





دانشگاه صنعتی شاهرود

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تقدیم بہ

ہمسفر مہربانم

و

فرزندان عزیزم

تقدیر و تشکر

بر خود و طیف می دانم که از زحمات آقایان دکتر سید رحمان ترابی و دکتر محمد عطائی به خاطر راهنمایی های ارزنده شان در طول انجام رساله تشکر و سپاسگزاری نمایم.

از استاد مشاور آقای دکتر کامران گشتابی که زحمت مشاوره این تحقیق را بر عهده داشتند تشکر نمایم. از مدیران محترم شرکت زغالسنگ البرز شرقی به خاطر مساعدت ایشان و همچنین پرسنل محترم معادن منطقه کمال تشکر و سپاسگزاری را دارم.

از اساتید محترم دانشکده مهندسی معدن دانشگاه صنعتی شاهرود که در طول تحصیل بنده رایاری رسانند، سپاسگزارم. از تمامی دوستان عزیز خودم بویژه آقایان احمد آریافر، حسین میرزایی نصیر آباد، رضا شکور شهبانی، محمد کاراموزیان و خداکرم غریبی که بحضات شیرینی را با آنها در طول تحصیل تجربه کردم، سپاسگزارم.

از پرسنل محترم آموزشی، اداری، فزاینکی و خدماتی دانشگاه صنعتی شاهرود بالانص پرسنل محترم دانشکده معدن کمال تشکر و سپاسگزاری را دارم.

دانشجو تأیید می نماید که مطالب مندرج در این رساله نتیجه تحقیقات خودش می باشد و در صورت استفاده از نتایج دیگران مرجع آن را ذکر نموده است.

کلیه حقوق مادی مترتب از نتایج مطالعات ، آزمایشات و نوآوری ناشی از تحقیق موضوع این رساله متعلق به دانشگاه صنعتی شاهرود می باشد .

محمد جوانشیر

اسفند ۱۳۸۷

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Dips-5

عناوین مقالات مستخرج از رساله دکتری

مقالات چاپ شده در کنفرانس های ملی

- ترابی، سید رحمان، جوانشیر محمد، ۱۳۸۵، اعتبار استفاده از جکش اشمیت در آزمایشات برجا و آزمایشگاهی برای تعیین مقاومت سنگ و ارزیابی پایداری سقف در کارگاه های استخراج زغالسنگ، مجموعه مقالات دومین همایش منطقه ای معدن و علوم وابسته، دانشگاه آزاد اسلامی، واحد طبس، اول خرداد ۱۳۸۵
- غریبی خداکرم، حسنی سعید، جوانشیر محمد، تعیین تابع شکست و تابع انتخاب کانسنگ اسفوردی توسط نرم افزار BFDS در آسیای میله ای، دومین کنفرانس مهندسی معدن، آبان ۱۳۸۷

مقالات چاپ شده در کنفرانس های بین المللی

- Sayed Rahman Torabi, F. Sereshki, M. Zare, Mohammad Javanshir, An Empirical Approach in Prediction of the Roof Rock Strains in Underground Coal Mines, Proceedings of the 2008 Coal Operators Conference, University of Wollongong, NSW
- Mohammad Javanshir, Dr. Mohammad Ataei, Sayed Rahman Torabi, 2008, Assessment of weathering and moisture effect on roof rock behaviour in East Albors coal mines, SGEM 2008. 8th International Scientific Conference, 16-20 June 2008 Bulgaria

مقالات چاپ شده ژورنالی

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۱-۲- میزان ذخایر و تولید زغال سنگ در ایران

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فصل دوم:

۱-۲- روش‌های متداول استخراج زغال سنگ در معادن ایران

۲-۱-۴- تنش در اطراف منطقه کاری در جبهه کار طولانی

الف- فشاری که به بخش جلویی کارگاه وارد می‌شود

ب- فشاری که به طرفین کارگاه وارد می‌شود

ج- فشاری که به قسمت پشت کارگاه وارد می‌شود

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(Peng)

(Peng, Hsiung, and Jiang, 1987)

(N)

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Peng

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CMRR

CMRR

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جدول ۱-۱- وضعیت تولید زغال سنگ و کنسانتره طی سه سال گذشته در مناطق عمده زغال دار ایران

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| (RQI) | | | |

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| K_{10} | | - |
| P_{15} | | |
| P_{15} | | - |

فصل اول

کلیات

(<http://www.en.wikipedia.org/wiki/coal>)

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.(Crickmer and Zegeer, 1981)

Brendow,)

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(2005)

(<http://www.en.wikipedia.org/wiki/coal>)

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(Brendow, 2005)

(Molinda, 2003)

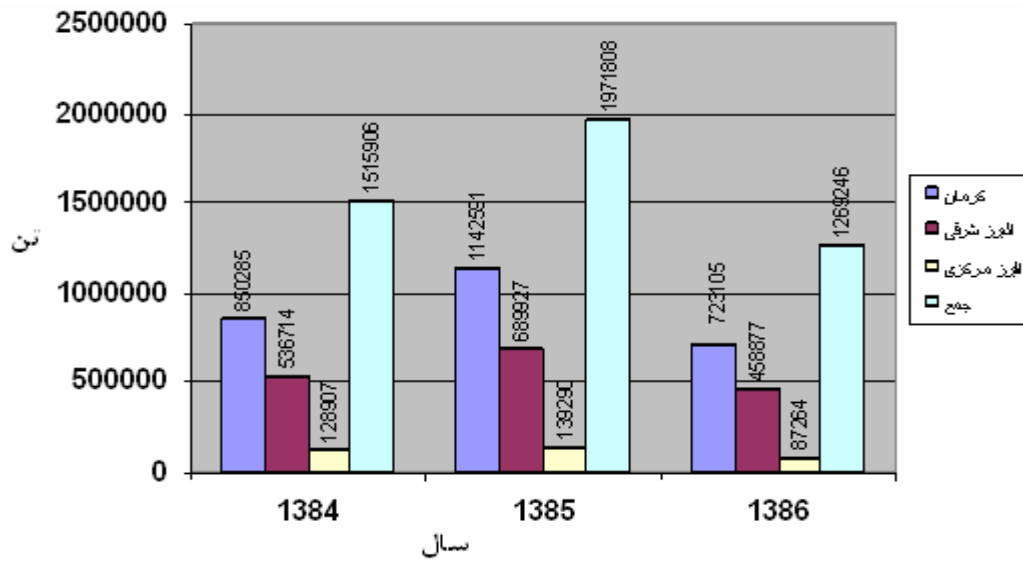
2 – World Bank

1 - Frankfurter allgemeine
2 - Peneumoconiosis

/

(<http://www.en.wikipedia.org/wiki/coal>)

/



شکل ۱-۱- نمودار سهم تولید معادن حوضه البرز شرقی از مجموع تولید زغال سنگ کشور (وزارت صنایع و معادن، معاونت معدنی، ۱۳۸۶)

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.(Unrug *et al*, 1980)

.(Mark *et al*, 2005)

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- 1- Coal Mine Roof Rating (CMRR)
 - 2- Coal Measure Classification (CMC)

فصل دوم

تعریف واژه‌های متداول در رفتار سنگ سقف در روش جبهه کار طولانی

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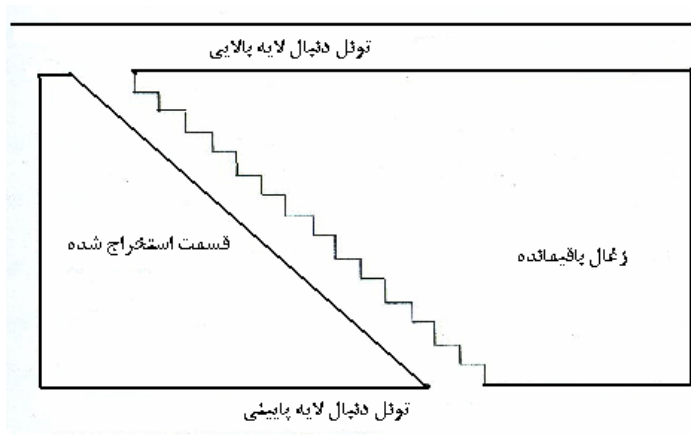
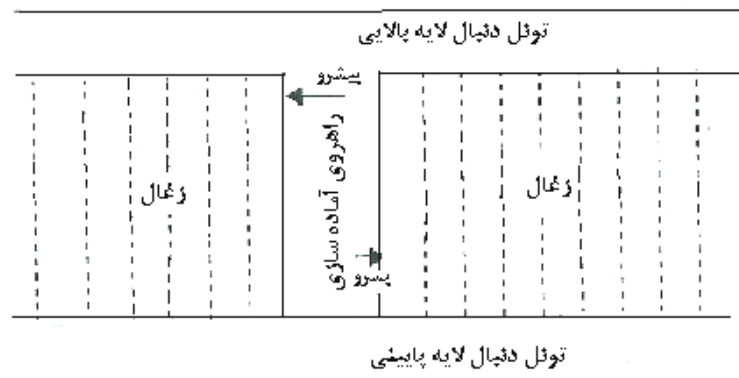
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.(Golosinski,2000)

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- 1- Coal recovery
 - 2- Rock bolt
 - 3- Overburden

(Peng, 1986)

(Peng, 1986)

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(YY)

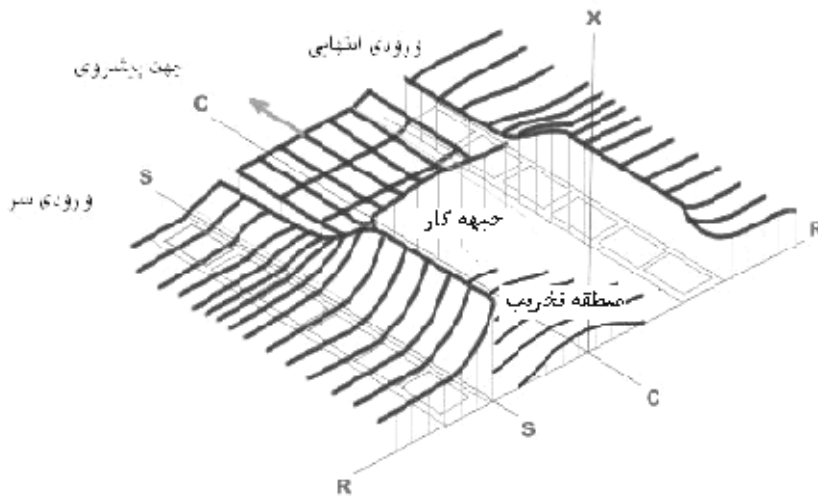
(ρ_0)

(ρ_0)

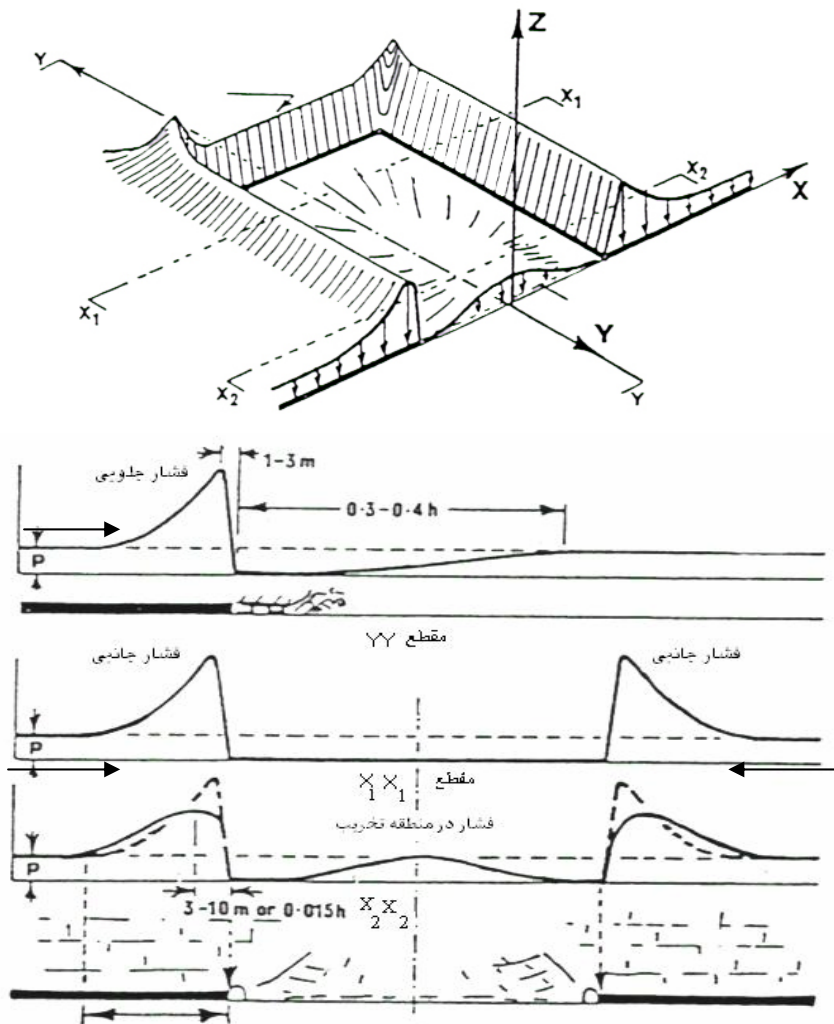
(X₁X₁)

X₂X₂

-
- 1- Front abutment pressure
 - 2- Side abutment pressure
 - 3- Gob pressure



(Modified by UOW)



شکل ۲-۴- توزیع مجدد فشار در اطراف یک کارگاه جبهه کار طولانی در مقاطع مختلف (Peng, 1986)

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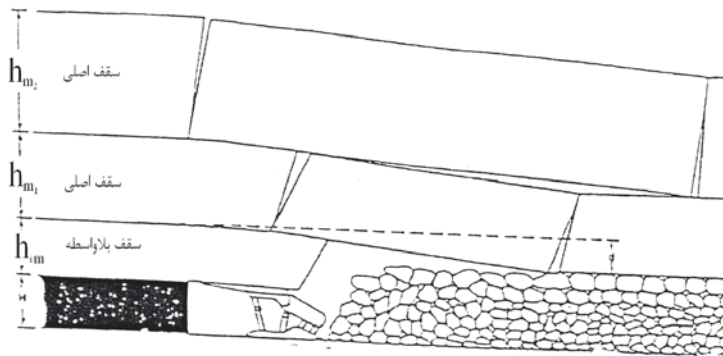
.(Crickmer and Zegeer, 1981)

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.(Peng, 1986)

1- Immediate roof
2 - Main roof

(Peng, 1986)



(Peng, 1986)

(Peng, 1986)

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$$h_{im} = \frac{H - d}{K - 1}$$

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:

: h_{im}

: H

: k

/ /

: d

1 - Caving height

(Peng,

1986)

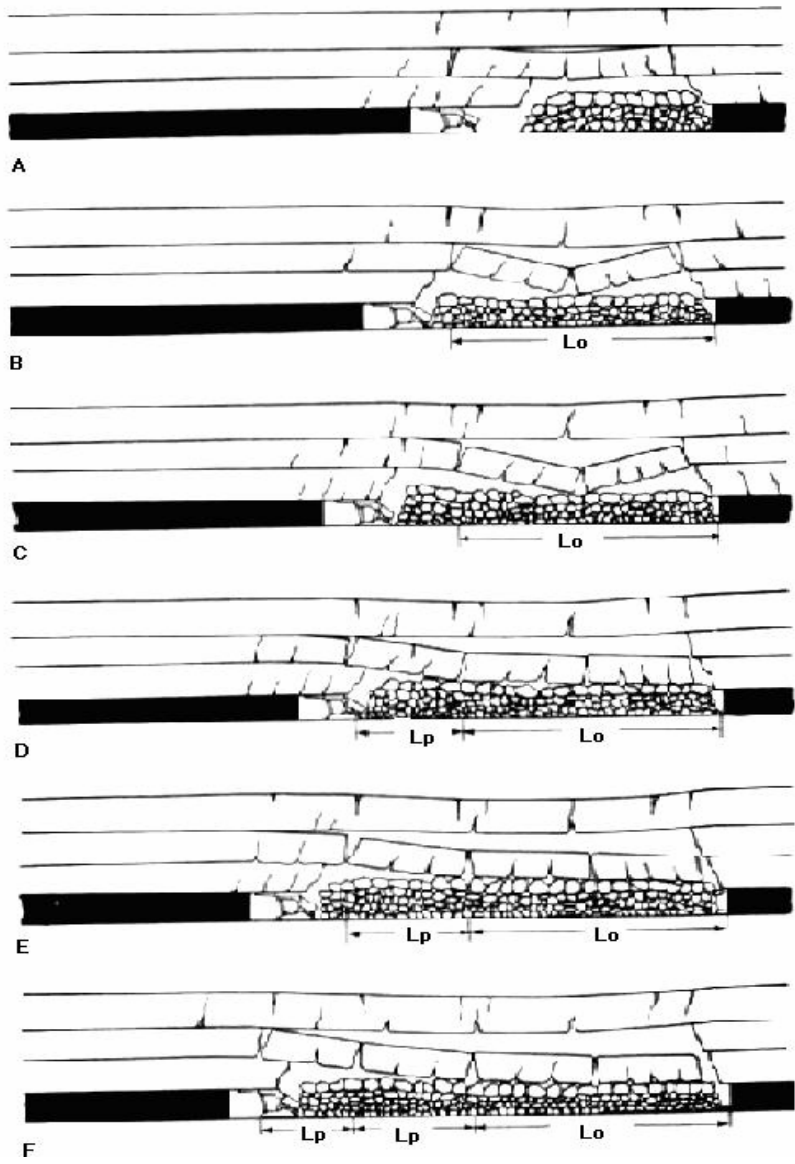
-

(-) .(Peng, 1986)

(L_p)

(L_0)

-
- 1- First roof weighting
 - 2- First roof weighting interval
 - 3-Periodic roof weighting
 - 4-Periodic roof weighting interval



(Peng, 1986)

فصل سوم

بررسی سابقه علمی موضوع

Q RMR

Q

RMR Q

.(Canbulat *et al*, 2002)

-
- 1 – Wickham
 - 2 – Barton
 - 3 - Bieniawski
 - 4 - Rock Mass Rating (RMR)
 - 5 –Djahanguiri
 - 6- Wyoming
 - 7- Rafia
 - 8 – Newman
 - 9- Rock Structure Rating (RSR)

. (Canbulat

et al, 2002)

() () :
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Q RMR

-
- 1- Laubscher and Tylor
 - 2- Laubscher
 - 3- Laubscher and Page
 - 4- Kendorski
 - 5- Cummings et al
 - 6- Modified Rock Mass Rating (MRMR), Modified Basic RMR (MBR)

CMRR

.(Canbulat *et al*, 2002)

1- Mark
2- Molinda

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.(Peng

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:(Peng *et al*, 1985)

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(Peng

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.(Bieniawski, 1997)

(Bieniawski, 1997)

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- 1 - Proyavkin
 - 2 - Roof Quality Index (RQI)
 - 3 - Unstable immediate roof
 - 4 - Medium stable immediate roof
 - 5 - Stable immediate roof

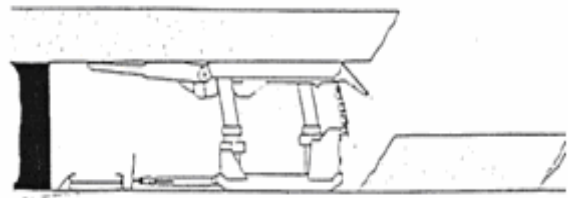
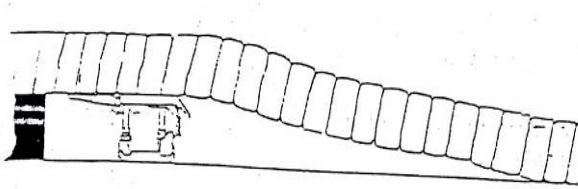
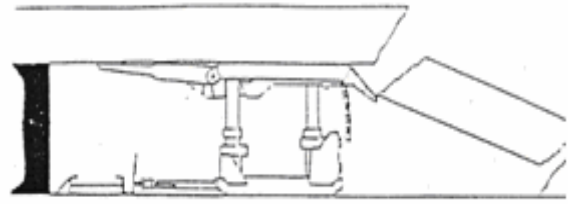
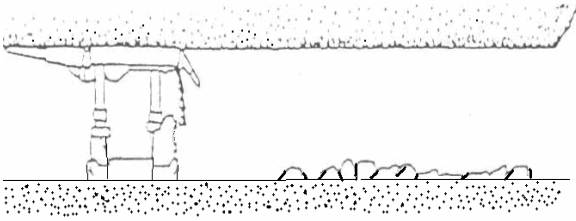
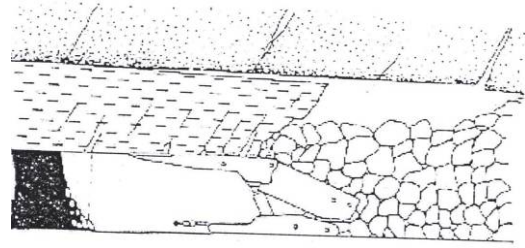
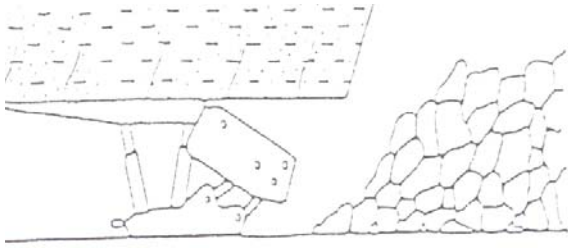
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| | | - A |
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| | C_1 | - C |
| | C_2 | |
| | C_3 | |

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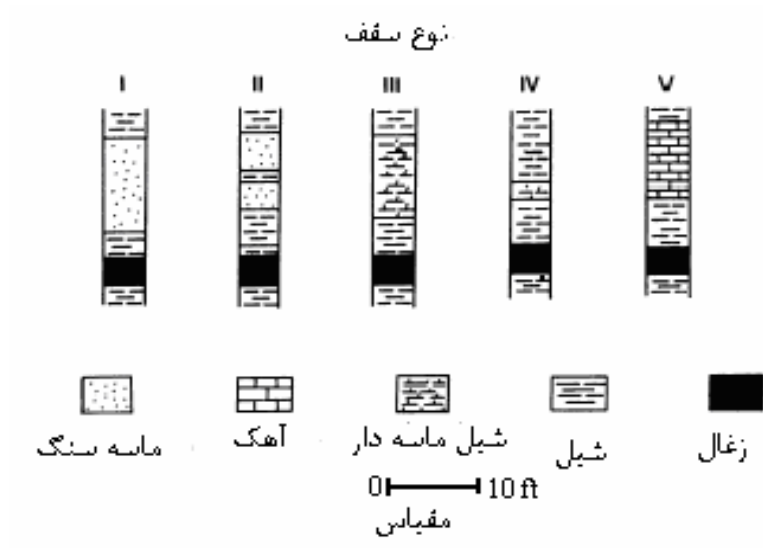
.(Peng *et al*, 1992)

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(Peng, 1984) Peng



(Peng *et al.*, 1992)

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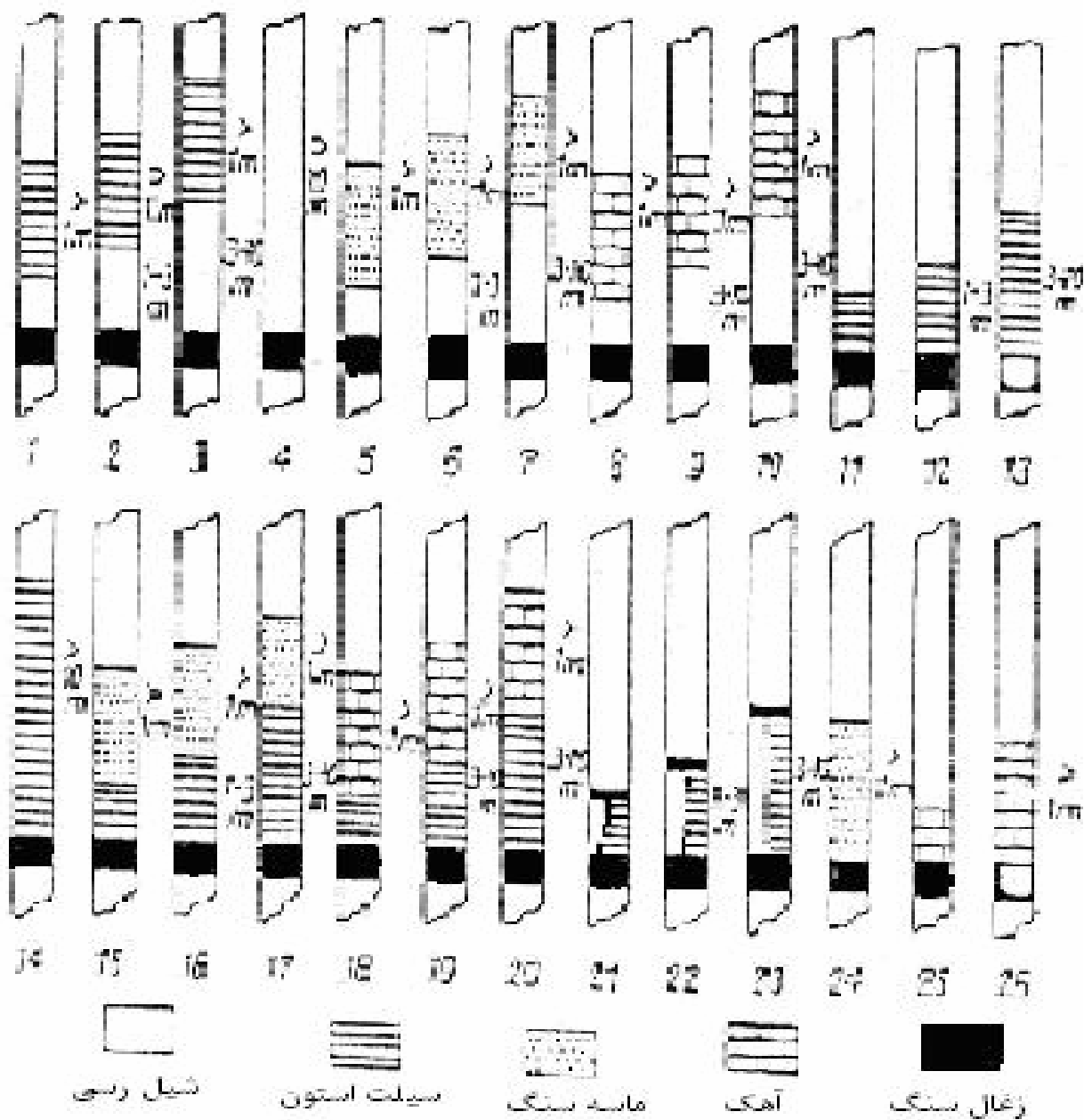
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- 1 - Proyavkin
 - 2 - Donetsk
 - 3 - Overhang



(Proyavkin *et al*, 1973)

() (Peng, 1984)

$$L_{0im} = \sqrt{\frac{2h_{im} \times T_{im}}{\gamma_{im}}} \quad ()$$

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: L_{oim}

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: h_{im}

: T_{im}

: γ_{im}

(Hongzhu, 1996)

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| > | - | | < | |

σ_1

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(σ_1)

.(Hongzho, 1996)

$$\sigma_1 = C_{oim} \times C_1 \times C_2$$

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:

: C_{oim}

: C_1

: C_2

.(Hongzho, 1996)

$C_2 C_1$

C₂ C₁

(Hongzho, 1996)

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(Hongzho, 1996)

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(N)

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(Hongzho,

N

:1996)

$$N = \frac{h_{im}}{H} \quad ()$$

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:N

: h_{im}

:H

N

(Hongzho, 1996)

N

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(RQI)

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$$L = 0.016 \times C_s \times d$$

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: C_s

: d

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C_s

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- 1 - Hongzhu, Z
 - 2- Rock Quality Index (RQI)
 - 3 - Unrug
 - 4 - Szwilski

$$C_s = C \times K_1 \times K_2 \times K_3 \quad ()$$

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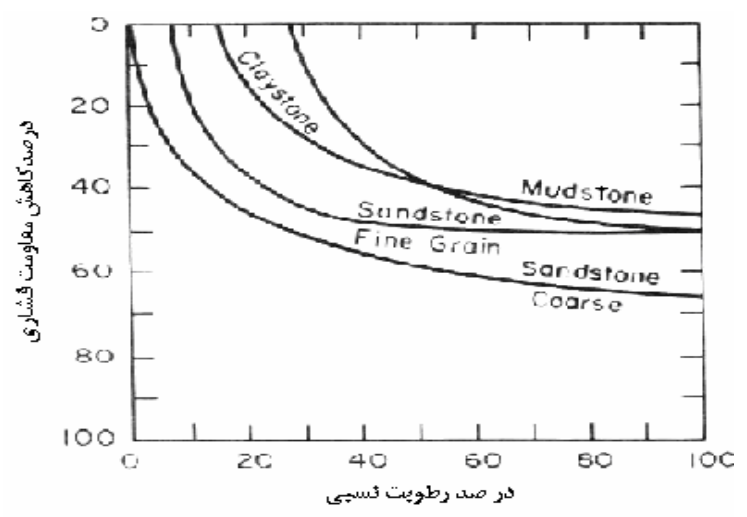
- / / :k₁

/

:K₂

/ /

- / :K₃



(Unrug et al, 1980)

L

.(Unrug *et al*, 1980)

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| > | | - | A |
| | | > | B |

L (RQI)

.(Unrug *et al*, 1980)

$$L=0.0064.C^{1.7}.K_1.K_2.K_3 \quad ()$$

:(Unrug and Szwilski, 1980) L

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$$R=4.47.L^{0.4} \quad ()$$

S

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$$S=5.h.L^{0.3}$$

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h

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(Unrug *et al*, 1980)

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$$P = \frac{H \times r}{0.222 - 0.0109 \times r}$$

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:P

:H

:r

h

$$H=1.33.h :$$

-

N σ L

P₁₀

(CMRR)

RQD RMR ,Q

2- Coal Mine Roof Rating (CMRR)
3- Mark
4- Molinda

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.(Mark et al,

2005)

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¹ -Buddery and Oldroyd

² - Damberger *et al*

³ - Ealy *et al*

⁴ - Hylbert

⁵ - Karmis and Kane

⁶ - Kester and Chugh

⁷ - Martin *et al*

⁸ - Milici *et al*

⁹ - Miler

¹⁰ - Moebs and Ferm

¹¹ - Moebs and Stacham

¹² - Newman and Bieniawski

¹³ - Schaffer

¹⁴ -Sinha and Venkateswarlu

¹⁵ - Venkateswarlu *et al*

¹⁶ - Stingelin *et al*

(CMRR)

CMRR

¹ - Zhou *et al*
7 - Longwall pillar desin

CMRR

(ALPS)

RMR

CMRR

(Mark and Molinda, 2005)

CMRR

RMR

CMRR

CMRR

CMRR

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- 1- Analysis of Longwall Pillar Stability (ALPS)
 - 1- Uniaxial Compressive Strength (UCS)
 - 2- Discontinuity intensity
 - 3- Shear strength of discontinuity
 - 4- Moisture sensitivity

CMRR

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CMRR

RMR

5- Strong bed

(ISRM)

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(CMRR)

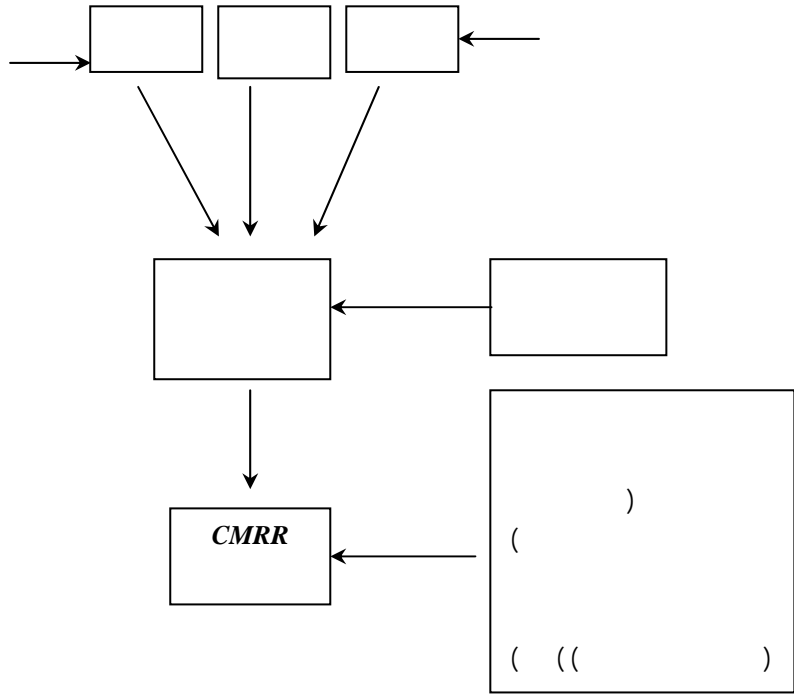
(CMRR)

(CMRR)

(RMR)

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(Mark and Molinda, 2005)

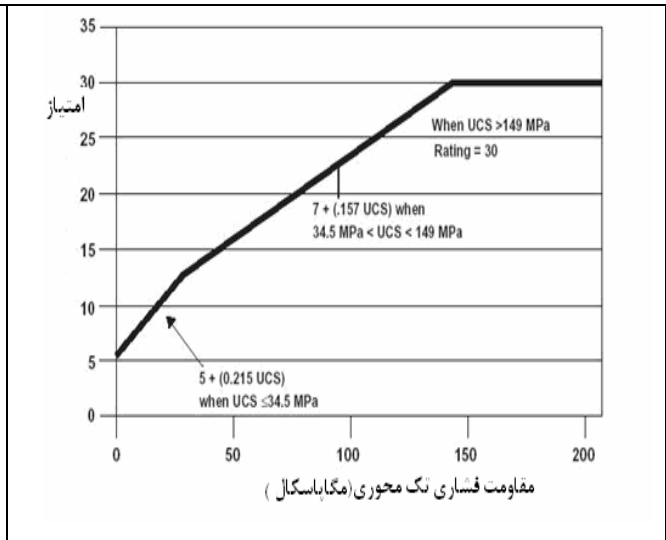
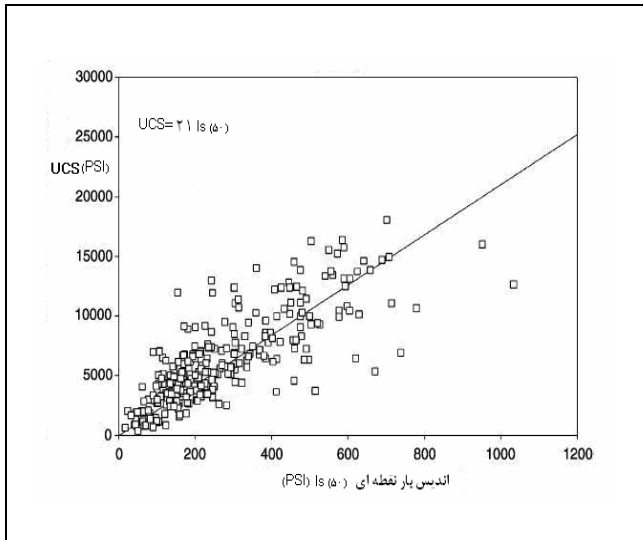
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| / | > / | | < | | | | Rebounds =1 | <p>1 2 3</p> <p>Rebound Pits Dents</p> <p>>120 Mpa 70-120 Mpa 35-70 Mpa</p> <p>4 5</p> <p>Craters Molds</p> <p>14-35 Mpa <14 Mpa</p> | | |
| / | / | | () | | | Pits =2 | | | | |
| | | | () | | | Dents =3 | | | | |
| > | | | () | | | Craters =4 | | | | |
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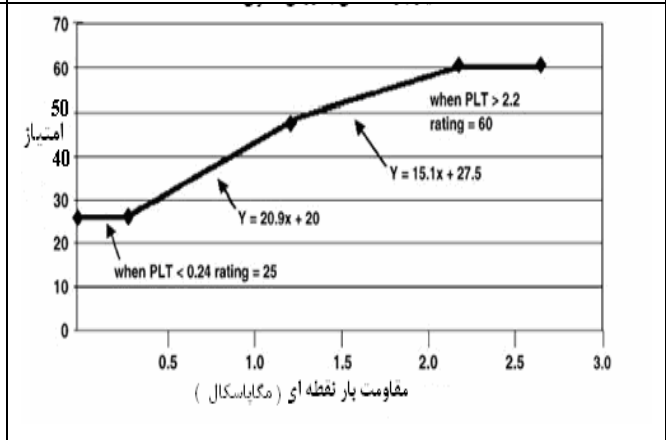
CMRR

(Mark and Molinda, 2005)

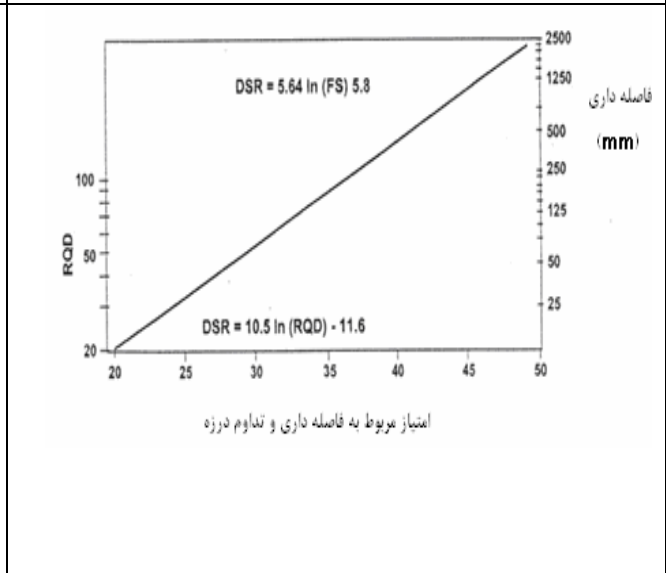
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CMRR

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Place change mining -¹
2-Ball pin hammer

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.(Whittles *et al*, 2006)

.(Anderson *et al*, 1979)

.(Whittles *et al*, 2002)

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- 1- Coal Measure Classification (CMC)
 - 2- cyclothem
 - 3- Bedding
 - 4- Lamination planes
 - 5- Shaleyness
 - 6 -Anisotropy

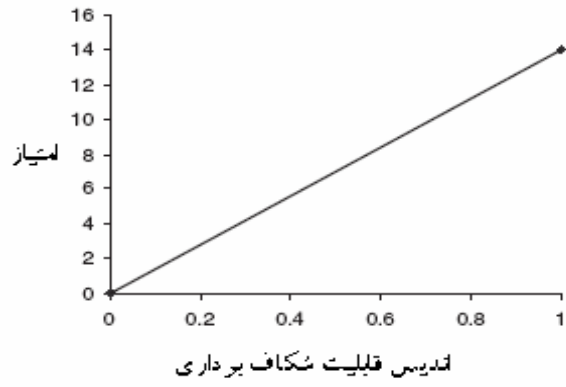
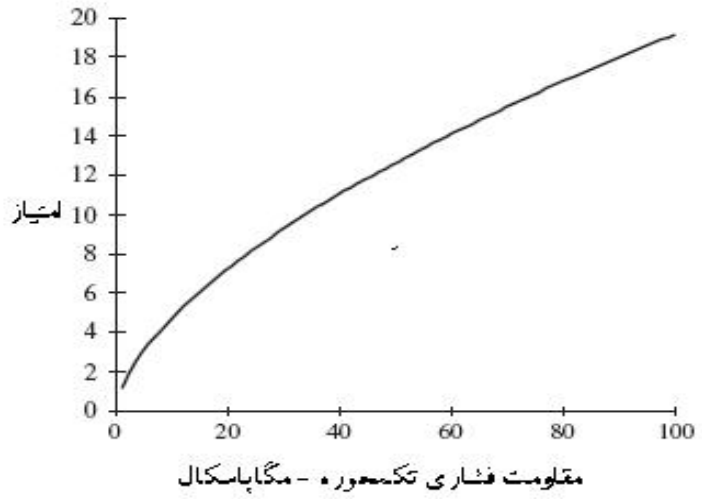
(Whittles, 1999)

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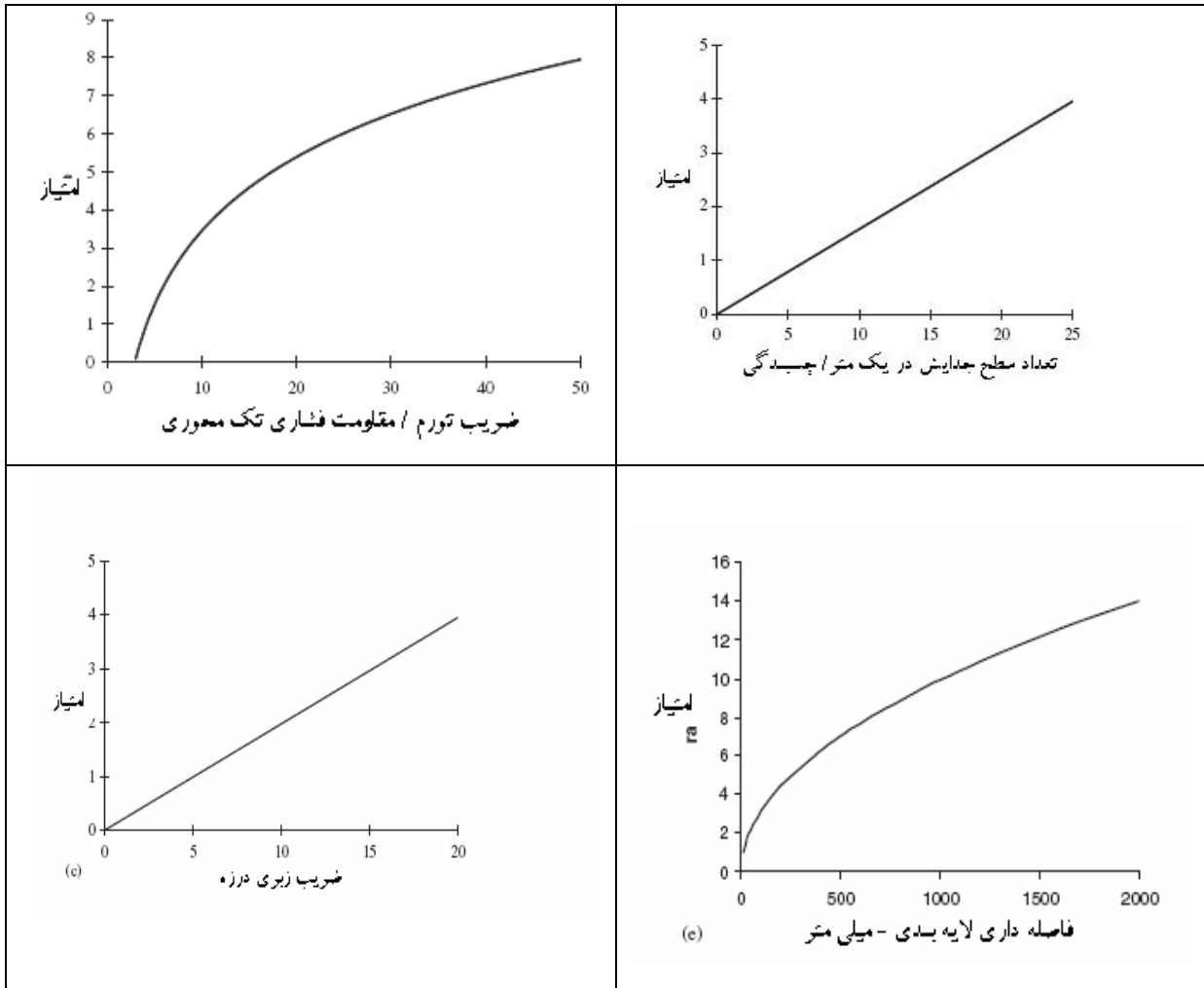
-
- 1- Discrete values
 - 2- Continuosly varying values

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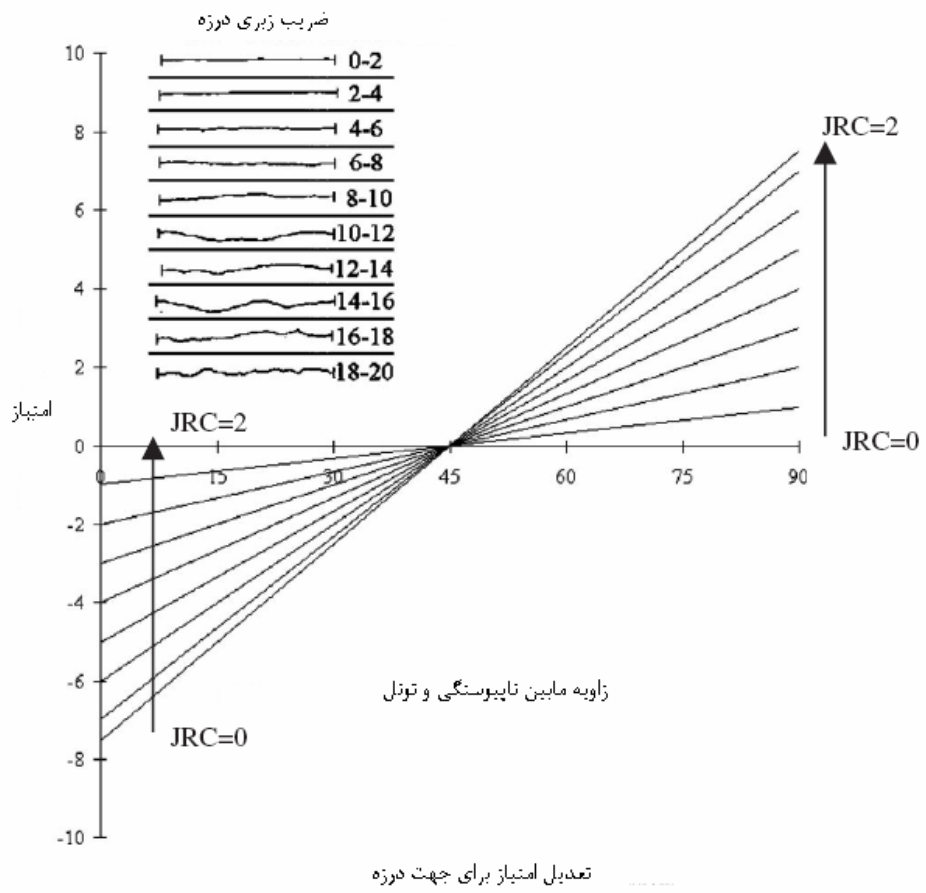


CMC



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CMC



CMC

فصل چهارم

اطلاعاتی در مورد زمین شناسی و معادن منطقه البرز شرقی

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¹ - SUITE

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¹ - Anticlinal

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فصل پنجم

رده بندی پیشنهادی برای رفتار سنگ سقف

:(Canbulat & Dlokweni, 2002)

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- 1- Analytical methods
 - 2- Geological methods
 - 3 -Observational methods
 - 4-Empirical methods

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- 1 - core drilling
 - 2- geological mapping
 - 3 - roof fall mapping

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(Canbulat and Dlokweni,

.2002)

¹ Vutukuri

² -Bieniawski

³ - Kirkaldi

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1-Whittles *et al*
2- Conceptual models

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1-Rusnak. and Mark
2-Das
3-Vandermerow

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| : | : | : | : | :(RQD) | : | OCRS ¹ 2000 |
| : | : | : | : | : | (UCS) : | CMRR 2005 |
| : | : | : | : | : | :(UCS) | CMC 2007 |

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(RQD)

(UCS)

4-Observations and classification of roof strata behaviour over longwall coal mining in India

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(UCS)

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(PLT)

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- 1- Uniaxial Compressive Strength (UCS)
 - 2- Point Load Test (PLT)
 - ³- Schmidt hammer

.(Buyuksagis et al, 2007)

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.(Katz et al, 2000)

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.(Amaral et al, 1999)

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¹ - Katz
² - Amaral
³ - Lisbon
⁴ - Yilmaz and Sendir
⁵ - Sivas

(Yilmaz *et al*, 2002)

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(Brown, 1981 ISRM)

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| MPa | / | / | / | P |
| / MPa ^P | / | / | / | PT |

(Brown, 1981) ISRM

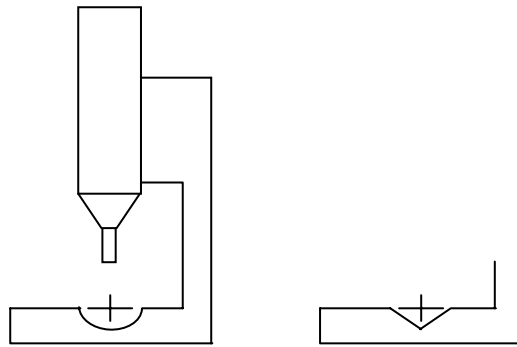
(Yilmaz,

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Sender, 2002).

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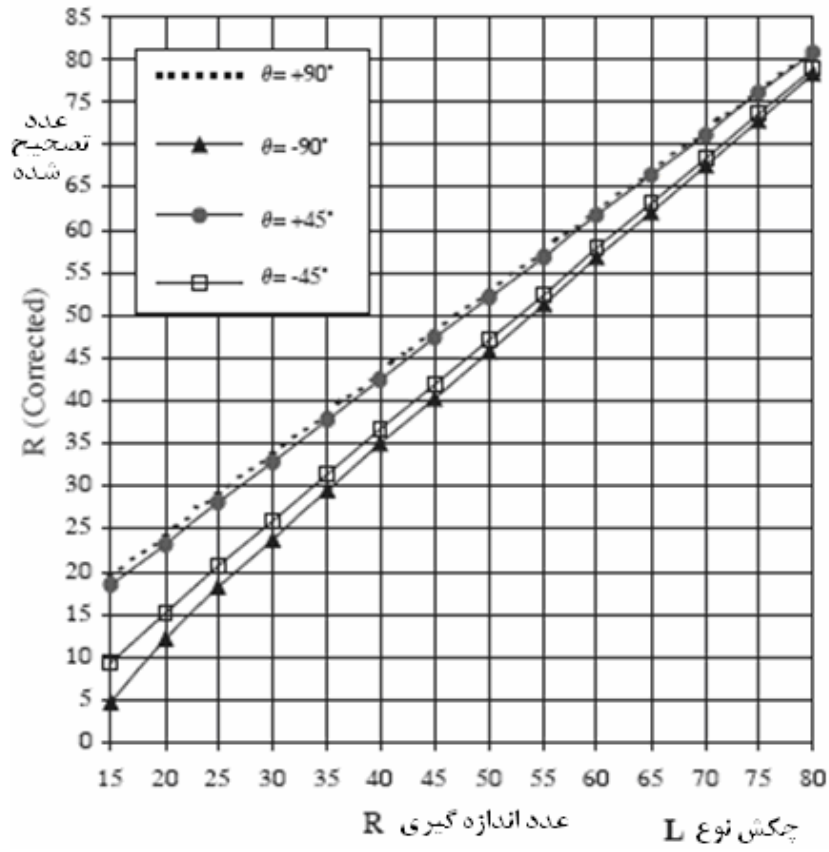


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(ISRM, 1981) .

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(Basu et al, 2004)



(Basu et al, 2004)

(Buyuksagis et al, 2007)



(Buyuksagis and Goktan, 2007)

= /

ISRM

(Goktan *et al*, 1993)

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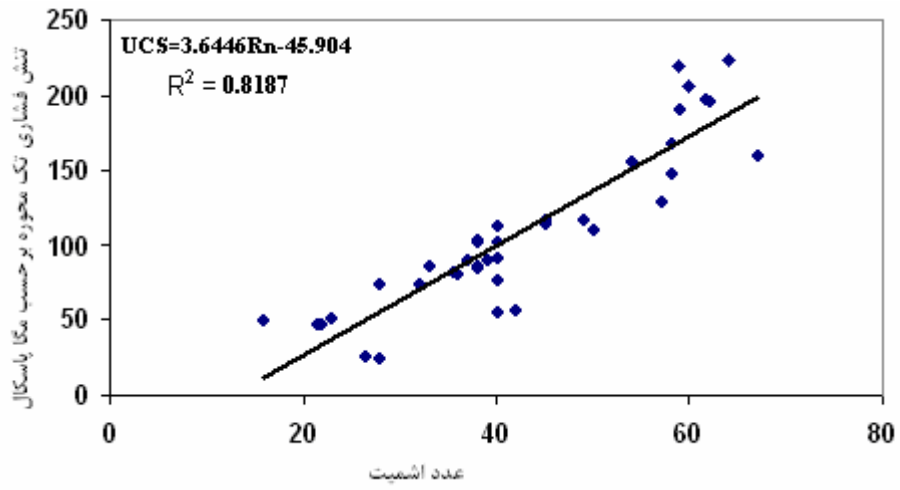
$\alpha =$



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| | Mpa | mm ² | (KN) | | | |
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$UCS = 3.6446 R_n - 45.904$

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Rn

UCS

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(Kidybinski, 1979)

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(Peng *et al*, 1987)

(Peng *et al*, 1983)

$$L_{0im} = \sqrt{\frac{2h_{im} \times T_{im}}{\gamma_{im}}} \quad ()$$

:

: L_{0im}

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: h_{im}

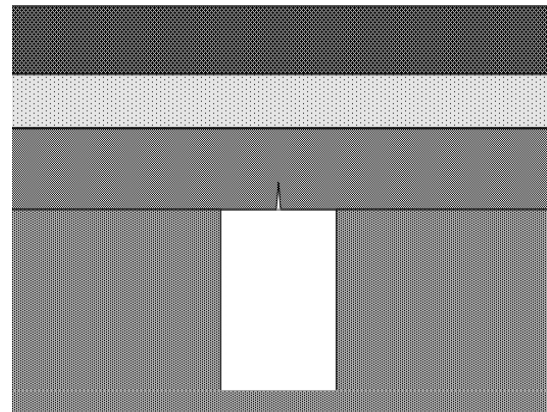
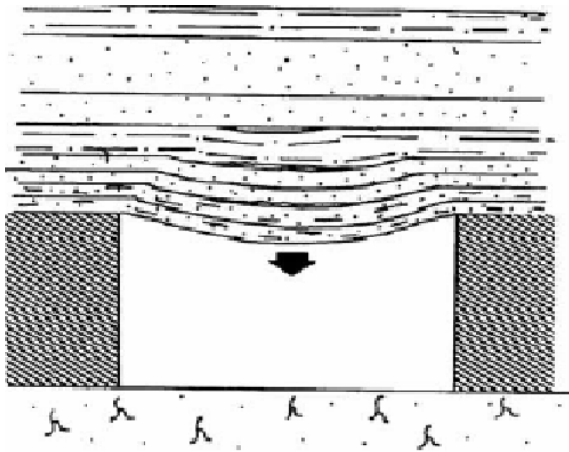
: T_{im}

: γ_{im}

(Peng, 1984)

¹¹⁶ - Tensile strength

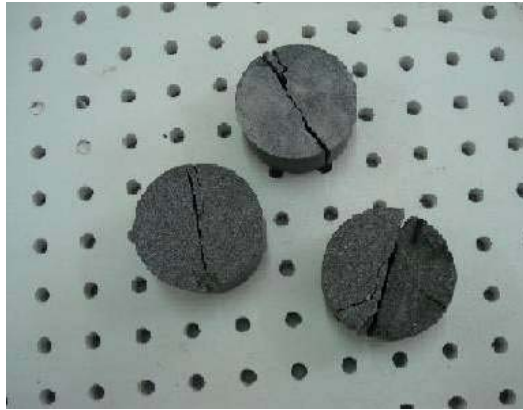
¹¹⁷ - Kidybinski



(Papp, 1998) (

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¹¹⁸ - Direct pull test
¹¹⁹ - Brazilian test



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.(Galvez *et al*, 1997)

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$$T_B = \frac{2P_{Peak}}{\pi \times D \times t}$$

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:T_B

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:P_{peak}

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:D

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:t

$$1/4 < t/D < 1/2$$

| (Mpa)T_B | (KN) | (m²)$\pi . D . t$ | / | (mm) | (mm) | |
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: I_s

$$I_s = \frac{P}{D_e^2} \quad ()$$

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: I_s

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: P

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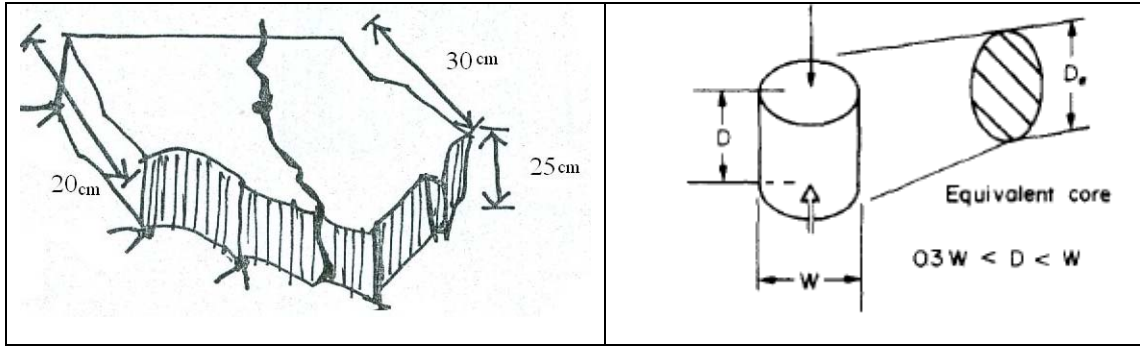
: D_e

D_e

$$D_e = \sqrt{\frac{4WD}{\pi}} \quad ()$$

D

W



I_s

..(ISRM, 1985)

$I_{s(50)}$

$$I_{s(50)} = F I_s \quad ()$$

F

$$F = \sqrt{\frac{D}{50}} \quad ()$$

..(Vutukuri et al, 1937)

$$\sigma_t = 0.75 K_m \frac{P}{A} \quad ()$$

:

$:\sigma_t$

$:P$

$:A$

K_m

$$K_m = \sqrt{\frac{A}{15}}$$

(Vutukuri *et*

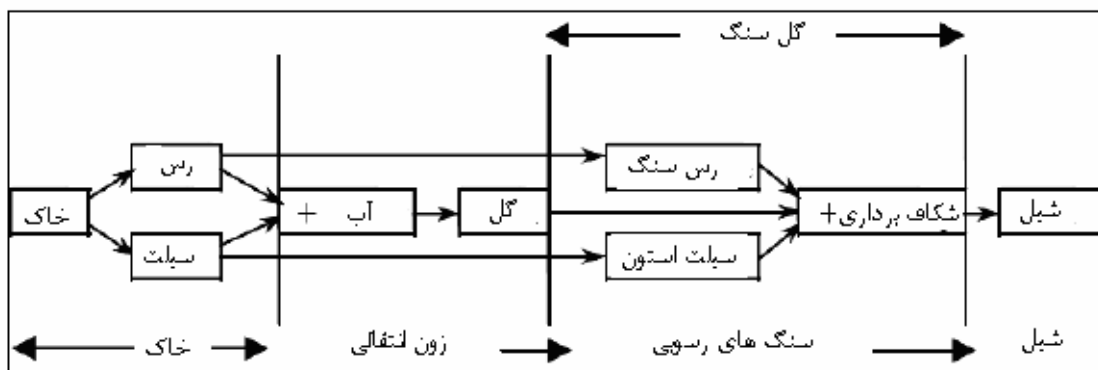
I_s (50)

.*al*, 1937)

.(Reichmuth, 1968)

| I_s (50) | T_B | F | I_s | D_e (mm) | D_e^2 (mm) ² | P(KN) | D(mm) | W(mm) | | |
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1-Reichmuth
2-Relative brittleness



(Yagis, 2001)

(Mark et al, 2005)

(SDT)

(Hoek, 1977)

(A)

¹²² - Slake Durability Test (SDT)
¹²³ - Franklin



$$Id_2 = \frac{C-D}{A-D} * 100$$

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:A

:D

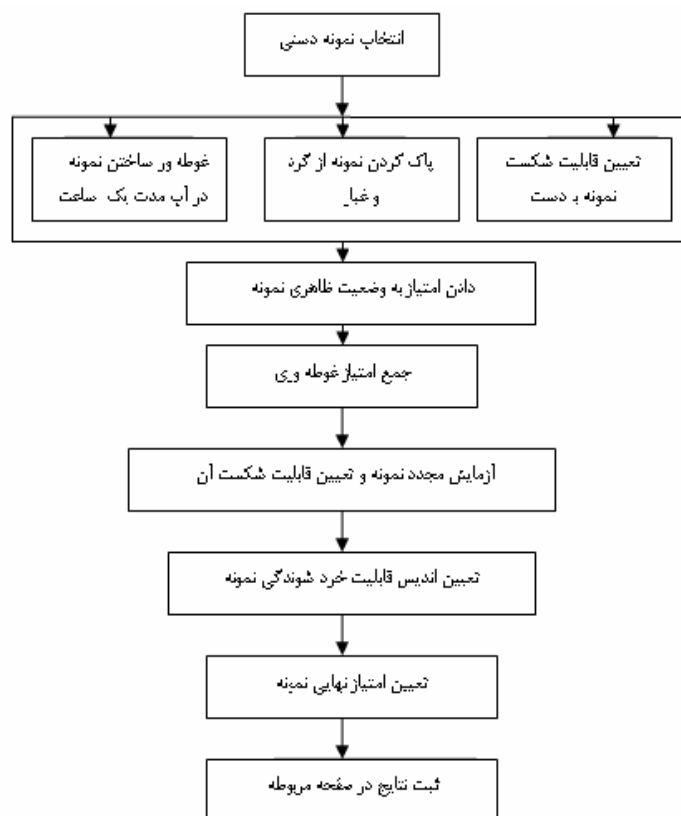
:C

(C)

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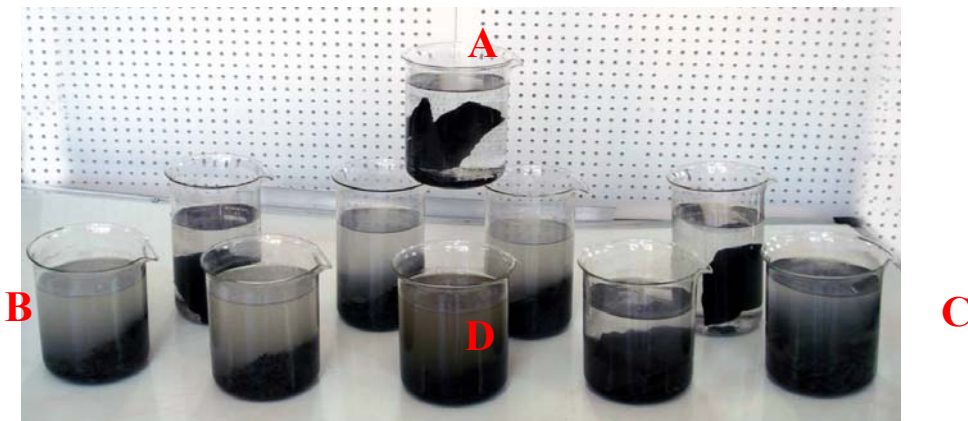
آزمایش غوطه‌وری

نام معدن:----- تاریخ:----- شماره واحد:----- نام آزمایش کننده:-----

شرح نمونه (سنگ شناسی، لایه بندی، و غیره):

| قابلیت خرد شدن نمونه با دست بعد از آزمایش | | غوطه‌وری | |
|---|--|----------|--|
| امتیاز | مشاهده | امتیاز | مشاهدات |
| | بدون تغییر = ۴ تغییر کم = ۲ تغییر زیاد = صفر | | ظاهر آب زالال = ۲ غیر زالال = ۱ گل‌لود = صفر |
| توضیح: از میان امتیازات مربوط به جمع امتیاز غوطه‌وری و امتیاز قابلیت خرد شدن نمونه با دست هر کدام کوچکتر باشد، به عنوان امتیاز نهایی نمونه مورد آزمایش منظور خواهد شد. | | | تشکیل سنگ‌ریزه در ته ظرف نیست = ۲ کم = ۱ زیاد = صفر |
| | | | ایجاد ترک در نمونه بدون ترک = ۶ ترک کم/نصادفی = ۲ ترک زیاد/ جهت یافته = ۱ خرد شدن کامل نمونه = صفر |
| | | | جمع امتیاز مربوط به امتیاز غوطه‌وری |
| | شاخص خردشدگی نمونه با دست بعد از آزمایش | | |

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$$SLD = 10.44N + 11.85$$

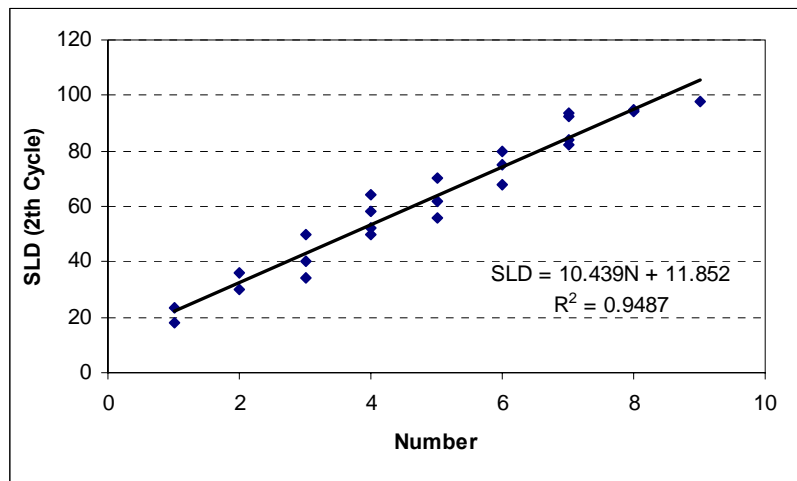
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SLD

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۴-۴-۵ - فاصله‌داري لايه‌بندي^{۱۲۶}

(Hoek et al, 1980)

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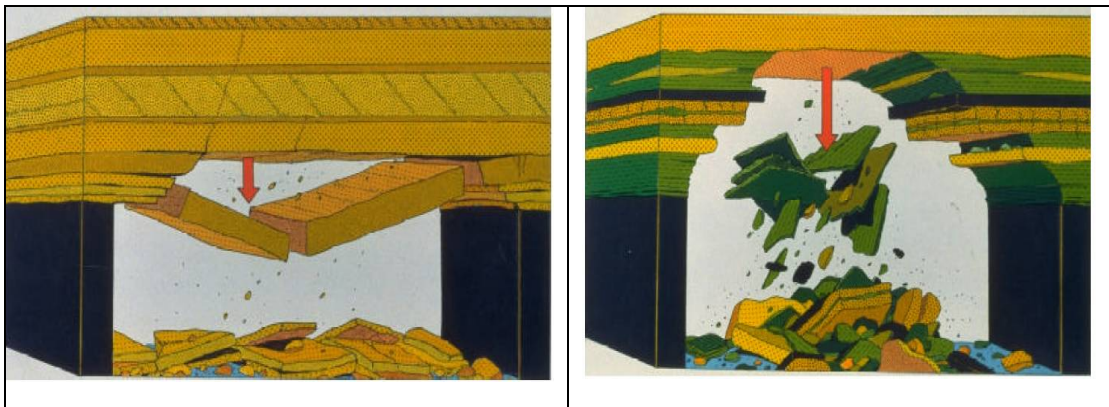
(Peng, 1984).

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(Papp, 1998)

-(Seedsman, 2000)

-(Seedsman, 2000)

(ISRM, 1981)

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(ISRM, 1981)

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¹²⁷ - Voissior beam theory

.(Amadei, 1996)

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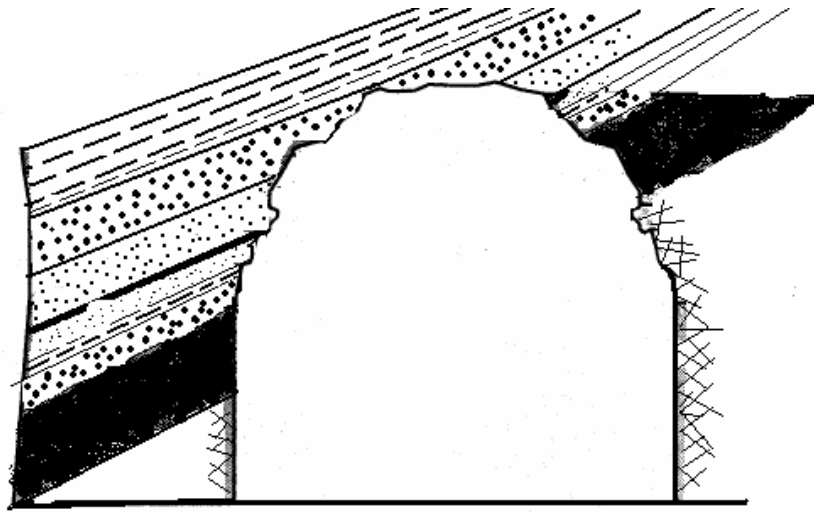
(Seedsman, 2000)

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(Votukori, 1978)

(Friedman, 1964)

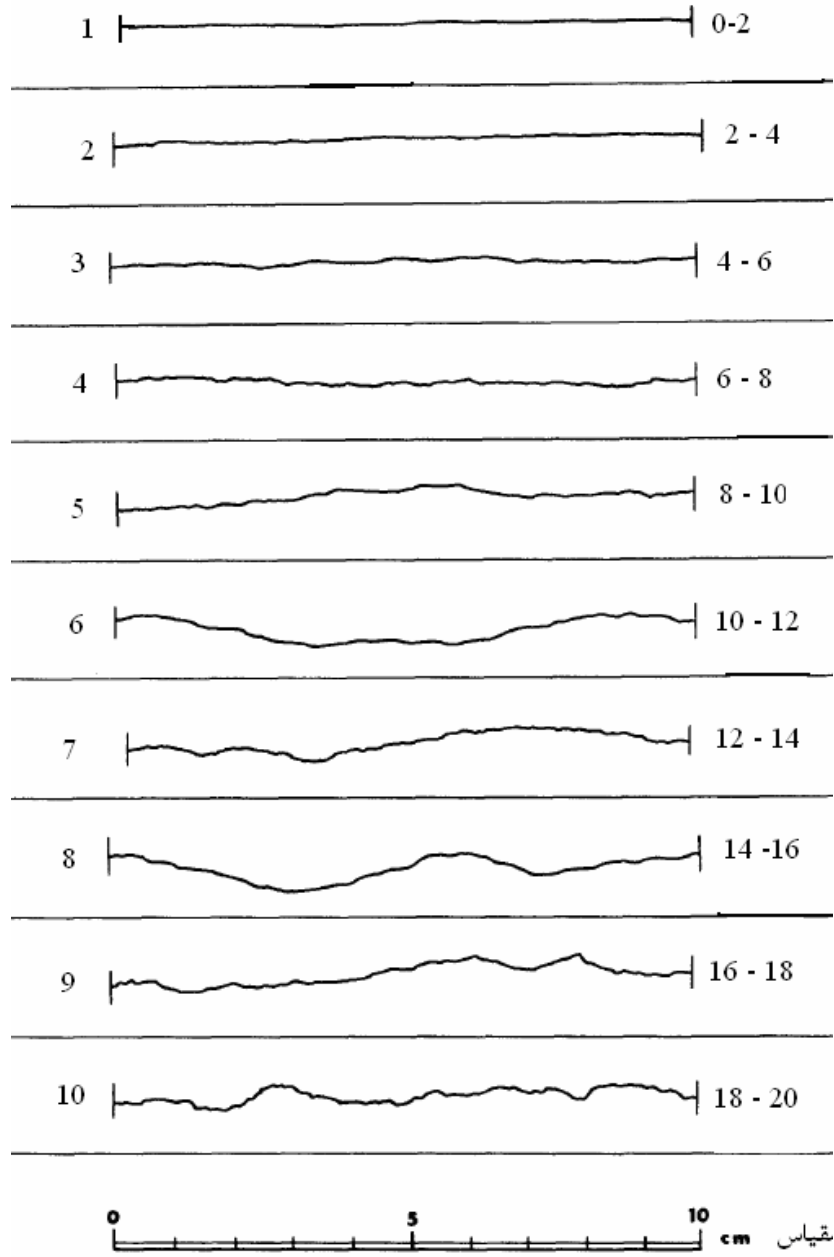
-
- 1- Face
 - 2- Slabbing
 - 3- Oblique

Dips

اندازه‌گیری زیری سطح درزه‌ها

:

¹Dips V.5.1



) α

ϕ_r

ϕ_b

(

:(Barton & Choubey, 1977)

JRC

$$JRC = \frac{\alpha - \phi_r}{\text{Log}\left(\frac{JCS}{\sigma_n}\right)} \quad (\quad)$$

σ_n

JCS

Barton &)

ϕ_r

:(Choubey, 1977

$$\phi_r = (\phi_b - 20) + 20(r/R) \quad (\quad)$$

R

r

r/R

Franklin)

ϕ_b

:(and Dusseault, 1989

$$\phi_b = \tan^{-1}(0.155 \tan \alpha) \quad (\quad)$$

JCS

.(Barton and Bandis, 1990)

r

(JCS)

¹³⁵ - Joint Roughness Coefficient (JRC)

2- Joint Compressive Strength

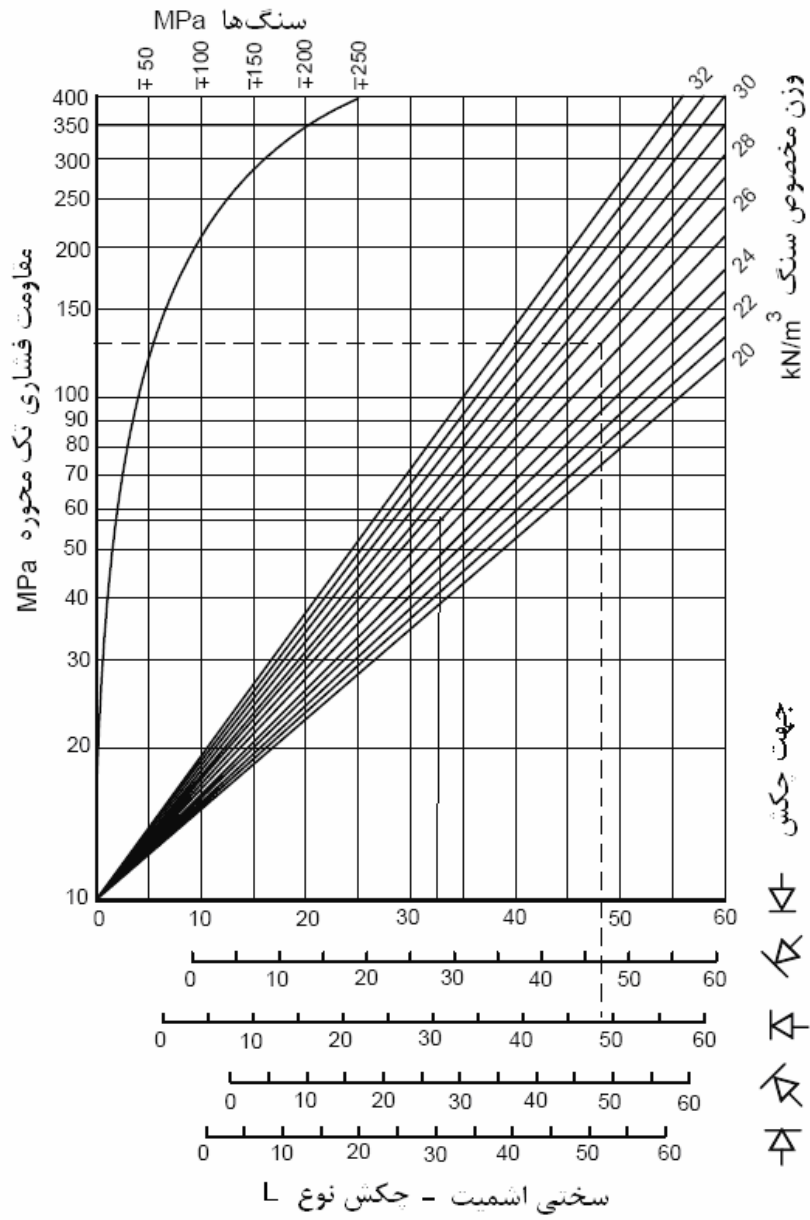
3- Residual Friction Angle

4- Basic Friction Angle

.(Haramy and DeMarco, 1985)

(JCS)

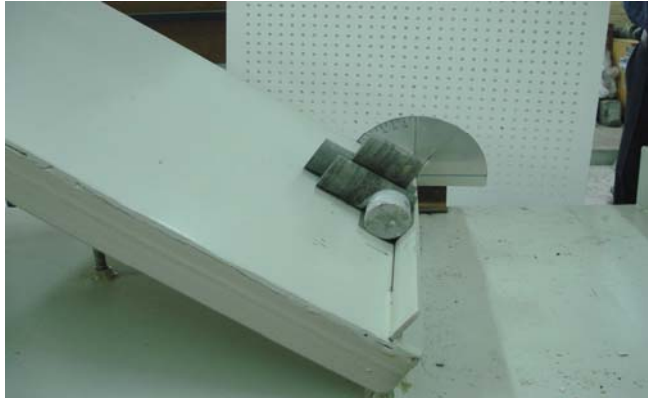
پراکندگی متوسط مقاومت در اکثر



(Miller, 1969)



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(RMR)

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(Wickham, Tiedeman, Skinner)

(CMRR)

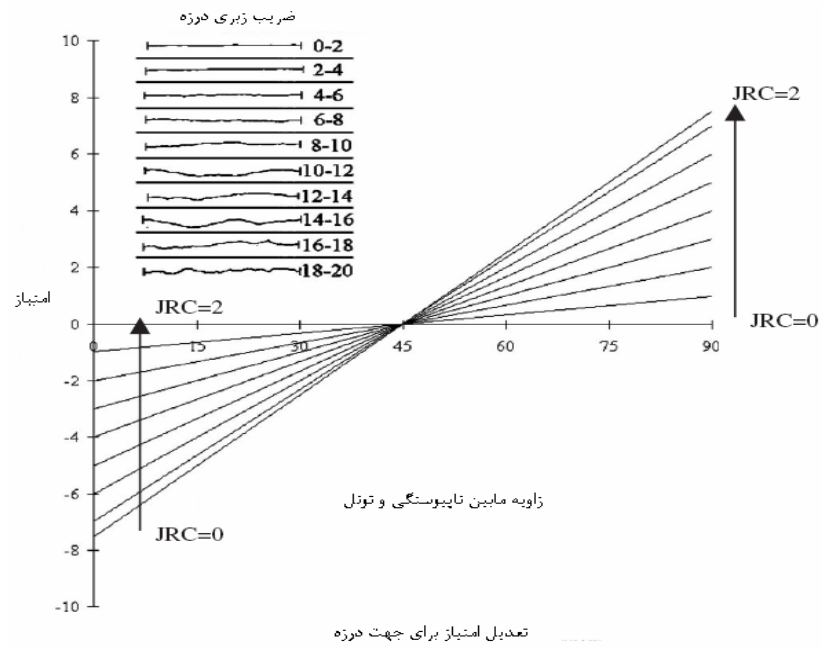
- (Whittles *et al*, 2006)

(CMC)

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- 1- Scan Line
 - 2- Rock Structure Rating (RSR)
 - 3- Coal Mine Roof Rating (CMRR)
 - 4- Coal Measure Classification (CMC)



(Whittles, 2006).

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(

(URL: <http://www.Minesafe.Org/underground/strata>, 2005)

(ISRM, 1973)

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فصل ششم

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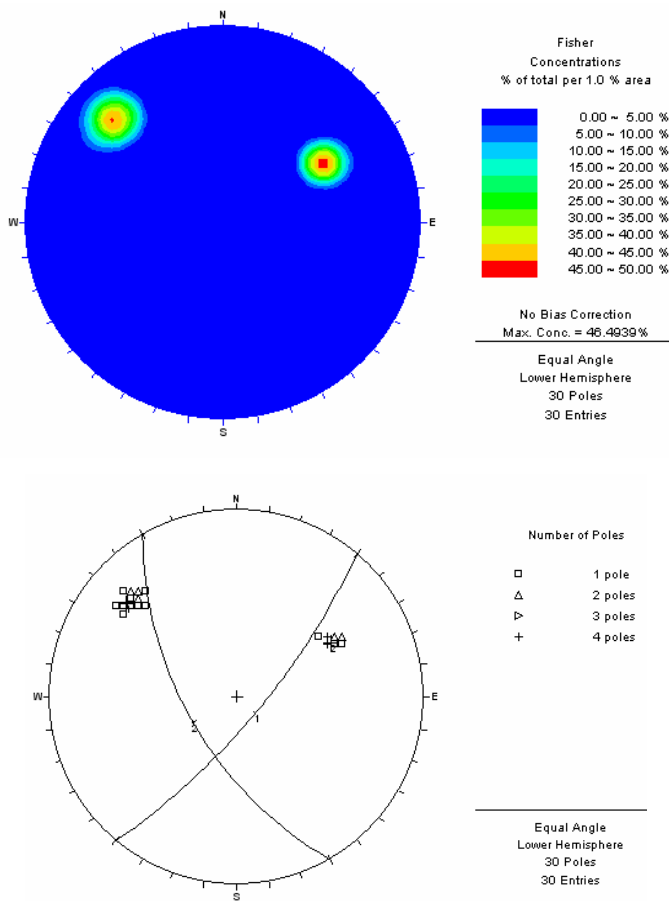
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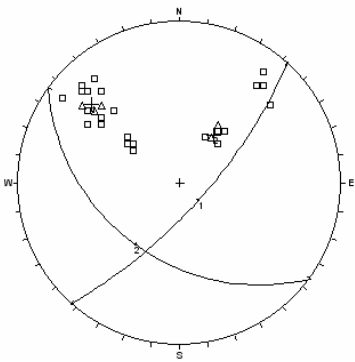
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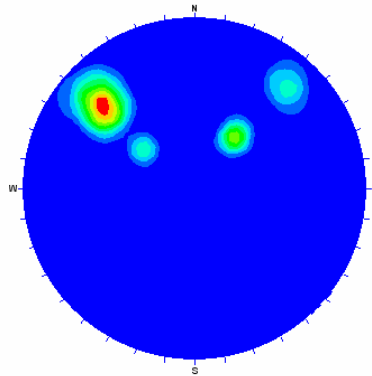
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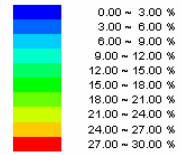


Number of Poles
 □ 1 pole
 △ 2 poles

Equal Angle
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No Bias Correction
 Max. Conc. = 29.6738%

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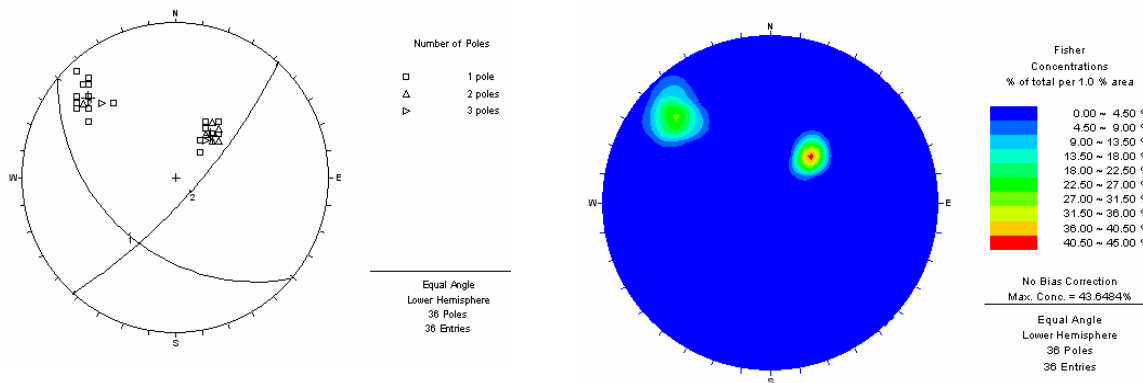
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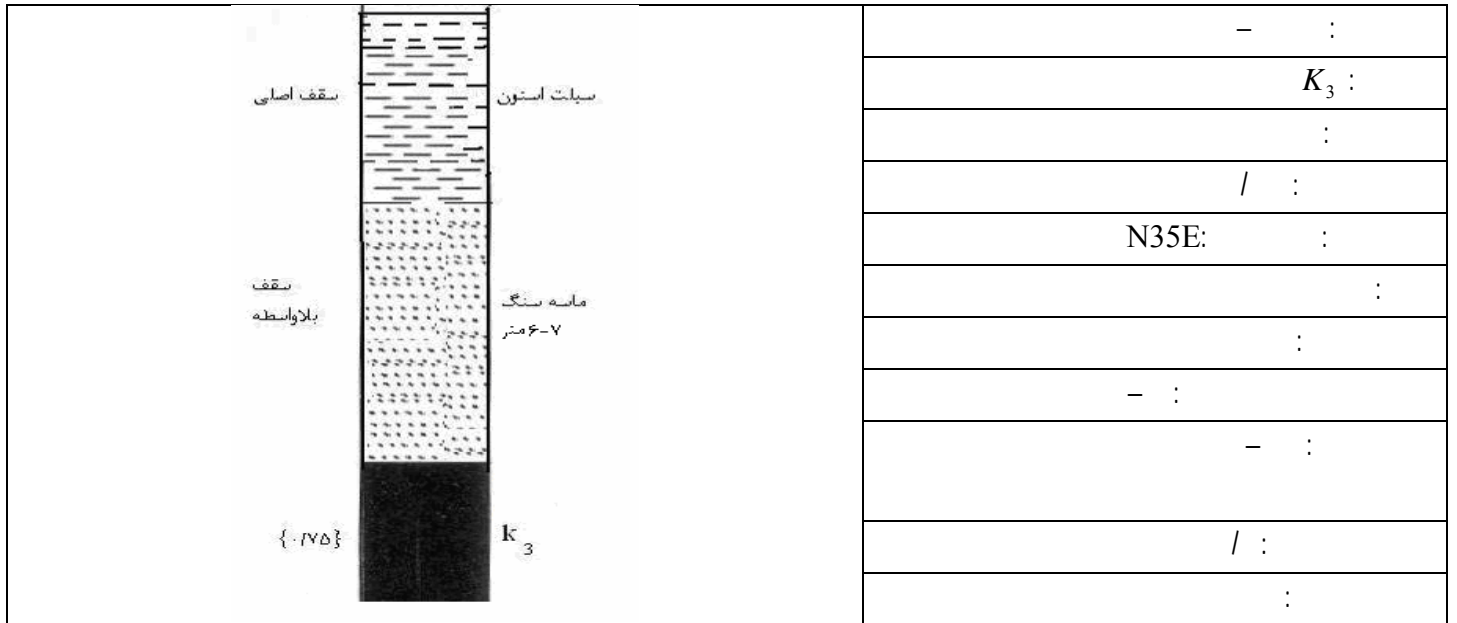
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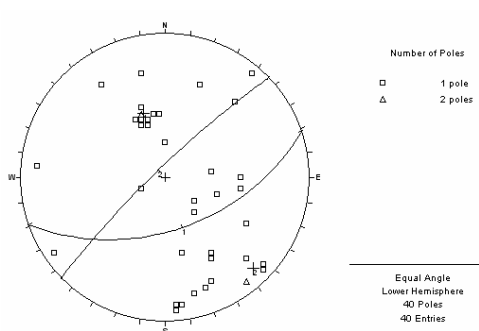
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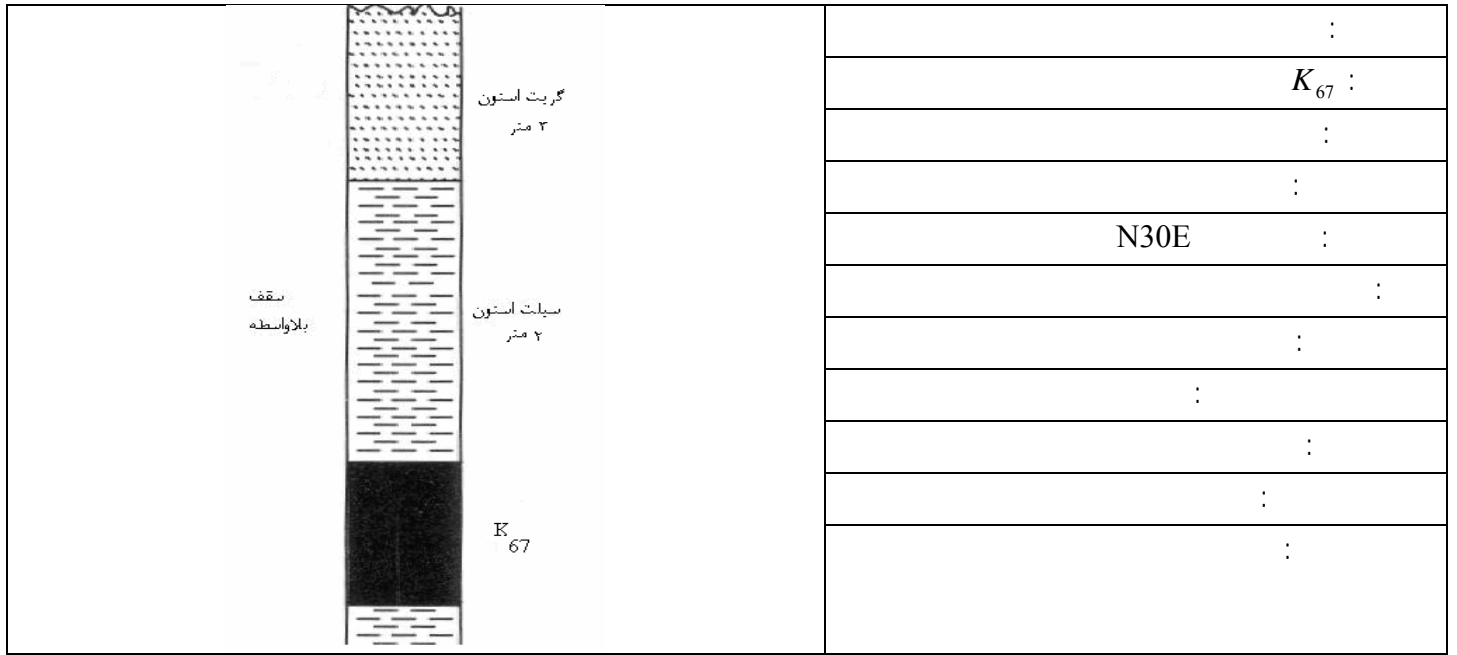
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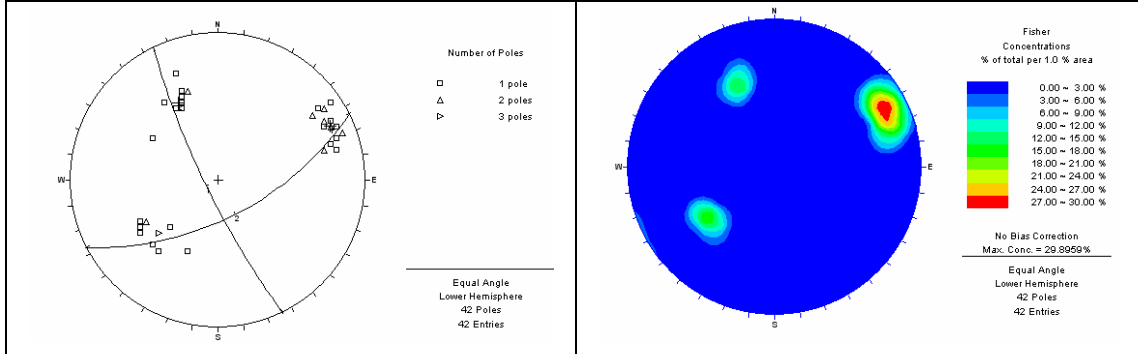
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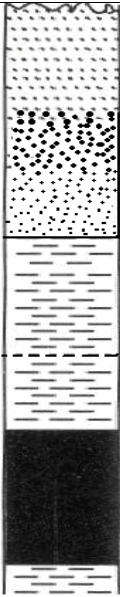
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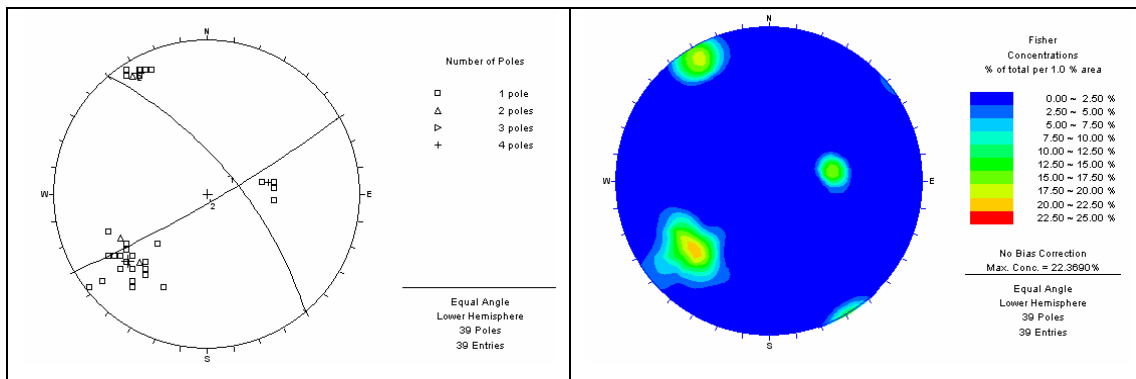
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| ۷۵ | ۳۰.۸ | ۴۴ | ۱۶۸ | ۷۰ | ۳۴۰ | ۸۴ | ۶۰ | ۸۳ | ۶۷ |
| ۸۲ | ۳۲۰ | ۴۸ | ۱۸۴ | ۷۲ | ۳۲۶ | ۸۷ | ۵۸ | ۸۴ | ۶۱ |
| ۸۷ | ۳۲۲ | ۷۲ | ۳۲۰ | ۶۲ | ۳۱۵ | ۸۵ | ۵۵ | ۶۴ | ۳۱۰ |
| ۶۹ | ۳۱۵ | ۶۵ | ۳۱۵ | ۶۸ | ۳۲۵ | ۸۴ | ۵۷ | ۶۸ | ۲۹۵ |
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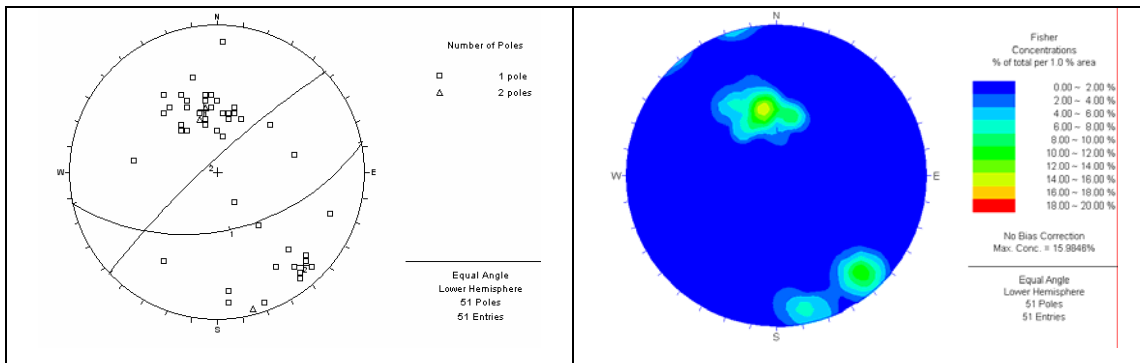
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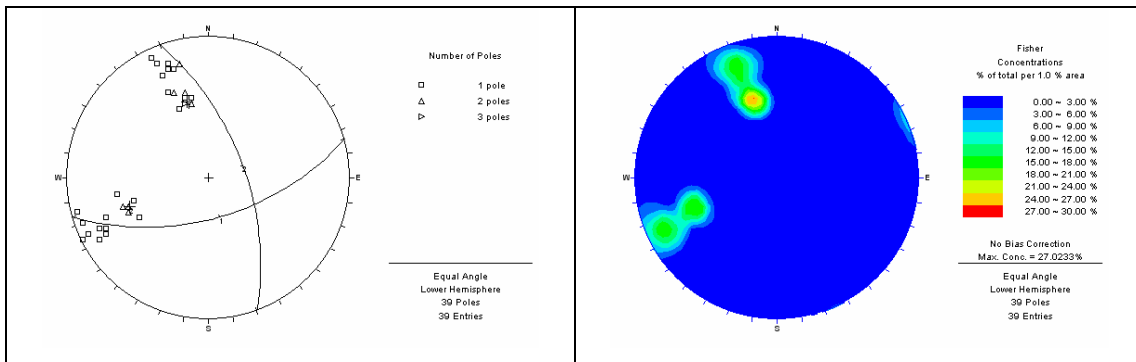
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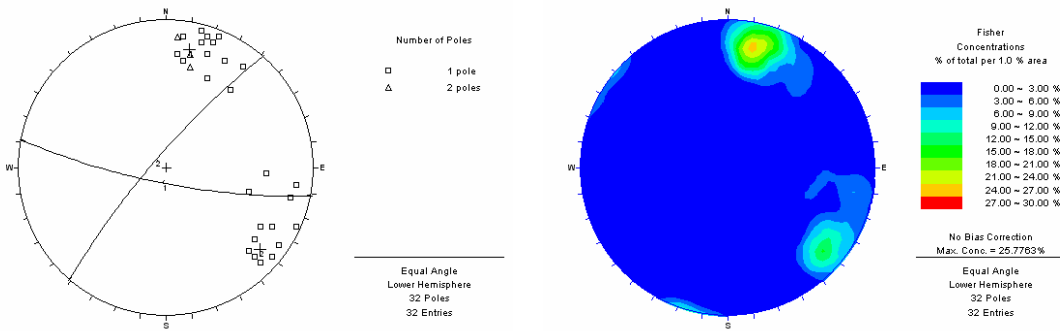
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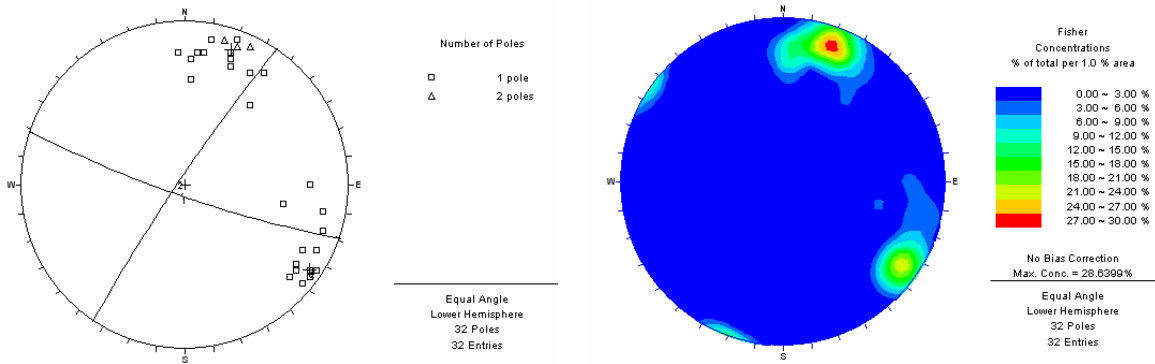
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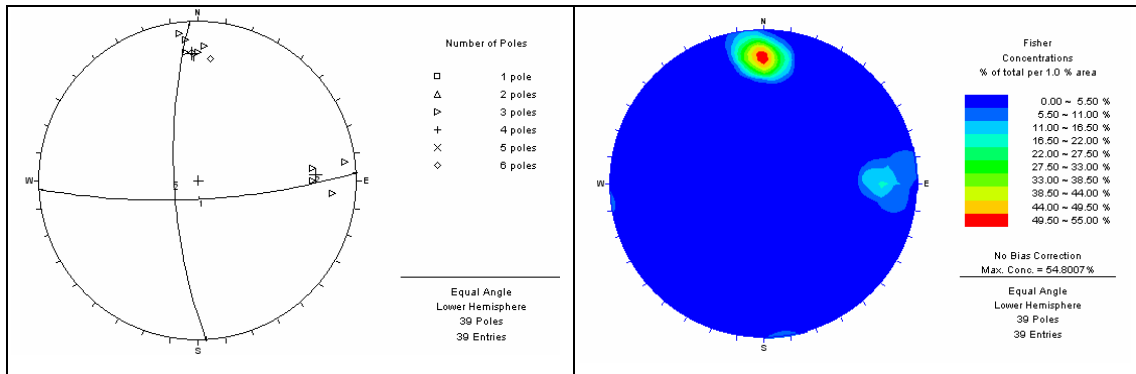
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| شیب | امتداد | شیب | امتداد | شیب | امتداد | شیب | امتداد | شیب | امتداد |
|-----|--------|-----|--------|-----|--------|-----|--------|-----|--------|
| ۸۴ | ۸۵ | ۸۰ | ۱۷۸ | ۸۰ | ۹۴ | ۸۲ | ۸۷ | ۷۳ | ۱۹۰ |
| ۸۲ | ۸۸ | ۷۴ | ۱۸۷ | ۷۸ | ۸۴ | ۸۷ | ۸۳ | ۷۵ | ۱۷۵ |
| ۸۴ | ۱۸۵ | ۷۵ | ۱۸۳ | ۷۵ | ۹۶ | ۸۵ | ۹۵ | ۷۸ | ۱۸۰ |
| ۸۳ | ۹۰ | ۸۶ | ۱۸۵ | ۸۰ | ۱۸۶ | ۷۹ | ۹۰ | ۷۹ | ۱۷۸ |
| ۷۵ | ۸۳ | ۸۰ | ۱۷۴ | ۸۵ | ۱۷۳ | ۸۳ | ۸۹ | ۸۴ | ۱۸۶ |
| ۸۲ | ۱۷۵ | ۸۳ | ۱۸۲ | ۷۰ | ۱۸۰ | ۸۵ | ۷۸ | ۸۵ | ۱۷۳ |
| ۷۶ | ۸۵ | ۸۰ | ۹۴ | ۷۲ | ۱۷۵ | ۷۶ | ۹۵ | ۷۸ | ۹۰ |
| ۸۲ | ۸۵ | ۷۸ | ۸۷ | ۷۶ | ۸۸ | ۸۲ | ۸۵ | ۸۵ | ۸۲ |

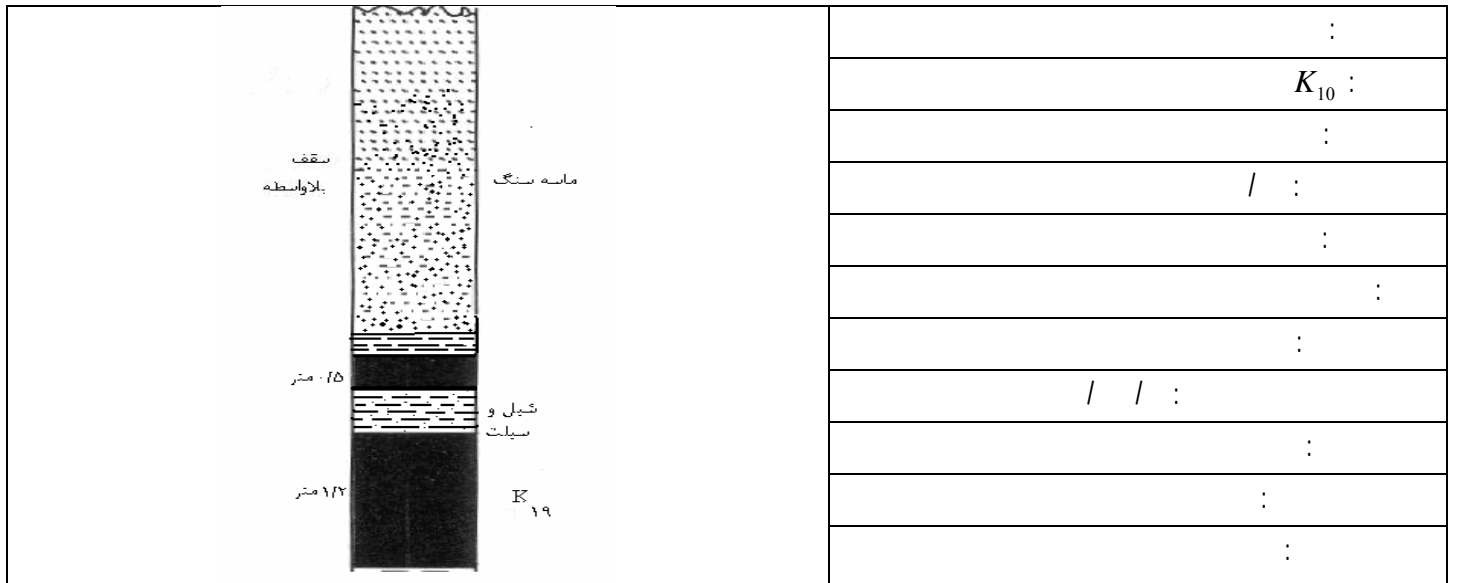
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| | () | () | |
| موازی با امتداد لایه و عمود بر امتداد کارگاه | ۸۸ | ۷۷ | |
| تقریباً عمود بر امتداد لایه و موازی با جبهه کار | ۱۷۷ | ۷۳ | |



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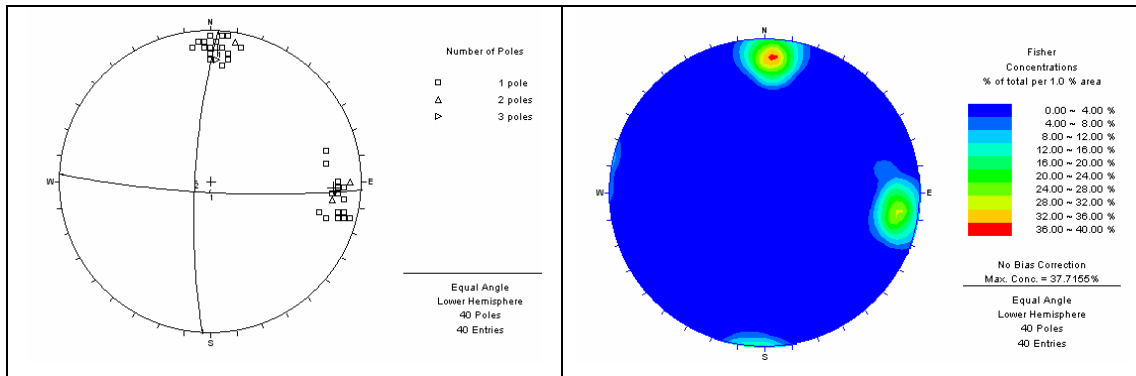
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| شیب | امتداد | شیب | امتداد | شیب | امتداد | شیب | امتداد | شیب | امتداد |
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| ۸۴ | ۸۸ | ۷۶ | ۱۶۵ | ۸۵ | ۹۹ | ۸۲ | ۹۴ | ۷۸ | ۱۹۸ |
| ۸۶ | ۹۲ | ۷۴ | ۱۹۴ | ۸۳ | ۹۰ | ۸۷ | ۸۹ | ۸۰ | ۱۸۲ |
| ۸۴ | ۱۹۵ | ۷۷ | ۱۹۰ | ۸۵ | ۱۰۲ | ۸۵ | ۱۰۰ | ۷۸ | ۱۸۸ |
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| ۸۷ | ۸۹ | ۷۴ | ۹۵ | ۷۶ | ۹۳ | ۷۸ | ۹۰ | ۸۵ | ۸۸ |



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| موازی با امتداد لایه و عمود بر امتداد کار | ۹۳ | ۸۲ | |
| عمود بر امتداد لایه و موازی با جبهه کار | ۱۸۳ | ۷۸ | |

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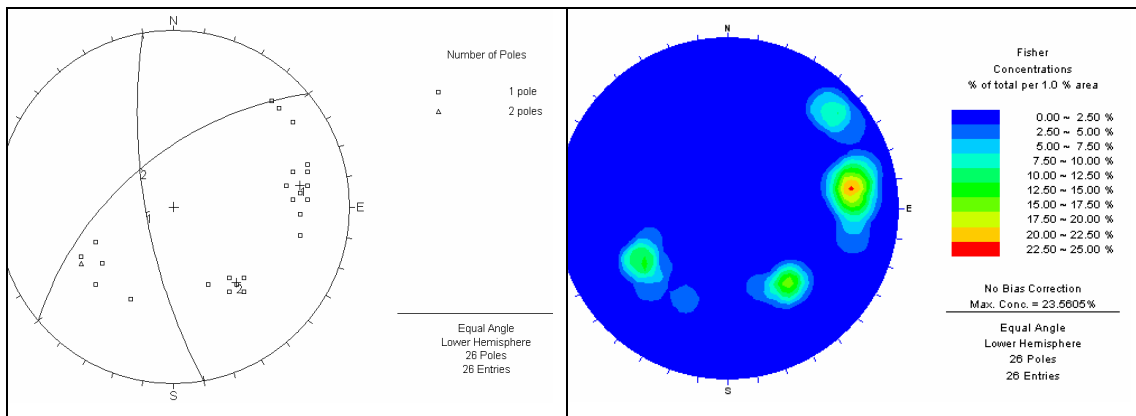
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| ۵۲ | ۲۴۸ | ۶۵ | ۱۶۸ | ۷۸ | ۱۳۶ | ۶۲ | ۲۳۰ | ۶۰ | ۳۳۲ |
| ۶۵ | ۳۱۵ | ۶۲ | ۳۳۰ | ۸۰ | ۱۴۵ | ۷۳ | ۱۹۳ | ۶۴ | ۳۲۹ |
| ۵۵ | ۳۲۰ | ۶۰ | ۲۹۵ | ۷۹ | ۱۳۴ | ۷۶ | ۱۷۶ | ۷۵ | ۱۶۵ |
| ۵۸ | ۲۲۴ | ۶۰ | ۲۳۸ | ۷۸ | ۱۶۴ | ۷۰ | ۱۶۵ | ۵۸ | ۲۳۲ |
| ۵۴ | ۲۳۰ | ۵۶ | ۲۲۰ | ۷۴ | ۱۷۰ | ۶۸ | ۱۷۵ | ۷۲ | ۱۷۵ |

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| موازی با امتداد لایه و عمود بر کارگاه | ۱۷۰ | ۷۲ | |
| با امتداد کارگاه زاویه تقریبی ۶۰ درجه | ۲۳۰ | ۵۸ | |

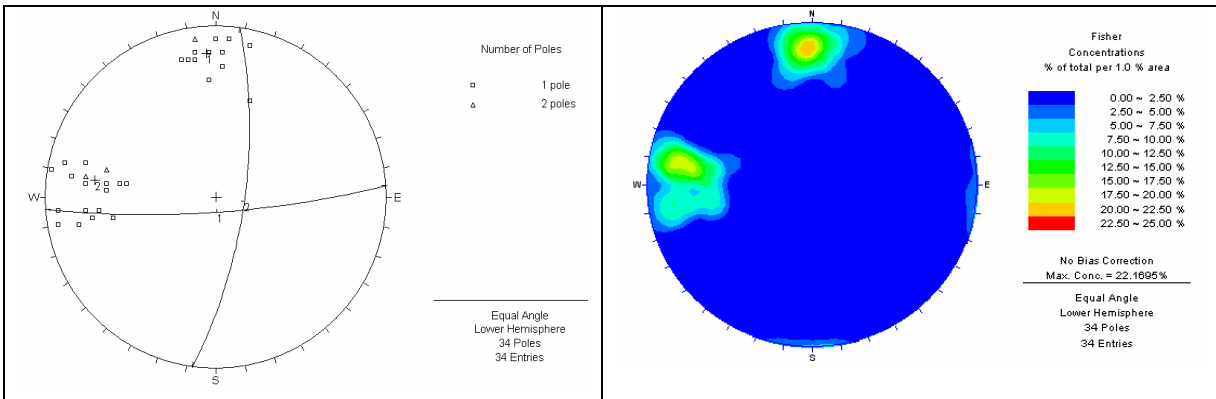
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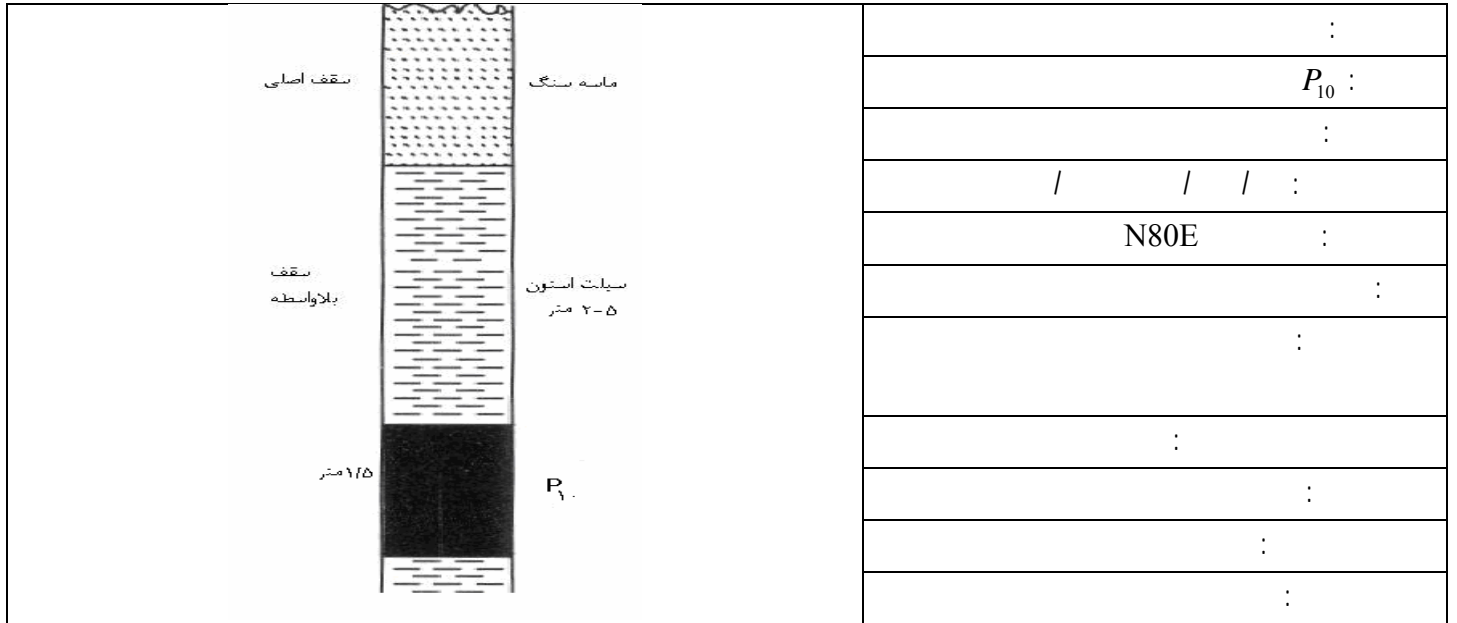
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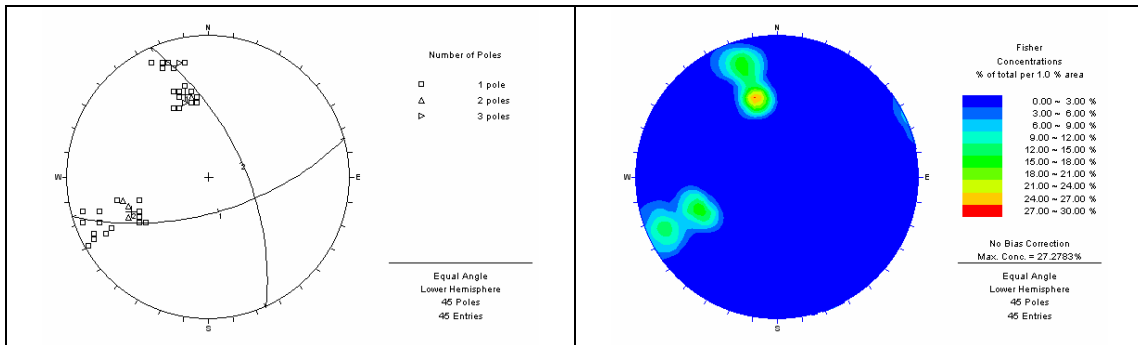
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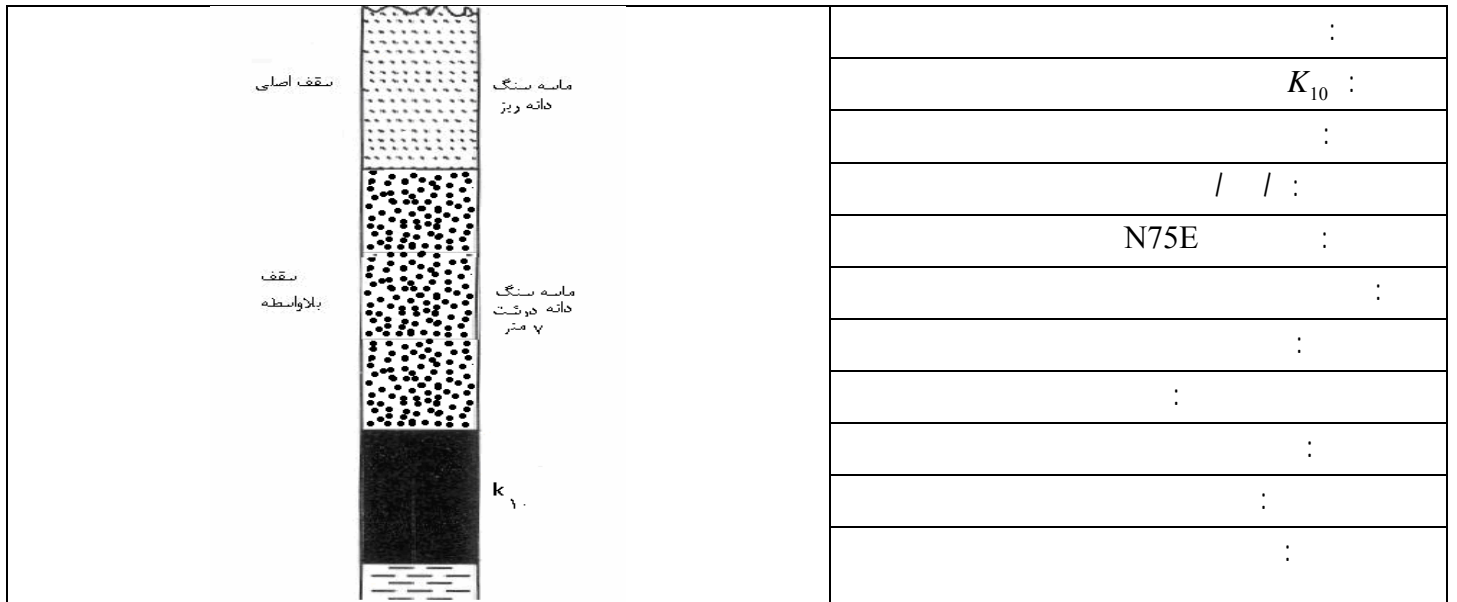
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| موازی با امتداد لایه و عمود بر جبهه کار | ۷۴ | ۶۱ | |
| زاویه ۱۰ درجه با امتداد جبهه کار | ۳۳۶ | ۷۳ | |



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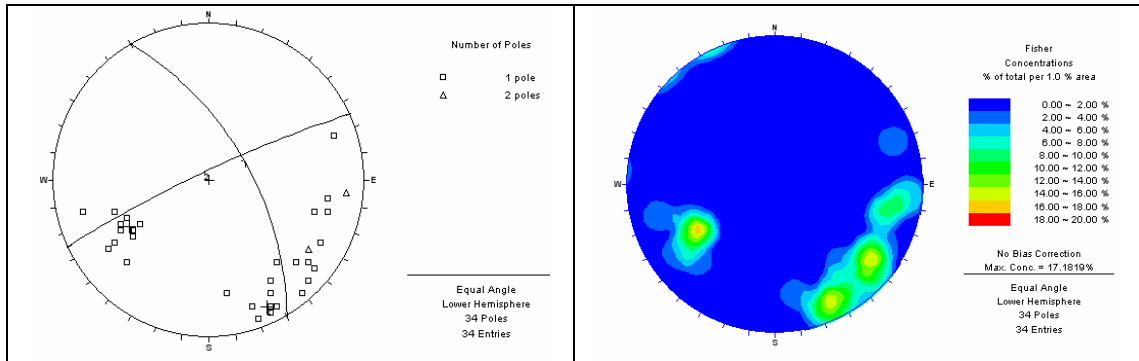
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| شيب | امتداد | شيب | امتداد | شيب | امتداد | شيب | امتداد | شيب | امتداد |
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| ۸۵ | ۲۴۰ | ۸۵ | ۲۴۵ | ۸۰ | ۱۶۰ | ۸۲ | ۲۲۰ | ۷۵ | ۲۳۷ |
| ۸۴ | ۲۴۵ | ۸۰ | ۲۲۰ | ۷۸ | ۳۴۵ | ۸۵ | ۲۳۰ | ۷۳ | ۲۶۰ |
| ۸۲ | ۱۸۵ | ۷۵ | ۱۹۵ | ۶۵ | ۳۳۰ | ۸۵ | ۲۲۴ | ۷۵ | ۲۱۵ |
| ۸۴ | ۱۸۵ | ۷۵ | ۲۱۵ | ۶۰ | ۳۲۵ | ۷۵ | ۲۲۲ | ۷۹ | ۲۱۰ |
| ۷۲ | ۱۹۷ | ۸۵ | ۲۵۰ | ۶۵ | ۳۴۰ | ۶۷ | ۲۳۰ | ۸۰ | ۲۵۰ |
| ۷۵ | ۱۹۰ | ۷۸ | ۲۴۰ | ۷۰ | ۳۲۶ | ۶۲ | ۳۲۵ | ۵۸ | ۳۳۵ |
| ۸۷ | ۲۲۵ | ۸۲ | ۱۶۵ | ۷۲ | ۳۱۵ | ۵۶ | ۳۲۸ | ۶۵ | ۳۳۲ |

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| کارگاه | پارامتر | مقاومت فشاری | مقاومت کششی | رطوبت | عدد دسته درزه | فاصله داری و تداوم درزه‌ها | زیر سطح درزه | ضخامت لایه‌بندی | هندسه کارگاه | جمع امتیاز |
|-------------------|---------|--------------|-------------|-------|---------------|----------------------------|--------------|-----------------|--------------|------------|
| قشلاق K_5 | ۱۲ | ۳ | ۵ | ۲ | ۷ | ۲ | ۶ | ۵ | ۴۲ | |
| قشلاق K_3 | ۱۸ | ۴ | ۸ | ۲ | ۹ | ۶ | ۸ | ۲۶ | ۸۱ | |
| قشلاق K_{60} | ۱۲ | ۳ | ۱ | ۲ | ۵ | ۳ | ۴ | ۴ | ۳۴ | |
| قشلاق K_{67} | ۱۲ | ۴ | ۵ | ۲ | ۶ | ۴ | ۶ | ۷ | ۴۶ | |
| رضی K_{30} | ۱۸ | ۵ | ۱۰ | ۲ | ۱۰ | ۶ | ۸ | ۲۶ | ۸۴ | |
| رضی K_{31} | ۱۲ | ۴ | ۵ | ۲ | ۸ | ۴ | ۶ | ۱۴ | ۵۴ | |
| ملج آرام K_{13} | ۶ | ۱ | ۲ | ۱ | ۳ | ۱ | ۶ | ۸ | ۲۸ | |
| تخت K_{19} | ۲/۵ | ۱ | ۱ | ۱ | ۵ | ۱ | ۳ | ۴ | ۱۸/۵ | |
| تخت K_{19} | ۱۲ | ۳ | ۵ | ۲ | ۸ | ۴ | ۳ | ۱۴ | ۵۰ | |
| کلاریز K_{10} | ۱۸ | ۳ | ۸ | ۲ | ۹ | ۶ | ۸ | ۲۰ | ۷۸ | |
| کلاریز P_{10} | ۱۲ | ۴ | ۸ | ۲ | ۱۱ | ۴ | ۸ | ۱۰ | ۵۹ | |
| طرزه K_{19} | ۶ | ۲ | ۲ | ۲ | ۸ | ۲ | ۳ | ۱۰ | ۳۵ | |
| طرزه P_{10} | ۱۲ | ۴ | ۵ | ۲ | ۸ | ۴ | ۸ | ۵ | ۴۸ | |
| رزمجا K_{10} | ۱۸ | ۴ | ۱۰ | ۲ | ۱۱ | ۶ | ۸ | ۱۰ | ۶۹ | |
| رزمجا P_{15} | ۱۲ | ۳ | ۵ | ۲ | ۸ | ۴ | ۶ | ۱۳ | ۵۳ | |

K_{19}

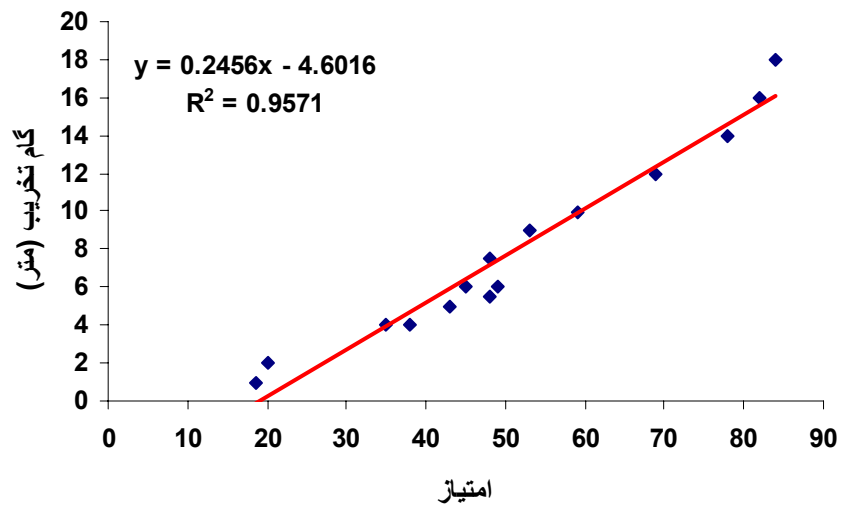
| امتیاز | توصیف |
|----------|---|
| < ۲۰ | بسیار ناپایدار: جنس این سقف شیل کربونیزه نرم و ضعیف، ماسه سنگ آرژیلیتی همراه با ورقه‌های شیل، میان لایه‌های نرم و شکسته، شیل خردشده. قطعات تخریب شده کوچک هستند. گام تخریب اولیه ۲ و گام تخریب دوره‌ای به ۱ متر می‌رسد. پس از گرفتن زغال، سقف در مدتی کمتر از یک ساعت ریزش می‌کند، بنابراین می‌بایست بلافاصله سیستم نگهداری در زیر این سقف نصب شود، در این شرایط علاوه بر سرلاهای مرسوم که در جهت شیب کارگاه نصب می‌شوند، می‌باید در جهت عمود بر امتداد کارگاه نیز سرلاهایی با طول ۱ متر نصب شوند. |
| ۲۱ - ۴۰ | ناپایدار: جنس این سقف ممکن است شیل ماسه‌ای، شیل کربونیزه نرم و ضعیف، میان لایه‌های زغالی نرم و شکسته، سنگ‌های با قابلیت جدایش بالا. مواد تخریب شده دارای ابعاد بزرگتری (۰/۵ * ۰/۱ * ۰/۲ متر) نسبت به حالت قبل هستند. گام تخریب اولیه ۶ و گام تخریب دوره‌ای به ۳ - ۲ متر می‌رسد. پس از گرفتن زغال، معمولاً سقف به مدت یک شیفت کاری، دچار ریزش عمده‌ای نمی‌شود. سیستم نگهداری می‌بایست در پایان هر شیفت کاری در زیر این سقف نصب شود. |
| ۴۱ - ۶۰ | متوسط: سقف از جنس انواع شیل‌های مختلف، ماسه‌سنگ ضعیف، لایه‌های متناوبی از انواع سنگ‌های رسوبی، میان لایه‌های ماسه‌سنگ و شیل. قطعات حاصل از تخریب آن ابعاد نسبتاً بزرگی دارند (حدود ۰/۳ * ۰/۵ * ۰/۵ متر)، گام تخریب اولیه ۱۸ و گام تخریب دوره‌ای به ۸ متر می‌رسد. این سقف به مدت ۳ تا ۴ روز پایدار بوده و مناسب‌ترین شرایط را برای جبهه کار طولانی دارد. در این نوع سقف پدیده ضربه سقف دیده نمی‌شود. نصب سیستم نگهداری با تاخیر تا ۲ روز مشکلی ایجاد نمی‌کند. |
| ۶۱ - ۸۰ | پایدار: سقف بلاواسطه از جنس ماسه‌سنگ متوسط و قوی، شیل سخت. ابعاد قطعات فضایی تخریب ۰/۸ * ۱/۵ * ۳ متر، گام تخریب اولیه ۲۴ و گام تخریب دوره‌ای به ۱۲ متر می‌رسد. این نوع سقف می‌تواند در یک ناحیه وسیع و در مدت زمان طولانی (۳ تا ۴ ماه) به صورت معلق باقی بماند. این سقف‌ها در هنگام تخریب بار ضربه‌ای شدیدی تولید می‌کنند و صدمه زیادی به سیستم نگهداری وارد می‌کنند. پرکردن قسمت‌های بالایی کارگاه یعنی زیر لنگه فوقانی، خصوصاً در کارگاه‌های با شیب بیش‌تر از ۴۵ درجه که به علت شیب زیاد و غلتیدن سنگ به پایین، کارگاه خالی مانده است، توصیه می‌شود. روش مناسب کار پلکانی معکوس و ترکیبی از روش تخریبی و پرکردن موضعی است. به منظور تخریب منظم سقف، می‌بایست روش‌های مصنوعی القایی شکستن سقف مانند آتشباری سقف پس از ۱۰ متر پیشروی جبهه‌کار ترتیب داده شود. |
| ۸۱ - ۱۰۰ | بسیار پایدار: سقف بلاواسطه از جنس شیل ماسه‌ای خیلی قوی، ماسه‌سنگ ریزدانه مقاوم با ورقه‌های شیل، ماسه‌سنگ توده‌ای ضخیم لایه. ابعاد قطعات فضایی تخریب ۱ * ۲ * ۴ متر، گام تخریب اولیه تا ۳۰ و گام تخریب دوره‌ای تا ۱۸ متر می‌رسد. این نوع سقف می‌تواند مدت بسیار طولانی معلق بماند. با توجه به این که بار زیادی از طرف سقف به سیستم نگهداری وارد می‌شود، استخراج می‌باید به صورت پلکانی معکوس و کندن و آکندن باشد. و به دلیل مسائل ایمنی پس از ۱۰ متر پیشروی می‌بایست در فاصله تقریبی یک متر مانده به جبهه‌کار تخته کوبی و فضای خالی پر شود. |

$$y = 0.2456x - 4.60$$

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x

y



فصل هفتم

نتیجه‌گیری و پیشنهادات

(Proyavkin, 1973)

CMC CMRR

(Peng, 1986)

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Abstract

Roof falls continue to be one of the greatest hazards faced by underground coal miners. For preventing unpredictable hazards and losses due to roof falls, assessment of roof rock behaviour in coal mines plays an essential role in ground control issue. However, based on the intensive reserchs in this area, various parameters influence the roof rock behaviour of the stratified rock mass. To identify the parameters that had the greatest degree of influence on the deformation of the stratified rock mass, In this research, using the experience of many geologist and mining engineers that have been worked for many years in East Albors coal mines six independent parameters were identified as being of the most influential on the processes of strata deformation which were namely; the unconfined compressive strength of the intact rock, the tensile strength, the bedding thickness characteristics, the joint properties, joint orientation and how sensitive the rock type was to changes in moisture content. From above mentioned parameters one of them, which is extremely important to coal mine ground control, is moisture sensitivity. Because many coal seams have immediate roofs with moisture sensitivity and weak shale compositions. Presence of moisture sensitivity mud rocks can cause ground control problems. They can severely damage the roof by reducing rock strength, and generating swelling pressures. Therefore, in roof rock assessment, moisture sensitivity is the factor, which must be assessed carefully and with high accuracy. Although slake durability test (SDT) has been widely used to evaluate moisture sensitivity of mud rocks, this method is a laboratory test and is a time consuming method. Furthermore in this method, rock samples must be carefully wrapped to maintain in situ moisture content. Therefore, determination of an index that can easily measure this parameter in situ and with high accuracy has great importance. Immersion test is a simple method which can easily determine this index. In this research, to compare the slake durability and immersion test and establish the relationship between the two tests, rock samples were collected from various mines of East Alborz coalfield. These samples tested with two methods. According to these analyses, a high correlation was found between the two tests.

Keywords: coal mine, roof rock classification, ground control, long wall mining, East Albors coal field