Assessing the soil type and layering in settlement of the soil under foundations by using Artifical Neural Network

Dr. asskar. janalizadeh[1], Hassan Seraj[2]

[1.] Chief of Noshirvani Institute of Technology in babol
[2.] Student of Noshirvani Institute of Technology in babol (MS)
Fox:+98111-3234201
asskar@nit.ac.ir, ehsan.seraj65@gmail.com

Abstract: There are defined Theoretical and empirical relationships for predicting settlement of shallow foundation on soils which in spite of the computational complexity, do not predict with high accuracy. Nowadays, artificial neural networks can be used for predicting the settlement of shallow foundation with lower computational complexity and higher accuracy. Modeling 27 samples of Shallow foundations on sandy soil under 14 types of Uniformly distributed load with different length to width ratio, using Plaxis program, the following settlement were calculated. The geotechnical information is obtained from the speculation surrounding the city of Babol. A neural network is designed using the data obtained from the Plaxis program to estimate the settlement of shallow foundation. Plaxis program analyzed the network by model samples. As you know, the neurons in the hidden layer of a neural network is an optimal value so With different values can be used to model the network was designed to optimize the optimal number of neurons in the hidden layer is 350. By changing the value of the friction angle of a soil sample in neural network models, we found that Increase the friction angle of a soil sample to a soil layer will reduce the Settlement and This is due to the increased contact area between the particles and better distribution of stress in a layer of soil to other layers happen.

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Keywords: Neural Networks, Dimension Effects of shallow foundation, Settlement of Shallow Foundations, Neuron, Friction angle, Plaxis program.

1. Introduction

Proper foundation design depends on accurate prediction of the meeting and its distribution. Factors such as material type and hardness of the Earth, Width, and depth,… Have an effect on the amount and distribution of foundation settlement.

Today, several classical equations for calculation of foundation settlement of shallow foundation engineering books available. These relationships are often based on experience or based on elasticity theory are presented. Considering various factors which influence this case, unfortunately, the use of this relationship, with no satisfactory results. In recent years the trend toward computerized tools that are similar to biological nervous systems of the body are increased. These tools are known as artificial neural networks anb Almost all branches of science and engineering applications have been increasing. As a result, the neural network in less time and with good accuracy can be used to solve engineering problems.

1-1- Geography of Babol

The city is located approximately 20 kilometers south of Caspian Sea on the west bank of Babol Rud River and receives abundant annual rainfall. Babol borders Babolsar to the north, Qaem Shahr and Savad Kooh to the east, and Amol to the west. Babol University is famous for its spectacular scenery.

Figure 1. Geography of Babol

2. Materials and methods

2-1- Introducing the soil parameters required for the plaxis program

Due to changes in soil parameters named in the report and geotechnical soil sampling variability expressed, total of 10 soil types have been analyzed, so All samples of the geotechnical characteristics and application requirements Plaxis Program, Displayed in tables 1(a…d) and Concrete parameters for shallow foundations are shown in Tables 1-e.

The data used in presented research, includes borehole logs (data collected from digging boreholes) bored in the study area Figure1and is collected by different institutions for different research purposes (Kusano et al., 1988). The database includes more than 40 borehole logs in an area of more than 6 km2 from Babol zone.

From the total of 40 raw borehole data, only 30 logs with a depth range of 10–30 m were acceptable for using in ANN model. The regular tests were performed on the samples. The available data set is divided into three sets, namely training, validation, and test sets, based on random selection.

By this division the validity of the model could be examined in a more comprehensive manner. To identify the layers of the soil, geotechnical information obtained from boreholes drilled were used in Town of Babylon These data are shown in figures 2-a and 2-b.

Geotechnical parameters obtained from boreholes drilled in the city of Babylon that have been used are shown in Table 1.

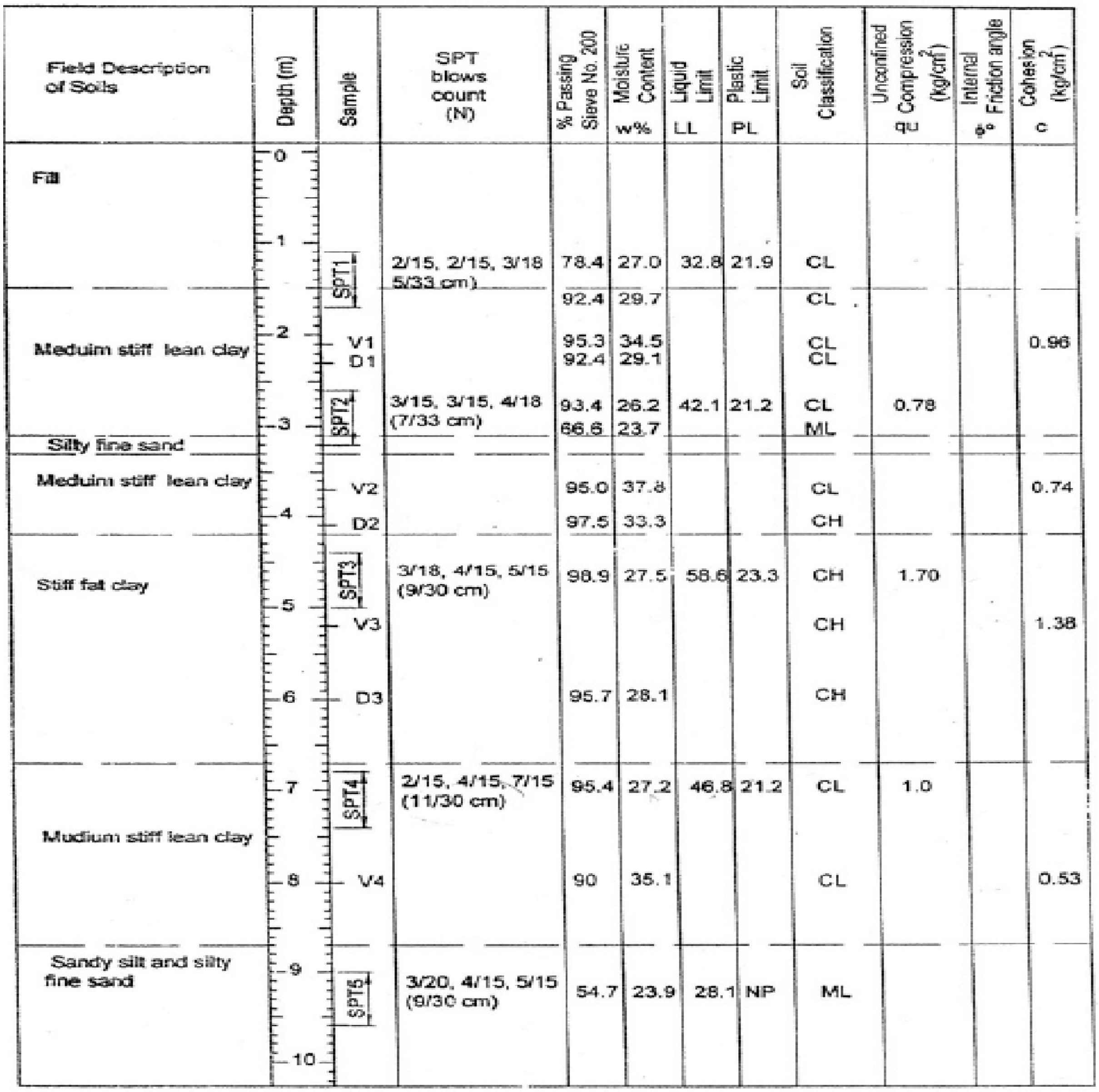


Figure 2-a. borehole log (A) from test borehole

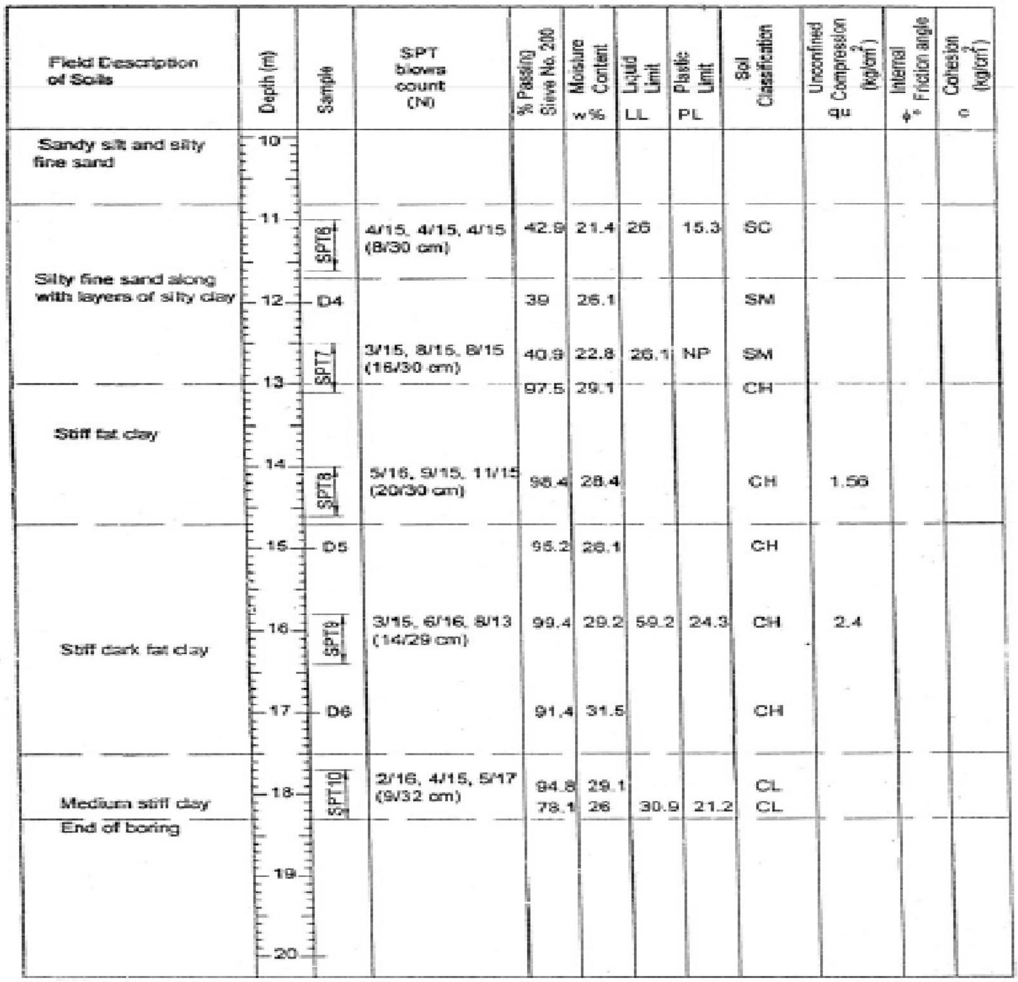


Figure 2- b. borehole log (B) from test borehole

SC										
$\gamma_d(\frac{KN}{m^3})$	$\gamma_{sat}(\frac{KN}{m^3})$	$E_{ref}(\frac{KN}{m^2})$	v	ψ	$G(\frac{KN}{m^2})$	$E_{oed}(\frac{KN}{m^2})$	φ	$C(\frac{KN}{m^2})$	$V_s(\frac{M}{S})$	$V_p(\frac{M}{S})$
16	19	20000	0.25	1	8000	24000	31.2	0.44	70	121.2

SC2										
$\gamma_d(\frac{KN}{m^3})$	$\gamma_{sat}(\frac{KN}{m^3})$	$E_{ref}(\frac{KN}{m^2})$	v	ψ	$G(\frac{KN}{m^2})$	$E_{oed}(\frac{KN}{m^2})$	φ	$C(\frac{KN}{m^2})$	$V_s(\frac{M}{S})$	$V_p(\frac{M}{S})$
16	19	30000	0.3	1	11540	40380	36	0.44	84.07	157.3

SC3										
$\gamma_d(\frac{KN}{m^3})$	$\gamma_{sat}(\frac{KN}{m^3})$	$E_{ref}(\frac{KN}{m^2})$	v	ψ	$G(\frac{KN}{m^2})$	$E_{oed}(\frac{KN}{m^2})$	φ	$C(\frac{KN}{m^2})$	$V_s(\frac{M}{S})$	$V_p(\frac{M}{S})$
16	19	15000	0.3	1	5769.231	20190	37.5	0.44	59.44	111.2

SC4										
$\gamma_d(\frac{KN}{m^3})$	$\gamma_{sat}(\frac{KN}{m^3})$	$E_{ref}(\frac{KN}{m^2})$	v	ψ	$G(\frac{KN}{m^2})$	$E_{oed}(\frac{KN}{m^2})$	φ	$C(\frac{KN}{m^2})$	$V_s(\frac{M}{S})$	$V_p(\frac{M}{S})$
16	19	20000	0.3	1	7692.308	26920	39	0.44	68.640	128.4

Table 1- a : Clay soil geotechnical parameters

SM										
$\gamma_d(\frac{KN}{m^3})$	$\gamma_{sat}(\frac{KN}{m^3})$	$E_{ref}(\frac{KN}{m^2})$	ν	ψ	$G(\frac{KN}{m^2})$	$E_{oed}(\frac{KN}{m^2})$	φ	$c(\frac{KN}{m^2})$	$V_s(\frac{M}{S})$	$V_p(\frac{M}{S})$
18	20	13000	0.3	3.7	5000	17500	33.7	1	52.17	97.610

SM2										
$\gamma_d(\frac{KN}{m^3})$	$\gamma_{sat}(\frac{KN}{m^3})$	$E_{ref}(\frac{KN}{m^2})$	ν	ψ	$G(\frac{KN}{m^2})$	$E_{oed}(\frac{KN}{m^2})$	φ	$c(\frac{KN}{m^2})$	$V_s(\frac{M}{S})$	$V_p(\frac{M}{S})$
18	20	14000	0.3	3.7	5384.615	18850	33.7	0	54.14	101.3

SM3										
$\gamma_d(\frac{KN}{m^3})$	$\gamma_{sat}(\frac{KN}{m^3})$	$E_{ref}(\frac{KN}{m^2})$	ν	ψ	$G(\frac{KN}{m^2})$	$E_{oed}(\frac{KN}{m^2})$	φ	$c(\frac{KN}{m^2})$	$V_s(\frac{M}{S})$	$V_p(\frac{M}{S})$
18	20	21000	0.28	3.7	8203.125	26850	40	1	66.83	120.9

Table 1-b : Silty sandy soil geotechnical parameters (SM)

SP1										
$\gamma_d(\frac{KN}{m^3})$	$\gamma_{sat}(\frac{KN}{m^3})$	$E_{ref}(\frac{KN}{m^2})$	ν	ψ	$G(\frac{KN}{m^2})$	$E_{oed}(\frac{KN}{m^2})$	φ	$c(\frac{KN}{m^2})$	$V_s(\frac{M}{S})$	$V_p(\frac{M}{S})$
16	20	30000	0.3	3	11540	40380	37	0.2	84.07	157.3

Table 1- c : Poor sandy soil geotechnical parameters aggregation (SP)

Sp2										
$\gamma_d(\frac{KN}{m^3})$	$\gamma_{sat}(\frac{KN}{m^3})$	$E_{ref}(\frac{KN}{m^2})$	ν	ψ	$G(\frac{KN}{m^2})$	$E_{oed}(\frac{KN}{m^2})$	φ	$c(\frac{KN}{m^2})$	$V_s(\frac{M}{S})$	$V_p(\frac{M}{S})$
18	20	100000	0.3	3	38460	134600	37	1	144.7	270.7

Table 1- c : Poor sandy soil geotechnical parameters aggregation (SP)

CH										
$\gamma_d(\frac{KN}{m^3})$	$\gamma_{sat}(\frac{KN}{m^3})$	$E_{ref}(\frac{KN}{m^2})$	ν	ψ	$G(\frac{KN}{m^2})$	$E_{oed}(\frac{KN}{m^2})$	φ	$c(\frac{KN}{m^2})$	$V_s(\frac{M}{S})$	$V_p(\frac{M}{S})$
16	19	13600	0.35	0	5037.037	21830	0	0.507	55.54	115.6

Table 1- d : Geotechnical parameters of clay with high plasticity (CH)

Concrete						
$\gamma_{unsat}(\frac{KN}{m^3})$	$E_{ref}(\frac{KN}{m^2})$	ν	$G(\frac{KN}{m^2})$	$E_{oed}(\frac{KN}{m^2})$	$V_s(\frac{M}{S})$	$V_p(\frac{M}{S})$
24	5000	0.25	2000	6000	28	49

Table 1-e : Geotechnical parameters of concrete

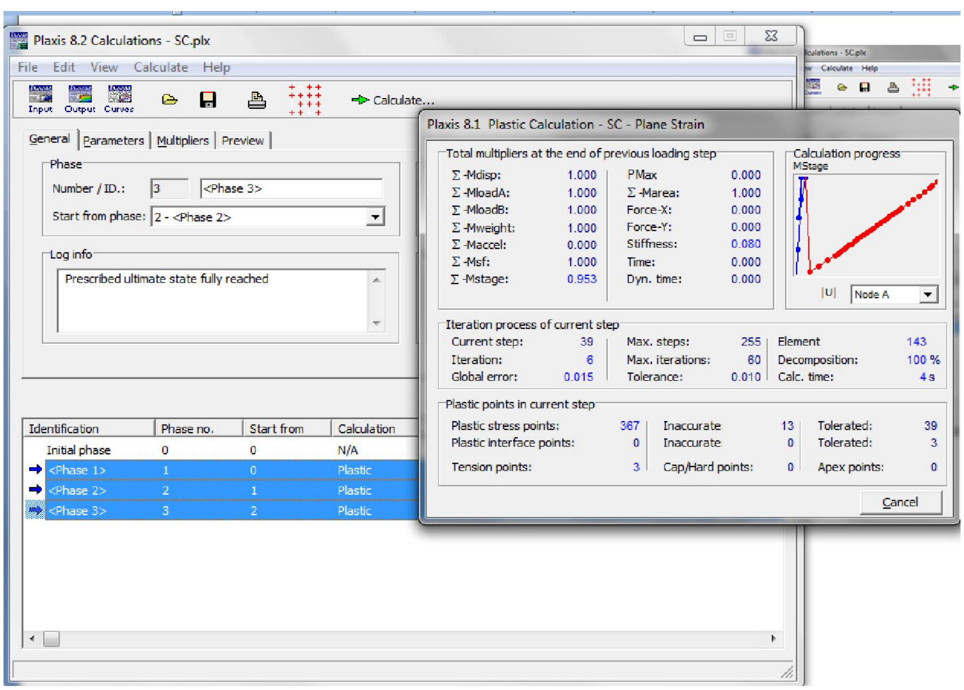
2-2- Modelin in Plaxis Program

The mesh and boundary conditions (soil behavior using finite element method), for the simulation executable work, three-phase program is defined as follows:

1- Definition of soil for Plaxis.

2- Declared shallow foundation material and foundation for program.

3- Load on the foundation.



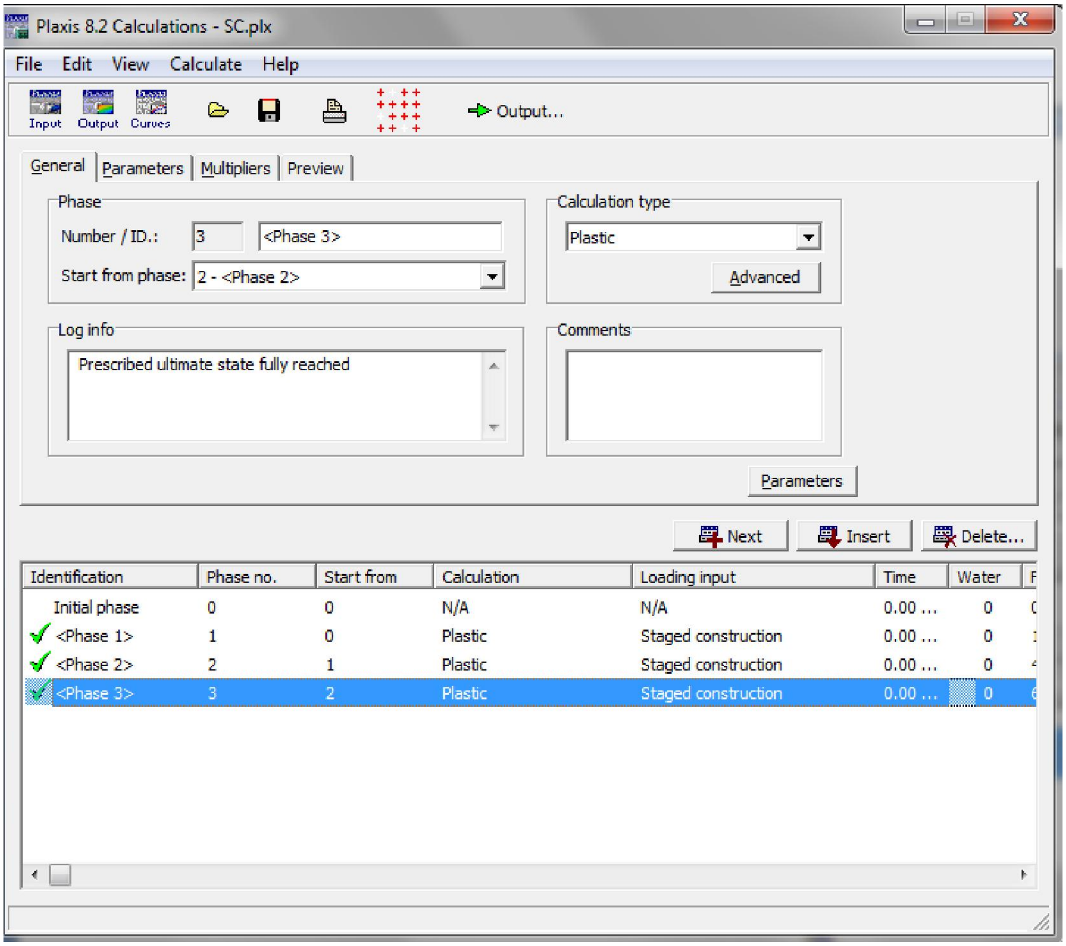


Figure 3.Calculations window

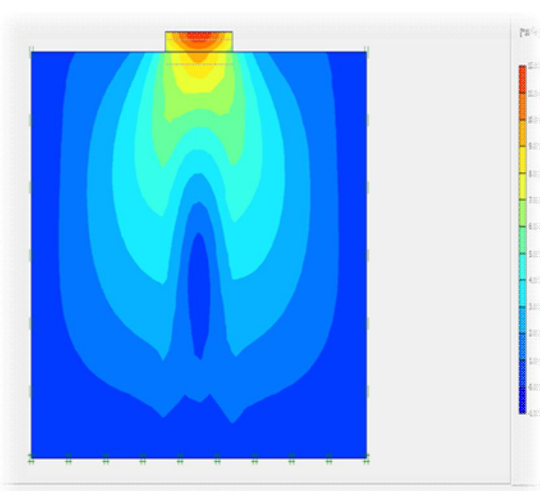


Figure 4-a. General Settelement of the Foundation

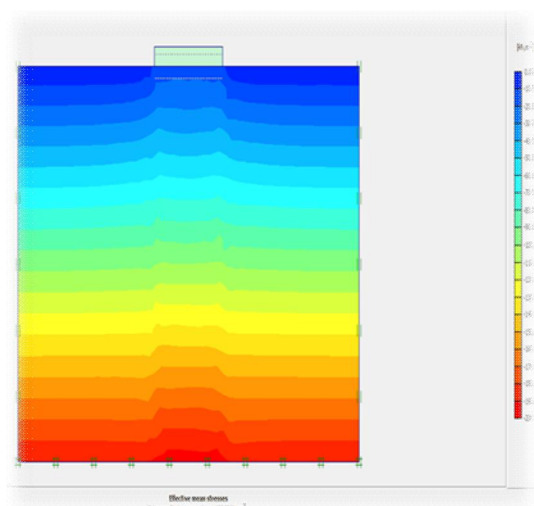


Figure 4-b. Effective stress in the soil

2-3- Define the network Initial input

In ANN forecasting models, 60% of the records are selected as training, 30% are taken for test for final evaluation, and the remaining 10% are used for validation or monitoring the performance of the model during the training phase.

For Neural Network Training, We consider three inputs:

1-Distributed load: q (KN/ m^2)

2-Standard Penetration Number (SPT)

3- Ratio of length to width of the foundation: L/B

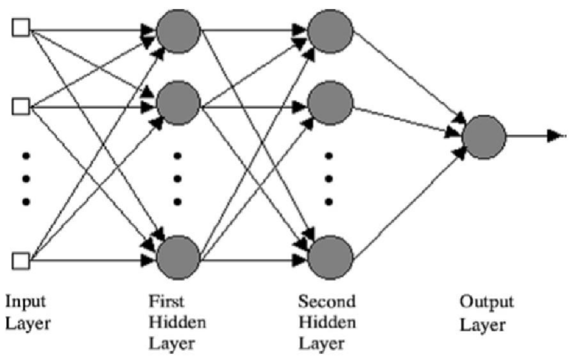


Figure 5: A three-layer feed-forward neural network structure.

2-3-1 Calculate of the Standard Penetration Number modified

This table 2, that Introduced in 1956 by Meyerhof is used for many of the papers Indicates that Empirical relationship between the angle of internal friction of soil and SPT.

Table2: The relationship between the angle of internal friction of soil with numbers SPT

SPT Penetration, N-Value (blows/ foot)	Density of Sand	ϕ (degrees)
<4	Very loose	<30
4 - 10	Loose	30 - 35
10 - 30	Medium	35 - 40
30 - 50	Dense	40 - 45
>50	Very dense	>45

Value of the SPT in granular soils, is dependent on the Overhead pressure (σ'_V). So under the Effective pressure, the value of SPT (N) needed to corrected by:

$$N_{cor} = C_N N$$

Several researchers such as (Peck et al.,1976), (Seed et al.,1976-1979) and (Tokimatsu and Yoshimi,1983), Empirical relations for C_N have been proposed but The easiest with good accuracy by (Liao and Whitman,1986) Proposed.

$$C_N = 9.78 \sqrt{1/\sigma'_V(KN/m^2)}$$

So:

$$\sigma'_V = \gamma$$

The two of input parameters (N_{cor}, L/B) For each soil sample are presented in the table 3. As you can see, For each model, Ratio of length to width of the foundation has changed until Dimension influence on Settlement of Shallow Foundations to be determined.

SC4		SM		SP1		SC		SC	
N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3
8.5	4	9.48	6	15.5	8	7.74	8	7.74	3

Table 3: Ratio of length to width and number SPT

SC4		SM		SM3		SM3		SC4	
N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8
15.5	8	7.74	6	11	8	11	3	15.5	8

SC2		SC 2		SC3		SC3		SC4	
N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3
8.5	3	8.5	8	11.6	3	11.6	8	15.5	3

Table 3. Ratio of length to width and number SPT

SM3		SM 3		SC4		SP1(3)		SC2(3)	
$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5
3	11	8	11	3	15.5	3	15.5	3	8.5

Table 3. Ratio of length to width and number SPT

CH		Sc 4		SM		SC		SC 3	
N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6
7	6	15.5	6	9.48	6	7.74	6	6	11.6

Table 3. Ratio of length to width and number SPT

Sm2		Sm3		Sp 1		Sp 2	
$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}	$\frac{L}{B}$	N_{cor}
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2
6	11	6	14.4	6	15.5	6	18.2

Table 3. Ratio of length to width and number SPT

2-4- Results of Analysis Plaxis Program

One of the Initial inputs of the neural network is the load on shallow foundations, Therefore, for each soil sample, We have considered 14 different loads to be sufficiently wide range of input data. After modeling the each samples under 14 different loads, the Settlement of Shallow Foundations is called output of Neural network.

Sc2 (8)		SC3(3)		SC3(8)		SC4(38)		SC4 (8)		SM(6)	
δ	q	δ	q	δ	q	δ	q	δ	q	δ	q
10.31	15	53.29	31	25.25	17	100.57	80	21.99	20	29.27	20
22.04	40	68.56	46	32.95	26	107.66	86	24.01	23	46.89	39
31.43	60	81	58	54.44	48	114.95	93	38.59	44	59.3	52
40.83	80	93.13	69	66.18	63	123.59	101	39.29	45	71.88	65
50.27	100	105.79	81	79.25	77	134.75	113	42.78	50	90.07	83
59.73	120	120.9	95	83.05	81	141.31	120	53.41	65	99.6	92
62.1	125	136.72	110	104.14	103	153.56	132	66.21	83	123.07	110
64.47	130	157.87	130	111.81	111	162.41	141	86.38	110	133.43	118
69.24	140	184.55	155	142.9	140	173.69	152	107.89	135	139.73	123
74.02	150	198.4	168	159.69	153	185.53	161	130.77	160	154.76	135
83.88	170	203.77	173	167.13	162	203.97	183	146.39	180	162.24	141
101.34	200	211.31	180	197.22	190	213.86	192	159.69	195	190.31	182
107.26	210	229.59	197	220.22	201	231.8	210	171.78	210	232.27	201
113.27	220	243.81	210	255.4	240	257.98	235	185.09	225	256.06	215

Table 4. Data obtained from the analysis of plaxis

Sc 4(4)		SM(6)		SP1(8)		SC(8)		SC (3)		SC 2(3)	
δ	q	δ	q	δ	q	δ	q	δ	q	δ	q
33.1	15	29.27	20	16.29	20	23.82	18	36.12	15	39.49	50
35.56	18	66.99	60	24.14	35	31.98	28	50.55	30	54.86	75
38.02	21	79.89	73	29.9	46	37.92	35	69.48	46	58.59	81
52.22	38	99.6	92	41.69	68	59.98	60	85.17	58	65.98	93
64.43	53	123.07	110	55.36	93	76.83	75	105.32	73	69.84	99
72	60	152.26	133	65.15	110	89.05	86	120.63	85	70.53	100
94.73	85	188.02	160	72.92	121	98.97	95	130.63	93	77.14	110
111.38	101	211.31	179	80.64	132	122.22	116	191.05	141	80.41	115
131.69	120	218.65	185	86.8	141	140.32	132	206.76	153	84.41	121
153.69	140	226	191	91.67	148	163.74	151	236.35	176	88.77	128
174.63	160	234.52	198	100.98	162	178.86	163	253.28	189	91.51	132
186.16	171	237.03	200	106.92	171	204.84	182	267.32	200	96.14	138
195.8	180	240.77	203	118.6	185	231.16	201	279.47	209	97.53	140
216.35	200	250.9	211	128.37	199	257.7	220	283.55	212	112.68	162

CH		Sc 3		SM		SC		Sc 4	
q	δ	q	δ	q	δ	q	δ	q	δ
5	13.6	10	18.42	3	15.31	1	4.16	15	17.6
6	14.68	20	26.1	7	19.11	5	6.5	21	21.27
25	36	30	34.31	20	31.8	38	26.39	29	26.54
45	58.6	38	40.78	38	49.94	66	47.03	55	43.27
55	69.99	44	45.75	56	68.65	93	71.08	69	53.06
70	87.17	61	59.99	80	93.92	121	98.87	73	55.76
74	91.78	70	68.89	98	113.39	132	110.78	81	61.7
89	109.23	89	93.26	119	136.41	150	130.46	108	89.71
100	122.16	100	106.69	160	187.01	180	162.73	120	100.41
110	134.28	115	123.36	190	225.63	200	186.29	133	111.51
130	162.63	120	128.57	215	258.58	208	195.65	160	133.49
180	239.69	145	154.36	218	262.53	222	212.87	200	165.49
200	272.62	160	168.96	225	272.1	250	248.12	200	179.09
240	341.96	183	193.3	243	296.29	255	254.8	220	181.84

Table 4. Data obtained from the analysis of plaxis

Sc2 (8)		SC3(3)		SC3(8)		SC4(38)		SC4 (8)		SM(6)	
δ	q	δ	q	δ	q	δ	q	δ	q	δ	q
10.31	15	53.29	31	25.25	17	100.57	80	21.99	20	29.27	20
22.04	40	68.56	46	32.95	26	107.66	86	24.01	23	46.89	39
31.43	60	81	58	54.44	48	114.95	93	38.59	44	59.3	52
40.83	80	93.13	69	66.18	63	123.59	101	39.29	45	71.88	65
50.27	100	105.79	81	79.25	77	134.75	113	42.78	50	90.07	83
59.73	120	120.9	95	83.05	81	141.31	120	53.41	65	99.6	92
62.1	125	136.72	110	104.14	103	153.56	132	66.21	83	123.07	110
64.47	130	157.87	130	111.81	111	162.41	141	86.38	110	133.43	118
69.24	140	184.55	155	142.9	140	173.69	152	107.89	135	139.73	123
74.02	150	198.4	168	159.69	153	185.53	161	130.77	160	154.76	135
83.88	170	203.77	173	167.13	162	203.97	183	146.39	180	162.24	141
101.34	200	211.31	180	197.22	190	213.86	192	159.69	195	190.31	182
107.26	210	229.59	197	220.22	201	231.8	210	171.78	210	232.27	201
113.27	220	243.81	210	255.4	240	257.98	235	185.09	225	256.06	215

Sc 4(4)		SM(6)		SP1(8)		SC(8)		SC (3)		SC 2(3)	
δ	q	δ	q	δ	q	δ	q	δ	q	δ	q
33.1	15	29.27	20	16.29	20	23.82	18	36.12	15	39.49	50
35.56	18	66.99	60	24.14	35	31.98	28	50.55	30	54.86	75
38.02	21	79.89	73	29.9	46	37.92	35	69.48	46	58.59	81
52.22	38	99.6	92	41.69	68	59.98	60	85.17	58	65.98	93
64.43	53	123.07	110	55.36	93	76.83	75	105.32	73	69.84	99
72	60	152.26	133	65.15	110	89.05	86	120.63	85	70.53	100
94.73	85	188.02	160	72.92	121	98.97	95	130.63	93	77.14	110
111.38	101	211.31	179	80.64	132	122.22	116	191.05	141	80.41	115
131.69	120	218.65	185	86.8	141	140.32	132	206.76	153	84.41	121
153.69	140	226	191	91.67	148	163.74	151	236.35	176	88.77	128
174.63	160	234.52	198	100.98	162	178.86	163	253.28	189	91.51	132
186.16	171	237.03	200	106.92	171	204.84	182	267.32	200	96.14	138
195.8	180	240.77	203	118.6	185	231.16	201	279.47	209	97.53	140
216.35	200	250.9	211	128.37	199	257.7	220	283.55	212	112.68	162

Table 4. Data obtained from the analysis of plaxis

Sm2		Sm3		Sp 1		Sp 2	
δ	q	δ	q	δ	q	δ	q
13.55	3	27.46	30	15.52	20	4.01	3
17.63	8	41.15	50	28.29	46	5.29	8
25.03	17	52.15	66	67.33	108	10.53	26
40.77	35	65.16	85	84.72	133	14.39	39
68.91	66	80.86	107	108.09	169	34.76	101
81.92	79	86.57	115	115.78	181	41.49	120
100.04	100	104.65	140	127.87	199	48.74	140
134.2	120	128.87	173	128.57	200	54.15	155
162.56	143	146.42	191	136.07	211	60.54	173
187.43	165	153.79	200	142.04	220	67.31	191
206.36	181	176.04	231	150.01	231	74.39	210
229.1	200	183.58	240	155.03	238	79.14	223
253.51	220	185.27	242	157.01	241	82.08	231
259.6	225	187.81	245	159.83	245	84.47	238

Table 4. Data obtained from the analysis of plaxis

```
    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000
   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000

  Columns 320 through 330

  132.0000  161.0000  172.0000   30.0000   45.0000   55.0000   70.0000   86.0000  100.0000  110.0000  135.0000
    6.0000    6.0000    6.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000
   11.0000   11.0000   11.0000   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000

  Columns 331 through 341

  152.0000  176.0000  192.0000  211.0000  220.0000  230.0000   15.0000   30.0000   46.0000   53.0000   73.0000
    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    3.0000    3.0000    3.0000    3.0000    3.0000
   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000

  Columns 342 through 352

   81.0000   96.0000  102.0000  115.0000  121.0000  132.0000  146.0000  162.0000  182.0000   15.0000   32.0000
    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000    8.0000    8.0000
   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000   15.5000   11.0000   11.0000

  Columns 353 through 363

   52.0000   64.0000   73.0000   82.0000   93.0000  110.0000  135.0000  142.0000  156.0000  167.0000  182.0000
    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000
   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000

  Columns 364 through 374

  200.0000   45.0000   56.0000   73.0000   85.0000   92.0000  101.0000  115.0000  120.0000  132.0000  146.0000
    8.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000
   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000   11.0000

  Columns 375 through 378

  155.0000  168.0000  181.0000  195.0000
    3.0000    3.0000    3.0000    3.0000
   11.0000   11.0000   11.0000   11.0000
```

Figure 6. P matrix

2-5- Input data into the MATLAB program

Input data are entered in MATLAB as a matrix. we define 3 initial input to the neural network and We had 27 models, each of which had 14 different types of loading, Thus, for each input, there will be 378 data.

2-5-1- P matrix

This matrix is called as the neural network input matrix and contains: q, N (N_{cor}), Z (L/B) and In Matlab is defined as p= [q;z;n] so that shown in Figure 6.

2-5-2-Output matrix of the neural network (t):

This Matrix with dimensions (1 × 378) is the output of the neural network as the Settlement of Shallow Foundations obtained by analyzing samples is modeled by the plaxis program called t matrix that shown in Figure 7.

2-5-3-Defines the structure of an artificial neural network

In this project, the multi-layer perceptron network as the most used type of artificial neural network in solving engineering problems was used. Figure 5.

2-6-Network code in MATLAB is given below

net = newff(PR ,[S1 S2...SNl],{TF1 TF2...TFNl},BTF)

(PR: min,max values; S1 S2...SNl: size of the ith layer; TF1 TF2...TFNl: activation function of ith layer; BTF: training algorithm)

Neural network training function is **trainlm**. After the data for classification and regression functions affected by this function, the learning process is to achieve a good correlation. in Figure 8 is an overview of the network.

Perceptron neural network with two layers and a middle layer that is hidden in the hidden layer There are 350 hidden neuron is composed of a single output of the network is taken. Code is as follows:

net=newff ([1 255;3 6;7 18.2], [350 1], {'tansig' 'purelin'},'trainlm)

ANN training code: Net 1 = train (net, P,T)

```
t=[13.6 14.68 36 58.6 69.99 87.17 91.78 109.23 122.16 134.28 162.63 239.69 272.62 341.96
15.31 19.11 31.8 49.94 68.65 93.92 113.39 136.41 187.01 225.63 258.58 262.53 272.10 296.29
4.16 6.5 26.39 47.03 71.08 98.87 110.78 130.46 162.73 186.29 195.65 212.87 248.12 254.8
18.42 26.1 34.31 40.78 45.75 59.99 68.89 93.26 106.69 123.36 128.57 154.36 168.96 193.3 17.6
21.27 26.54 43.27 53.06 55.76 61.7 89.71 100.41 111.51 133.49 165.49 179.09 181.84 13.55
17.63 25.03 40.77 68.91 81.92 100.04 134.2 162.56 187.43 206.36 229.1 253.51 259.6 27.46
41.15 52.15 65.16 80.86 86.57 104.65 128.87 146.42 153.79 176.04 183.58 185.27 187.81 15.52
28.29 67.33 84.72 108.09 115.78 127.87 128.57 136.07 142.4 150.01 155.03 157.01 159.83 4.01
5.29 10.53 14.39 34.76 41.49 48.74 54.15 60.54 67.31 74.39 79.14 82.08 84.47 33.1 35.56 38.02
52.22 64.43 72 94.73 111.38 131.69 153.15 174.63 186.16 195.8 216.35 29.27 66.99 79.89 99.6
123.07 152.26 188.02 211.31 218.65 226 234.52 237.03 240.77 250.9 16.29 24.14 29.9 41.69
55.36 65.15 72.92 80.64 86.8 91.67 100.98 106.92 118.6 128.37 23.82 31.98 37.92 59.98 76.83
89.05 98.97 122.22 140.32 163.74 178.86 204.84 231.16 257.7 36.12 50.55 69.48 85.17 105.32
120.7 130.63 191.05 206.76 236.35 253.28 267.32 279.47 283.55 39.49 54.86 58.59 65.98 69.84
70.53 77.14 80.44 84.41 88.77 91.51 96.14 97.53 112.68 10.31 22.04 31.43 40.83 50.27 59.73
62.1 64.47 69.24 74.02 83.88 101.34 107.26 113.27 53.29 68.56 81 93.13 105.79 120.9 136.72
157.87 184.55 198.4 203.77 211.31 229.59 243.81 25.25 32.95 54.44 66.18 79.25 83.05 104.14
111.81 142.9 159.69 167.13 197.22 220.22 255.4 100.57 107.66 114.95 123.59 134.75 141.31
153.56 162.41 173.69 185.53 203.97 213.86 231.8 257.98 21.99 24.01 38.59 39.29 42.78 53.41
66.21 86.38 107.89 130.77 146.39 159.69 171.78 185.09 29.27 46.89 59.3 71.88 90.07 99.6
123.07 133.45 139.73 154.76 162.24 190.31 233.27 256.06 24.93 29.53 43.79 56.39 64.21 76.12
89.2 101.28 118.69 130.71 139.74 163.33 206.14 218.88 35.33 44.41 57.88 72.88 86.55 93
119.37 135.34 155.48 164.44 174.22 191.12 232.12 247.18 28.89 39.29 46.27 56.98 68.35 78.82
86.38 107.89 123.82 143.27 157.52 172.75 180.96 189.74 32.07 43.94 57.12 63.11 92.57 102.2
118.15 124.29 136.6 142.28 153.56 167.66 184.52 202.95 24.93 40.98 60.33 72.12 81.05 90.01
101.28 118.69 149.39 158.26 176.21 188.44 208.7 232.03 71.91 84.14 105.81 123.11 133.93
147.05 167.39 174.72 191.69 211.13 223.81 241.74 259.43 278.45]
```

Figure 7. t matrix

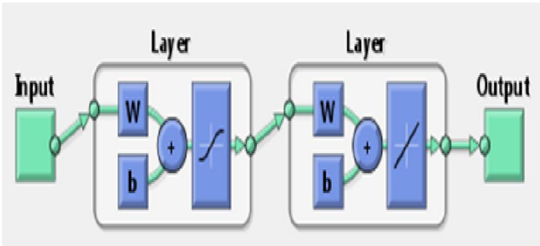


Figure 8. Overview of network

The network codes is the error rate of the network can be set so that the desired error rate reached a certain stage.

net.trainParam.show = 50;
net.trainParam.lr = 0.05;
net.trainParam.epochs =1000;
net.trainParam.goal = 1e-3

3- Results and discussion

With all of the steps described, the Neural network error rate has reached **0.98125**. This figure 9, shows a good training program to suit a wide range of input data networks.

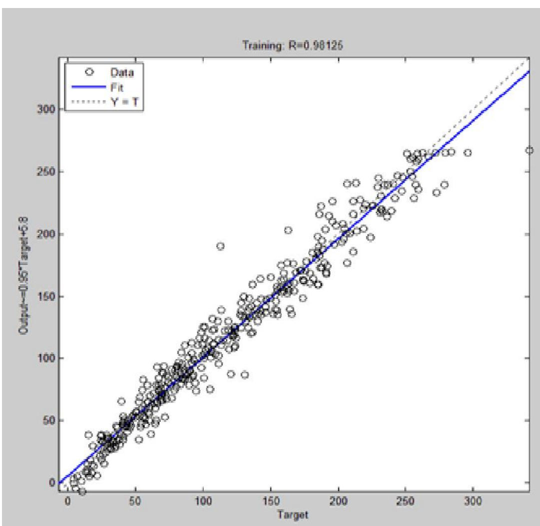


Figure 9 –a. Neural network performance

The code can be used to query the network.

a= sim (net1, P);

For example, soils The ratio of length to width 6 and number oo SPT 14.4, Plaxis Program, the answer is **128.87** and A neural network designed **129.0209** gives an approximate answer is acceptable.

Below this number is shown in the MATLAB programming environment. The question of the program is as follows:

a= sim (net1, [173;6;17.4])

```
>> net1 = train(net, p, t);
>> a= sim(net1,[173;6;14.4]);
>> a= sim(net1,[173;6;14.4])

a =

  129.0209
```

Figure 10. Answer in Matlab

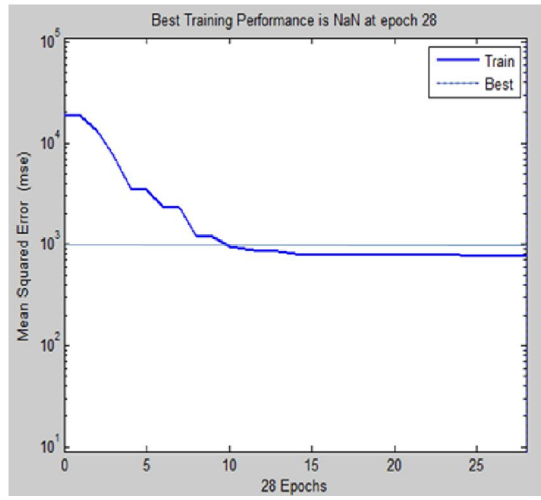


Figure 9-b. Best Training Performance of the Network

3-1- Influence Of neurons in the hidden layer on R

Given the importance of this issue in regression neural network input data so The number 350 was used in the artificial neural network which is the value obtained experimentally.

If: net=newff ([1 255;3 8;7 18.2], [320 1], {'tansig' 'purelin'},'trainlm');

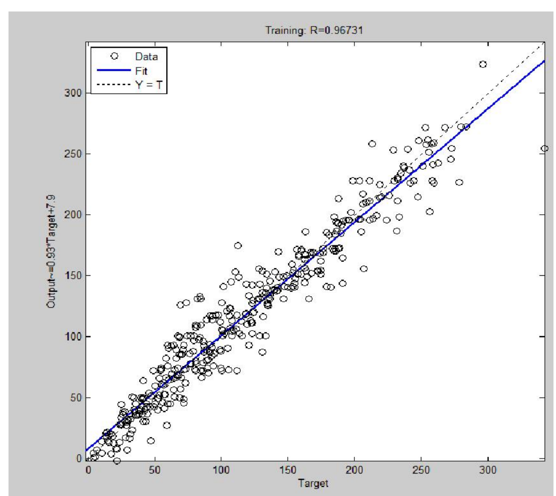


Figure 11-a. Amount of R in 320 Neron is 0.96731

If: net=newff ([1 255;3 8;7 18.2], [360 1], {'tansig' 'purelin'},'trainlm');

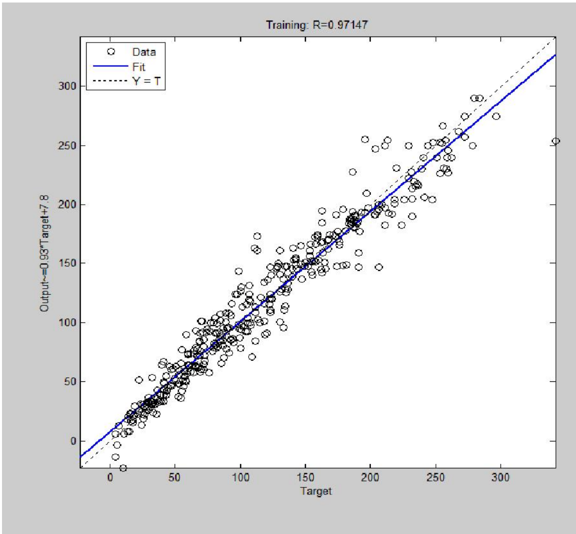


Figure 11-b. Amount of R in 320 Neron is 0.9714

4. Conclusion

The data from the neural network being used as a test of the soil was SC3 with The ratio of length to width is 8. The results of the Settlement by using neural network has a good agreement with the results of Plaxis and All results are shown in Table 5.

SC3 (8)		ANN Results
q(KN/m^2)	δ ($10^{-3}mm$)	δ ($10^{-3}mm$)
52	60.33	55.53
59	67.23	63.93
60	68.21	63.75
65	73.11	66.86
75	83.12	85.03
80	88.19	78.76
100	108.41	107.145
111	119.72	115.37
117	125.91	117.43
120	129.42	123.94
135	149.39	140.93
140	155.46	147.59
150	168.28	157.2
160	180.22	172.03

Table 5. A comparison of neural network and applications

4-2-Dimensions Foundation effects on Settlement

Soil samples were taken to be SC4. The parameters are shown in Table. The soil under the 4 Different Dimensions foundation and the load 100 $\frac{Kg}{m^2}$. The coordinates of the selected point by (11,12.5) to calculate the rate of change of meeting dates and results of these studies are shown in Figure 12.

Curve A: Of the soil friction angle SC4 is 39 degrees under a uniform load of 100 $\frac{Kg}{m^2}$ On shallow foundations with length to width ratio is 3. (6 meters long and 2 meters wide).

Curve B: Of the soil friction angle SC4 is 39 degrees under a uniform load of 100 $\frac{Kg}{m^2}$ On shallow foundations with length to width ratio is 4. (8 meters long and 2 meters wide).

Curve C: Of the soil friction angle SC4 is 39 degrees under a uniform load of 100 $\frac{Kg}{m^2}$ On shallow foundations with length to width ratio is 8. (8 meters long and 1 meters wide).

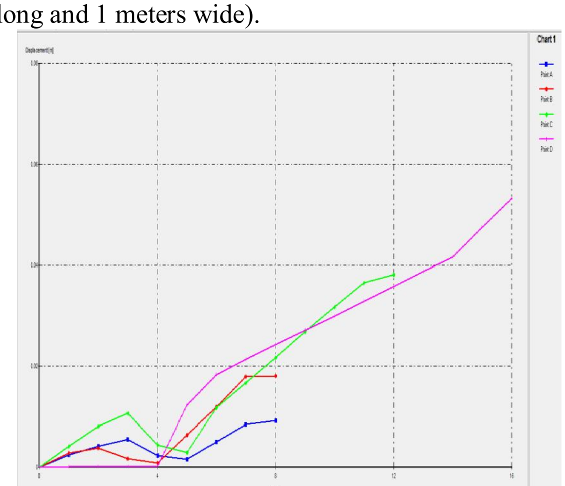


Figure 12. Dimensions Foundation effects on Settlement

Curve A: Of the soil friction angle SC4 is 39 degrees under a uniform load of 100 $\frac{Kg}{m^2}$ On shallow foundations with length to width ratio is 3. (6 meters long and 2 meters wide).

Curve B: Of the soil friction angle SC4 is 39 degrees under a uniform load of $100 \frac{Kg}{m^2}$ On shallow foundations with length to width ratio is 4. (8 meters long and 2 meters wide).

Curve C: Of the soil friction angle SC4 is 39 degrees under a uniform load of $100 \frac{Kg}{m^2}$ On shallow foundations with length to width ratio is 8. (8 meters long and 1 meters wide).

Curve D: Of the soil friction angle SC4 is 39 degrees under a uniform load of $100 \frac{Kg}{m^2}$ On shallow foundations with length to width ratio is 6. (6 meters long and 1 meters wide).

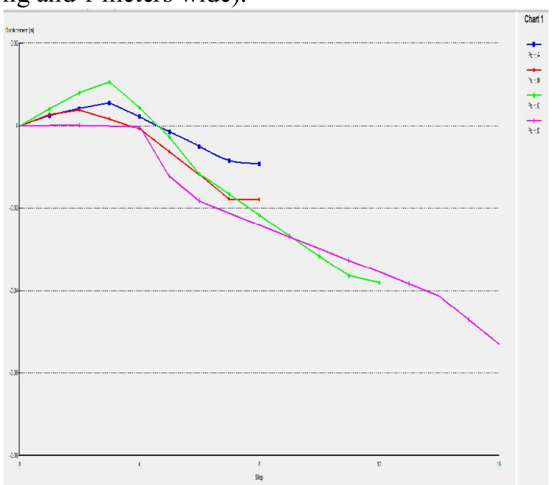


Figure 13. Angle of internal friction curve effects

4-3- Angle of internal friction effects

To evaluate the influence of internal friction angle of a soil sample in a Amount of Settlement s, at one point considered for the analysis of soil SC4.

A type of foundation and the load, the changes we observed the effects of friction.

Curve A: Of the soil friction angle SC4 is 39 degrees under a uniform load of $100 \frac{Kg}{m^2}$ On shallow foundations with length to width ratio is 4. (8 meters long and 2 meters wide).

Curve B: Of the soil friction angle SC4 is 45 degrees under a uniform load of $100 \frac{Kg}{m^2}$ On shallow foundations with length to width ratio is 4. (8 meters long and 2 meters wide).

Curve C: Of the soil friction angle SC4 is 30 degrees under a uniform load of $100 \frac{Kg}{m^2}$ On shallow foundations with length to width ratio is 4. (8 meters long and 2 meters wide).

Curve D: Of the soil friction angle SC4 is 35 degrees under a uniform load of $100 \frac{Kg}{m^2}$ On shallow foundations with length to width ratio is 4. (8 meters long and 2 meters wide).

As is known in the form of increasing the amount of soil friction angle, the highest Settlement in the lower reaches Also, the curves A and B Against two curves are much more friction, the Settlement is also lower than the other two curves.

Increase the contact area of foundation soil was modeled on, the settlement amount will be reduced. Distribution of the stress distribution in the soil layers below the foundation would be better and reduce the stress level in the soil layers and also to reduce the amount of foundation settlement.

Increase the friction angle of the soil in a layer of soil to reduce settlement will increase the contact area between the particles of the soil layer will be.

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