Four Major Topics:

A. Geology
B. Pillar
C. Roof Bolting
D. Shield

A. Geology


Geological Anomalies

Fractures
Faults
Normal
Reverse
Thrust

Slips
Joints in rocks
Cleats in coal
Slickensides
Hill Seams

Paleochannels (Sandstone Channels or Rolls)
Scours
Washouts
Pinchouts
Clay Veins (spars)
Stackrock
Kettlebottom (Horseback)
Homework #1

A report on geologic effect in coal mine ground control, after having reviewed the above-listed 4 papers, consists of the following items:

1. Summary - a summary of all the 4 papers including objectives and major conclusions.
2. Important items of information that you learn from these papers.
3. Your questions that include:
   a. those items that you do not understand.
   b. those items that you do not agree.
   c. Any others.

The report must address all the three items above and must be at least 2 pages long, 12-point font, double spaced with maximum 1-in margin on the top and bottom of the page.

B. Pillar

Methods of Evaluating the Usage of Ground Control Technologies
1. By literature search
2. By field survey of actual application
   Due to the large gap between theoretical solution and mine production application, the two methods could produce vast different results.
US Mining Method
Room and Pillar Mining with or without pillar extraction since coal mining began. Longwall Mining began mainly in the 1970's

Current Practice of (Stiff) Pillar Design in US Coal Mines (See Paper No. 1 above)
* No individual pillar failure occurred. But massive pillar failures in a panel/section or panels/sections had been recorded.
* Definition of “pillar failure.”
* Yield pillar  28-30 ft for 2-entry system in the West
  20 ft for 4-entry system in the East

Coal Pillars
1. By objective
   Chain pillar: a block of coal left in its nature state to support the overburden roof and protect adjacent entries.
   Barrier pillar: A block of coal left in its nature state to isolate the effect of failure/mining of an adjacent section or sections.
   Outcrop barrier pillar - pillar left to avoid punching out into atmosphere and prevent impounded water from blowing out.

2. By mechanism
   Stiff (Abutment) pillar: pillar strength is larger than the expected applied load on it.
   Yield pillar: pillar strength is less than the expected applied load on it. A yield pillar is designed to yield at proper time and transfer proper amount of load to adjacent supporting blocks of coal.

Pillar Design Method for Stiff Pillars
1. Conventional formula for individual pillar - homogeneous materials and uniform loading on pillar only
   a. Holland formula
   b. Bieniawski Formula
2. Semi-conventional method for group of pillars - homogeneous materials but nonuniform loading on pillar only
   a. ALPS by Mark
   b. Wilson and Carr’s yield-stiff-yield
3. Mine structural Analysis - non-homogeneous materials and nonuniform loading on roof, pillar & floor and their interaction
   Computer numerical analysis of coal mine structure, e.g. longwall panel & R&P sections.

Historical Development of Stiff Coal Pillar Design Formulae/Methods
2. Late 1970's and early 1980's:
   * Introduction of Bieniawski (for R&P) and Wilson and Carr (for longwall) formulae
   * Began emphasis of 2-D and then 3-D mine structure analysis by S. Peng, etc.
3. Late 1980's/early 1990's
   * ALPS
4. Mid 1990's - 3-D mine structural analysis

**Historical Development of Yield Coal Pillar Design Formulae/Methods**

1. 1960's and early 1970's: Holland’s yield pillar concept
3. 1960's - present: evolvement of 2-entry experimental yield pillar in the West
4. 2003: Morsy’s yield pillar design

**Time Element**

Does coal pillar strength change with time? Does coal deteriorate with time?

* There exits literature with conflicting conclusions
* Coal block in Mt Hope, WV standing since 1939
* Coals are resistant to water and weathering, but weathering of partings with time that affects coal strength?

**Homework #2**

This Homework consists of several reports due in separate dates depending on class progress. For content and format of the report, please refer to Homework #1, p.2

**C. Roof Bolting**

6. W. J. Gale and M. W. Fabjaneczyk, Application of Field Measurement Techniques to the Design of Roof Reinforcement System in Underground Coal Mines,
Lecture Note
Type of Bolts
* by mechanism - two basic types of bolts
  Mechanical anchor vs fully-grouted resin bolt (Type A vs Type B)
  (Tensioned vs non-tensioned bolts)
* enhanced point-anchored bolts for heavy-duty high pre-tension application
  (Type C)
* combination of tensioned and non-tensioned resin grout (Type D)

Four Types of Roof Bolts

A. Mechanical Anchor Bolt
   Conventional (Tensioned) Bolt
   Mechanical Bolt
   Point-anchored Bolt

   It is for strong and medium-strong roof rocks and installed with pre-tension.
   It is simple and easy to install. It works mainly by suspension effect. Final installation
   torque requirements are in CFR 75-201.

B. Fully-grouted Resin Bolt
   Resin Bolt
   Rebar Bolt

   It works on all types of roof strata and employs both suspension and beam
   building effects. It is installed without pre-tension.

C. Resin-Assisted Mechanical Anchored Bolt
   Combination Bolt
   Double-Lok Bolt
   Hy-tec Bolt
   Instal Bolt
   Cable Bolt

   It is a high capacity tensioned bolt designed for heavy duty use, for instance, thick
   weak roof or areas subject to high abutment pressures.
   Cable bolts are made of 7 high-strength wires (6 outer wires wound around a
   center core) installed with/without pre-tension for extra-heavy duty applications.

D. Torque-Tension Bolt
   Tensioned Rebar Bolt
It can be installed two ways: as a fully-grouted bolt with two sets of resin; the top one shorter but faster curing while the lower one longer but much slower curing so that there is a pre-tensioned built up with installation. It combines the advantage of both the fully-grouted resin bolt and mechanical anchor bolt. The second installation method is with a resin anchor only at the top and then tensioned after the resin has cured.

Other Types of Roof Reinforcement

Cable Bolt  
Cable Sling  
Truss

Theory of Roof Bolting

1. Suspension  
2. Beam Building  
3. Keying

D. Shield

Types and Evolution of Powered Support for Longwall Mining

a. Frame: 1951 - 1984  
c. Shield: 1975 - present  
   i. By number of legs  
      * 2-leg shield  
      * 4-leg shield  
   ii. By shield canopy tip locus  
      * caliper
* lemniscate

Lecture Notes - Powered Support
* Two Types of Modern Shield Support
* Statistics of Support Type by Year
* Statistics of Support Capacity by Year
* Major specifications of 2-leg shield
* Ranking of Powered Supports