

TBM

-

3 2 *1

-1

-3 2

1391/10/27 : 1391/08/02 :

(TBM)

TBM

(AR: Advance Rate)
(PR: Penetration Rate)

(Sanio) (Roxborough & Phillips)
(Boyd) TBM

[2] [1]

20 TBM

Colorado) CSM

[3]

(School of Mines

Farmer)

(Graham)

(Tarkoy)

(Nelson)

(& Glossop

[7] [6] [5] [4]

(Innaurato)

(Cassineli)

(Park)

[14]

(Grima, et al.)

Q RQD RSR RMR

NTH

[11]

[10]

[9]

[8]

(UCS)

Q_{TBM}

[12]

(CFF: Core Fracture Frequency)

Q

(Barton)

(RPM)

[13]

[15]

Q_{TBM} NTH

RQD

[16]

(Yagiza, et al.)

1391 1 1

[17]

[17]

[18]

RQD

-2

[19]

673 26
 (TBM)
 400 1000
 1 TBM

[20] TBM -1

26 (KM)
 673 (m)
 42
 90 (mm)
 432 (mm)
 0.905 (1/min)

1

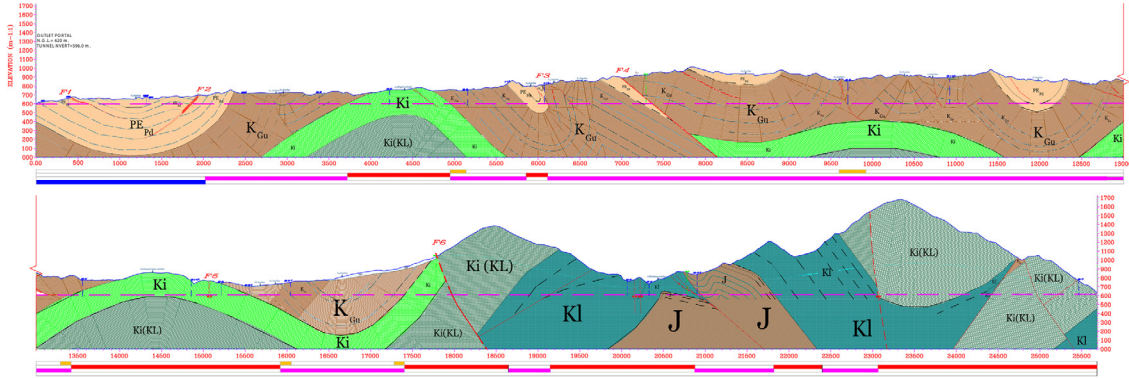
SH LI :
 LS ML MA

[21]

21

(2)

10



[20]

-1

-3

-2

(

)

()

-3

(2)

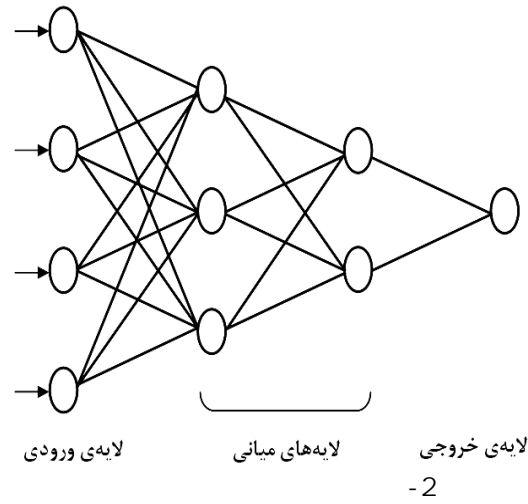
-1

[21]

10

-2

(%)	(gr/cm^3)	RMR	RQD (%)	(MPa)	(MPa)	
10-15	24-25	48	68-75	1-3	10-30	SH-ML 1
10-15	23-25	44	52-60	1-3	15-30	SH-ML 2
5-15	23-25	44	50-65	1-3	10-20	SH-ML 3
2-5	25-26	62	85-72	5	50-100	ML-SH 1
5-10	22-25	48	70-60	1-3	15-30	ML-SH 2
5-15	205-25	46	65-50	2-4	25-50	ML-SH 3
5-10	22-25	50	75-65	2-4	15-30	ML-SH 4
3-5	23-26	49	85-75	5	50-100	ML-SH 5
3-15	24-25	44	70-60	1-3	15-30	SH-LS 1
3-10	23-26	50	80-75	2-4	30-50	SH-LS 2
5-15	23-25	44	75-65	1-3	15-30	SH-LS 3
5-10	23-26	48	75-70	2-5	15-30	SH-LS 4
25-6	25-26	57	90-80	25-6	100-150	LI 2



()
[23] [14]

[22] [24]

[22]

()

(Feed Forward Back Propagation)

-1 1

[24] [23] [14]

[22]

(Training) -1

(Generalization) -2

(Operation) -3

[23] [14]

.- 4

.-1-4

TBM

-1

-2

RQD)

-3

(RMR

RMR

9

RQD

:

() -1

10

() -2

() -3

[26] [25]

() RQD -4

() RMR -5

3 -6

() -7

() -8

() -9

[22]

()

-3

[14]

1

2

3

4

[31]

(Caudill) (Hecht-Nielsen)

I 2I+1

[30] [29] [28] [27]

[33] [32]

.-2-4

11 10 9 8

y=x

[14]

(4)

[24]

+1 -1

10 9 8

5

11

(Tansig)

(Purelin)

-4

Levenberg-

(Marquardt)

3	2	1	
$y=x+2$	$y=x+1.5$	$y=x+1$	
2	1.5	1	(mm/rev)

8

5

5

9x8x1

(Berke)

2 1.5 1

-5

93 68 50

11	10	9	8	
13	19	16	14	1
18	22	21	19	2
20	23	24	26	3
1,36	1,17	1,2	1,07	
0,71	0,74	0,77	0,83	

90

-3

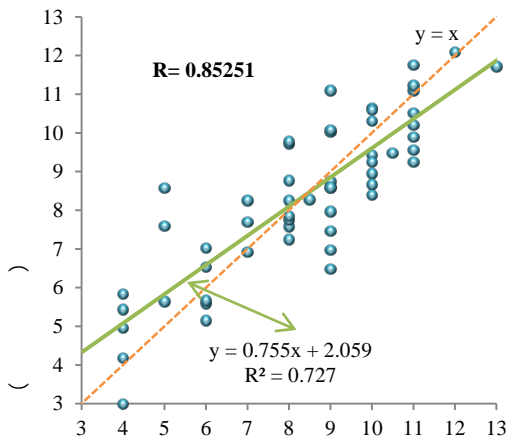
83 85

-4

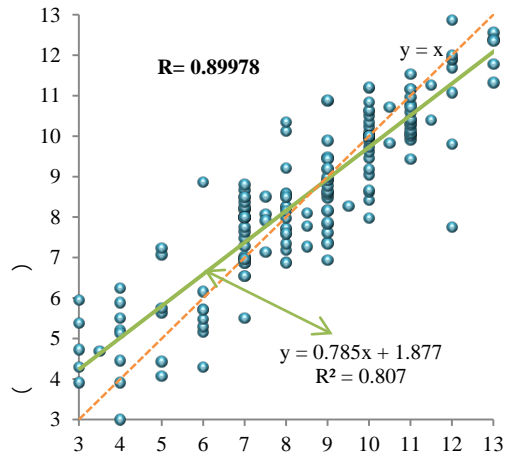
-3

-4

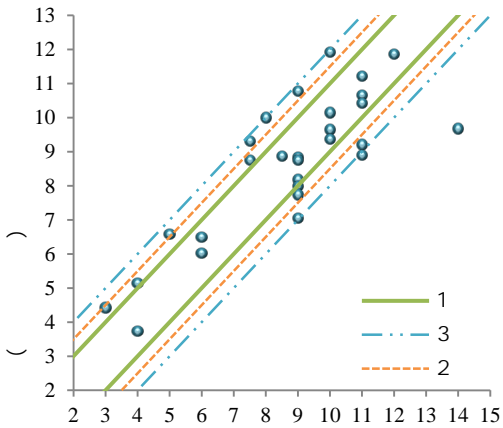
1,07



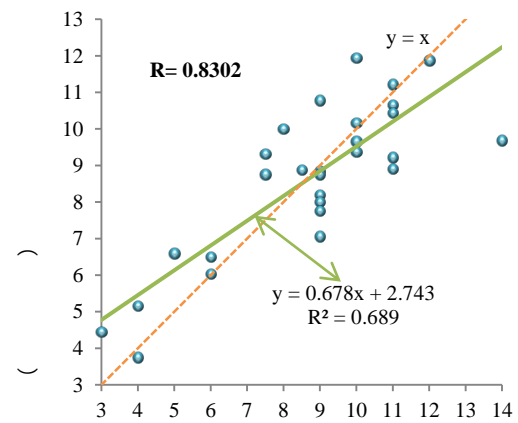
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()



()



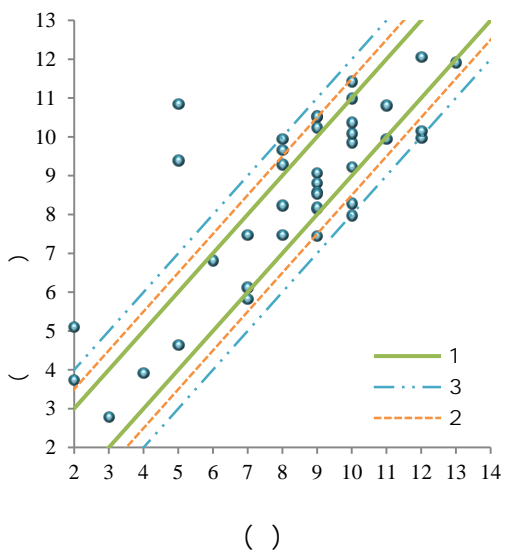
()

-4

(-5) 79
1,17

2 1,5 1
88 70 50

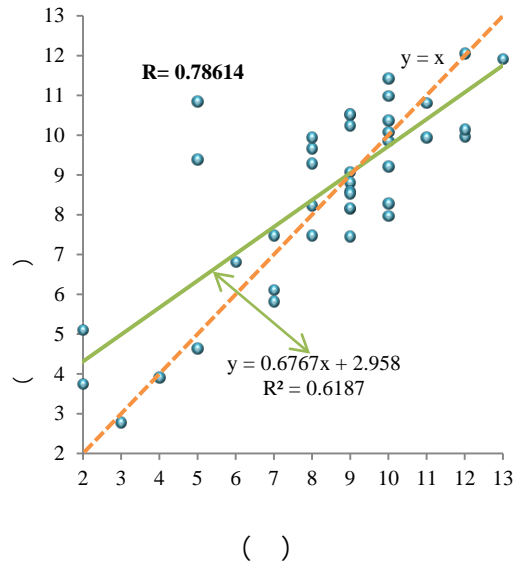
-5



(9x8x1)

) 0,5

(10,5 10
40



-5

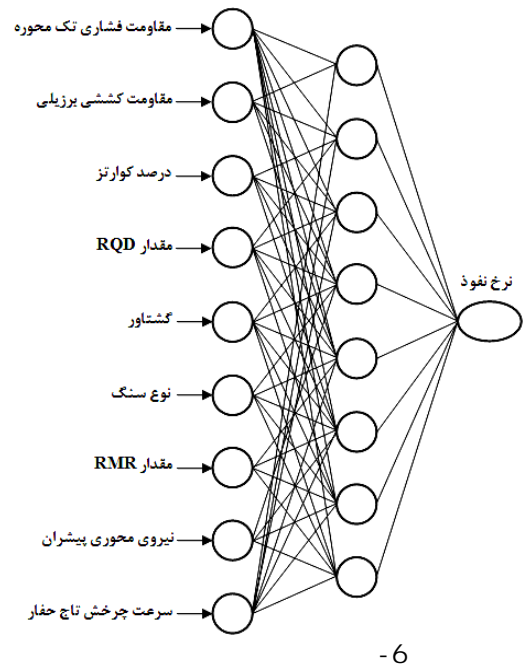
(RPM)

8
(9x8x1)

9
1

(6)

6

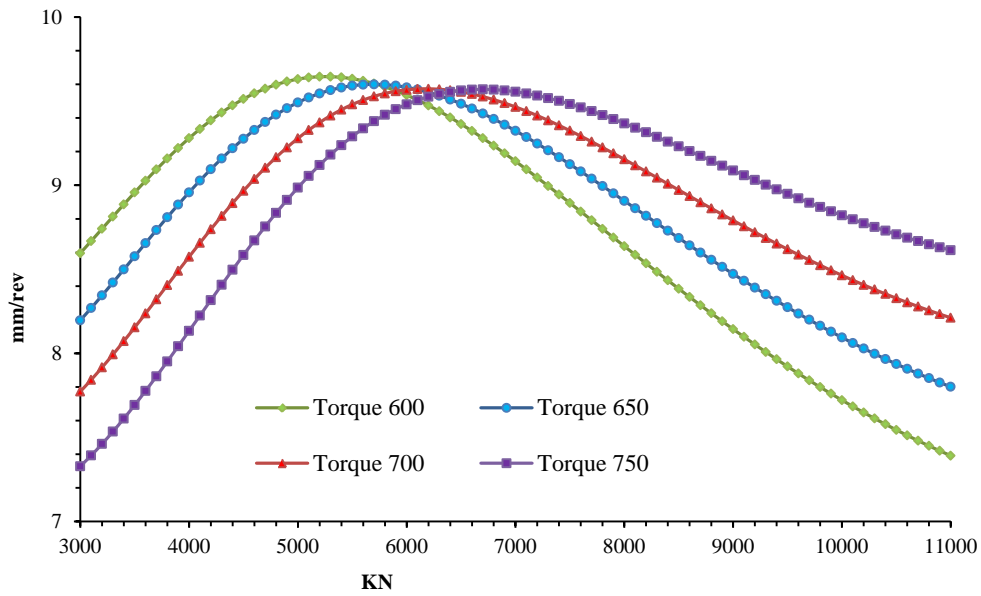


-6

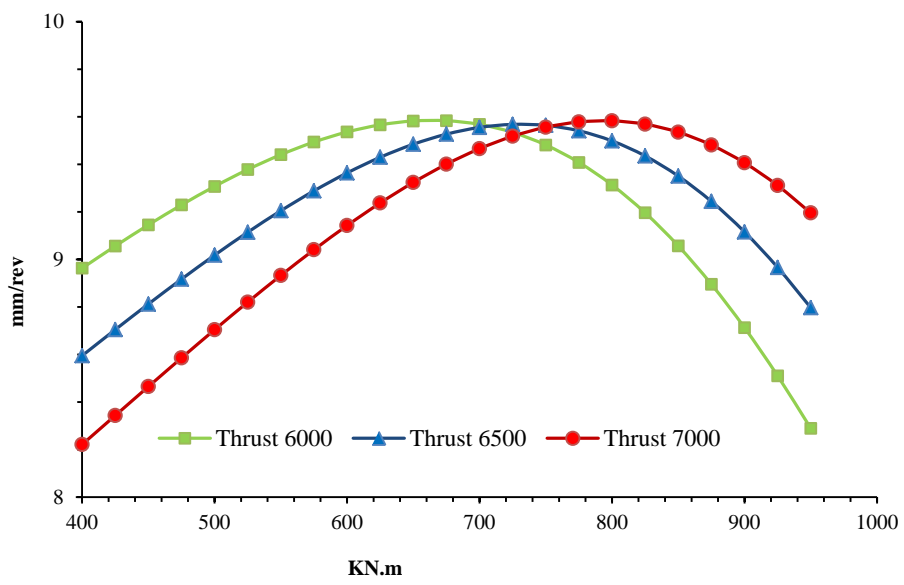
-6

125	(MPa)	
0,5		
4,25	(MPa)	
85		(%) RQD
57		RMR

7



-7



8

79

TBM

(Heuristic)

- 6

- [1] Roxborough, F. F., & Phillips, H. R. (1975). Rock Excavation by Disc Cutter. *International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts*, 12(12), 361-366. [http://dx.doi.org/10.1016/0148-9062\(75\)90547-1](http://dx.doi.org/10.1016/0148-9062(75)90547-1).
- [2] Sanio, H. (1985). Prediction of the Performance of Disc Cutters in Anisotropic Rock. *International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts*, 22(3), 153-161. [http://dx.doi.org/10.1016/0148-9062\(85\)93229-2](http://dx.doi.org/10.1016/0148-9062(85)93229-2).
- [3] Nilson, B., & Ozdemir, L. (1993). Hard Rock Tunnel Boring Prediction and Field Performance. In L. D. Bowerman & J. E. Monsees (Ed.), *Proceeding of Rapid Excavation and Tunneling Conference* (pp. 833-852). Boston: Society for Mining Metallurgy. ISBN: 9780873351270.
- [4] Tarkoy, P. J. (1974). Prediction TBM Penetration Rate in Selected Rock Types. *Proceeding of the Ninth Canadian Rock Mechanics symposium* (pp. 257-269). Montreal: Mines Branch, Department of Energy, Mines and Resources.
- [5] Graham, P. C. (1976). Rock Exploration for Machine Manufacturers. In Z. T. Bieniawski (Ed.), *Exploration for Rock Engineering: Proceedings of The Symposium on Exploration for Rock Engineering* (pp.173-180). Johannesburg: A A Balkema. ISBN: 9780869610893.
- [6] Farmer, I. W., & Glossop, N. H. (1980). Mechanics of Disc Cutter Penetration. *Tunnels and Tunneling International*, 12, 622-625.
- [7] Nelson, P., O'Rourke, T. D., & Kulhawy, F. H. (1983). Factors Affecting TBM Penetration Rates in Sedimentary Rocks. In C. Christopher (Ed.), *24th U.S. Symposium on Rock Mechanics* (pp. 227-237). Texas: American Rock Mechanics Association.

- [8] Cassinelli, F., Cina, S., Innaurato, N., Mancini, R., & Sampaolo, A. (1982). Power Consumption and Metal Wear in Tunnel-Boring Machines: Analysis of Tunnel-Boring Operation in Hard Rock. In M. J. Jones (Ed.), *Tunnelling 82* (pp. 73-81). London: Institution of Mining and Metallurgy. ISBN:090048862X.
- [9] Innaurato, N., Mancini, A., Rondena, E., & Zaninetti, A. (1991). Forecasting and Effective TBM Performances in a Rapid Excavation of a Tunnel In Italy. *7th ISRM Congress* (pp. 1009-1014). Aachen: International Society for Rock Mechanics.
- [10] Park, C. W., Park, C., Synn, J. H., Sunwoo, C., & Chung, S. K. (2001). TBM Penetration Rate with Rock Mass Properties in Hard Rock. *AITES-ITA 2001 World Tunnel Congress* (pp. 413-419). Milano. ISBN: 9788855525947.
- [11] Hassanpour, J., Rostami, J., & Zhao, J. (2011). A New Hard Rock TBM Performance Prediction Model for Project Planning. *Tunnelling and Underground Space Technology*, 26(5), 595-603. <http://dx.doi.org/10.1016/j.tust.2011.04.004>.
- [12] Bruland, A. (2000). *Hard Rock Tunnel Boring*. Trondheim: Doctoral thesis, Norwegian University of Science and Technology, Engineering Science and Technology. ISBN:8247102811.
- [13] Barton, N. R. (2000). *TBM Tunnelling in Jointed and Faulted Rock*. Rotterdam: A A Balkema. ISBN:9058093417.
- [14] .(1391) . . . [14]
.9789644630873
- [15] Grima, M. A., Bruines, P. A., & Verhoef, P. W. (2000). Modelling Tunnel Boring Machine Performance by Neuro-Fuzzy Methods. *Tunnelling and Underground Space Technology*, 15 (3), 259-269. [http://dx.doi.org/10.1016/S0886-7798\(00\)00055-9](http://dx.doi.org/10.1016/S0886-7798(00)00055-9).
- [16] .(1385) . . . [16]
.121-115 (1)40
- [17] Yagiza, S., Gokceoglu, C., Sezer, E., & Iplikci, S. (2009). Application of Two Non-Linear Prediction Tools to The Estimation of Tunnel Boring Machine Performance. *Engineering Applications of Artificial Intelligence*, 22 (4-5), 808-814. <http://dx.doi.org/10.1016/j.engappai.2009.03.007>.
- [18] Gholamnejad, J., & Tayaran, N. (2010). Application of Artificial Neural Networks to The Prediction of Tunnel Boring Machine Penetration Rate. *Mining Science and Technology(China)*, 20 (5), 727-733. [http://dx.doi.org/10.1016/S1674-5264\(09\)60271-4](http://dx.doi.org/10.1016/S1674-5264(09)60271-4).
- [19] Torabi, S. R., Shirazi, H., Hajali, H., & Monjezi, M. (2011). Study of The Influence of Geotechnical Parameters on The TBM Performance in Tehran-Shomal Highway Project Using ANN and SPSS. *Arabian Journal of Geosciences*. <http://dx.doi.org/10.1007/s12517-011-0415-3>.
- [20] Khademi Hamidi, J., Shahriar, K., Rezai, B., & Rostami, J. (2010). Performance Prediction of Hard Rock TBM Using Rock Mass Rating (RMR) System. *Tunnelling and Underground Space Technology*, 25 (4), 333-345. <http://dx.doi.org/10.1016/j.tust.2010.01.008>.
- [21] .2026 . . . (1386) . [21]

- [22] Demuth, H., Beale, M., & Hagan, M. (2006). *Neural Network Toolbox for Use with Matlab: User's Guide, 5th*. Natick, Massachusetts, United States of America: The Mathworks, Inc.
- . : . *TBM* .(1382). [23]
- .9786005237009: . : *MATLAB* .(1389). [24]
- TBM* .(1389) . . [25]
- [26] Eftekhari, M., Baghbanan, A., & Bayati, M. (2010). Predicting Penetration Rate of A Tunnel Boring Machine Using Artificial Neural Network. In K. G. Sharma (Ed.), *ISRM International Symposium-6th Asian Rock Mechanics Symposium-Advances in Rock Engineering*. New Delhi, India: International Society for Rock Mechanics.
- [27] Hornik, K. (1989). Multilayer Feed Forward Networks Are Universal Approximators. *Neural Networks*, 2(5), 359-366. [http://dx.doi.org/10.1016/0893-6080\(89\)90020-8](http://dx.doi.org/10.1016/0893-6080(89)90020-8).
- [28] Hecht-Nielsen, R. (1989). Theory of The Back-Propagation Neural Network. *International Joint Conference on Neural Networks* (pp. 593-605). Washington, DC, USA: IEEE TAB Neural Network Conference. <http://dx.doi.org/10.1109/IJCNN.1989.118638>.
- [29] Cybenko, G. (1989). Approximation by Superpositions of A Sigmoidal Function. *Mathematics of Control, Signals and Systems*, 2 (4), 303-314. <http://dx.doi.org/10.1007/BF02551274>.
- [30] Basheer, I. A. (2000). Selection of Methodology for Neural Network Modeling of Constitutive Hysteresis Behavior of Soils. *Computer-Aided Civil and Infrastructure Engineering*, 15(6), 445-463. <http://dx.doi.org/10.1111/0885-9507.00206>.
- [31] Berke, L., & Hajela, P. (1991). Application of Neural Networks in Structural Optimization. *NATO-DFG Advanced Study Institute on optimization of large structural systems* (pp. 731-745). Berchtesgaden: Springer. ISBN:0792321294.
- [32] Hecht-Nielsen, R. (1987). Kolmogorov's Mapping Neural Network Existence Theorem. In M. Caudill (Ed.), *1st IEEE International Conference on Neural Networks* (pp. 11-14). San Diego. California.
- [33] Caudill, M. (1988). Neural Networks Primer, Part III. *AI Expert*, 3 (6), 53-59. ISSN:0888-3785.