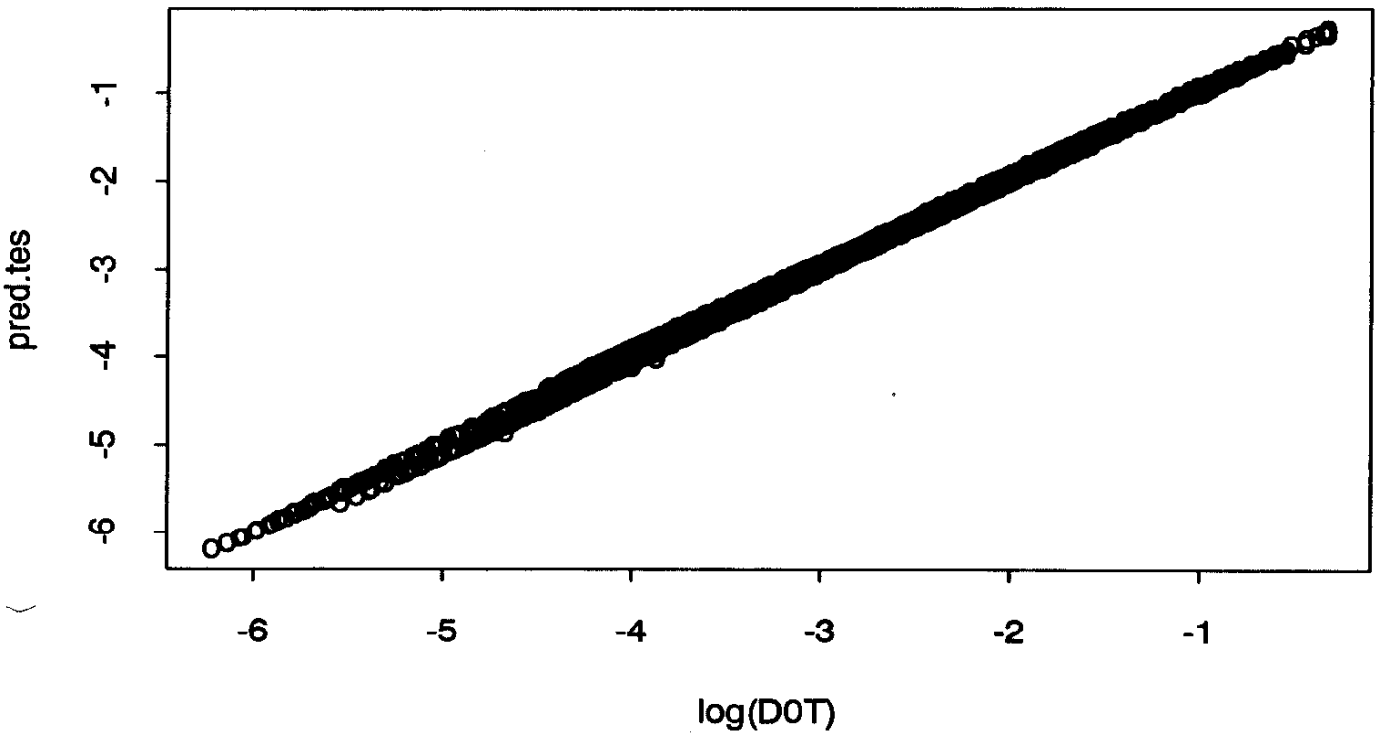




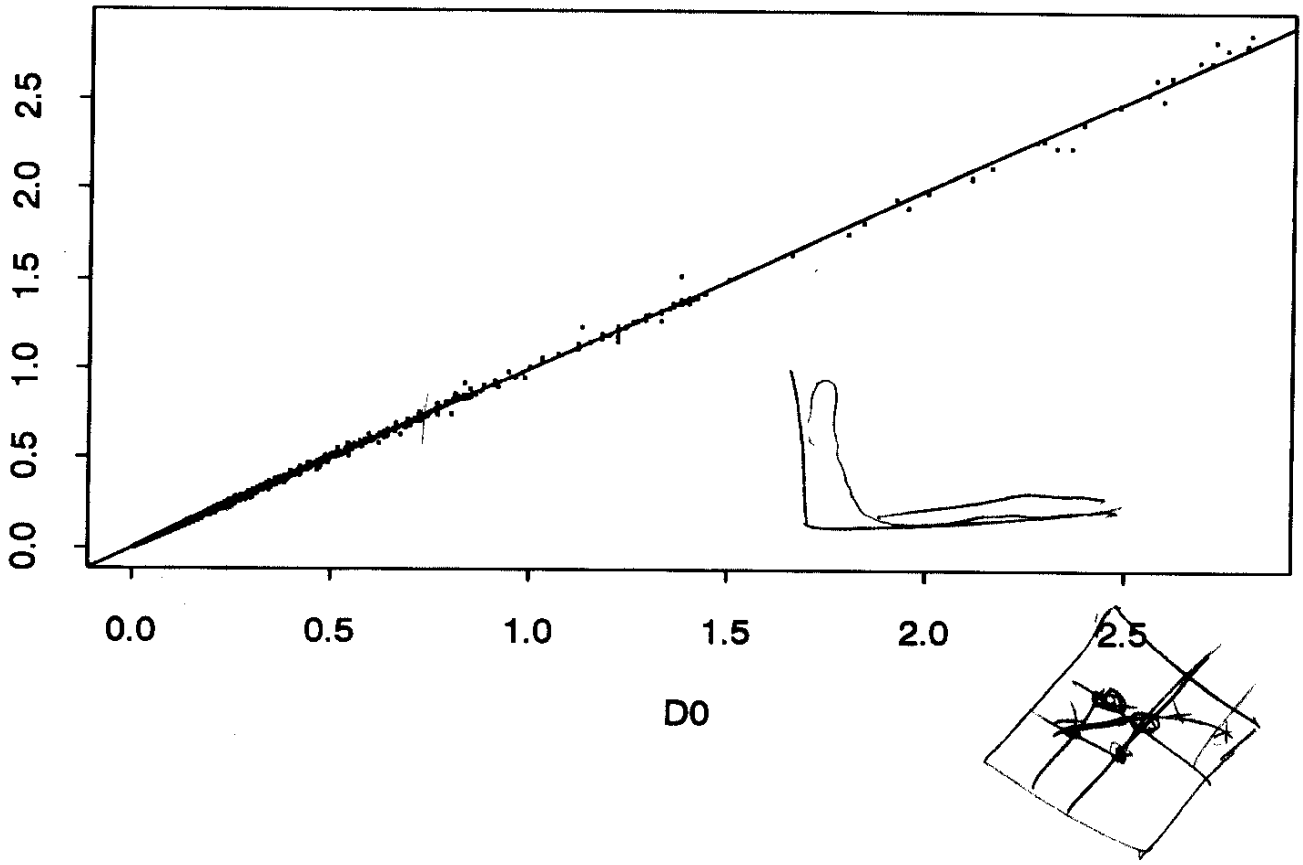
```
source("loess4.s")
pav> #pav.loess <- loess(D0 ~ K1 * K2 * H * A, span=0.5, degree=2, normalize=F)
#pav.loess2 <- update(pav.loess, span=0.1)
#pav.loess3 <- update(pav.loess2, span=0.05, trace.hat="approximate")
#print(pav.loess)
#print(pav.loess2)
#print(pav.loess3)
#fit3 <- summary(lm(D0 ~ predict(pav.loess3)))
#print(fit3)
#pav.loess4 <- update(pav.loess3,formula=log(D0)~log(K1)*log(K2)*H*A)
pred <- predict(pav.loess4)
pav> pred.tes <- predict(pav.loess4, pav.tes)
pav> fit4 <- summary(lm(log(D0) ~ pred))
pav> fit4.tes <- summary(lm(log(D0T) ~ pred.tes))
pav> print(fit4)

Call: lm(formula = log(D0) ~ pred)
Residuals:
      Min        1Q   Median      3Q     Max
 -0.09384 -0.03058 0.002553 0.0214 0.1599

Coefficients:
                Value Std. Error    t value   Pr(>|t|)
(Intercept)   -0.0139     0.0014    -9.7554     0.0000
       pred    0.9962     0.0005  2116.1744     0.0000

Residual standard error: 0.04083 on 3598 degrees of freedom
Multiple R-Squared: 0.9992

Correlation of Coefficients:
     (Intercept)
pred      0.8793
pav> print(fit4.tes)

Call: lm(formula = log(D0T) ~ pred.tes)
Residuals:
      Min        1Q    Median      3Q     Max
 -0.08679 -0.03371 -0.006159 0.02943 0.1823

Coefficients:
                Value Std. Error    t value   Pr(>|t|)
(Intercept)   -0.0753     0.0029   -26.1181     0.0000
   pred.tes    0.9845     0.0009  1088.4228     0.0000

Residual standard error: 0.04415 on 1726 degrees of freedom
Multiple R-Squared: 0.9985

Correlation of Coefficients:
         (Intercept)
pred.tes      0.9296
pav> fit4.d0 <- summary(lm(D0 ~ exp(pred)))
pav> fit4.tes.d0 <- summary(lm(D0T ~ exp(pred.tes)))
pav> print(fit4.d0)

Call: lm(formula = D0 ~ exp(pred))
Residuals:
     Min         1Q    Median      3Q   Max
 -0.1426 -0.001368 0.0005445 0.00168 0.132

Coefficients:
                Value Std. Error    t value   Pr(>|t|)
(Intercept)   -0.0006     0.0002    -4.0562     0.0001
  exp(pred)    0.9979     0.0005  2215.7563     0.0000

Residual standard error: 0.008086 on 3598 degrees of freedom
Multiple R-Squared: 0.9993
```

```
Correlation of Coefficients:
          (Intercept)
exp(pred) -0.5107
pav> print(fit4.tes.d0)

Call: lm(formula = D0T ~ exp(pred.tes))
Residuals:
      Min         1Q   Median       3Q      Max
 -0.01978 -0.000998 0.000328 0.001669 0.03043

Coefficients:
                  Value Std. Error    t value   Pr(>|t|)
  (Intercept)    -0.0006     0.0001    -5.4184     0.0000
exp(pred.tes)     0.9698     0.0008  1226.1851     0.0000

Residual standard error: 0.003866 on 1726 degrees of freedom
Multiple R-Squared: 0.9989

Correlation of Coefficients:
              (Intercept)
exp(pred.tes) -0.6309
pav> postscript("loess4.ps1")
pav> oldpar <- par(mfrow = c(2, 1))
pav> plot(log(D0), pred)
pav> plot(log(D0T), pred.tes)
pav> par(oldpar)
pav> graphics.off()
pav> vga()
Set up for DOS graphics mode 12h, graphics buffer: 153600 bytes.
sink()
```


pred
0
-2
-4
-6
-6
-4
-2
0
log(D0)


pred.tes
-1
-2
-3
-4
-5
-6
-6
-5
-4
-3
-2
-1
log(D0T)

N = 3600, SEE = 0.008086, R^2 = 0.9993 Local Regression



N = 1728, SEE = 0.003866 R^2 = 0.9989