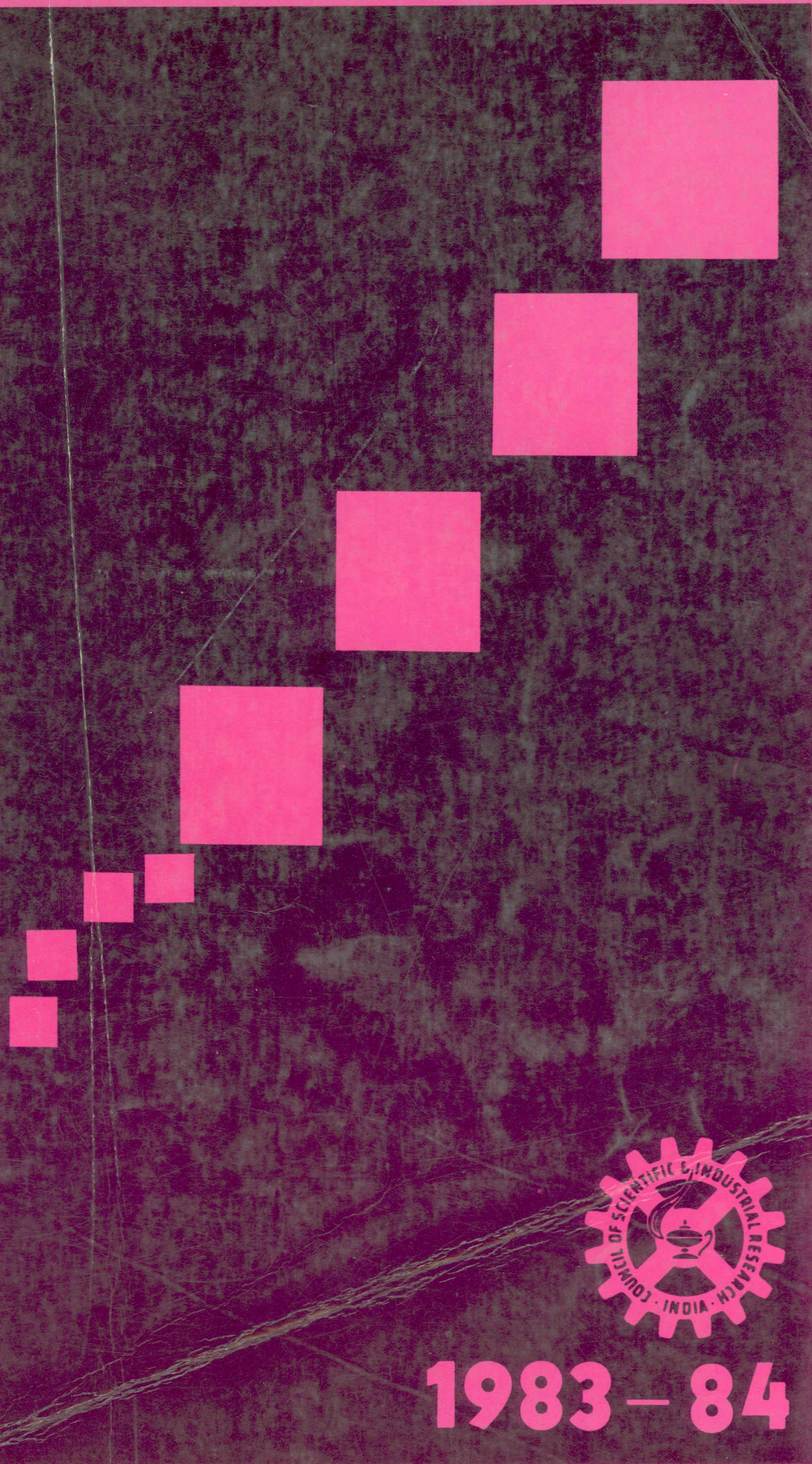


ANNUAL REPORT

REGIONAL RESEARCH LABORATORY

BHOPAL



1983 - 84

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REGIONAL RESEARCH LABORATORY, BHOPAL
NEAR HABIBGANJ NAKA
HOSHANGABAD ROAD
BHOPAL-462026 (M.P.)

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PREFACE

It is my pleasure to present the 1983-84 Annual Report of the Regional Research Laboratory (Bhopal) of the Council of Scientific and Industrial Research. This laboratory was started in 1981 in response to the report of a committee set up by the M.P. Government in collaboration with the CSIR; the committee recommended the establishment of a full fledged CSIR research laboratory to do research related to resources of M.P.

From a small strength of six personnel starting work at the library building of Bhopal University in 1981, the laboratory has grown to a staff of about fifty and is now housed in the newly constructed Co-operative Training College building complex on Hoshangabad Road, Bhopal since December 1983. Modern facilities for materials preparation and characterization, including foundry, Optical and Scanning microscopes, Instron and other Fibre testing equipment, testing of building materials, and chemical characterization have started to function in full swing. A final lease deed for possession of 73 acres of land adjacent to the present campus, given by the M.P. Government to CSIR, has also been signed.

While the details of research activities in progress are given in the subsequent sections of this report, it will be appropriate to mention some salient features and achievements here.

Considerable work on preparation and characterization of Al-alloy based composites, utilizing resources and products of M.P. has been completed. Contacts have been established with industries to jointly upscale the technology of aluminium-graphite composites which are now regularly produced on a small scale level in the laboratory using graphite powder produced near Bhopal. Talc and Mica powders found in M.P. have been successfully combined with aluminium as cast composites. Work has also been initiated on rapid solidification and powder metallurgical processing of composite materials, to further improve their properties.

A report on mineral resources of M.P. and the possible industries that can be set up based on these resources has been brought out. A detailed report of research and development imperatives on the bauxite mineral of M.P. has been completed. Mica powder suitable for making polymer and metal based composites has been beneficiated from mica schists of M.P. on a laboratory scale. Work has been started on polymer red mud composites.

Studies on locally available natural fibres like sisal, banana, sunhemp, sawai, kusha and stems like Ipomoea have been continued to generate a whole host of new information on thermal behaviour, physical and mechanical properties, and utilization of these fibres in materials like polymer based composites. A comprehensive report on resources, structure, properties and uses of natural fibres of Madhya Pradesh has been completed. Test components of polymer-natural fibre composites and cement-natural fibre composites have been made and contacts have been initiated with local agencies to produce these.

Work continued on perspective studies on Madhya Pradesh using formal technology forecasting techniques with emphasis on future materials, to provide requisite inputs for

long range planning of research projects at the laboratory. These were used in preparing Seventh Five Year Plan for the laboratory with emphasis on special and pure materials. The laboratory has been assigned to carry out technology forecasting exercises on materials, by CSIR.

Facilities for testing services, and technical advice have been extended to a number of institutions and industries in and around M.P., and the laboratory has provided training and research facilities to a large number of young scientists. The laboratory was also associated by the Department of Science and Technology in examining proposals of R&D units of several industries in Madhya Pradesh. Distinguished scientists and technologists delivered several lectures at the laboratory which were frequently attended by the community at large. In this sense the laboratory has started to act as a promoter of scientific temper in the region.

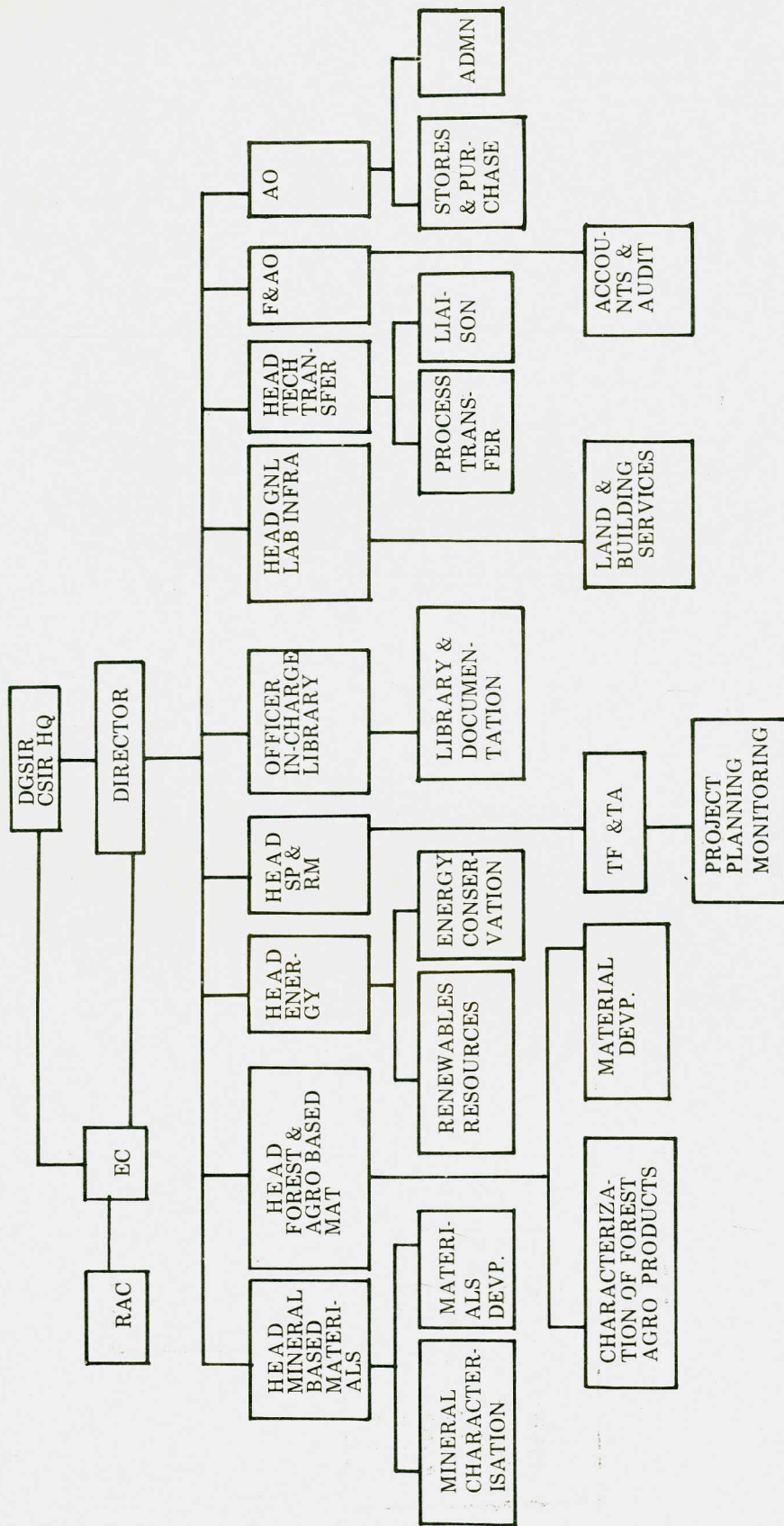
Two Reports on the ongoing sponsored projects, namely the DST project on techno-economic forecasting on aluminium towards the year 2020 A.D.; and the Thapar R&D Centre project on technology forecasting were completed. In addition to this ongoing sponsored work, a new scheme has been received from the Tata Trust, on technology forecasting. Sponsored work on Ultrasonic testing of minerals for HINDALCO, Renukoot was successfully completed during this period.

The scientific publications by the scientists of RRL, Bhopal in prestigious research journals have helped in promoting the reputation of Bhopal as centre of excellence, and in attracting top rate scientific staff to the laboratory.

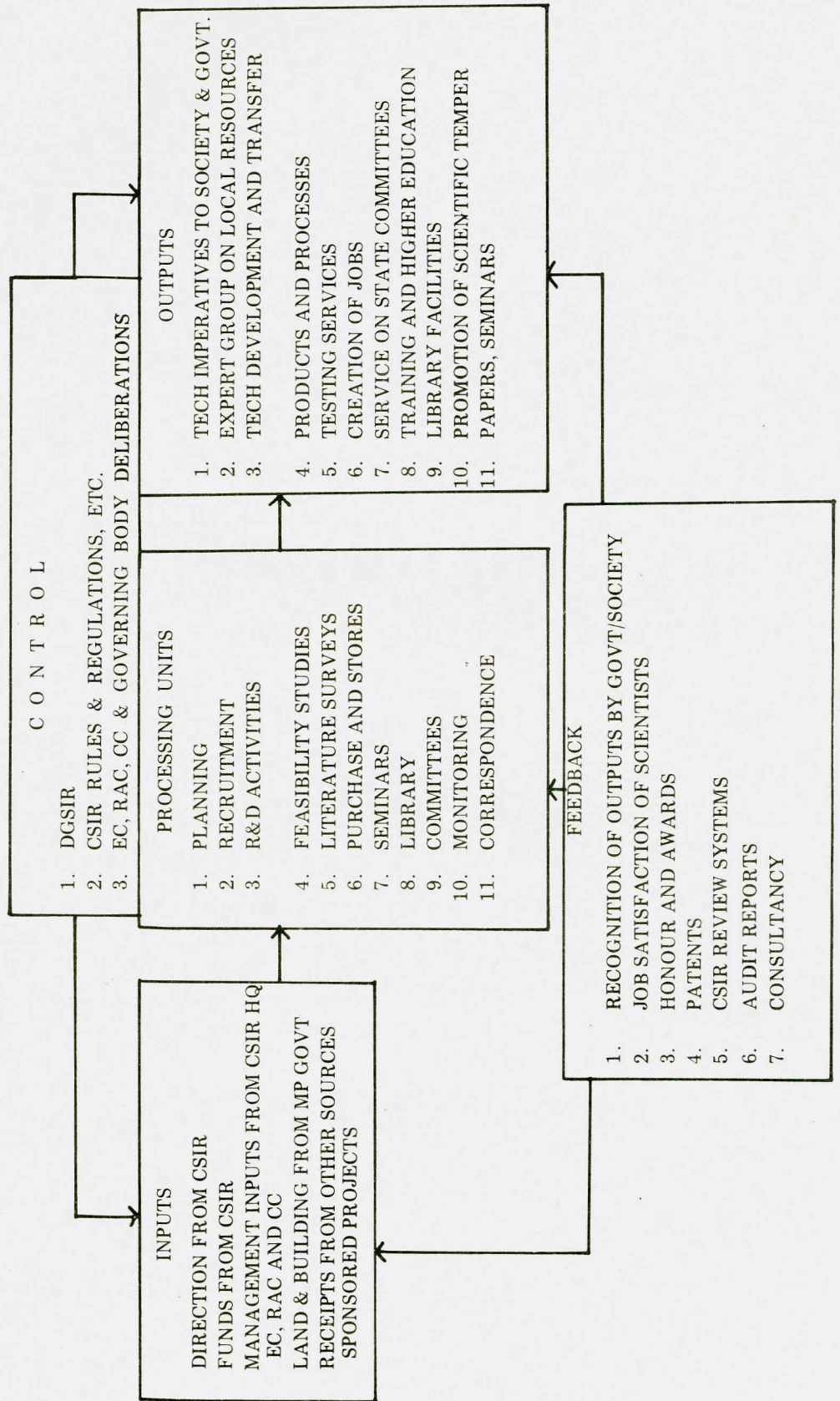
Special mention needs to be made of the visit of Shri Shivraj Patil, Hon'ble Minister of State for Science and Technology and Vice-President of CSIR, on 2nd December, 1983. He visited various laboratories and was shown the research activities undertaken. Later in his address to the staff he stressed upon the paramount importance of development of new materials for the country, and appreciated the lead taken by the scientists at RRL, Bhopal in this direction.

I am indeed grateful to the Vice-President, CSIR and the Director General, CSIR, for their support and encouragement in the inception of this laboratory. Guidance and support received from CSIR headquarters, the Research Advisory Council, the Executive Committee and the help by sister institutions like Bhopal University, MACT, BHEL, IITs, IISc., CIAE, HEG, Malik Industries is acknowledged. I wish to record my gratitude for the generous support given by the State Government of Madhya Pradesh, and its agencies. I will be failing in my duty if I do not record the excellent cooperation and hard work rendered by the staff of this young laboratory, under sometimes very difficult circumstances associated with the inception of new institutions.

ORGANIZATION CHART OF RRL, BHOPAL

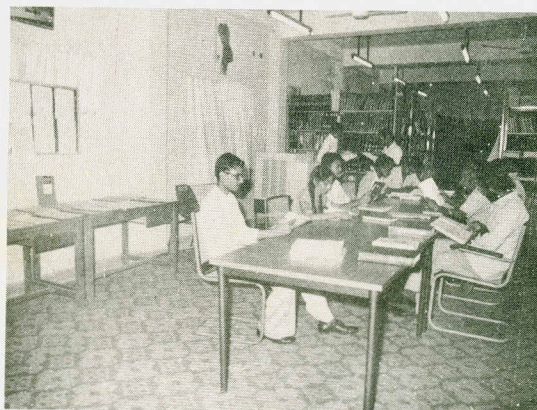


A SYSTEMS VIEW OF LABORATORY

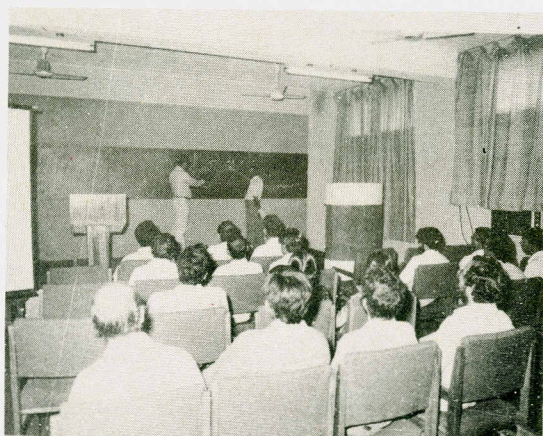




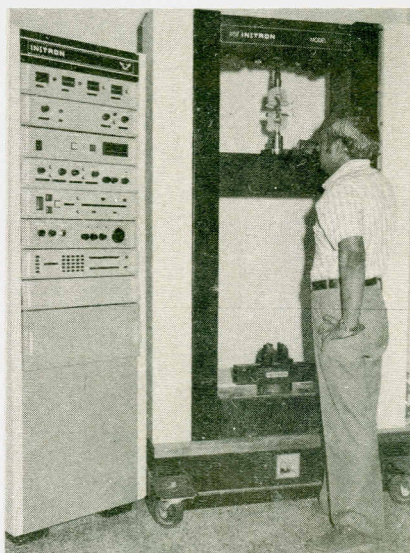
Regional Research Laboratory (Bhopal)



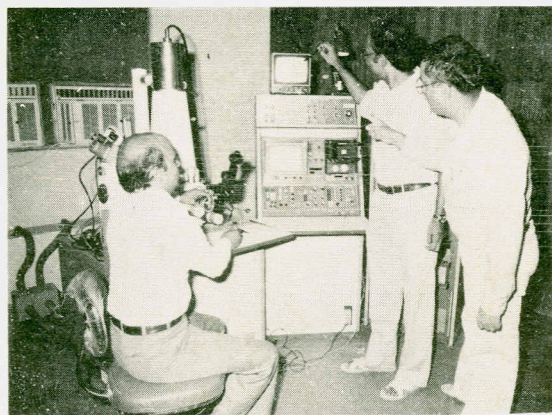
Library



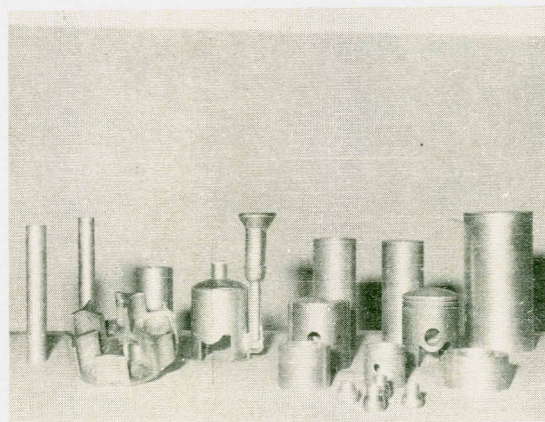
*Discussions towards the end of a seminar in
RRL (Bhopal) Seminar Hall*



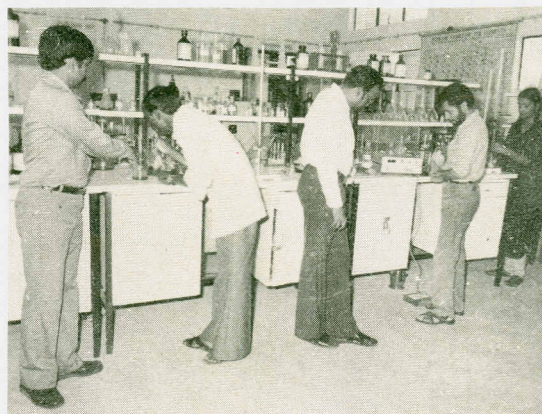
Tensile Testing with INSTRON



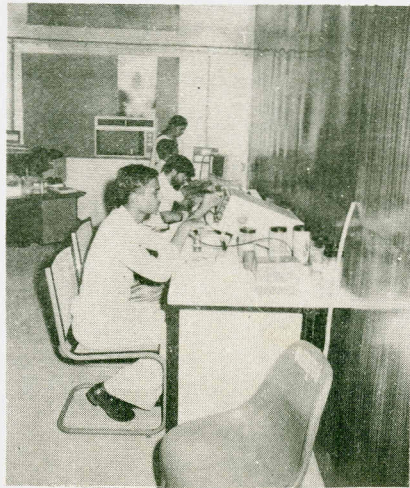
*Scanning Electron Microscopic studies with
JEOL JSM 35 CF*



*Components of Cast Aluminium-Ceramic Particle
Composites made at RRL, Bhopal*



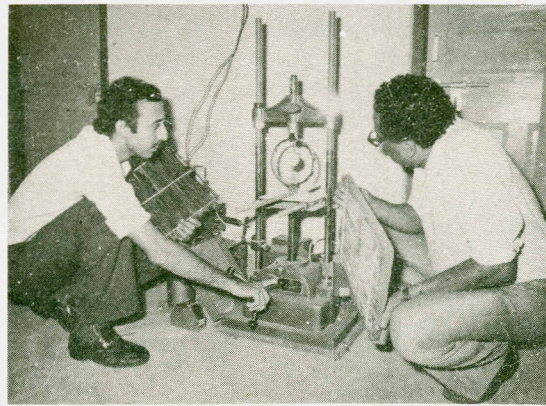
Chemical Analysis in progress



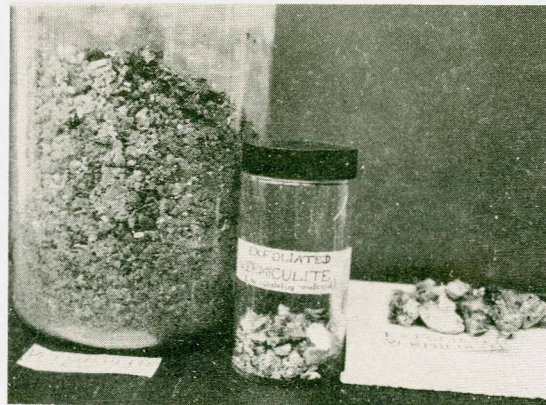
*A view of the Natural Fibre-Polymer Composite Laboratory
The chair in the front is fabricated at RRL using Sunhemp and polyester*



A typical slum house showing use of local plant materials like sunhemp and Beshram (Ipomoea) reeds



Testing of sunhemp-cement composite wall panels in the Building Material Laboratory



Insulating materials from Vermiculite of M.P. Large beaker has the raw Vermiculite mineral and the other two samples are exfoliated Vermiculite

INTRODUCTION

Regional Research Laboratory (RRL), Bhopal established in May 1981, is the first laboratory of the Council of Scientific and Industrial Research (CSIR) in the state of Madhya Pradesh (M.P.). M.P., the largest state in India, is also blessed with vast agricultural, forest and mineral resources. The charter of the laboratory is to carry out scientific studies on the natural resources of the region which would eventually lead to better industrial utilization of these resources. Main objectives of the laboratory are:-

- o Research on mineral, forest and agro-based resources of M.P.
- o Find new uses of mineral, forest and agro-based resources for meeting the societal needs of materials, and energy.
- o Research in aluminium technology, specially to develop products to facilitate substitution of scarce and expensive, imported materials by aluminium.
- o Use of modern management techniques including technology forecasting and assessment to derive research and developmental imperatives.

It is hoped that the activities of the laboratory in research, development and technology transfer will serve the state of M.P. by bringing to the attention of various agencies the technologies which could be developed in the region. The laboratory has been identified to work in the area of special and pure materials.

RESEARCH PROJECT AND PLANS

The Seventh Five Year Plan, of the laboratory concurrent with National Seventh Five Year Plan (1985-86 to 1989-90) has been prepared and submitted to CSIR. S&T projects in the areas of Metallurgy, Minerals, Natural fibres, Building materials, and Information have been incorporated. While the new projects planned will be executed in the 7th Plan period, preparatory work for the same has already been started. Presently the laboratory has undertaken research activities in following areas:-

- o *Development of Al-based composites using resources and products of M.P.*

These composites are made up of dispersions of second phase particles, like the locally available graphite, mica and talc in aluminium alloys, and possess attractive properties which can lead to enormous energy savings, particularly in the transportation sector. Work on latest advances in materials processing, including rapid solidification techniques and powder metallurgy has also been undertaken.
- o *Evaluation of mineral resources of M.P. and identification of research, development, and industrial imperatives.*

The object is to develop process/product/technical know-how, to help mineral based industries in better utilization of resources. The work involves studies on evaluation of minerals, beneficiation of low grade ores, developing techniques for direct utilization of low grade ores and fines. For instance mica powder and talc powder suitable for making composites have been beneficiated from local ores of M.P.

- o *Utilization of natural fibres available in M.P.*

ment of new products like polymer-natural fibre composites for components like table tops, roofing sheets, chairs and other daily use materials from natural fibres like sisal, banana, sunhemp, local grasses like sawai and kusha.

Development of components, bricks, cementitious materials, roofing elements, etc. using locally available resources, including wastes from aluminium industry.

This involves study of local stem like Ipomoea for housing alone or in combination with clay and cement; using the red mud to make bricks and; combining the red mud with polymers to make pipes and other components.

SPONSORED RESEARCH

The laboratory has a sponsored project from Department of Science & Technology (DST) on long range planning and technoeconomic forecasting on aluminium towards the year 2020 A.D. Considerable progress has been made and a major report has been submitted to DST. Similarly work on the consultancy assignment on technology forecasting for materials research for the Thapar Corporate R&D Centre, Patiala is continuing and one major report has been prepared and submitted. The Tata Trust has sponsored a new project in the laboratory on technology forecasting.

BUDGET AND EXPENDITURE

The expenditure pattern over the period of three years since the inception of the laboratory is indicated in the Table below:-

Year	Total expenditure (Rs. in lakhs)
1981-82	9.860
1982-83	110.000
1983-84	94.242

MANPOWER

The staff has grown from six persons in December 1981 to 55 (fiftyfive) as on March 31, 1984. This figure includes scientists, administrative and technical staff, research associates, fellows, pool officers, research officers on sponsored projects and consultants. Steps have been taken for recruitment of additional manpower. Responding to the need to deploy multidisciplinary task forces for the execution of research projects the manpower has been drawn from a number of disciplines in basic and applied sciences, engineering and management sciences.

INSTITUTIONAL LINKAGES

Useful links established earlier with different institutions engaged in development of science, technology and industrial potential of Madhya Pradesh have been further nurtured during this period. This has earned a reputation for the laboratory, and as a consequence several

agencies, industries and institutions have requisitioned expert opinion. Assistance has been frequently sought from the laboratory on formulation of research projects by different institutions.

Contracts have been established with M.P. Council of Science & Technology, State Planning Board, M.P. Energy Development Corporation, State Mining Corporation, Geological Survey of India, Bharat Heavy Electricals Ltd., Central Institute of Agricultural Engineering, Maulana Azad College of Technology, Bhopal University, Hindustan Electro-Graphites, Malik Industries and Steel Abrasives.

RRL, Bhopal was associated in evaluation of a proposal from Bank of India to adopt CSIR technologies for rural development programme in Khargaon district of M.P. RRL, Bhopal has been also associated in evaluation of projects submitted for seed money by Industrial Development Bank of India.

The laboratory has received metallic coins of Madhya Pradesh dating to B.C. era from Prof. S.P. Tewari, Archaeologist, and has done some metallurgical studies on them. In continuation of its pursuit to look at regional materials problems, the laboratory has made observation of the decay of rock paintings at the Bhimbetika caves near Bhopal.

SEMINARS/TRAINING PROGRAMS/WORKSHOPS ORGANISED

RRL, Bhopal co-sponsored the "3rd International School on sintered materials" at New Delhi in December, 1983 and contributed a paper on Aluminium Metglass composites.

The Institute of Indian Foundrymen, Bhopal Chapter, worked in close collaboration with the laboratory, and number of invited talks and seminars were jointly organised in the laboratory. The laboratory made plans to host a "National Seminar on Solidification and Casting of Metals - Future Trends" jointly organised by IIF, Bhopal Chapter and RRL, Bhopal in April, 1984.

In addition fifty seminars by eminent scientists, scholars, technocrats and latest advances in Metallurgy, Materials Science, Natural resources and R&D Management provided useful opportunities for exchange of ideas and in house training to the staff of the laboratory.

A training programme was organised by CBRI, Roorkee in collaboration with RRL, Bhopal and CSIR-PTC Bhopal, for training masons for making building products.

VISITS BY FOREIGN SCIENTISTS

Professor Sister Marie T. Dimond of Trinity College, Washington, D.C., visited the laboratory for collaborative work and gave a talk on Bioethics in April 1983.

Professor R.F. Anderson, Department of Materials Science, San Jose State University, California, USA, visited RRL, Bhopal under CSIR-NSF Exchange Programme in January 1984. During his stay, he delivered lectures on modern trends in aluminium extraction, surface modification of fibres and particles for composites, and electrochemical behaviour of composites. He also described some of his work on amalgam coating on materials including marble and composites. He made observation that the aluminium based composites developed at RRL, Bhopal have a great potential in electrochemical applications.

Mr. Henry Hicks, Palo Alto, California gave a talk in January 1984 on Ancient Indian Bronzes and problems associated with dating these artifacts.

Dr. Shyam N. Shukla, Project Manager, University of California, Livermore, USA, 10 visited the laboratory in January 1984. His talks on fibre glass reinforced concrete, methods

of design of material foundations, and finite element method evoked considerable interest in the scientists of the laboratory, particularly with reference to the activities in the fields of natural fibre products, metal based composites and new building materials.

Professor I. Minkoff, Department of Materials Engineering Technion - Israel Institute of Technology, Haifa, Israel on an invitation from the Institute of Indian Foundrymen Bhopal Chapter visited the laboratory. He delivered three talks on fundamentals of solidification and rapid solidification phenomena, casting of Al-Si alloys, and casting of cast iron. He gave very valuable suggestions on the ongoing work on solidification of composite materials in the laboratory.

Mrs. R.F. Anderson of Hewlett Packard Company, California, gave a talk in January 1984 on use of computers in management and administration.

PROGRESS ON ESTABLISHMENT, STAFF AMENITIES, WELFARE

In December 1983, the laboratory moved into the premises of the newly built Co-operative Training College building complex on Hoshangabad Road near Habibganj Naka, Bhopal. This new building provided nearly 45,000 Sq.ft. area for the various laboratories, library, seminar hall, administrative block and offices of the laboratories. This has enabled installation and operation of modern research facilities including Optical and Scanning Electron Microscopy, Instron and other mechanical testing equipment, equipment for testing fibres and building materials and equipment for chemical characterization.

Simultaneously extensive negotiations were undertaken with State Government of M.P. as a result of which, the final lease deed for 73 acres of land adjoining the present Co-operative Training College campus, has been signed. Negotiations are underway to get the possession of additional land committed by the State Government.

As reported in the first Progress Report (May 1981 to May 1983) of the laboratory, the CSIR approved the purchase of twenty four housing units of HIG and MIG types, from the Bhopal Development Authority. The necessary payments towards the same have already been made and one block is completed. Installation of water and electricity connections is being completed and it is expected that the blocks will be ready for allotment to the staff very soon. Similarly the single room tenements in Subhash Nagar have been allotted to staff and many modifications have been carried out on the buildings. For transport facility of the staff, a bus has been purchased.

A staff club was formally inaugurated on 26th January 1984, in the laboratory. The club aspires to function in order to provide recreational outlets to the staff and their families. The club has formally requested the CSIR Sports Promotion Board for affiliation and recognition. A variety entertainment program was organized on Republic Day and proved a great success.

RESEARCH IN PROGRESS

ALUMINIUM BASED PARTICULATE COMPOSITE MATERIALS

Considerable work has been carried out on developing a modified process for making aluminium based particulate composites which is more reproducible during production. Several melts of composite alloy upto 30 Kg. have been successfully made using aluminium alloys from Balco, Korba and graphite powder from Hindustan Electro Graphite, Bhopal. Various process parameters like stirrer design, its rotation speed and position in the melt, processing time, dispersion time and temperature, pretreatment of dispersoid, particle size and rate of addition of dispersoid, degassing time and temperature and mould temperatures, have been optimised. Melting and casting system based on a coal fired circular pit furnace has been set up to facilitate the transfer of technology to small industries (Fig. 1).

It has been possible to successfully remelt prealloyed composites and cast them by different techniques like gravity die casting, pressure die casting, melt spinning, and squeeze casting. This will facilitate the transfer of technology since the composite alloys can be made by one large manufacturer, and supplied to a number of small industries for remelting and casting into components. Attempts are now being made to install centrifugal casting machine and extrusion press, in order to make it possible to process the composites using different sequences to get desired properties and to fabricate various shapes.

The top stirring and top pouring set up at the laboratory has also been successfully used to make aluminium-talc, aluminium-mica, aluminium-rice husk ash and aluminium-zircon composites. Figure 2 and 3 show micrographs of LM-13 graphite composites at low and high magnification respectively.

Detailed laboratory investigation of aluminium-graphite composites is being carried out covering a wide range of properties like corrosion behaviour, surface finishing and deformation characteristics, which are important in developing various industrial applications.

Attempts are now being made for heat treatment of such aluminium base particulate composites for further improving their properties. Initial indications are that the mechanical property improvement upon suitable heat treatment is more pronounced for the particulate composite than for the base LM-13 alloy. It is felt that spheroidisation of silicon around

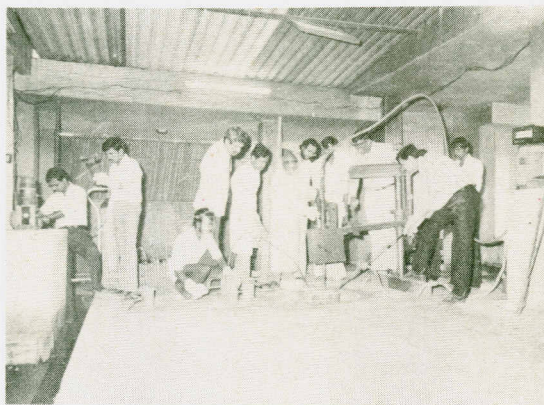


Fig. 1. Coal fired furnace for preparation of cast Al based composites by liquid metallurgy technique

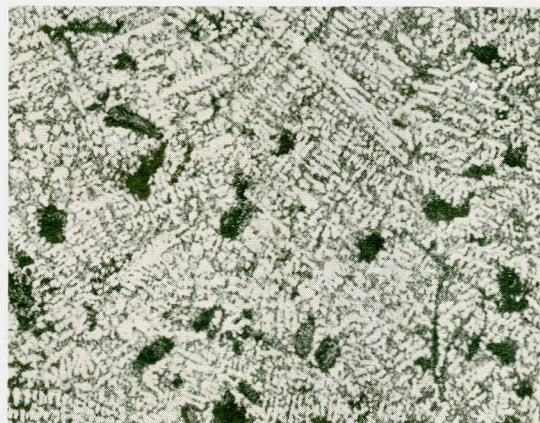


Fig. 2. Typical microstructure of LM-13 graphite composite at 40 X magnification.



Fig. 3. High magnification photographs of LM-13 graphite composite, showing the microstructure around a graphite particle (400 X)

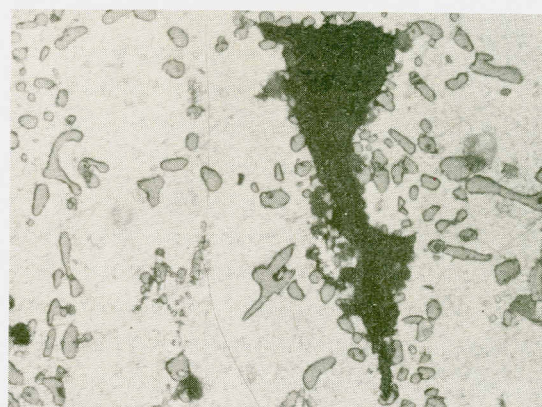


Fig. 4. A typical microstructure of solution treated and age hardened composite, (460 X)

graphite particles is responsible for the greater improvement of strength. A typical micrograph of a heat treated LM-13 graphite composite is shown in Fig. 4.

Further detailed studies are in progress for optimising the heat treatment process.

Madhya Pradesh has very large resources of soapstone and talc which are known to be good solid lubricants. Research work on casting characteristics, mechanical properties, tribological behaviour, corrosion characteristics of Al-talc composite using locally available talc is in progress. This aluminium-talc composite can be used for bearing and anti-friction applications (Fig. 5).

Rice husk ash has been successfully dispersed in aluminium alloys using the techniques developed in the laboratory.

A study has been completed on the theoretical analysis of strength properties exhibited by different aluminium based composites and limited predictive capability has been developed in this direction.

The composites have initially been classified, and the strengthening mechanism analysed in terms of microstructural details and fracture morphology. In the case of Al-graphite system it is found that the strength versus volume fraction follows a two thirds power law. This has been explained in terms of post yield fracture theory. It has been found that in the case of Al-glass and Al-SiC systems, the measured strengths are higher than theoretically predicted by mechanistic theories. It is shown quantitatively that tremendous potential exists in improving the strength of particulate composites, through suitable rolling and extrusion operations.

For evaluating performance of aluminium-graphite composite under actual industrial conditions, samples have been sent to Saha Industries, Varanasi; Premier Automobiles, Bombay; IIT, Delhi; and MACT, Bhopal. Samples of aluminium-graphite pistons and bearings for field trials have also been asked for by ESCORTS Limited (Patiala), Railways Design and Standards Organization (Lucknow), Diesel Locomotive Works (Varanasi), Scooters India (Lucknow) and Eicher Goodearth Limited (Ballabgarh). Interest in getting the process has been expressed by a number of organizations including Hindustan Electro Graphite (Bhopal) and India Thermit Corporation (Kanpur). Negotiations are going on with some piston manufacturing companies in India for jointly upscaling the technology to manufacture pistons of composites under assembly line production conditions.

Attempts to synthesise aluminium based composites containing dispersoids, like gra- 13



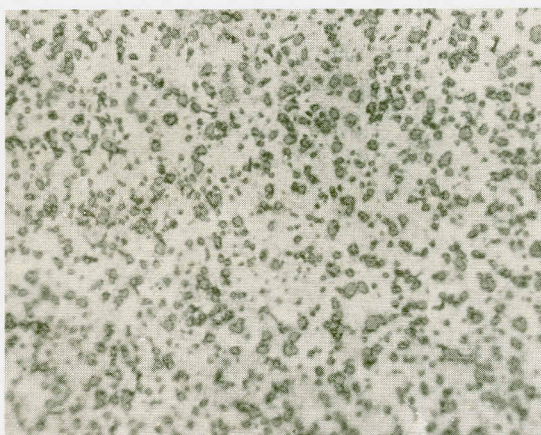
Fig. 5. Microstructure of LM-13 matrix containing dispersion of talc particles, (160 X)



Fig. 6. Microstructure of rice husk ash dispersed LM-13 Aluminium alloy, (160 X)



(a) (800 X)



(b) (400 X)

Fig. 7. Microstructure of LM-13 alloy (a) quenched, and (b) heat treated at 450°C for 17 hours.

phite, talc, mica, rice husk ash, by powder metallurgy techniques are also underway at the laboratory. For certain applications, powder metallurgy produced composites will be advantageous, specially where controlled porosity is also desired.

Work has been undertaken on rapid solidification processing of Al-based composites to obtain still better properties than obtained in slow solidification. For preparation of rapidly solidified composite alloys, a melt spinning equipment, with provision of variable speed drive has been fabricated and some ribbons and splats have been made and examined. Figure 7(a) shows microstructure of LM-13 alloy quenched from the melt. Figure 7(b) is a micrograph of the same alloy, but heat treated for 17 hours at 450°C.

EVALUATION AND EXPLOITATION OF MINERAL RESOURCES OF MADHYA PRADESH

The objective of this project is to derive R&D imperative related to mineral based resources of M.P. and to develop new process/products, based on local mineral resources and mineral wastes.

A comprehensive report has been prepared on the mineral resources of Madhya Pradesh, specially outlining the research and industrial imperatives based on these resources. This report was requested by various agencies including the M.P. Council of Science & Technology.

The major thrust of the project has been on bauxite, and aluminosilicates such as mica, talc, zeolite, vermiculite, clays, lepidolite and cassiterite, in view of the major focus of the laboratory being on special materials including aluminium and composite materials. Already some petrographic studies on bauxite, lepidolite, cassiterite occurring in M.P. have been completed and reported. A comprehensive report on research and industrial imperatives related to bauxite has been prepared.

Work on development of silicon carbide from rice husk (Fig. 8) and foam, fibrous refractory materials from resources of M.P. have been initiated and some success has been ascertained from the preliminary results. Studies on the utilization of low grade bauxite of M.P. are in progress.

A number of mineral, ceramic and chemical industries in and around M.P. have approached for analysis of raw materials, technical advice and consultancy services.

Mica

A laboratory scale process to beneficiate mica powder from mica schists of M.P. suitable for several industrial applications has been developed. The mica has been identified to be muscovite from X-ray, IR and DTA - studies. Aluminium-mica composites have been made using this mica, with both casting and powder metallurgy techniques. Polymer-mica composites have also been made and their properties are being determined. This mica powder is available in very large quantities.

Talc

Pure talc powder has been made from talc bearing minerals of M.P. DTA and IR studies have been completed on this talc. This talc powder has been found suitable to make cast aluminium-talc composites.

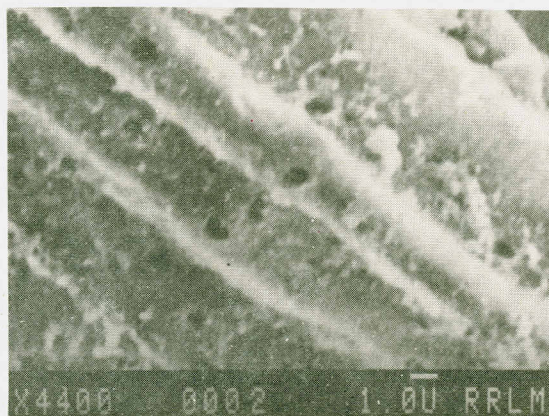


Fig. 8. SEM picture of silicon carbide from rice husk ash

Clay

X-ray analysis and DTA of local samples have been completed and the data are being analysed. Likely industries that can be set up from clays of M.P. have been identified, and the information brought to the attention of local agencies.

Zeolite

Minerals of M.P. containing significant amount of zeolite have been examined at RRL, Bhopal. Preliminary study shows that the mineral is stilbite. Possibility of using this zeolite for storage of hydrogen and other industrial uses, is being examined.

Vermiculite

Samples of vermiculite mineral of M.P. have been collected and studies are underway to find out the possibility of producing refractory foam and insulating material from this mineral.

Silica sand

Silica sand from Narmada river is already in extensive use for building and foundry purposes. The oversize (+32 mesh) is being rejected at present by these industries. RRL has tested the coarse fraction of this sand and found it suitable for water filtration. Research work is going on to investigate the magnetic impurities in this sand.

STUDIES ON NATURAL FIBRES OF MADHYA PRADESH

A comprehensive report on resources, structure, properties and uses of natural fibres of Madhya Pradesh has been brought out by the laboratory.

Two new types of fibres from the agro-resources of Madhya Pradesh have been extracted. Cross sections and longitudinal sections of sunhemp, sawai, kusha, palm leaf, banana fibres and Ipomoea stem were studied. Figure 9 is a photomicrograph of the cross section of an Ipomoea stem showing cell structure.



Fig. 9. Microstructure of Ipomoea stem (200 X)

Composites containing different volume fractions of sisal fibre and sunhemp and polyester have been prepared and their mechanical, electrical, and ultrasonic behaviour has been studied.

Efforts are being made for microbially extracting fibres from fibrous materials of Madhya Pradesh. Scanning electron microscopic studies are being done to correlate the fracture behaviour of different speeds of testing with mechanical behaviour of fibres.

In terms of components, a voltage stabilizer cover and a chair have been fabricated out of polyester-sisal and polyester-sunhemp fibres respectively. Organisations have been contacted who are interested in manufacturing this kind of components after the long-term tests are completed. Attempts are also underway to increase the volume percentage of natural fibres and decrease the amount of expensive polymers, possibly by increasing the wettability of fibres with polymers, selecting the optimum size distribution of fibres and even exploring inexpensive plant exudates as a replacement of synthetic polymer.

Attempts are also underway to study and improve the bonding between the natural fibres and the polymeric matrix, increase the strength, modulus and moisture resistance of natural fibres.

ACTIVITIES IN BUILDING MATERIALS RESEARCH

The major thrust of the laboratory in the area of building materials has been towards the development of building bricks from waste products of aluminium industries i.e. red mud, and also utilization of agro and forest based materials for walling and roofing panels for housing.

Study of low cost housing materials in typical rural and slum surroundings was carried out by the laboratory which revealed that a very large number of poor people in M.P. use local plant material, grasses and reeds like Ipomoea (commonly known as Beshram), sunhemp, patar grass for wall and roofing elements without any pre-treatment or using scientific techniques to improve their performance. In addition to the need of frequent replacement, fire hazards, leakages and dangers of pests and rodents still remains a problem in the use of these materials for housing. These houses also remain poor in appearance. Work has been undertaken to improve the life, reduce flammability and leakages of these materials by studying their structure property relationships and by suitable manipulation of their structures and surfaces.

Cement fibre sheets

Local fibres e.g. Beshram, sunhemp, saja are under study for making cement fibre composite sheets for partition walls and fibre roofing. The strength properties of these sheets are under study. Large wall panels of sunhemp and beshram reed also are being designed and under study.

Building bricks

The red mud was mixed with local materials and briquettes were cast and tested for strength as per ISI specifications. The comprehensive strength was 50 Kg/cm^2 and water absorption 22%. It is therefore proposed to make full size building bricks and test the same as per standard specifications, in view of the encouraging preliminary results mentioned above.

ACTIVITIES IN BIOMATERIALS SCIENCE

This group is principally working with Dr. Ravi Prakash, Consultant and Emeritus Scientist at the laboratory.

Collagen fibres which play a major role as far as ageing in animals is concerned have been successfully isolated from the cardiac and brain tissue of turtles which are well noted for a lengthy span of life. The precipitation and crystallization of cardiac fibres have also been done.

Histochemical and Neurohistological techniques have been developed to study the structure of heart, brain and endocrine system. Microdissections were done to locate the nerve supplies to the heart as well as to observe the traversing patterns of nerves within the myocardium. The physiological peculiarities of ovaries and testis in turtles were observed in terms of neural activities. Turtle's nesting, mating and ecological conditions of Chambal and Narmada rivers, Upper lake and Patra canal of Bhopal were also studied with regard to the environmental parameters.

Structural studies using light microscope were done to understand the pattern of organisation of carapace. Attempts have been made to separate the fibres and extract the oil from the carapace and plastron to understand why both are so resistant to natural exposure for such a long period.

Two papers on brain and heart fibres have been accepted to be read to VIIIth European Anatomical Congress to be held in Innsbruck (Austria).

PUBLICATIONS AUTHORED BY STAFF OF RRL, BHOPAL DURING APRIL 1983 TO MARCH 1984

1. K.G. Satyanarayana, A.G. Kulkarni and P.K. Rohatgi – Retrospect and prospect of natural fibres – Journal of Scientific and Industrial Research, (India), Vol. 42, Aug. 1983, pp 425-428.
2. C.K.S. Pillai, M.A. Venkataswamy, K.G. Satyanarayana and P.K. Rohatgi – Preserving coconut leaf thatch – A simple method – Indian Coconut Journal, Vol. 33A, 1983, pp 4-6.
3. S.V. Prasad, C.V. Pavithran and P.K. Rohatgi – Alkali treatment of coir fibres for coir polyester composites – Journal of Material Science, (U.K.), Vol. 18, 1983, pp 1443-1454.
4. A.G. Kulkarni, K.G. Satyanarayana and P.K. Rohatgi – Weibull analysis of strengths of coir fibres – Fibre Science and Technology, (U.K.), Vol. 19, 1983, pp 59-76.
5. A.G. Kulkarni, K.G. Satyanarayana and P.K. Rohatgi – Mechanical properties of banana fibres (*Musa Sepientum*) – Journal of Materials Science, (U.K.), Vol. 18, 1983, pp 2290-2296.
6. B.P. Krishnan, N. Raman, K. Narayanaswamy and P.K. Rohatgi – Performance of aluminium alloy graphite bearings in a diesel engine – Tribology International, (U.S.A.), Vol. 16, No. 5, October 1983, pp 239-244.

7. P.N. Mohandas, V.S. Kelukutty and P.K. Rohatgi – Studies on fuel briquettes prepared from agrowastes like coconut pith, coconut shell powder and saw dust – Proceedings of the Regional Workshop on Biomass Energy Management, December 27-29, 1983.
8. P.K. Rohatgi and M.K. Surappa – Deformation of graphite during hot extrusion of Cast Al-Si graphite particle composites – Materials Science and Engineering, (U.S.A.), Vol. 62(2), 1984, pp 159-162.
9. K.G. Satyanarayana, P.N. Mohandas, C.K.S. Pillai, C. Pavithran, K. Gopakumar and P.K. Rohatgi – Characterisation and utilization of coconut tree based materials – Indian Coconut Journal, Vol. XIV, No. 9, January, 1984, pp 18-29.
10. B.P. Krishnan and P.K. Rohatgi – Modification of graphite particle dispersed aluminium silicon alloy – Metals Technology, (U.K.), February, 1984, pp 41-44.
11. B.N. Keshavaram, K.G. Satyanarayana and P.K. Rohatgi – Preparation and properties of Al-glass particulate composites – Proc. First National Symp. on 'Recent Trends in the Development of Composite Materials' organised by Indian Society for Composite Materials, Decemebr 10-11, 1983.
12. K.G. Satyanarayana, A.G. Kulkarni, S.G.K. Pillai and P.K. Rohatgi – Performance of banana fabric polyester composites – Proc. 2nd Int. Conf. on Composite Structures organised by Pastley College, Scotland, U.K., September 13-16, 1983.
13. K. Gopakumar, T.P. Murali and P.K. Rohatgi – Preparation and properties of copper titania particulate composites – Proc. of 3rd Int. School on Sintered Materials, New Delhi, December 6-9, 1983.
14. A.K. Jha, G.S. Upadhyaya – Properties of sintered 2014 aluminium alloy composite containing WC – Journal of Material Science letters, (U.K.) 2, 1983, pp 801-804.
15. A.K. Jha, G.S. Upadhyaya – Effect of atmosphere on sintering of age hardenable 2014 Al-alloy and its composites – Light Metal Age, (U.S.A.), Oct., 1983, pp 42-43.
16. A.H. Yegneswaran and K. Tangri – Deformation behaviour of two phase materials – Cu-Al system, Metal Science, (U.K.), 18, 1984, 161..
17. T.K. Dan, K. Jayachandran, P. Mukundan – Improved structure pipes using Kerala clays – Research and Industry (India), 28, 1983, pp 210-216.
18. T.K. Dan, K. Jayachandran – Effect of additives on sintering characteristics of triaxial porcelain bodies – Indian Ceramics 26(9), 1983, pp 163-171.
19. A.H. Yegneswaran, K. Tangri – Investigation of the early stages of deformation of two phase copper-aluminium alloys – Met. Trans., (USA), 14A, 1983, pp 2407.
20. A.H. Yegneswaran and K. Tangri – Strain distribution and load transfer characteristics of a Cu-9 wt% Al dual phase structure – Z Metallkunde, (F.R.G.), 74-8, 1983, p 521.

21. K. Tangri, A.H. Yegneswaran and P. Griese – The effect of moderate temperature effluents on selected materials used in air to air energy recovery equipment – ASHRAE Trans., 1983.
22. M. Patel – Silicate materials for storage of hydrogen – Journal of Energy Management, (India), 8, 1984, p 33 and Trans. Indian Ceramic Society, 42, 1983, p 1.
23. M. Kermarec, M. Patel, P. Rabette, H. Pezerat and D. Delafosse – Reactivity and structure of Nickel exchanged praysae vermiculite, J. Chem. Soc. Faraday Trans. (USA), 79, 1983, p 599.
24. Navin Chand – Effect of co-polymerization on Tg of PAN – Indian Journal of Technology, 3, 1983.
25. S. Suresh Kumar and P.K. Rohatgi – Evaluation methods in R&D Management, Journal of Scientific and Industrial Research, (India), Vol. 42, No. 11, November 1983, pp 591-593.
26. K. Gopakumar, S. Mohan and P.K. Rohatgi – Need for Regional Materials Policy: Kerala State, Journal of Scientific and Industrial Research, (India), Vol. 42, No. 12, December 1983, pp 671-681.
27. B.S. Majumdar, A.H. Yegneswaran and P.K. Rohatgi – Strength and fracture behaviour of metal matrix particulate composites. (In press), Materials Science and Engineering, (USA), 1984.
28. B.N. Keshavaram, K.G. Satyanarayana, B.S. Majumdar, P.K. Rohatgi and B. Dataguru – Studies in fracture and strength behaviour of Al-flyash and Al-glass composites, (accepted for publication), Proceedings of International Conference on Fracture 6, Delhi, 1984.

REPORTS PREPARED BY THE STAFF OF RRL, BHOPAL

<i>Title of the Report</i>	<i>Report No.</i>
(1) Corrosion behaviour and surface finishing of Aluminium-Graphite particulate composite and electroless metal coating on ceramic particle and natural fibres.	RRLB/TR/M 01 (83) - I.
(2) Mechanical behaviour of particulate composites.	RRLB/TR/M 01 (83) - 2.
(3) Strength and fracture behaviour of metal matrix particulate composites.	RRLB/TR/M 01 (83) - 3.
(4) Ultrasonic velocity and moduli studies in Al-Zircon and Al-alloy Zircon composites.	RRLB/TR/M 01 (83) - 4.
(5) Melting kinetics of some standard geometries of chills.	RRLB/TR/M 01 (83) - 5.

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|-----|---|------------------------|
| (6) | Acoustic properties of sisal fibre filled polyester composites. | RRLB/TR/M 02 (83) - 1. |
| (7) | Mineral resources of Madhya Pradesh and the prospects of mineral based industries in the State. | RRLB/TR/M 02 (83) - 2. |
| (8) | Research and Development Imperatives on bauxite. | RRLB/TR/M 02 (83) - 3. |

PAPERS PRESENTED IN SEMINARS/SYMPOSIA/CONFERENCES

1. Crystallization of Iron-Boron metallic glasses – S. Das et al at International Seminar on light metals, BHU, Varanasi, November 1983.
2. Corrosion of Al-graphite particulate composites – Mohini Saxena, A.H. Yegneswaran, P.K. Rohatgi at 37th Annual Technical Meeting of IIM at BHU, Varanasi, November 1983.
4. Strength and fracture mechanisms in metal particulate composite materials – B.S. Majumdar, A.H. Yegneswaran, P.K. Rohatgi at the Conference on Advanced Structural materials at IISc., Bangalore, December 1983.
5. 2014 Al-alloy-Ni-Mo metal glass powder metallurgical particulate composite – A.K. Jha, at 3rd International School of Sintered Materials, at New Delhi, December 1983.
6. Natural fibres in M.P. as a resource for industrial materials – S. Sood, Navin Chand, K.G. Satyanarayana, P.K. Rohatgi, National Seminar on Development in Polymer Science, 23 December 1983, Madras.
7. Development of electronic instruments in CSIR – K.K.S. Gautam, in seminar on Technology Transfer in electrical and electronic industries, at Bhopal, January 1984.
8. Current time relationship and temperature, pressure and conc. dependence on d.c. conductivity – Navin Chand, in Seminar on Technology Transfer in electrical and electronics industries, Bhopal, January 1984.
9. Concentration dependence of d.c. conductivity in polymers – Navin Chand, in Seminar on Technology Transfer in electrical and electronic industries, at Bhopal, January 1984.
10. Casting process for producing electronic ceramic components using alumina as substrate – M. Patel in Seminar on Technology Transfer in electrical and electronic industries, at Bhopal, January 1984.
11. Recent developments in cast ceramic particle composites – P.K. Rohatgi at the 33rd Annual Convention of IIF at New Delhi, March 1984.
12. Problems in production of magnesia refractories from sea water in India – M. Patel, 48th Annual Session of Indian Ceramic Society, New Delhi, March 1984.

13. Beneficiation of montmorillonite mineral from bentonite – M. Patel, 48th Annual Session of Indian Ceramic Society, New Delhi, March 1984.
14. Increasing the efficiency of lime kiln; limestone; lime and kiln – M. Patel, 48th Annual Session of Indian Ceramic Society, New Delhi, March 1984.
15. Clinkerization of cement raw mix containing chloride – M. Patel, 48th Annual Session of Indian Ceramic Society, New Delhi, March 1984.

SEMINARS/SYMPOSIA/CONFERENCES ATTENDED BY STAFF

1. Dr. T.K. Dan, Dr. C.B. Raju attended National Seminar on problems and prospects of ferroalloy industry in India at NML, Jamshedpur in October, 1983.
2. Dr. A.H. Yegneswaran, Shri O.P. Modi, Shri S. Sarangi, Dr. (Miss) Mohini Saxena, Shri S. Das attended "International Seminar on light metals" and annual technical meeting of IIM at BHU, Varanasi in November, 1983.
3. Dr. T.K. Dan, Dr. A.H. Yegneswaran, Dr. B. Majumdar, Shri P.D. Ekbote, Shri A.K. Jha, Shri S. Das, Shri M. Subhash, Shri P.K. Verma, Shri A.V. Ramana Rao, Shri S.C. Arya, Shri O.P. Modi attended the seminar on "Cupola melting" organized by IIF, Bhopal chapter in November, 1983.
4. Dr. T.K. Dan, Shri A.K. Jha, Dr. A.K. Ray attended "3rd International School on sintered materials – sintered metal-ceramic composites" at New Delhi in December, 1983.
5. Dr. (Miss) Mohini Saxena attended symposium on Advances in fundamentals of corrosion and corrosion monitoring, SAEST, Karaikudi, 1983.
6. Prof. P.K. Rohatgi, Shri A.C. Khazanchi, Dr. M. Patel, Dr. Navin Chand, Shri K.K.S. Gautam, Shri Vivek Gupta attended a seminar on Technology Transfer in electrical and electronics industries at TTTI, Bhopal on 2nd and 3rd January, 1984.
7. Shri K.K.S. Gautam attended the 3rd World Instrumentation Symposium organized by WISITEX Foundation in New Delhi in January, 1984.
8. Dr. A.H. Yegneswaran attended the committee meeting on "International Conference on Aluminium - 1985" organized by IIM Delhi chapter and Aluminium Association of India in February, 1984.
9. Shri S. Das attended a seminar on "High strength aluminium alloys for Defence and Industry" organized by DRDO Pune in February, 1984.
10. Dr. M. Patel attended the 48th Annual Session of Indian Ceramic Society at New Delhi in March 1984.
11. Prof. P.K. Rohatgi attended the 33rd Annual Convention of the Institute of Indian Foundrymen at New Delhi in March, 1984.

TRAINING PROGRAMS ATTENDED

1. Dr. Navin Chand undertook one week training on 'Quality Control and Testing of Plastics' at CIPET Madras in September, 1983.
2. Dr. R.N. Yadava attended a 21 days course in COBOL language at M.P. Government Computer Centre at Bhopal in October, 1983.
3. Dr. R.N. Yadava attended a refresher course on Information processing through mini and microcomputers, organised by Society for Information Science at New Delhi in February, 1984.
4. Mr. Omman Panicker, SPA to Director, attended a course on Administrative Management at NIO, Goa, March, 1984.
5. Dr. P.K. Rohatgi, Dr. A.H. Yegneswaran and Dr. Navin Chand attended an intensive course on "Fibre composites : Design Manufacture and Performance" organized by IIT, Kanpur at New Delhi in March, 1984.
6. Dr. R.N. Yadava undertook training in BASIC language organised by Computer Society of India, Bhopal chapter in March, 1984.

TECHNICAL ENQUIRIES/SERVICES/ADVICE GIVEN

S.No.	Party	Regarding
(1)	Hindustan Aluminium Co., Renukoot.	Ultrasonic testing of Al-alloys.
(2)	Bharat Heavy Electricals, Bhopal.	SEM Studies on the structure of mica and polymeric insulation.
(3)	Hindustan Electro Graphite Ltd., Mandideep, Bhopal.	SEM and Optical microscopic studies on graphite samples. Setting up of R&D Centre.
(4)	Rotary Club of Jobat, Jobat, Jhabua, M.P.	To find the suitability of local resources for setting up of mineral based industries.
(5)	Ganesh Chemical Industries Jobat, Jhabua.	To improve the working efficiency of the lime kiln for better quality of lime.
(6)	Bharat Plastics & Allied Chemicals, Bhopal.	Production of mica powder for paints.
(7)	Neelam Sanders, Bhopal.	Suitability and testing of sands for water purification and glass industry.
(8)	M.P. Electricity Board, (M.P.), Bhopal.	Production of cement from Fly-ash.
(9)	Agarwal Brick Industries, Dewas, (M.P.).	Production of building bricks from local clays.

LECTURES AT RRL, BHOPAL

LECTURES DELIVERED BY OUTSIDE SPEAKERS

<i>Lecture delivered by</i>	<i>Subject</i>
Dr. N.K. Jain, Jaipur	ESR and thermo mechanical processing of RR-58 alloy.
Dr. V.K. Agarwal, Hindalco	New aluminium alloys.
Prof. S.G. Dixit, University of Bombay	a) High gradient magnetic separation of paramagnetic materials. b) Imperatives in mineral processing and extractive metallurgy.
Mr. S. Sarangi, BHU, Varanasi.	The future of iron and steel making technology with reference to fuel/reductants in the light of emerging constraints.
Dr. R.C. Sharma, IIT, Kanpur	a) Thermodynamics of Phase equilibria b) Decomposition of Austenite c) Rapid solidification.
Dr. M.K. Surappa, Cambridge, England	Rheocasting of super alloys
Dr. P.K. Biswas, RRL, Trivandrum	Microchilling effect of cast Al-alloys.
Dr. Brahm Prakash IIT, Delhi	Engine bearing materials.
Dr. J.A. Sekhar DMRL, Hyderabad	a) Solidification – an overview b) Rapid solidification processing.
Dr. C.S. Narendranath, Bangalore	Permanent moulding of S.G. Iron
Dr. S.D.N. Tiwari, Ex-Conservator of Forests, M.P.	Natural Fibres of M.P.
Dr. Mohd. Hammiudin, AMU, Aligarh.	Powder metallurgy of Aluminium.
Mr. R.N. Mathur, Director, Dept. of Forests, Bhopal.	Forest based resources of M.P.
Dr. Ratho, Vice Chancellor, Manipur University Manipur.	Determination of macro molecule by X-ray scattering method.
Dr. R.C. Gupta, BHU, Varanasi	a) Environmental problem by iron foundry emissions. b) Metallurgical Education in India – Future prospects

Prof. Bhanu Prakash,
 BHU, Varanasi
 Dr. Shyam N. Shukla,
 Project Manager, University of
 Calif, Livermore.

Dr. R.F. Anderson,
 Dept. of Mat. Science, San Jose
 State University, California, USA

Mr. H. Hicks,
 Palo Alto, California.

Mrs. R.F. Anderson,
 Hewlett Packard, USA.

Prof. T.R. Ramachandran,
 IIT, Kanpur

Dr. Rajendra Kumar Tiwari,
 Sardar Vallabh Bhai Patel University,
 Vallabh Vidyanagar.

Prof. Minkoff. I.,
 Guest of Institute of Indian Foundrymen

Dr. A.D. Telang,
 MACT, Bhopal.

Mr. Anand Sanadi

Mr. Gulati,
 BHEL, Bhopal.

INTERNAL SEMINARS DELIVERED BY STAFF

Dr. A.H. Yegneswaran

Mr. S. Madhavan

Mr. A.V. Ramana Rao

Dr. Ajay Kumar Ray

Dezincification of brass.

- a) Fibre glass reinforced concrete properties and products.
- b) Primer on Finite element method.
- c) A simplified method of design of mat foundation.

- a) New techniques of extraction of aluminium.
- b) Surface modification of fibers.
- c) Electrochemical behaviour of composites.

Ancient Bronzes in India and problems associated with dating them.

Use of computers in Management and Administration.

- a) Electron Optical studies on Al-alloys including X-ray micro-analysis.
- b) Microstructural aspect of heat treatment of Al-alloys.

X-ray crystallographic study of some medicinal plants.

- a) Fundamentals of solidification and rapid and solidification.
- b) Casting of Al-Si alloys.
- c) Casting of cast iron.

Lubricant metal compatibility – boundary lubrication.

- a) Polymer composites - a brief review.
- b) Parameters affecting the tensile properties of short glass fiber reinforced epoxy.

Computers in Management.

Deformation behaviour of two phase materials.

Technological process of forging.

Tribological properties of Al-graphite.

Solid Electrolytes.

Prof. Bhanu Prakash,
 BHU, Varanasi
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Mr. H. Hicks,
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Mrs. R.F. Anderson,
 Hewlett Packard, USA.

Prof. T.R. Ramachandran,
 IIT, Kanpur

Dr. Rajendra Kumar Tiwari,
 Sardar Vallabh Bhai Patel University,
 Vallabh Vidyanagar.

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INTERNAL SEMINARS DELIVERED BY STAFF

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Mr. S. Madhavan

Mr. A.V. Ramana Rao

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Dezincification of brass.

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Technological process of forging.

Tribological properties of Al-graphite.

Solid Electrolytes.

Miss V.L. Keshwani	Microstructural studies of particulate composites.
Mr. B.K. Prasad	Thermal cycling – an alternative method of grain refinement.
Dr. C.B. Raju	Research Imperatives on minerals of M.P.
Dr. Navin Chand	Structural studies of polyacrylonitrile through dielectric relaxation.
Mr. O.P. Modi	Electrochemical behaviour of 9 Cr-1 Mo ferritic steels in H ₂ SO ₄ .
Dr. Miss Mohini Saxena	Corrosion of Aluminium Graphite particulate composites.
Mr. S. Das	Crystallisation of Iron Boron metallic glasses.
Mr. A. Banerjee	Cast metal matrix ceramic composites.
Prof. P.K. Rohatgi	Recent trends in processing and application of cast metal ceramic particulate composites.

LECTURES IN OUTSIDE ORGANIZATIONS

- Prof. P.K. Rohatgi
- Key note address at seminar on "Future shortages of technical faculty in engineering colleges" at SATI Vidisha, Feb. 1984.
 - Key note address at seminar on "Technology transfer in electronics industry" at TTTI, Bhopal.

DISTINGUISHED VISITORS TO THE LABORATORY

1. Dr. (Mrs) Manju Sharma, Director, DST, New Delhi, August 9th, 1983.
2. Dr. G. Thyagarajan, Director, Regional Research Laboratory, Hyderabad, August 29th, 1983.
3. Dr. Ratho, Vice Chancellor, Manipur University, Manipur, September 11th, 1983.
4. Dr. Shamsher Prakash, Director, Central Building Research Institute, Roorkee, November 16th, 1983.
5. Shri Shivraj V. Patil, Hon'ble Minister of State for Science & Technology and Vice-President, CSIR, December 2nd, 1983.

6. Dr. Bhanu Prakash, Head, Department of Metallurgy, BHU, Varanasi, January 4th, 1984.
7. Dr. Shyam N. Shukla, Project Manager, University of California, Livermore, USA, January 12th, 1984.
8. Dr. R.F. Anderson, Department of Materials Science, San Jose State University, California, USA, January 27th - 31st, 1984.
9. Shri T.S. Rajagopalan, Scientist-in-Charge, INSDOC, New Delhi, February 27th, 1984.
10. Prof. I. Minkoff, Department of Materials Engineering, Technion - Israel Institute of Technology, Haifa, Israel, March 26th, 1984.

HONOURS AND AWARDS RECEIVED BY STAFF

- (1) Prof. P.K. Rohatgi, Director, received the Distinguished Aluminus Award from the Department of Metallurgical Engineering, Banaras Hindu University, in April 1983.
- (2) Prof. P.K. Rohatgi, Director, received the Binani Gold Medal, instituted by the Indian Institute of Metals, Calcutta, for his research paper on Energy Analysis of Aluminium extraction, in November 1983.
- (3) Dr. Ravi Prakash, Consultant and Emeritus Scientist, received the Ist All India Congress of Zoology Gold Medal, instituted by Zoological Society of India.
- (4) Dr. Ravi Prakash, Consultant and Emeritus Scientist, received 'Nagar Shree' honour from the Bhopal Municipal Corporation, Bhopal on Republic Day 1984.

MEMBERS OF RESEARCH ADVISORY COUNCIL OF RRL, BHOPAL

- | | | |
|----|--|----------|
| 1. | Dr. Brahm Prakash*
6/2, Jupiter Apartments, Cuffe Parada,
Colba, Bombay-400005 (Maharashtra) | Chairman |
| 2. | Mr. V.K. Agarwal
R&D Manager,
Hindalco, Renukoot (U.P.) | Member |
| 3. | Prof. S.K. Saraf
Department of Chemical Engg.,
University of Roorkee, Roorkee (U.P.) | Member |
| 4. | Prof. R.C. Malhotra
Department of Mechanical Engg.,
IIT, Delhi. | Member |

* Dr. Brahma Prakash expired in Jan. 1984.

- | | | |
|-----|---|--------|
| 5. | Dr. B.B. Ramaiah
Managing Director,
Andhra Sugar Ltd., Tanuku, (Andhra Pradesh) | Member |
| 6. | Mr. N.R. Krishnan
Secretary
Council of Science & Technology,
Government of Madhya Pradesh, Bhopal (M.P.) | Member |
| 7. | Dr. T.S. Murthy
Director,
Council of Science & Technology,
Govt. of Madhya Pradesh, Bhopal (M.P.) | Member |
| 8. | Dr. Anil Sadgopal
Kishore Bharati,
Hoshangabad (M.P.) | Member |
| 9. | Prof. G.S. Upadhyaya
Professor of Metallurgy,
IIT, Kanpur, Kanpur (M.P.) | Member |
| 10. | Dr. B.L. Mehrotra
Principal,
Maulana Azad College of Technology,
Bhopal (M.P.) | Member |
| 11. | Prof. J.P. Sharma
Head, ITMMEC,
IIT, Hauz Khas, New Delhi. | Member |

MEMBERS OF THE EXECUTIVE COMMITTEE OF RRL, BHOPAL

- | | | |
|----|---|----------|
| 1. | Dr. P.K. Rohatgi,
Director,
RRL, Bhopal. | Chairman |
| 2. | Mr. N.R. Krishnan,
Secretary,
Department of Science & Technology,
Govt. of Madhya Pradesh, Bhopal. | Member |
| 3. | Dr. B.B. Ramaiah,
Managing Director,
Andhra Sugar Ltd.,
Tanuku, Andhra Pradesh. | Member |
| 4. | Prof. G.S. Upadhyaya,
Professor of Metallurgy,
IIT, Kanpur (U.P.). | Member |

3. Dr. Ram Narayan Yadav
 - Member, Computer Society of India.
 - Member, Institute of Indian Foundrymen.
4. Dr. T.K. Dan
 - Member, Indian Ceramic Society.
 - Member, Institute of Indian Foundrymen.
5. Dr. A.H. Yegneswaran
 - Member, TMS-AIME
 - Institute of Indian Foundrymen.
6. Dr. C.B. Raju
 - Member, Indian Ceramic Society.
7. Mr. P.D. Ekbote
 - Member, Indian Institute of Metals.
 - Member, Institute of Indian Foundrymen.
8. Mr. A.K. Jha
 - Member, Powder Metallurgy Association of India.
9. Mr. K.K.S. Gautam
 - Member, Institute of Electronics and Telecommunication Engineers (IETE).
 - Member, Indian Physics Association, Bombay chapter.
 - Member, Electron Microscopic Society of India.
10. Mr. O.P. Modi
 - Member, Society for Advancement of Electrochemical Science and Technology, Karaikudi.
11. Mr. S. Das
 - Member, Institute of Indian Foundrymen.

STAFF AT RRL, BHOPAL

<i>Name/Designation</i>	<i>Qualifications</i>	<i>Area of Interest</i>
Director		
1. Prof. P.K. Rohatgi	B.Sc.(Met), Banaras D.Sc. (MIT, USA)	Materials Science, Technology Forecasting, Solar Energy.
Scientist-E-II		
2. Shri A.C. Khazanchi	M.Sc., B.Sc. (Engg) (London) A.C.G.I. (London)	Civil Engg., Building Materials Foundation, Cement Concrete.

Scientist-E-I

- | | | | |
|----|--------------|---|-----------------------------|
| 3. | Dr. M. Patel | Ph.D. (IIT, Delhi)
Dr.Sc. (Univ. of Paris, France) | Ceramics, Mineral Chemistry |
|----|--------------|---|-----------------------------|

Scientist-C

- | | | | |
|----|----------------------|-----------------------------|-----------------------------------|
| 4. | Dr. Ram Narayan | Ph.D. (IIT, Bombay) | Maths, Fracture, Systems Analysis |
| 4. | Dr. Ram Narayan | Ph.D. (IIT, Bombay) | Maths, Fracture, Systems Analysis |
| 5. | Dr. T.K. Dan | Ph.D. (Calcutta University) | Ceramics, Composite Materials |
| 6. | Dr. A.H. Yegneswaran | Ph.D. (IISc., Bangalore) | Deformation and Texture |
| 7. | Dr. B.S. Majumdar | Ph.D. (Rochester, USA) | Deformation and Fracture |
| 8. | Dr. C.B. Raju | Ph.D. (LPI, USSR) | Ceramic Materials |

Scientist-B

- | | | | |
|-----|--------------------|--------------------------|--------------------------------------|
| 9. | Shri P.D. Ekbote | M.E. (Nagpur University) | Chem. Engg., Metallurgy, Management |
| 10. | Dr. Navin Chand | Ph.D. (IIT, Delhi) | Polymers, Composites, Natural Fibres |
| 11. | Shri K.K.S. Gautam | B.E. (Raipur) | Electronics, Instrumentation |
| 12. | Shri A.K. Jha | M. Tech. (IIT, Kanpur) | Powder Metallurgy |
| 13. | Shri S. Das | M. Tech. (IIT, Kanpur) | Rapid Solidification |
| 14. | Shri K.K. Verma | B.E. (Durgapur) | Civil Engineering |
| 15. | Shri Rajiv Asthana | M.Tech. (IIT, Kharagpur) | Metallurgy, Process Modelling |
| 16. | Shri O.P. Modi | M.Tech. (IIT, Kanpur) | Electrochemistry, Corrosion Science |

Sr. Scientific Asstt.

- | | | | |
|-----|--------------------------------|---------------|-------------------------------|
| 17. | Shri A. Banerjee
(On leave) | B.Tech. (BHU) | Materials Science, Composites |
|-----|--------------------------------|---------------|-------------------------------|

Technical Assistant

- | | | | |
|--|-----------------|-----------------|------------------------|
| | Shri P.K. Verma | B.E. (Jabalpur) | Mechanical Engineering |
|--|-----------------|-----------------|------------------------|

Scientists

- | | | | |
|-----|--|---|-------------------------------|
| 19. | Dr. Ravi Prakash
(Emeritus Scientist) | Ph.D. (Agra University)
DSc. (Agra University) | Zoology, Biological Materials |
| 20. | Shri S.C. Arya | B.Sc.(Engg) (BHU) | Metallurgy |
| 21. | Shri U. Mohan Rao | B.Sc.(Engg) (BHU) | Metallurgy |

Research Officers (On DST Sponsored Project)

- | | | | |
|-----|------------------|------------------------|---------------------|
| 22. | Shri S. Sarangi | M.Tech. (BHU) | Ferrous Metallurgy |
| 23. | Shri B.K. Prasad | M. Tech. (IIT, Kanpur) | Physical Metallurgy |

Pool Officers

- | | | | |
|-----|-----------------|-----------------------------|---------------------------------|
| 24. | Dr. A.K. Ray | Ph.D. (Calcutta University) | Analytical Chemistry |
| 25. | Shri M. Subhash | M.Sc. Engg (Met), USSR | Forging and stamping technology |

Research Associates

- | | | | |
|-----|---|---------------------------|--------------------------------|
| 26. | Dr. (Mrs.) Sudha Raman | Ph.D. (Jiwaji University) | Ultrasonics, Materials Science |
| 27. | Dr. (Ms.) Mohini Saxena
(CSIR quota) | Ph.D. (Bhopal University) | Electrochemistry |
| 28. | Shri A.K. Gupta | M.Tech. (BHU) | Metallurgy |

Senior Research Fellows

- | | | | |
|-----|--|--------------------------|------------------------|
| 29. | Shri A.V. Ramana Rao
(Upto Feb. 1984) | M.Tech. (IIT, Madras) | Chem. Engg., Tribology |
| 30. | Mrs. Savita Gulati | M.Sc.(Meerut University) | Zoology |

Junior Research Fellow

- | | | | |
|-----|---|---------------------------|-----------------------|
| 31. | Shri Vivek Gupta | M.Sc. (Indore) | Electronics |
| 32. | Miss V.L. Keshwani
(Upto October 1983) | B.Tech. (Raipur) | Metallurgy |
| 33. | Shri N.B.R.Mohan Rao | M.Tech. (BHU) | Industrial Metallurgy |
| 34. | Shri Gururaj Char | B.Tech. (Raipur) | Metallurgy |
| 35. | Shri Ajit Hundet | M.Sc. (Bhopal University) | Zoology |
| 36. | Shri Udayan Banerjee | M.Sc. (Bhopal University) | Zoology |
| 37. | Ms. Shabana Nargis | M.Sc.(Bhopal University) | Chemistry |

Graduate Trainees

- | | | | |
|-----|---------------------|-------------------|-----------------|
| 38. | Shri S.K. Haider | M.Sc. (Bhopal) | Zoology |
| 39. | Miss Seema Phakka | M.Sc. (Ujjain) | Botany |
| 40. | Shri G. Shrivastava | M. Tech. (Saugar) | Applied Geology |

Technical Staff

- | | | | |
|-----|------------------|---------------------------------------|----------------|
| 41. | Shri S.K. Tiwari | B.Sc. (Library Science) | Jr. Librarian |
| 42. | Shri N. Saha | B.Sc., P.G. Diploma in
Mech. Engg. | Draughtsman |
| 43. | Shri R.K. Gurjar | | Lab. Assistant |

Administrative Staff

- | | | | |
|-----|---|---------------------|----------------------------|
| 44. | Shri Tariq Qutbuddin | M.Sc. | Administrative Officer |
| 45. | Shri T.V.Apasthamban
(Upto 30.12.1983) | B.Sc. | Finance & Accounts Officer |
| 46. | Shri M.A. Baig | Dip. Com.(Govt) | Finance & Accounts Officer |
| 47. | Shri N.C. Chakravarty | B.A. | Section Officer |
| 48. | Shri R.K. Bajaj | B.A. | Stores & Purchase Officer |
| 49. | Shri Omman Panicker | B.A. | SPA to Director |
| 50. | Shri T.P. Prasannan | B.A. | Sr. Stenographer |
| 51. | Shri M.L. Sharma | B.P.Ed. | Security Assistant |
| 52. | Shri R.N. Ram | | Assistant (Admn) |
| 53. | Shri Dhirendra Kumar | | Assistant (F&A) |
| 54. | Ms. Shyamala K. | | Jr. Stenographer |
| 55. | Shri Kapoor | | U.D.C. |
| 56. | Shri M.A. Malla | | U.D.C. |
| 57. | Shri Girish Chand | M.A.(Poly. Science) | Telex Operator |
| 58. | Shri P.K. Satyanesan | | L.D.C. |