1. Name: Rajendra Singh

2. Date of Birth: 20.01.1959

3. Current Position and Address: (with E-mail & Phone no.)

Chief Scientist & Head,
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4. Educational qualifications: (Graduation and above):

Sl.. No	Degree/ Certificate	Year of Passing	University/ Institute	Subjects
1.	B.Sc. (Phy. Hons.)	1978	Magadh University	Physics (Hons.), Chemistry & Math*
2.	M.Sc. (Phy.)	1980	Magadh University	Physics (Electronics as special paper)
3.	Ph. D. (Engg.)	1996	University College London	Geomatic Engineering

*Distinction in all Subjects.

5. Work experience:

After post-graduation in Physics, I joined CSIR-CIMFR (JRF in 1983 and Scientist in 1986) and found myself comfortable in applying basic rock mechanics principles for improvement in practical mining conditions. I was awarded the Commonwealth Scholarship of Government of UK in 1993. Under this scholarship, I conducted R&D work for three years (1993 to 1996) at University of London (UCL) leading to my Ph.D. Owing to my good academic background of mechanics, I found myself comfortable in studying rock-mechanics during interaction of different mining structures with *in-situ* and mining induced stresses. I devoted last 30+ years of service at CSIR-CIMFR in different investigations related to more than 150 in-house and industry-sponsored projects, including eight S&T projects of the Ministry of Coal, Govt. of India and one collaborative (international) S&T projects and some other collaborative researches with different institutions like Indian School of mines, IIT (Kharagpur) and IIT (BHU). Extensive field investigations and studies on simulated (numerical and physical) models were the basic tools of the study. Worked as Honorary University Fellow at Camborne School of Mines (CSM), UK from November 2010 to May 2011. Successfully guided couple of Ph.D.s (Mining Engg.) and some M.Sc./M.Tech./B.Tech. students also. Details of different working posts/positions are given below in the table:

Designation	Institution/company	From	To	Nature of work
JRF and SRF	CSIR-CIMFR	January, 1983	November, 1986	R&D for efficient u/g coal mining
Junior Scientist	CSIR-CIMFR	December, 1986	November, 1989	-do-

Scientist	CSIR-CIMFR	December, 1989	November, 1994	-do-
Senior Scientist	CSIR-CIMFR	December, 1994	November, 1999	-do-
Principal Scientist	CSIR-CIMFR	December, 1999	November, 2004	-do-
Sr. Principal Scientist	CSIR-CIMFR	December, 2004	November, 2009	-do-
Chief Scientist	CSIR-CIMFR	December, 2009	till date	-do-
Commonwealth Scholar	*UCL, UK*[1]	*October, 1993*	*September, 1996*	*Geomatic Engg.*
Honorary University Fellow	*CSM, UK*[2]	*November, 2010*	*May, 2011*	*Rock Mech. for deep coal mining*

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6. Area of specialization: Strata/Rock Mechanics for Strata Control in Underground Coal Mining, Efficient Mining of deep seated Coal (Locked- up Coal in Thick Seams & Developed Pillars), Modelling and Simulation of Mining Structures, Cuttability of Coal Seams, Underground Instrumentation and Monitoring of Strata and Photogrammetric Measurements.

7. Honours/Awards received:

Honours

Invited to be a ***Honorary University Fellow*** at Camborne School of Mines (CSM), UK by the **University of Exeter, UK** in the field of Rock mechanics**:** 2010-2011.

Awards

Received the ***CSIR-Golden Jubilee CMRI-Whitaker Award,*** 1999-2000.

Recipient of the ***National Mineral Award*** (*first among the present working scientists of CSIR-CIMFR to receive this Award*), generally, awarded annually by the Ministry of Mines, Government of India to the best performing academician in the field of "Mining Technology" **–** 2002-2003.

Medals/prizes

Received some medals/prizes from different professional organisations as mentioned below:

- ***Gold card of Coal India Ltd. (CIL)*** for the contribution towards growth of the Coal Industry, 1994.
- ***Gold Medal*** *of the Mining Geological & Metallurgical Institute of India (MGMI), 2003-2004.*
- ***Silver Medal*** *of the Mining Geological & Metallurgical Institute of India (MGMI), 2005-2006.*
- ***Hindustan Zink Limited Prize*** *of the Institution of Engineers (India),* 2007**.**

8. Fellowships/Scholarships:

- Awarded the **National Merit Scholarship** during post-graduation study.

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[1] *Worked as Commonwealth Scholar at UCL (University of London) from October 1993 to September 1996 three years under Commonwealth Scholarship of UK (study leave from CSIR-CIMFR) and obtained Ph. D.*

[2] *Worked as Honorary University Fellow at CSM (University of Exeter, UK) from November, 2010 to May, 2011 under sabbatical leave from CSIR-CIMFR.*

- CSIR- Junior (JRF) and Senior Research Fellowship (SRF) in 1983-1986.
- First CSIR-CIMFR scientist to receive ***the Commonwealth Scholarship*** of UK (after succeeding in multi-stage screening process of the open selection procedure), and conducted R&D *at University College London, UK for three years and awarded Ph.D. degree: 1993-1996.*
- Awarded the **Academic Staff Fellowship of UK** for 2010-2011 by the Association of Commonwealth Universities, London. The selection for this fellowship is based on the Academic merit of the candidate, quality of the proposal and the impact of his/her work on the development of the candidate's country.

9. No. of Research Publications: Total = 123
   - Papers in journals: Forty eight (Twenty three in foreign journals)
   - In conference proceedings: Sixty three (Twenty seven in international confrences)
   - Invited/key-note addresses: Eleven

   - List of best 05 publications:
     1. **R. Singh**, D. P. Chapman and K. B. Atkinson, 1997. Digital photogrammetry for automatic close range measurement of textureless and featureless objects. *Photogrammetric record; an International Journal of Photogrammetry,*15(89): 691-702
     2. **R. Singh,** P K Mandal, A K Singh and T. N. Singh, 2001. Cable bolting based mechanised depillaring of a thick coal seam. *International Journal of Rock Mechanics and Mining Sciences,* **38***(2), 245-257.*
     3. **R. Singh**, A K Singh and P K Mandal, 2002. Cuttability of coal seams with igneous intrusion. *Engineering Geology, an international journal*.7(2002), 127-137.
     4. **R. Singh,** 2004. Staggered development of a thick coal seam for full height working in single lift by blasting gallery method. *International Journal of Rock Mechanics and Mining Sciences*, **41**(5): 745-759.
     5. **R. Singh**, A Kumar, A. K. Singh, J. Coggan and S. Ram, 2016. Rib/snook design in mechanised depillaring of rectangular/square pillars. *Communicated to International Journal of Rock Mechanics and Mining Sciences.*

10. Number of Books authored/edited: Two

11. (a) No. of Patents granted/applied for: Three

    [i] "A novel method for underground extraction of coal from contiguous seams/sections" by P. K. Mandal, **R. Singh,** T. N. Singh, B. K. Dubey and A. K. Singh: December, 2000.

    [ii] "A novel method for underground extraction of coal from a critically thick coal seam standing on pillars and the development made along the roof horizon" by **R. Singh,** P. K. Mandal and A. K. Singh: February, 2002.

    [iii] "A model for rib/snook design in mechanised depillaring under moderate roof strata" by R. Singh, A. K. Singh, S. Ram, A. Kumar, R. Kumar and A. K. Singh: November 2015.

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[iv] "Combined-Instrument-Approach (CIA) for analysis of underground instrumentation data." by **R. Singh,** P. K. Mandal, A. K. Singh, R. Kumar, A. Sinha, May 2009.

(b) Technologies developed, Licensed and/or commercialized:

I devoted my research activities in studying response of rock-mass for a redistributed state of stress and strain situation of the underground coal mining with widely varying geo-mining conditions ranging from nearly flat, hard and massive formations of Lower Gondwana coal of Jharia coalfield to highly folded, soft and fragile formations of Tertiary coals of Makum coalfield. In addition to my active contribution in development of the award winning mining methods like - cable bolting based depillaring of thick seams, wide stall mining etc.; my recently developed mining methods like: "Underpinning based simultaneous extraction of contiguous sections under fragile parting" and "Cross development based underground extraction of a critically thick coal seam standing on pillars and the development made along the roof horizon" have added new dimension in the field of optimal underground extraction of thick & contiguous coal seams of the country. Development and application of a new process: known as "Combined instruments Approach" (CIA) for the strata mechanics proved to be an efficient method to improve safety of underground workings. Development of models for the design of rib and breaker-line support for CM based mechanised depillaring proved to be crucial for the efficiency of the mass production technology.

After laboratory validations (on simulated models) of different conceptual ideas, successful efforts are made to translate some of these ideas into large scale practice by the industry for optimal design of underground mining structures. My contributions to characterise rock-mass behaviour under changing stress conditions of mining proved to be significant for safe and efficient extraction of locked-up coal pillars. Coal mining industry of the country has widely accepted and acknowledged the techno-economical superiority of these R&D developments. These R&D efforts have earned considerable appreciations, large number of citations and prestigious awards too.

12. Foreign visits:

Czech Republic	23-Sep-1991	25-Oct-1991	CSAV and Institute Geonics, Ostrava	Interacted with scientists of Czech under CSIR-CSAV exchange programme
United Kingdom	04-Oct-1993	03-Oct-1996	University College London (UCL)	Worked at Department of Geomatic Engineering of UCL for three years under Commonwealth Scholarship/fellowship of UK (study leave from CSIR/CIMFR)and obtained Ph. D.
United States of America	21-Oct-1995	30-Oct-1995	Philadelphia	Attended and presented a paper in the international conference: "Videometric IV"
Austria	07-Jul-1996	21-Jul-1996	Vienna	Participated in XVIII Congress of ISPRS and present a paper in person

Australia	11-Jul-1998	19-Jul-1998	Sydney & Wollongong	Participated in an Int. Conf. and present a paper in person
Canada	27-May-2007	31-May-2007	Vancouver	Participate in the 1st Canada-US Rock mechanics Symposium, presented a paper and Co-chaired the first technical session.
China (People's Republic of)	18-May-2009	23-May-2009	Hong Kong	Participated in the ISRM Symposium, presented a paper and Chaired a technical session.
Czech Republic	20-Oct-2009	05-Nov-2009	Ostrava-Poruba	Participated in a joint research project under ASCR, Czech Republic - CSIR, India bilateral S&T Programme on “Rock mechanics investigations to meet challenges of strata control of deep underground coal mining” and interacted with scientists during 7th Czech-Polish Conference (CZPK‘09) on Geology of Coal Basin at the Institute of Geonics.
United Kingdom	14-Nov-2010	13-May-2011	Camborne School of Mines, UK	Worked as honorary University Fellow at CSM, UK in the field of Rock Mechanics under the Commonwealth Academic Fellowship of UK .
Czech Republic	16-Sep-2013	22-Sep-2013	Ostrava-Poruba	Delivered two invited lectures and worked (including underground visit) for a joint research project under ASCR, Czech Republic - CSIR, India bilateral S&T Programme on “Rock mechanics investigations to meet challenges of strata control of deep underground coal mining.
United States of America	27-Jul-2014	02-Aug-2014	Morgantown, West Virginia, USA	Participated in the 33rd International Conference on Ground Control in Mining (ICGCM), presented a paper in person and interacted with different experts participating in the Conference.

13. Details of Professional memberships:

a. International society of Rock Mechanics — Life Member
b. Mining, Geological and Metallurgical Institute of India — Life Member
c. National institute of Small Mines — Life Member
d. Indian Society of Remote Sensing — Life Member

14 . Major contributions: (Max.150 words)

My R&D efforts and management skill to lead a small team of researchers resulted successful completion of important projects, development of some popular methods of mining for safe and clean extraction of difficult coal seams, appreciation from the associated industry and academicians, considerable number of publications in the best rock-mechanics/mining engineering journals and prestigious honours/awards of this area. As per the feedbacks received

from the industry, my contributions have found perfect matching with the geo-mining conditions and found to be of immense importance for excellence of the coal mining industry.

An idea of impact of my development may be obtained from following two feedbacks: one given by the industry and the other by an academician.

About our developed Underpinning technology, practiced at Bartunga Hill Mines of SECL, to extract locked-up coal, ***Chief General Manager, Chirimiri Area, SECL*** *writes:*

".... ***Underpinning technology, thus, increased life and increased percentage of extraction and added mineable property of the mine in addition to manpower deployment opportunity. In addition to safety & production, Coal valued ₹200.0 crores (approx) has already been extracted....."***

Further, while accepting one of our papers for publication in the ***International Journal of Rock Mechanics***; Prof. Hudson, **Chief Editor writes***:*

"***It is exactly the type of paper that we like to publish in the Journal because the work is of high quality and…..".***

Our recent effort to design a mechanised depillaring operation in the country (after self withdrawal of the associated foreign expert) has made a ***nation record of coal production***.

15. Technologies and Products/ Services

(i) Developed:

Developed following Nine *(four patented)* mining methods and processes for efficient and safe underground coal mining -

- Wide Stall (WS) mining for optimal recovery of coal from thick seams locked under the surface features.
- Cable bolting based semi-mechanised depillaring of total thickness of a thick coal seam in single lift.
- Staggered development of a thick coal seam (already developed along roof horizon) for full height working in single lift by blasting gallery method.
- Underpinning based simultaneous extraction of contiguous sections of a thick coal seam consists of the weak and laminated parting.
- Manner of extraction and norms to design underground mining structures for a fully mechanized depillaring of locked-up coal pillars in the deep seated deposits.
- Combined-Instrument-Approach (CIA) for analysis of underground instrumentation data for strata dynamic study during final extraction.
- Development and execution of a hard roof management technique during underground coal mining under bump/rock-bursts prone geo-mining conditions of the deep seated deposits.
- Empirical model to assess nature and amount of mining induced stress development over the coal pillars during a depillaring operation and
- Rib/snook design in CM based mechanised depillaring under moderate roof strata.

(ii) Licensed:

All these developments are, mainly, based on fundamental rock mechanics principles and large scale investigations in field and laboratory. However, these developments are to be adopted under the existing geo-mining conditions of a coal seam. Further, it is very difficult to have any "typical" geo-mining condition, which can be used as a benchmark to standardize different parameters associated with these

developments. Therefore, all these developed technologies are directly provided to the mining industry by CSIR-CIMFR only *after a suitable endorsement/tuning in the design parameters* (as per the selected site conditions). The requirement of good knowledge/understanding of rock-mass (natural material) properties, geology and stress conditions for each implementation site are important inputs for the endorsement/tuning. Accordingly, CSIR-CIMFR did not give license directly to any industry/organization but makes it adoptable for the given site conditions.

(iii) Commercialized:

All the above mentioned methods/processes are extensively used and being used by the coal mining industry. Technical services related to implementation of these developments under the given site conditions have been rendered (in terms of sponsored/ consultancy projects) to more than 100 coal mines and most of them have achieved good success.

16. Designs and Prototype Developed:

Consistent involvement in different important geo-technical investigations helped me in developing good understanding of geology and rock mass of Indian coalfields. This helped me not only in development of above mentioned indigenous technologies but enriched my knowledge and understanding about the complete spectrum of uniqueness of Indian geo-mining conditions. This knowledge base and understanding enabled me to develop following designs and prototypes, in addition to the above mentioned methods/technologies:

- Cuttability model for hard coal seams with igneous intrusions,
- Computer vision based system for monitoring hazardous areas of mines,
- Adoption of suitable caving models under varying depth of cover and the nature of roof strata for efficient depillaring,
- Design of underground instrumentation pattern and monitoring frequency and
- Optimisation of design of roof bolt based breaker-line for a mechanised depillaring.

17. Honours and awards won for technological contributions or sociological impact of R&D:

i. Recieved the ***National Mineral Award*** (*first among the present working scientists of CSIR-CIMFR to receive this Award*), generally, awarded annually by the Ministry of Mines, Government of India to the best performing academician in the field of "Mining Technology" **–** 2002-2003.
ii. ***Gold card of Coal India Ltd. (CIL)*** for the contribution towards growth of the Coal Industry, 1994.
iii. ***Gold Medal*** *of the Mining Geological & Metallurgical Institute of India (MGMI), 2003-2004.*
iv. ***Silver Medal*** *of the Mining Geological & Metallurgical Institute of India (MGMI), 2005-2006 and*
v. ***Hindustan Zink Limited Prize*** *of the Institution of Engineers (India)****,*** 2007**.**