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Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

Mining Research Laboratories
Laboratoires de recherche minière

NOTES FOR CLOSING REMARKS BY JOHN E. UDD AT MINE TECHNOLOGY SESSION, SECTOR B FINAL BRIEFING CANADA/MANITOBA MINERAL DEVELOPMENT AGREEMENT Holiday Inn, Winnipeg, Manitoba

JOHN E. UDD and YANG S. YU

DIVISIONAL REPORT November 30, 1989
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INTRODUCTION

by

John E. Udd
Mining Research Laboratories

It was a very great pleasure for me to have been asked to deliver the closing remarks at the end of this first day of the final briefing session for the Sector B projects that have been completed under the Canada/Manitoba MDA. The day has been a very full one and I am certain that you will wish to join me in congratulating all of those who have risen to the challenging task of summarizing no less than five years of work in 15 minutes. This has been tremendously difficult and the technology transfer has been excellent. Gentlemen, thank you very much.

Giving closing remarks such as this after a full day is also a bit of a challenge. You have sat all day without many breaks, eaten a full lunch and are now filled with as much information as you can probably handle without overload.

I am going to be very brief and make what I think are two key points that I would like to make.

First during many of the presentations today and at previous debriefing sessions, the cooperation which has been a feature of the research has been very clear. Several authors have shown organization charts of their project teams and these have been impressive - the companies, consultants, academics, and government. Key words are partnership and collaboration in research.

Today, more than ever, we are all seeing the results of the enormous change that has taken place in mining research during the past five years. Much of the credit for this advance must be given to the Canada/Manitoba MDA and to the people who made it possible.

Lest we forget it, five or six years ago, most mining research was conducted in the three solitudes of academe, government, and industry, and very often there was little dialogue in between. The Canada/Manitoba has made a major change in that it created a new process by which the needs of the industry could be determined and addressed. You may recall that at all stages in the MDA Sector B program there was a continuing dialogue between government and industry and the mining association to determine what the needs were and the priorities. Government served as the catalyst and provided some of the financing with industry making an equally large, if not larger, contribution. The result of all this was that the projects were determined by the industry for the industry and were mainly delivered by the industry.

Often, in the research business one hears criticisms of the relevance of work or its applicability. I think that you would all agree that no such criticisms can be made of the work that has been described today. The process to which I have referred has guaranteed both the relevance and the applications of the work.

That process, at least from my perspective, has been the model for all of the other Federal/Provincial MDAs that include mining research. With only a few small changes it is still the model which is followed today. It has, I believe, also had a strong influence on the way in which the industry has chosen to organize its own research efforts through the development of research directorates and research committees of the various mining associations. Five years ago there were almost none of these. Today, a network is developing on a national scale.

Second, the network and the communications which have developed have been another great feature of the MDA projects. Where five years ago we know each other and talked occasionally, today we know each other well and are in a regular dialogue. Mining research has come out of the labs and into the mines and I am certain that we all hope that the momentum will be continued. It has been a joy for CANMET to have been involved in this and it's great to know that the view of civil servants has changed. Let's hope that we are seen as being both. Have a good evening in Winnipeg.

CANADA/MANITOBA MINERAL DEVELOPMENT AGREEMENT
SECTOR B
MINING AND PROCESSING
(1984 - 1989)

OBJECTIVE - MINING

Through mission-oriented mining projects, to develop new mining technology
for
Manitoba metal mines in order to improve both productivity and safety.

PROJECTS (FEDERAL DELIVERY)

Task 1

Vertical Block Method (V.B.M.) Design Guidelines for a Steeply Dipping Orebody; Scaling Techniques.

1. Contractor: Inco Ltd., Manitoba Division, Thompson;
2. Contract signed: February, 1985;
3. Funding: $362,500;
4. Delivery Date: December 20, 1989.

Task 2

Ground Stability Evaluation with Particular Reference to an En Echelon Lensed Orebody (Phases 1 & 2).

1. Contractor: Ruttan Operations, Hudson Bay Mining and Smelting Co. Ltd., Leaf Rapids;
2. Contract signed: January 1985;
3. Funding: $352,000;
4. Delivery Date: December 20, 1989.

Task 3

Optimization of Blast Design for Blasthole Mining Operations.

1. Contractor: Inco Ltd., Manitoba Division, Thompson;
2. Contract Signed: April, 1986;
3. Funding: $260,000;
4. Delivery Date: December 20, 1989.

Task 4

Geotechnical Database System for Ground Control in Underground Mines.

1. Contractor: Inco Ltd., Manitoba Division, Thompson;
2. Contract signed: February, 1985;
3. Funding: $250,000;
4. Delivery Date: December 20, 1989.

Task 5

Delayed Backfill Consolidation.

1. Contractor: Hudson Bay Mining and Smelting Company Ltd., Flin Flon, Manitoba;
2. Contract Signed: June 1986;
3. Funding: $100,000;
4. Delivery Date: The contract was cancelled in February 1988 due to the lack of a suitable experimental stope in the Flin Flon area, and a shortage of manpower.

Task 6

Communications System for Isolated Areas in Mines; Especially in an Orebody Composed of Multi-Lenses.

1. Contractor: Ruttan Operations, Hudson Bay Mining and Smelting Company Ltd., Leaf Rapids;
2. Contract Signed in February 1985;
3. Funding: $429,400;
4. Delivery Date: Contract completed on June, 1989. (1st phase successfully completed; 2nd phase evaluation partially completed and was terminated due to a change of management and labour problems.

Manitoba MDA Project - Task 1

Vertical Block Method (V.B.M.) Design Guideline for a Steeply Dipping Orebody; Scaling Techniques and Hang-ups Removal

Contractor: INCO, Thompson Division, Thompson.

Funding: $362,500.

Completion Date: December 20, 1989.

This task includes two separate elements which are :

(A) V.B.M. Design Guidelines, and

(B) Removal of hang-ups, and Scaling Techniques.

(A) V.B.M. Design Guidelines

The objectives are:

(a) Reviewing cut and fill mining practices in Manitoba, assessing the potential for optimization, and developing cost-benefit criteria for conversion from cut and fill mining to vertical block mining.

(b) Instrumenting and monitoring the ground behaviour and performance of V.B.M.

(c) Evaluating the parameters such as geological structures, depth, rock mass quality, which might influence the sizes/shapes of stopes.

(d) Evaluating ground stability for the optimum extraction sequences based on both geotechnical and numerical models.

(e) Evaluating ground support and delayed fill requirements associated with V.B.M. total extraction.

(f) Assessing the practice of drilling and blasting associated with V.B.M.

(g) Developing and reporting on V.B.M design guidelines which include treatment of the all relevant parameters including:

- stope and pillar dimensions;
- influence of geological structures;
- drilling and blasting considerations;
- mining sequence; stress conditions;
- ground support and fill requirements;

(B) Scaling Techniques and Hang-ups Removal

The objectives are:

(a) To review the state-of-the-art of scaling tools used in underground mining operations.

(b) To develop novel scaling tools/techniques which can be safely applied in development headings.

(c) To assess remedial measures for bringing down loose rock in drifts, draw points, headings and hang-ups in ore/waste pass systems.

Achievements and Benefits:

1. A number of progress reports have been issued. The final reports will be completed by December 20, 1989.

2. A V.B.M. engineering manual has been developed, and it consists of several chapters:
   - Cut and Fill Mining;
   - Data Colloection for Stope Stability Evaluation;
   - VBM Stope Design;
   - VBM Stoping Procedures;
   - Drilling and Blasting;
   - Support Requirements.

   This Engineering Manual will be useful for all Canadian mines in applying the VBM method.

3. Development of a light-weight, hand-held scaler;

4. Development of a projectile for hang-up removal; it is less expensive, produces low concussion in the general work area, accurate, and relatively easy to set up.

Manitoba MDA - Task 2

Ground Stability Evaluation With Reference To Echelon Lensed Orebody -Phase I

Contractor : Ruttan Operations, HBM&S Co., Ltd., Leaf Rapids.

Funding: $289,000.00

Objectives:

1. To review various rock classification methods and identify the most suitable one for practical application to underground mining operations.
2. To determine and establish a data base which includes: static and dynamic mechanical properties of mine rocks, in-situ fill properties, in-situ stresses, failure criteria, ground water conditions, and geological information for modelling and/or back analysis purposes.
3. To develop a remote monitoring program underground to forewarn of any failure. The equipment shall be capable to transmit data to surface via an underground communications network.
4. To identify the stabilizing effect that fill has on individual stopes and to evaluate its effectiveness for overall stability.
5. To install rock mechanics devices which include shear strips, multi-wire extensometers, IRAD stress gauges, and pressure load cells, in test stope areas and to evaluate ground and fill stability.
6. To conduct back analyses of field data and to validate the geo-numerical models used (2D/3D nonlinear FEM - fill studies; 3D/2D BEM - stope/pillar evaluation; 2D/3D FEM - crown pillars).
7. To develop design guidelines for mining a multi-lensed orebody, including the relevant parameters such as : pillar and stope dimensions; crown pillar sizes; mining sequences; rock mass quality; ground support; fill requirements; and instrumentations.
8. To develop rock mechanics computer modules system for strategic rock mechanics analysis, ground control and mine planning purposes.

Achievements and Benefits:

The project was completed and the final report was issued on March, 1989.

1. Improved efficiency in mine design and ground control. The program is being used for production planning. Ground stability analyses and ground control measures can be done quickly to avoid or minimize major ground failures. Uncontrolled ground failures may cause serious damages to mine structures and human lives, as well as having significant impacts on regional economic and socio-political environments.
2. Minimized dilution.
3. Improved mine safety and productivity.
4. Development of expertise.

Manitoba MDA - Task 2

Ground Stability Evaluation With Reference To Echelon Lensed Orebody -Phase II

Contractor : Ruttan Operations, HBM&S Co., Ltd., Leaf Rapids.

Funding: $63,000.00

Objectives:

1. Review the state-of-the-art of artificial ground reinforcement (cable bolting) used in Canada and around the world.
2. Install grouted cable bolts in a stope hangingwall or crown pillar, and determine their effectiveness in attempting in controlling the dilution in a large blasthole stope.
3. Verify the influence of the dynamic effects (blasting) on ground stability and cable bolting using the finite element technique.
4. Submit a comprehensive report on the above studies by March 1989.
5. Develop the pre and post processor modules in a micro computer environment for the MINTAB and OFREEF programs.
6. Deliver software programs and user's manual.

Achievements and Benefits:

1. All of the key elements of the project were completed. The final report is being prepared.
2. Improved efficiency in mine stability evaluation.
3. Minimized dilution.
4. Improved mine safety and productivity.
5. Development of expertise.

Manitoba MDA Project - Task 3

Optimization of Blast Design for Blasthole Mining Operations

Contractor: INCO, Thompson Division, Thompson.

Funding: $260,000.

Completion Date: December 20, 1989.

Background:

- Many factors potentially influence rational design: Rock mass properties, stope geometry, pre-blast stress level, explosive properties, method of initiations, blasthole layouts, ...
- Considerable effort has been expended to research these factor in open pit mines, the technology is not immediately applicable underground.

Objectives:

1. To develop a rational blast design which incorporates the important properties of the rock to be blasted, the stability of excavations, and the properties of explosive properties and methods of use, etc.
2. To prepare the blast design method as a user-friendly computer software package, together with instruction manual, to run on personnel computer; interactive graphics to assist the blast design function must be also provided.
3. To provide guidelines for safely blasting "hang-ups" in ore/waste systems.

Achievements and Benefits:

1. The project will be completed and the final reports will be issued by December 20, 1989.
2. The benefit of this study are numerous:

   Optimal fragmentation implies minimization of draw point delays, dilution, and wall instability.

   The effects on costs are significant in that drilling and blasting can be 60 % of all workplace costs.

Manitoba MDA Project - Task 4
Geotechnical Database System for Ground Control in Underground Mines

Contractor: INCO, Manitoba Division, Thompsom.

funding: $250,000.

Completion Date: December 20, 1989.

Objectives:

1. To Develop a geotechnical database system for use in connection with mine stability evaluations and mine design. This database system shall include the treatment of all relevant parameters including :
   (a) rock types; lithology; major geological structures; discontinuities; orientations and spacing;
   (b) in-situ ground stresses;
   (c) mechanical properties of various mine rocks;
   (d) mine geometries; stope stability with regard to mining activities;
   (e) ground support requirements; etc.
2. This database system should be designed in such a manner that data (input) can be practically obtained from the field and easily entered, modified or retrieved.
3. To develop a numerical modelling package for use in connection with the design of underground openings. This package includes a nonlinear two-dimensional F.E. program and a coupled 3-D boundary element and displacement discontinuity program. These models shall be capable of handling:
   (a) mining sequence, i.e., sequential excavation and backfill simulations;
   (b) structural discontinuities, such as joints and faults;
   (c) interactions between surface mining and underground workings;
   (d) multiple and/or folded seam simulations;
   (e) improved windowing procedures;
   (f) multiple mode post-failure material behaviour; practical failure criteria;
   (g) energy balance; change of strain energy, and potential energy; energy released, and energy absorbed by backfill;
   (h) user friendly; and restart capability.
   (i) Conducting calibration and verification of the models (geotechnical and numerical) by case history studies.
4. To provide computer packages and fully-documented user's manuals (geotechnical and numerical);
5. Post-processor should be capable of representing information in graphical forms such as: contour plots of stress distribution around an underground stope(s); plots of stress trajectories and displacements; plots of variables (stress, convergence, displacements or factors of safety, etc.) versus distance, etc.
6. Recommending further R&D to improve the system.

Achievements and Benefits:

1. A number of progress reports have been issued. The final reports will be completed by December 20, 1989.
2. Uncontrolled ground failure in underground mines may cause serious mine structural damage and production loss and pose a threat to human life. It is anticipated that software packages developed as part of the project will significantly contribute to increased mine safety and productivity in mines where they are used.
3. Improved efficiency in mine design, stope stability analysis and ground control.
4. Both geotechnical and numerical models are applicable to underground mines in general.
5. Several packages of software have developed/enhanced for mine structural stability analyses. Some of the packages have been used by Canadian mines and other research organizations, such as Noranda Technology Centre and Queen's University, for their in-house R&D work.

Manitoba MDA - Task 6
Communications System for Isolated Areas in Mines

Contractor: Ruttan Operations, HBM&S Co., Ltd., Leaf Rapids

Funding: $429,400

Objectives:

Phase I

1. To review the current state-of-the-art of underground communication systems for vocal and data transmission applications including communications from and to the cages in the shafts, and analyze existing systems in Canadian underground mines.
2. To identify experience gained from existing systems operating in rugged mining conditions, e.g., safety improvements and operational benefits.
3. To recommend the most suitable and cost-effective system and establish costs and work plan for a field trial to demonstrate the commercial and technical feasibility of the system.

Phase II

4. To install and evaluate the performance and cost-effectiveness of the system for a pilot area only.
5. To install and evaluate the performance and cost-effectiveness of the system on a full scale.
6. To provide demonstrations for interested parties for a period of at least one year.
7. To recommend further R&D to improve the system.

Achievements and Benefits:

1. The project was completed and the final reports were issued on June, 1989.
2. The project significantly generated, and tremendously stimulated interest among the mining industry, government agencies and research organizations. Consequently, mine communications projects have been revitalized and initiated.
3. Improved morale of workers working in isolated areas.
4. Increased utilization of human resources and mine equipment.
5. Improved emergency preparedness.
6. Improved general level of safety.
7. Improved mine productivity.

ORGANIZATIONS INVOLVED

1. Manitoba Department of Energy and Mines
2. CANMET, Energy, Mines and Resource Canada
3. Mining Association of Manitoba
4. Inco Ltd., Manitoba Division, Thompson, Manitoba.
5. Ruttan Operations, Hudson Bay Mining and Smelting Company Ltd., Leaf Rapids, Manitoba.
6. Hudson Bay Mining and Smelting Company Ltd., Flin Flon, Manitoba.
7. Steffen Robertson & Kirsten (B.C) Inc., Vancouver, B.C.
8. Golder Associates, Vancouver, B.C.
9. State Industries, Winnipeg, Manitoba.
10. International Mining Services Inc., Vancouver, B.C.
11. Falconbridge Limited, Sudbury, Ontario.

Canada/Manitoba MDA II ?

1. The first phase of the Canada/Manitoba MDA has been successfully completed.
2. It was generally recognized that the success of Manitoba MDA program was due to the excellent cooperation between the Manitoba mining industry, the Mining Association of Manitoba, Consulting firms, the Provincial and Federal governments.

   The imformation generated from the program are very beneficial not only to Manitoba mines but also to Canadian mines as a whole.
3. In view of the needs to continue to develop new mining technology for the Manitoba mining industry, CANMET representatives have taken steps to consult with Manitoba mines, the Mining Association of Manitoba, and the Provincial Government in identifying the new requirements for further research and
   development for improving productivity and safety in Manitoba mines.
4. A number of new areas of importance for Manitoba mines, either provincial delivery or federal delivery, have been identified for further research.
5. These are now under discussion.

BENEFITS TO CANMET/MRL

1. Vastly improved linkage with the industry which we serve in Manitoba.
2. Increased commitment of in-house resources to serve the Manitoba mining industry (8% of MRL's resources in 1988-1989; Manitoba contributed 5.1% of Canada's mineral production in 1987).
3. Greater relevance of research efforts. Applications are certain since projects were <u>defined by the industry</u>, <u>performed by the industry</u> and are <u>for the industry</u>.
4. Scale of projects has moved significantly from <u>lab scale</u> to <u>pilot scale</u>.
5. Opened up a continuing dialogue.