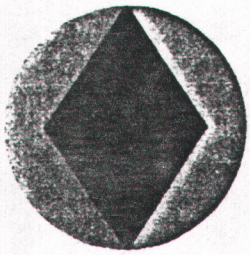
Appendix 5-2

GENWAL COAL COMPANY
Coal Pillar Sizing Report

Pride & Performance

GENWAL COAL CO.



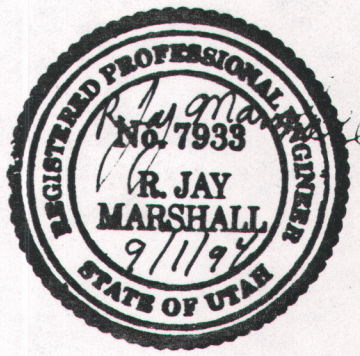
CRANDALL CANYON MINE

Huntington, Utah

Prepared By:

R. Jay Marshall P.E.

September 1, 1994



COAL PILLAR DESIGN[1]
Genwal Coal Company

INTRODUCTION

The design of mine pillars involves the determination of proper sizes of pillars compatible with the expected load and the in situ strength of the coal. When sizing mine pillars factors such as pillar load (the stress on pillars), pillar strength, and the factors of safety.

There are two approaches to coal pillar design, the ultimate strength approach and the progressive failure approach.

The **ultimate strength** approach contends that pillars will fail when the supplied load reaches the compressive strength of the pillars. This approach presumes that the load-bearing capacity of a pillar reduces to zero the moment its ultimate strength is exceeded. In the United States, the Federal Coal Mine Health and Safety Act of 1969 prescribes the safety concept of failure initiation as the criterion rather than ultimate failure. Probably due to simplicity MSHA and other agencies use the ultimate strength approach which results in an additional margin of safety.

The **progressive** failure approach considers the nonuniform stress distribution in the pillar; failure initiates at the most crucial point and propagates gradually to ultimate failure. This approach more closely represents what actually happens in the mining process.

For the purpose of this section formulas from both the ultimate strength approach and the progressive failure approach will be used for comparison.

PILLAR LOAD

The simplest and most often used approach to determine the pillar load, or more correctly the average pillar stress, is by the tributary area method. This approach assumes that , there are uniform stress distributions and that there is a large extent of mining. The average pillar load for such cases can be calculated from

$$SP = [1.1H(W + B)(L + B)]/(W \times L)$$

where SP = pillar load (average pillar stress) in psi,

H = depth below surface, ft,

B = width of opening (room or entry), ft,

W = pillar width, ft,

L = pillar length, ft.

The above formula was used to determine average pillar stress for coal pillars at Genwal Coal Company.

PILLAR STRENGTH

The strength of coal pillars, ie., the ultimate load per unit area, is dependent upon three elements: (1) the size or volume effect (strength reduction from a small laboratory specimen of coal to a full-size coal pillar), (2) the effect of pillar geometry (shape effect), and (3) the properties (compressive strength) of the coal material.

Size Effect

The size effect is best characterized by the concept of the "critical size". Critical size simply means for cubical specimens of coal the strength decreases with increasing specimen size until the strength becomes nearly constant from a certain "critical specimen size" onward. The size characterizes the difference in the strength between the small-size specimens tested in the laboratory and the large-sized coal pillars mined in situ.

Hustrulid, 1976 has shown that the scaling of coal properties from laboratory measured data to field values can be satisfactorily achieved by the following:

$$@cube = k/(36)^{1/2}$$

In the above equations, the constant k must be determined for each coal seam; k is obtained as shown below

$$k = @c(D)^{1/2}$$

where @c = uniaxial compressive strength of coal specimens tested in lab, psi.

D = diameter or cube side dimension, in.

Shape Effect

Of the five available pillar strength formulas, Obert-Duvall, Holland-Graddy, Holland, Salamon-Muro, and

Bieniawski, the most commonly used formula in coal when evaluating on an ultimate strength approach is Bieniawski.

$$@p = @cube(.64 + 0.36\ W/h)$$

where @p = pillar strength,

W = pillar width, ft,

h = mined height.

The results of underground test on coal pillars performed by Wagner (1974) have shown that pillars of rectangular cross section are about 40 pct stronger than square pillars of the same width and height. This suggests that the @p number obtained above can be increased by 40 pct. Wagner measured the stress distributed across pillars at various stages of deformation and found that the perimeter of a pillar is capable of carrying relatively little stress, but this portion of the pillar provides lateral confinement, which enhances the strength at the center of the pillar. Which supports the progressive failure theory.

When considering the progressive failure approach to pillar design the following formula "all cell formula"(2) may be used.

$$@p = \frac{(12{,}300 \times W^2 - 95{,}000 \times W \times h + h^2)}{w^2}$$

where @p = pillar strength

W = pillar width, ft.

h = mined height.

The "all cell formula" was derived from measuring stresses in the field then constructing formulas based upon field data. The formula is an average of four of the most commonly used formulas for pillar strength.

FACTOR OF SAFETY

A factor of safety F is defined as the ratio of the strength of a pillar to the load acting on it. Thus,

$$F = @p/Sp$$

It is concluded that factors of safety ranging from 1.5 to 2.0 are appropriate for room-and-pillar coal mining when using the Bieniawski formula for pillar strength. Guidelines for the stability factors using the Bieniawski formula are as follows for Room-and-pillar mining:

Nonretreating panels	1.5
Retreat panels	2.0
Mains	2.0
Barrier pillars	2.5

All pillar formulas have there own safety factors and the Bieniawski safety factors should not be applied to Holland-Gaddy, Obert-Duvall, Holland, Salamon-Munro or other formulas. Formulas calculated from the above formula may not apply to other pillar strength methodology.

In addition, it should be noted that safety factors are mine specific. For example, a safety factor of 1.2 may be adequate and stable at Genwal Coal Company, but may fail at some other mine in the same vicinity.

It must be emphasized, however, that these figures should be used as a guide only and the local mining experience must and will be taken into consideration.

The following pages show calculations for safety factors using the above formulas at various depths. It should be noted that a @cube strength used is 2,400 psi. Mining history at Genwal proves that this is a low approximation and extremely conservative estimate, of the uniaxial compressive strength of Genwal coal. Of the three samples tested at Serata Geomechanics, Inc.(see appendix 5-1 of current MRP) two of the samples exhibited observed cracks on the surfaces prior to testing. This artificially lowered the compressive strength values.

Because of the quality of the overlying strata (i.e., massive sandstones; few fractures; and benefits of geologic structures creating a bridging effect) lower stresses are being applied to the underlying Hiawatha coal seam than have been calculated. Thus, utilizing this understanding results in a greater factor of safety than has been calculated.

As requested by the USFS on 9/21/94 a safety factor of 2.5 will be used under Perennial streams with cover of less than 1000' and a safety factor of 2.0 will be used in areas of more than 1000' of cover.

REFERENCES

1. Bieniawski, Z. T. A Method Revisited: Coal Pillar Strength Formula Based on Field Investigations. BuMines IC9315 pp. 158-165.

2. Mark, C. and A. T. Iannacchione. Coal Pillar Mechanics: Theoretical Models and Field Measurements Compared. BuMines IC9315 pp.78-92.

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	100	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	222	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor			
	Ultimate	=	11.88	
	Progressive	=	15.71	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	100	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	120	Feet
(w)	Width	=	120	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
================

(L)	Pillar length	=	100	Feet
(W)	Pillar width	=	100	Feet
(SP)	Pillar Stress	=	158	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	5,134	PSI*
	Progressive	=	6,598	PSI
	Recovery	=	0.31	%
(F)	Safety Factor			
	Ultimate	=	32.41	
	Progressive	=	41.65	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	250	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
================

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	556	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
(@p)	Pillar Strength Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor Ultimate	=	4.75	
	Progressive	=	6.28	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	250	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	120	Feet
(w)	Width	=	120	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
================

(L)	Pillar length	=	100	Feet
(W)	Pillar width	=	100	Feet
(SP)	Pillar Stress	=	396	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
(@p)	Pillar Strength Ultimate	=	5,134	PSI*
	Progressive	=	6,598	PSI
	Recovery	=	0.31	%
(F)	Safety Factor Ultimate	=	12.96	
	Progressive	=	16.66	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	500	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	1,112	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
(@p)	Pillar Strength Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor Ultimate	=	2.38	
	Progressive	=	3.14	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	500	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	120	Feet
(w)	Width	=	120	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	100	Feet
(W)	Pillar width	=	100	Feet
(SP)	Pillar Stress	=	792	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	5,134	PSI*
	Progressive	=	6,598	PSI
	Recovery	=	0.31	%
(F)	Safety Factor			
	Ultimate	=	6.48	
	Progressive	=	8.33	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	540	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	1,201	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor			
	Ultimate	=	2.20	
	Progressive	=	2.91	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	630	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	1,401	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
(@p)	Pillar Strength Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor Ultimate	=	1.89	
	Progressive	=	2.49	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	750	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	1,668	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
(@p)	Pillar Strength Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor Ultimate	=	1.58	
	Progressive	=	2.09	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	750	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	120	Feet
(w)	Width	=	120	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	100	Feet
(W)	Pillar width	=	100	Feet
(SP)	Pillar Stress	=	1,188	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	5,134	PSI*
	Progressive	=	6,598	PSI
	Recovery	=	0.31	%
(F)	Safety Factor			
	Ultimate	=	4.32	
	Progressive	=	5.55	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	1,000	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	2,224	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor			
	Ultimate	=	1.19	
	Progressive	=	1.57	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	1,000	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	120	Feet
(w)	Width	=	120	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	100	Feet
(W)	Pillar width	=	100	Feet
(SP)	Pillar Stress	=	1,584	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	5,134	PSI*
	Progressive	=	6,598	PSI
	Recovery	=	0.31	%
(F)	Safety Factor			
	Ultimate	=	3.24	
	Progressive	=	4.17	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	1,250	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	2,781	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor			
	Ultimate	=	0.95	
	Progressive	=	1.26	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	1,250	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	120	Feet
(w)	Width	=	120	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab,	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	100	Feet
(W)	Pillar width	=	100	Feet
(SP)	Pillar Stress	=	1,980	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	5,134	PSI*
	Progressive	=	6,598	PSI
	Recovery	=	0.31	%
(F)	Safety Factor			
	Ultimate	=	2.59	
	Progressive	=	3.33	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	1,500	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab.	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	3,337	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor			
	Ultimate	=	0.79	
	Progressive	=	1.05	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	1,500	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	120	Feet
(w)	Width	=	120	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab,	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	100	Feet
(W)	Pillar width	=	100	Feet
(SP)	Pillar Stress	=	2,376	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	5,134	PSI*
	Progressive	=	6,598	PSI
	Recovery	=	0.31	%
(F)	Safety Factor			
	Ultimate	=	2.16	
	Progressive	=	2.78	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	1,750	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab.	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	3,893	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor			
	Ultimate	=	0.68	
	Progressive	=	0.90	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	1,750	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	120	Feet
(w)	Width	=	120	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab.	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	100	Feet
(W)	Pillar width	=	100	Feet
(SP)	Pillar Stress	=	2,772	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	5,134	PSI*
	Progressive	=	6,598	PSI
	Recovery	=	0.31	%
(F)	Safety Factor			
	Ultimate	=	1.85	
	Progressive	=	2.38	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	2,000	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	4,449	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor			
	Ultimate	=	0.59	
	Progressive	=	0.79	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	2,000	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	120	Feet
(w)	Width	=	120	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	100	Feet
(W)	Pillar width	=	100	Feet
(SP)	Pillar Stress	=	3,168	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	5,134	PSI*
	Progressive	=	6,598	PSI
	Recovery	=	0.31	%
(F)	Safety Factor			
	Ultimate	=	1.62	
	Progressive	=	2.08	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	2,250	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	70	Feet
(w)	Width	=	65	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab.	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	50	Feet
(W)	Pillar width	=	45	Feet
(SP)	Pillar Stress	=	5,005	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	2,642	PSI*
	Progressive	=	3,494	PSI
	Recovery	=	0.51	%
(F)	Safety Factor			
	Ultimate	=	0.53	
	Progressive	=	0.70	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

"INPUT
========

(H)	Mining Depth from surf	=	2,250	Feet
(h)	Mining Height	=	7.5	Feet
(l)	Centers Length	=	120	Feet
(w)	Width	=	120	Feet
(B)	Width of entries	=	20	Feet
(@c)	Uniax Comp Stren Lab,	=	2,400	PSI
(D)	D of Lab Specimen	=	2.84	Inches

"Calculations"
==========

(L)	Pillar length	=	100	Feet
(W)	Pillar width	=	100	Feet
(SP)	Pillar Stress	=	3,564	PSI
(K)	K Factor	=	4,045	Dimensionless
(@cube)	Adjust Strength	=	674.1	PSI
	Pillar Strength			
(@p)	Ultimate	=	5,134	PSI*
	Progressive	=	6,598	PSI
	Recovery	=	0.31	%
(F)	Safety Factor			
	Ultimate	=	1.44	
	Progressive	=	1.85	

* Adjusted as suggested by Wagner

Coal Pillar Design
Genwal Coal Company

Factors of Safety

	70' X 65'		80' X 65'		80' X 80'		85' X 70'		85' X 80'		95' X 70'		95' X 80'		120' X 70'		120' X 80'		120' X 120'	
Depth	Ultimat	Prog	Ultimat	Prog	Ultimat	Prog	Ultimat	Prog	Ultimat	Prog	Ultimat	Prog	Ultimat	Prog	Ultimat	Prog	Ultimat	Prog	Ultimat	Prog
100	11.88	15.71	12.47	16.49	16.99	22.39	14.25	18.58	17.32	22.83	14.71	19.19	17.88	23.57	15.52	20.25	18.87	24.88	32.41	41.65
250	4.75	6.28	4.99	6.60	6.79	8.96	5.70	7.43	6.93	9.13	5.88	7.67	7.15	9.43	6.21	8.10	7.55	9.95	12.96	16.66
500	2.38	3.14	2.49	3.30	3.40	4.48	2.85	3.72	3.46	4.57	2.94	3.84	3.58	4.71	3.10	4.05	3.77	4.98	6.48	8.33
750	1.58	2.09	1.66	2.20	2.26	2.99	1.90	2.48	2.31	3.04	1.96	2.56	2.38	3.14	2.07	2.70	2.52	3.32	4.32	5.55
1000	1.19	1.57	1.25	1.65	1.70	2.24	1.42	1.86	1.73	2.28	1.47	1.92	1.79	2.36	1.55	2.03	1.89	2.49	3.24	4.17
1250	0.95	1.26	1.00	1.32	1.36	1.79	1.14	1.49	1.39	1.83	1.18	1.53	1.43	1.89	1.24	1.62	1.51	1.99	2.59	3.33
1500	0.79	1.05	0.83	1.10	1.13	1.49	0.95	1.24	1.15	1.52	0.98	1.28	1.19	1.57	1.03	1.35	1.26	1.66	2.16	2.78
1750	0.68	0.90	0.71	0.94	0.97	1.28	0.81	1.06	0.99	1.30	0.84	1.10	1.02	1.35	0.89	1.16	1.08	1.42	1.85	2.38
2000	0.59	0.79	0.62	0.82	0.85	1.12	0.71	0.93	0.87	1.14	0.74	0.96	0.89	1.18	0.78	1.01	0.94	1.24	1.62	2.08
2250	0.53	0.70	0.55	0.73	0.75	1.00	0.63	0.83	0.77	1.01	0.65	0.85	0.79	1.05	0.69	0.90	0.84	1.11	1.44	1.85
2300	0.52	0.68	0.54	0.72	0.74	0.97	0.62	0.81	0.75	0.99	0.64	0.83	0.78	1.02	0.67	0.88	0.82	1.08	1.41	1.81