

# **Bio-Data**

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# Summary of Bio-Data

Prof. Upendra K. Singh, Dept. of Mining Engineering, ISMU, Dhanbad

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**Present Position:** Professor, Dept. of Mining Engineering

**Address:** Indian School of Mines University, Dhanbad -826004  
09431126466 (mob), Email: uksinghism@yahoo.co.in

**Date of Birth:** Dec. 09, 1956

## Educational Qualifications

- B Tech (Hons.) (Mining Engineering), FIRST CLASS FIRST in order of merit, BHU, 1979.
- Ph.D. in Rock Mechanics, Luleå University of Technology, **Sweden**, 1988

## Positions held

- (a) Head, Department of Mining Engineering, Indian School of Mines University, Dhanbad (2004 - 2007)
- (b) Professor, Dept. of Mining Engineering, Indian School of Mines University, Dhanbad (1993 – contd.)
- (c) Scientist 'EI', Central Institute of Mining and Fuel Research Institute, then CMRI, 1988-1993
- (d) Research Scholar, Division of Rock Mechanics, Lulea Technical University, Lulea, Sweden (1983-1988)
- (e) Underground Manager, Mochia Mine, Hindustan Zinc Ltd., Zawar Mines, Udaipur, (1979-1983)

## Major Contributions

### Administrative (as Head, Dept. of Mining Engineering):

- (a) Five-year integrated courses were introduced and syllabus prepared. They are
  - (ii) BTech in Mining Engineering and MTech in Mining Engineering
  - (iii) BTech in Mining Engineering and MBA
- (b) Three national Seminars on underground metal mining, coal mining and mine surveying and one national workshop on numerical modeling were organized
- (c) The earning to the Department increased from Rs. 6.5 million in 2003-2004 to 16.4 million in 2006-2007 from these projects.

### Teaching:

- (a) Introduced stress analysis by numerical technique in Rock Mechanics Practical.
- (b) Introduced computerized Data Acquisition System in Rock Mechanics Practical.

(c) Developed Physical models for teaching mining methods.

#### **Research and development:**

- Numerical modeling approaches have been developed for **simulating progressive caving and load on the powered roof support in long wall mining** (Guidance of PhD work of Dr. GSP Singh)
- **An Intrinsically safe Data Logging System** has been developed for use in monitoring of pressure in legs of hydraulic powered roof supports and closure of the support in coal mines. This system will be used by CMFRI and NIRM for their project and monitoring of hydraulic powered long wall faces in future
- **An in-situ stress measurement setup** has been developed and trial is undergoing in laboratory. After successful trial in lab., a field trial will be undertaken.
- Successful design of **Steel Fibre Reinforced Shotcrete (SFERS)** that is effective in supporting of severe side spalling and roof failure in coal mines.
- A state of the art setup for testing of **hydraulic STDA and DTDA legs for powered roof support required as per ICIS-001/1991**, has been developed in the Department of Mining Engineering under his coordination. Earlier, this facility was only available only with JESSOP, Kolkata.
- Developed different numerical models of non-coal mines namely, Mochia, Balaria and Rajpura Dariba of HZL and Mosaboni of HCL for **successful prediction of stability of pillars and excavations**.
- His recent numerical simulation work is “**Simulation of induced caving of massive roof by hydraulic fracturing**”. The fracture-breakdown and fracture-extension pressures predicted by this numerical model agree well with the recent experiment of hydraulic fracturing in Kumda New colliery of SECL.
- Developed computer (mathematical) model for **post-failure analysis of pillars and walls in mines** using Continuum Damage Mechanics Approach.
- Guided research work on development of a statistical method for computing **in-situ stress from hydraulic fracturing data**.
- Guided a Ph D research on development of an empirical approach for **predicting failure under high stress condition in mines** and suitable economical stoping method under this condition.
- Guided a Ph D research on **optimum investment decision model** for economic evaluation of mining venture.

#### **Developments leading to patent:**

- A Steel Fibre Making Machine: Patent No.: 193 510(1778/Cal/96).
- Self Advancing Goaf Edge Support(SAGES): Indian Patent Application No. 1123/KOL/2006 dated 25.10.2006.

#### **R&D Projects (on-going)**

1. Coordinator of an R&D project on **Investigations of cavability of overlying strata and development of guidelines for estimation of support capacity for longwall faces-CMRI**,

**NIRM, & ISMU**, sponsored by the Ministry of Coal, Total Rs. 454 Lakhs, , ISM share Rs. 64 Lakhs, 2005-contd.)

2. Coordinator of an R&D project on **Development of a setup for stress measurement in concrete tunnel lining dam walls and pillars**. Ministry of Water Resources, R & D Division, New Delhi. (15.22 Lakhs, 2005.. contd)
3. Co-coordinator of an R&D project on FEM Analysis of Spread Footing Foundation on Weak Floor Jointed and Layered Rock Mass. Department of Science and Technology, NewDelhi (22.5 Lakhs, 2008 ... contd.)

## **Publications**

International Journals: 20

National Journals: 7

Seminars, Symposia, Conferences, Workshops proceedings: 35

Total Publications : 62

Edited proceedings of Seminar and workshop: 3

## **Distinctions**

Dr. U. K. Singh is at present a member of **Editorial Advisory Board of Int. Journal of Damage Mechanics** published from U.S.A. He has also reviewed a number of papers for International Journals. He is a Life Member of International society of Rock Mechanics The Institution of Engineers (India) and International Society of Rock Mechanics and Tunelling Technology, Life Fellow of Indian Academy of Social Sciences, and Life Member of Indian Society of Technical Education.

Dr. Singh represented ISMU in several Government and no-government bodies as a Head of the Department of Mining Engineering. He has served several institutions as an expert member of selection committees, syllabus revision committees and Advisory Boards. He is also invited for special lectures.

Dr. Singh organized and attended national and international seminars, conferences and workshops.

# Bio-data

## 1. General

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1. Name : Upendra Kumar Singh
2. Fathers Name : Shri Jaiprakash Singh
3. Nationality : Indian
4. Date of Birth : December 09, 1956
5. Present position : Professor, Department of Mining Engineering, ISMU, Dhanbad
6. Present Address : Department of Mining Engineering,  
Indian School of Mines, University,  
DHANBAD - 826004, INDIA  
Tel. (0326) 2235222 (D), 2235279 (o)  
2235322, 2296522 (Res.) 09431126466 (mob)  
FAX: (0326) 2296628, 2296563  
Email: uksinghism@yahoo.co.in
7. Marital Status : Married
8. Sex : Male
9. Number of Dependents : Three ( Wife and children (one))
10. Knowledge of Language other than English :

Name of Language(s)	Read	Write	Speak	Understand
<b>Hindi</b>	√	√	√	√
<b>Swedish</b>	√	√	√	√

### 11. Positions held :

- (f) Head, Department of Mining Engineering, Indian School of Mines University, Dhanbad (2004 - 2007)
- (g) Professor, Dept. of Mining Engineering, Indian School of Mines University, Dhanbad (1993 – contd.)
- (h) Scientist 'EI', Central Institute of Mining and Fuel Research Institute, then CMRI, 1988-1993
- (i) Research Scholar, Division of Rock Mechanics, Lulea Technical University, Lulea, Sweden (1983-1988)
- (j) Underground Manager, Mochia Mine, Hindustan Zinc Ltd., Zawar Mines, Udaipur, (1979-1983)

## 2. Academic Profile

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- B Tech (Hons.) (Mining Engineering)  
**FIRST CLASS FIRST** in order of merit, **BHU**, 1979.
- Technical Licentiate (Equivalent to MTech),  
Luleå University of Technology, **Sweden**, 1986.
- Ph.D. in Rock Mechanics,  
Luleå University of Technology, **Sweden**, 1988

Thesis: Simulation of Progressive Failure of Brittle Rock: a  
Continuum Damage Mechanics Approach.

- Publications out of PhD work:
  - Two papers in **International Journal of Solids and Structures**.
  - Several papers in conferences and symposia.

PhD work **cited** in several international publications and books, some of them are given below:

- Rock Fracture Mechanics by Whittaker, et. al., 1992, page 547.
- Rock Stress and Its Measurements by Amadei, et.al. , 1999, page 324.
- Int. Journal of Damage Mechanics, V7, N2, 1998, Page 206.

## 3. Post-graduate research (1983-1988)

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Post-Graduate research at the Division of Rock Mechanics, Luleå University of Technology, Sweden from October 1983 to May 1988. During that period, worked on the project "Development of a Computer (mathematical) Model for Post-Failure Analyses of Mine Structure". The project was supported by Luleå University of Technology and the National Swedish Board of Technical Development.

In the above project, a material model (stress-strain relation) for the progressive failure of brittle rock, based on a Continuum Damage Mechanics (CDM) approach was developed. The work was reported in Licentiate Thesis for which Licentiate Degree in Engineering by the Luleå University was awarded. The material model was numerically tested under tensile and compressive stress fields. The numerical experiments (with the material model) simulate most of the experimentally observed behaviours of the progressively failing brittle rock under the stress conditions encountered in mines.

A plain strain case of the above general material model was implemented in a Non-Linear Finite Element Computer code called NFEMP (The NFEMP was developed in the Luleå University). This was used to simulate the progressive failure of a typical rib pillar and a

rectangular opening in a hard rock mine. The results obtained from the simulation are physically realistic and promising.

During the Post-Graduate studies at the Luleå University, also worked in various projects, a few of which are:

- Heat induced fracturing of rocks,
- Detail modelling of a part of Jinchuan Mines in China using Finite Element computer program for optimum location of permanent openings; and
- Generic model analysis of large faulted rockmass using HNFEMP computer code for nuclear waste disposal Programs.

## **4. Experience in Mining and Underground Excavations**

- **Underground Manager** in Zawar Mines , HZL ( 1979-1983)
  - Underground mine planning and operations.
  - Planning and installation of various rock mechanics instruments in the mine for monitoring mechanical response of the excavations due to mining.
  - In-situ stress measurement in Mochia mine by over-coring method
  - Interpretation of the rock instrument data
- **Study visit to the mines in Sweden and Finland** (1983-1988)
  - Kiruna Iron Ore Mine, (LKAB), Sweden
  - Liasvall Pb-Zn mine, (Boliden), Sweden
  - Kristenberg mine, (Boliden), Sweden
  - Tytyri underground lime stone, (Oy Lohja), Finland
- Visited Äspö **hard rock laboratory of Swedish Nuclear Fuel and Waste Management Co.** , Sweden (1992)
- Visited several **Coal and Non-coal Mines in India** in connection with R&D and consultancy services.

## **5. R&D Experience**

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### **SCIENTIST – EI, CMRI, DHANBAD (1988 – 1993):**

- **Led a team of scientists** doing R&D work in the following fields:
  - Numerical modelling of the mechanical behavior of excavations in rock. For example, behaviour of stopes and pillars due to mining were simulated using different types of numerical methods on computer for
    - (i) mine planning and design and
    - (ii) support of galleries and tunnels
  - In-situ stress measurement.
  - Rock monitoring.
  - Design of stopes and pillars in mines of HCL and HZL
- **Coordinator** of an R&D project on Design of Methods of work for Non-coal mines, sponsored by the Ministry of Mines (15 lakhs, 1988-1993). Project completed successfully.
- **Consultancy projects** for design of pillars and support in non-coal mines, and design of support for galleries in coal mines.

### **PROFESSOR, INDIAN SCHOOL OF MINES UNIVERSITY (1993 – contd.)**

#### **R&D Projects**

4. Coordinator of an R&D project on **Investigations of cavability of overlying strata and development of guidelines for estimation of support capacity for longwall faces-CMRI, NIRM, & ISMU**, sponsored by the Ministry of Coal, Total Rs. 454 Lakhs, , ISM share Rs. 64 Lakhs, 2005-contd.)
5. Coordinator of an R&D project on **Development of a setup for stress measurement in concrete tunnel lining dam walls and pillars**. Ministry of Water Resources, R & D Division, New Delhi. (15.22 Lakhs, 2005.. contd)
6. Co-coordinator of an R&D project on FEM Analysis of Spread Footing Foundation on Weak Floor Jointed and Layered Rock Mass. Department of Science and Technology, NewDelhi (22.5 Lakhs, 2008 ... contd.)
7. Coordinator of an R&D project on Fibre Reinforced Shotcrete Support in Mines, sponsored by the Ministry of Coal (14 Lakhs, 1995-1998). Project completed successfully.
8. Coordinator of an R&D project on Fibre Reinforced Shotcrete–Bolt support subjected to high induced stresses, sponsored by the Ministry of Coal (Rs. 21 Lakhs, 2001-2004) Project completed successfully

#### **Consultancy projects in coal and non-coal mines.**

Some of the consultancy works undertaken are:

1. Design and location of a major crown pillar in Balaria Mine, HZL.

2. Steel fiber reinforced shotcrete support design for a gallery in coal at Digwadih mine (TISCO) and its implementation.
3. Stabilisation of a shaft pillar by steel fiber reinforced shotcrete in Mudidih colliery, BCCL.
4. SFRS support of lateral drivages in poor ground in Chasnalla Collilery.
5. Sealing of fissured zones in Murulidih Colliery for stoppage of water flow in the mine.
6. Numerical simulation for Bord & Pillar mining under soft floor condition in GDK5 mine of SCCL
7. Numerical simulation of Blasting Gallery method of Mining GDK8 mine of SCCL.
8. Design of fly ash fill and filling system for filling voids of open cast and underground mines for NTPC and ECL.
9. Numerical modeling studies for shaft pillar stability and prediction of surface subsidence, ECL and BCCL.

## 6. Facility Development

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- Coordinated development of a state of the art fully automatic computer controlled setup for testing of **hydraulic STDA and DTDA legs for powered roof support, required as per ICIS-001/1991**, in the Dept. of Mining Engineering. Earlier, this facility was available only with JESSOP, Kolkata.
- A state of the art test centre for testing for hydraulic valves and dynamic response of hydraulic legs and powered roof support for Longwall mining is under development.

## 7. Research Supervision

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Major Ph.D. and M. Tech researches were guided in the following areas:

- Development of Fibre Reinforced Support;
- In-situ Stress Measurement by Hydraulic Fracturing method;
- Development of Boundary Element Method Software for Mine Design;
- Development of Rock mass failure predicting models and their application in extraction of marginal grade deposits; and
- Techno-economic evaluation of mining projects.
- Numerical simulation for cavability assessment and support design for Longwall mining.

### Foreign students

Graduate dissertation works supervision at ISM (1995-96), for Scholars of The Royal Institute of Technology, Stockholm, Sweden	Two students
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### Indian students

Research Degree	No. Of Students
M Tech (degree awarded)	5
Ph D (degree awarded)	3

## 8. Teaching

- Rock mechanics to the graduate students at Luleå Technical University, Sweden.
- ISM, Dhanbad:
  1. Underground Metal Mining.
  2. Rock Mechanics/Applied Rock Mechanics.
  3. Mine Planning.
  4. Project feasibility studies.to B Tech, M Tech and MSc Tech Students.
- Contribution in teaching at ISM
  1. Introduced stress analysis by numerical technique in Rock Mechanics Practical.
  2. Introduced computerized Data Acquisition System in Rock Mechanics Practical.
  3. Developed Physical models for teaching mining methods.

## 9. Administrative Experience

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2. Served as a **Head, the Dept. of Mining engineering ISMU from 2004 to 2007.**  
Achievements of the Department during that period:
  - (a) Two 5-year integrated courses were introduced and syllabus prepared. They are
    - (i) BTech in Mining Engineering and MTech in Mining Engineering
    - (ii) BTech in Mining Engineering and MBA
  - (d) Three national Seminars on underground metal mining, coal mining and mine surveying and one national workshop on numerical modeling were organized
  - (e) Prof. D.N. Prasad Memorial Lectures were organized

- (f) Several projects related to service to the industry were undertaken in the Department of Mining Engineering. The earning to the Department increased from Rs. 6.5 million in 2003-2004 to 16.4 million in 2006-2007 from these projects.
3. Served as **Head of the Division of Metal Mining and Ground Support** (1989-1993) during my tenure at CMRI, Dhanbad.

## **10. Awards and Distinctions**

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### **Awards**

1. Best paper award for the year 2002, under category “Underground Space Technology” by ISRMTT for paper “Steel Fibre Characterisation Section of Shotcrete” in Jl. of Rock Mech. & Tunnelling Technology.
2. Awarded Robertson Medal of the Mining, Geological and Metallurgy Institute of India (MGMI), for the year 1979, for standing first in order of merit with more than 75% marks in Final Year B Tech Examination in Mining Engineering, Banaras Hindu University, Varanasi, India.
3. Winner of the Golden Jubilee Shield (1978-1979) of the Mining Society, Banaras Hindu University, Varanasi, India, for the overall best performance.

### **Distinctions**

1. Member of the Editorial Advisory Board of "**International Journal of Continuum Damage Mechanics**", USA.
2. Reviewer of technical papers of International Journal of Rock Mechanics and Mining Sciences, International Journal of Damage Mechanics and Journal Institution of Engineers India.
3. Represented ISMU in several Government and no-government bodies as a Head of the Department of Mining Engineering.
4. Member of Revision of Syllabus under Coal Mines Regulation, 1957 & Metalliferous Mines Regulation, 1961, DGMS, Dhanbad.
5. Served as an expert member in selection committees of Jai Narain Vyas University, Jodhpur, CMRI, Dhanbad and NIT. Surathkal.
6. Member, Board of Courses and Studies of B. Tech (Mining Engg.) at Department of Mining engineering at IT-BHU, Varanasi and BIT, Sindri.
7. Member of Advisory Committee of CAS, Dept. of Mining Engineering, IT-BHU, Varanasi.
8. UGC nominee of the Advisory/Administrative Committee of DSA Pase-III, Department of Civil Engineering, Jadavpur University, Kolkata
9. One of the expert members of AICTE team for accreditation of Bengal Engineering College, Shivpur, Kolkata

## **11. Affiliation to professional bodies**

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### **Life member**

- International Society for Rock Mechanics (ISRM).

- MGMI
- Institution of Engineers (India)
- Indian Society for Technical Education (ISTE)
- Indian Society of Rock Mechanics and Tunneling Technology (ISRMTT)
- Information Centre for Fibre Reinforced Concrete Composites (CFRC)

**Life Fellow:** Indian Academy of Social Sciences

## **12. Conference and Invited lectures**

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### **Organized**

- 2008: 19th National Convention of Mining Engineers and National Seminar on Disaster in Mines, Indian School of Mines University, Dhanbad, 10-11th March, 2008
- 2007: - National WorkShop on “ Application of Numerical Modelling in Strata Control for Coal Mines”, Dept. of Mining, Engineering, ISMU, Dhanbad. Oct. 29-30, 2007
- 1999: A National workshop on Fibre Reinforced Shotcrete in Mines, 5-6 April, 1999, Dhanbad.

### **Attended**

- 2009: SINOROCK 2009- ISRM –sponsored symposium on Rock Mechanics: Rock Characterisation, Modelling and Engineering Design Methods, 19-22, May 2009, Hong Kong
- In International Symposium on “*Rock Mechanics and Geo-Environment in Mining and Allied Industries*” (RGMA-09) in February 12-14, 2009; BHU, Varanasi.
- “Mining in India: the Expanding Horizon”, Organized by MMR, January 17, 2009, Mumbai.
- 2008: National Seminar on Frontiers in electronics, communication, Instrumentation and Information Technology, Indian School of Mines University, Dhanbad, India, October, 13-15, 2008
- 2007: 2<sup>nd</sup> Coal Summit 2007, New Delhi, Dec. 10-11, 2007.
- 2006: - Indian Conference on Mine Surveying ICMS-2006), Dept. of Mining Engineering, ISMU, Dhanbad, 8 – 9 September 2006
- National Seminar on Underground Coal Mining & Expo-2006, Dept. of Mining Engineering, ISMU, Dhanbad, Nov.9-10, 2006
- 2004: Attended 3<sup>rd</sup> Asian Rock Mechanics Symposium 2004, Contribution of Rock Mechanics to the New Century, Nov. 30 – Dec. 2 2004, Kyoto Japan,
- 2003: Attended Conference on Geomechanics and Ground Control, 24-25, September, 2003, CMRI, Dhanbad.
- 2003: Attended Workshop on Challenges of 21<sup>st</sup> Century – Introspection, 13 July 2003, DGMS, Dhanbad

- 2002: - Attended International Seminar on Mining Technology and Management for Excellence, Nov, 15-16, 2002, New Delhi.
- Attended ISRM India Symposium on Advancing Rock Mechanics Frontiers to meet the Challenges of 21<sup>st</sup> Century, 24-27, Sept, 2002, New Delhi.
- 2001: Attended International Mining Machinery Exhibition – held at Kolkata, Nov 6-11, 2001.
- 2000: Attended Workshop on Underground Metal Mining Practices, 6-7 February, Bhubaneswar
- 1999: Attended and presented a paper in Platinum Jubilee Symposium, Dept. of Mining, IT-BHU, 29-30 January 1999.
- 1998: Attended and presented a paper in “ खनन के साथ विकृत भूमि का पर्याहितैषी पुनर्वास, राष्ट्रीय संगोष्ठ 17 – 18 अप्रैल, केन्द्रीय खनन अनुसंधान संस्थान, धनबाद.
- 1996: Attended and presented a paper in National conference on Ground Control, Jan. 1996, Varanasi.
- 1995: Attended and presented paper in VIII National Convention of Mining Engineering, Nov. 1995, Udaipur.
- : Invited to deliver a lecture on "Strata Control in Metal Mining" in the **Deptt. of Mining Engineering, BHU, Varanasi.**
- 1993: Attended and presented paper in
- (a) Int. Seminars in Mineral Sectors in India, Hyderabad.
- (b) IV Asian Mining Int. Conference, Nov. 1993, Calcutta.
- 1991: Invited for pursuing research on Continuum Damage Mechanics (CDM) at **The Royal Institute of Technology, Stockholm**, for three months in March 1992.
- 1989: Invited by the **Mining Department, IT-BHU**, Varanasi for delivering a lecture on "Simulation of the Progressive Failure of Brittle Rock".
- 1988: Invited to deliver a lecture on "Simulation of Strain Softening of Brittle Rocks" in the Division of Solid Mechanics, **Chalmers Technical University, Gothenburg, Sweden.**
- 1998 : Attended an International Conference on Fracture and Damage of Concrete and Rock, Vienna, July 1988.
- 1987: Attended an International Conference on Constitutive Laws of Engineering Materials: Theory and Applications, Arizona, USA, January 1987.

### **13. Publications**

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International Journals (published): 20  
 National Journals (published): 7  
 Seminars, Symposia, Conferences, Workshops proceedings: 35

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**Edited:**

1. **Singh, U.K. (2007)**, Editor, Application of Numerical Modelling in Strata Control for Coal Mines, Dept.of Mining, Engineering, ISMU, Dhanbad. Proceedings of National WorkShop, Oct. 29-30, 2007
2. Pal, P.S. and **Singh, U.K. (2008)**: Editors, Disaster in Mines, Proc. of the 19th National Convention of Mining Engineers and National Seminar, Indian School of Mines University, Dhanbad, 10-11th March, 2008
3. VMSR Murthy, **Singh, U.K.** et.al , Editors: Underground Metal Mining: Status and Prospects, Proceedings National Seminar , Dept. of Mining Engineering, Feb 13-14, 2006.

**14. Achievements****Major achievements in Research and Development****(i) During (2005-2008)**

<b>R&amp;D work</b>	<b>Achievements</b>
(1) Investigations of cavability of overlying strata and development of guidelines for estimation of support capacity for longwall faces-CMFRI, NIRM, & ISM. (A joint S&T Project from Ministry of Coal; Rs. 455 Lakhs, ISM share Rs. 64 lakhs); Ongoing	<ul style="list-style-type: none"> <li>• Numerical modeling approaches have been developed for simulating progressive caving and load on the powered roof support in longwall mining (PhD work of Dr. GSP Singh)</li> <li>• An Intrinsically safe Data Logging System has been developed for use in monitoring of pressure in legs of hydraulic powered roof supports and closure of the support in coal mines. This system will be used by CMFRI and NIRM for their project and monitoring of hydraulic powered long wall faces in future.</li> </ul>
(2) Development of a setup for stress measurement in concrete tunnel lining dam walls and pillars. (A S&T project, Ministry of Water Resources; Rs. 15 Lakhs)	<ul style="list-style-type: none"> <li>• A setup has been developed and trial is undergoing in laboratory. After successful trial, a field trial will be undertaken.</li> </ul>

**(ii) During (1993-2005)**

<b>R&amp;D work</b>	<b>Achievements</b>
1. Design of Steel Fibre Reinforced Shotcrete (SFERS) for support in mines <sup>(a)</sup>	<ul style="list-style-type: none"> <li>• Developed design guide lines SFERS- bolt support using RMR</li> <li>• The SFERS is successful in solving the difficult ground control problems in coalmines galleries effectively and economically. It is economical compared to the conventional steel supports. There</li> </ul>

	<p>is a <b>demand of this technology in different mines.</b></p> <ul style="list-style-type: none"> <li>• In a BCCL mine, a shaft pillar and shaft wall have been stabilized using the SFRS. This has saved Rs. 3.5 Crores and the <b>shaft from closure.</b></li> <li>• The SFRS is being used in several mines, for example, Chasnala colliery and Jaduguda mines for supporting galleries in poor ground.</li> <li>• Publications in International and national journals</li> </ul>
2. Development of a state of the art facility for testing hydraulic legs used in powered support at Longwall faces.	<ul style="list-style-type: none"> <li>• This has facilitated indigenous development of powered support for Longwall faces and also helped the coal industry in testing of the powered support.</li> </ul>
3. Numerical simulation of controlled caving of massive roof in coalmines by hydraulic fracturing.	<ul style="list-style-type: none"> <li>• The fracture-breakdown and fracture-extension pressures predicted by this numerical model agree well with the recent experiment of hydraulic fracturing in Kumda New colliery of SECL. An S&amp;T project at, ISM is being planned on this line.</li> </ul>
4. Development of a cement grout and a method of grouting for sealing fissured zone in underground mines for stopping flow of water under pressure of more than 10 kg/cm <sup>2</sup> . Successful trial of sealing of a borehole in Murulidih coal mine has been conducted. Full-scale trial is awaited.	<ul style="list-style-type: none"> <li>• It will <b>save cost of energy in pumping the water</b> out of the mine by reducing flow of water into the mine. It may be noted that, in BCCL, on an average 10,000 litres of water is being pumped for producing one tonne of coal.</li> </ul>

5. Guided Research work on Economic Evaluation of mining projects <sup>(b)</sup> .	<ul style="list-style-type: none"> <li>• A simple and effective model for early evaluation of mining projects has been developed.</li> <li>• Ph.D. awarded</li> <li>• Publications in an International and national Journals.</li> </ul>
6. Guided research work on development of a statistical method for computing in-situ stress from hydraulic fracturing data. <sup>(b)</sup>	<ul style="list-style-type: none"> <li>• A unique method, which considers inclined and pre-existing hydraulic fractures for computation of 3D in-situ stress tensor.</li> <li>• Publications in international and national journals.</li> </ul>
7. Guided research work on development of empirical models for predicting rock mass failure in opens stopes under high stress conditions and suitable economical stoping method under these conditions. <sup>(b)</sup>	<ul style="list-style-type: none"> <li>• Borehole Breakout and Drive Failure Models were developed. The models were successfully applied in design of sublevel open stopes in mines of HZL.</li> <li>• Ph.D. degree awarded to P.K. Rajmeny, Sr. Manager (HZL).</li> <li>• Publications in international and national Journals.</li> </ul>

### (iii) R&D Achievements before year 1993.

<p>8. Developed various numerical models of non-coal mines namely, Mochia, Balaria and Rajpura Dariba of HZL and Mosaboni of HCL (c)</p>	<ul style="list-style-type: none"> <li>• The numerical models were successful in prediction of stability of pillars and excavations.</li> <li>• Results of the numerical models were accepted and implemented by the management and engineers of the respective mines.</li> <li>• Publications in international and national Journals.</li> </ul>
<p>9. Postgraduate research (Ph D) work on the project titled "Development of a Computer (mathematical) Model for Post-Failure Analyses of Mine Structures". (d)</p>	<p>The postgraduate Ph D work published in International and national journals. The work has been <b>cited</b> in several International publications and books, for example,</p> <ul style="list-style-type: none"> <li>• Rock Fracture Mechanics, by Whittaker, et. al., 1992, page 547.</li> <li>• Rock Stress and Its Measurements, by Amadei, et.al. , 1999, page 324.</li> <li>• Int. Journal of Damage Mechanics, V7, N2, 1998, Page 206.</li> </ul>

(a) Financial support of Ministry of Coal (Rs. 14 Lakhs)

(b) MTech and Ph.D. guidance

(c) Financial support from the Ministry of Mines (15 Lakhs), during my tenure at CMRI, Dhanbad

(d) Luleå University of Technology and the National Swedish Board of Technical Development supported the project.

## 15. Patents

### 1. A Steel Fibre Making Machine.

(Steel fibres are required for reinforcement of shotcrete. These are not readily available in India and are mostly imported.)

#### Status

- Patent No.: 193 510(1778/Cal/96).
- Improved version under development and fabrication.

### 2. Self Advancing Goaf Edge Support(SAGES)

A model of mobile roof support for supporting goaf edge has been developed at ISM. It has a unique mobility feature. An application for **patent of SAGES has been filed vides Indian Patent Application No. 1123/KOL/2006 dated 25.10.2006.**

This will be used as **Goaf Edge Support** for mining of coal from underground by Bord & Pillar method of Mining. This is will enhance safety and economy of mining coal pillars. Some manufactures of support and Coal Company are interested in this development.. Will be getting fund for further development.

## 16. Impact of Contributions on Mineral Industry

- (a) Steel Fibre Reinforced Shotcrete (SFRS) support has been successful in solving difficult ground control problems in coal mine galleries effectively and economically. The trial results have yielded:

- Saving of Rs. 5000/- – 6000/- per metre of gallery length over conventional steel supports.
  - Stabilisation of a shaft pillar and the shaft walls of 6 pit Mudidih colliery, BCCL, and this has saved Rs. 35 million by saving the pit from closure.
- (b) The SFRS has potential for economic support of Longwall gate roads at depth and support of rib pillars between panels. It is to be noted that, in future, the coal has to be won from deeper levels by Longwall method of mining.
- (c) The cement grout and the method of grouting of rock for sealing flow of water into the mines and will save cost of energy in pumping the water out of the mines.
- (d) The testing set-up for hydraulic STDA and DTDA legs for powered roof support would cater the need of the coal mining industry and the indigenous support manufacturers.
- (e) Numerical models of mines have been successful in predicting stability of pillars and excavations in mines. The results of recent numerical model study of controlled caving of strata by hydraulic fracturing would be used for planning the experiment of hydraulic fracturing to induce caving of massive roof.