ANNUAL REPORT

1984–85

REGIONAL RESEARCH LABORATORY, BHOPAL

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PREFACE

It is my privilege to present the Annual Report (1984-85) of the Regional Research Laboratory (Bhopal), of the Council of Scientific and Industrial Research (CSIR).

Starting from scratch in 1981, this year has been a period of consolidating the research infrastructure to make RRL, Bhopal a major centre of science and technology in the region of Madhya Pradesh. Sophisticated equipment like Scanning Electron Microscope, Instron, X-ray diffraction machine, microcomputer have been installed. The experimental facilities and the library of RRL, Bhopal are increasingly being used by scientists of the region. The research projects of the laboratory have reached important milestones, and steps for interaction with the industry on technology development and transfer have been initiated.

The Co-operative Training College building complex where the laboratory is presently housed is being purchased. Flats have been acquired from BDA and allotted to the staff. The tenements at Subhash Nagar have also been occupied by the staff.

The laboratory has made major strides in upscaling the technology of making aluminium alloy-graphite particulate composites under industrial conditions,M/s.La Cast Metal & Components (Pvt.) Ltd., Goregaon, Bombay have extended their shop floor facilities for carrying out the field trials on the making of Al-graphite composites under an agreement with the laboratory. Al-graphite pistons have been successfully cast and machined. Steps have been taken for testing these pistons at the Automotive Research Association of India (ARAI) Pune. Another important feature on product development from these composite materials has been the joint trials undertaken by the laboratory with M/s. Sah Industrial Research Institute, Varanasi, on Al-graphite bushes for fans. Many industries and institutions in India including Sah Industrial Research Institute, Varanasi, the Structural Engineering Research Centre, Roorkee have already contacted the RRL, Bhopal to make use of the metal ceramic particulate composites for fan bushings, fan base and window frames.

Studies incorporating minerology, beneficiation, analysis, product development related to minerals of Madhya Pradesh, particularly alumino-silicates, mica, talc, clay, vermiculate, pyrophillite, silica sands, zeolite, cassiterite, phosphorite and graphite have been initiated.

Exploratory work has been completed on utilization of natural fibres of Madhya Pradesh covering evaluation of properties, surface treatments, and incorporation of fibres into polymer and cement matrices for new products. Ipomoea carnea plant has been identified as a major potential resource of M.P. Pioneering studies on the structure and properties of Ipomoea stem have been completed to improve its performance as a composite building material.

The Seventh Five Year Plan has been prepared and approved by area reviewers of CSIR and accepted by CSIR. A monograph on Materials Science and Technology in the Future of Madhya Pradesh is being brought out.

The laboratory had to shoulder the responsibility of acting as base from where the scientific work under the leadership of Dr. S. Varadarajan, DGSIR, was done after the MIC leakage from Union Carbide plant. During this period over one hundred scientists from all over the country worked from RRL, Bhopal. It was indeed one of the finest hours of

RRL, Bhopal in successfully responding to the unprecedented call of the society, and in fulfilling its charter of a Regional Research Laboratory.

During this year RRL, Bhopal had the privilege of visits by Shri Arjun Singh, Hon'ble Chief Minister of Madhya Pradesh, Shri Digvijay Singh, Union Minister of State for Environment, Prof. M.G.K. Menon, Member, Planning Commission and Dr. S.Z. Qasim, Secretary, Department of Ocean Development.

Two national seminars on foundry technology and building materials respectively were held at the laboratory. Invited lectures and seminars at RRL, Bhopal by experts within India and abroad have received great response from the industries, R&D and academic institutions in and around Bhopal. Scientists of RRL, Bhopal submitted publications to prestigious national and international journals and presented several papers at different seminars including Metals Congress, USA, International Conference on Progress in Metallurgical Research, and International Conference on Building Materials and national seminars on solidification and casting of metals. This is establishing the reputation of RRL, Bhopal as a premier research centre in Materials Science as is also evidenced by the international and national awards received by scientists of RRL, Bhopal this year. This is beginning to attract first rate scientific staff to RRL, Bhopal.

I take this opportunity to express our gratefulness to Shri Shivraj Patil, Vice-President CSIR and Dr. S. Vardarajan, Director General, CSIR for help and guidance. The support of CSIR headquarters in helping with the establishment of this laboratory is gratefully acknowledged. The help and advice received from numerous scientists from within the country and from other countries is also acknowledged. I also thank the staff of the laboratory for their hard work and co-operation.

(P.K. ROHATGI)

INTRODUCTION

The Regional Research Laboratory, Bhopal (CSIR) now in its fourth year of existence since May, 1981, has undertaken research activities on utilisation and development of natural resources of Madhya Pradesh. The main thrust has been on generating new information on mineral, agro and forest based resources of the region, through research and development, primarily in the area of Materials Science.

This report describes the details of the R&D activities, development of infrastructure and over all growth of the Regional Research Laboratory, Bhopal.

RESEARCH PROJECTS AND PLANS

Two ongoing research projects namely "Development of Al-based particulate composites" and "Evaluation of mineral based resources of M.P.", and twelve new proposals in the area of Metallurgy, Materials Science, Minerals, Composite Materials and Technology Forecasting have been incorporated in the Seventh Five Year Plan of the laboratory. These have been approved by Research Advisory Council, Executive Committee and area reviewers of CSIR. The details of work on the two ongoing research projects, and the exploratory studies on Natural Fibres of Madhya Pradesh and Development of Building Materials using resources of M.P. are described in a separate chapter.

SPONSORED RESEARCH

The laboratory has successfully completed a consultancy project sponsored by Thapar Corporate R&D Centre, Patiala, on Technology Forecasting for Materials Research. The work involved futuristic studies on Materials for electromechanical and electrical machinery, chemical industry, particularly pulp and paper, chloralkali, membrane technology, and glass and ceramics. Two major reports were submitted on the above aspects. Under the DST sponsored project on "Long range planning and techno-economic forecasting on Aluminium towards the year 2020 AD" continuous monitoring exercises have been carried out to up-date the earlier reports. This project has been extended to 1986.

BUDGET AND EXPENDITURE

The expenditure pattern over the period of four years since the inception of the laboratory is indicated below:

Year	Total expenditure (Rs. in lakh)
1981-82	9.860
1982-83	110.000
1983-84	94.242
1984-85	172.00

INFRASTRUCTURE DEVELOPMENT AND GROWTH

RRL, Bhopal is now equipped with some of the most modern scientific and analytical equipment and instrumentation. This includes the facilities for Materials Science, chemical and physical characterization and for mechanical testing of materials.

Scanning Electron Microscope, JEOL 35 CF with following accessories is now fully operational :

- Wave length dispersive X-ray spectroscope for in-situ elemental analysis.
- A tensile stage for in-situ study on fracture and deformation behaviour.
- Heating stage.
- Cryogenic unit for examination of biological samples.

The optical microscopy and metallography facilities have been further added up with important accessories. Following attachments have now been added to the Leitz Metalloplan microscope.

- Computerized image analyser (Tas PLUS) for quantitative metallography.
- Hot stage microscope (upto 1000^{o}C).
- Transmission and reflection attachments.

For mechanical testing, INSTRON testing machine (10 Ton capacity) with following facilities is available:

- Tension, compression, and flexure.
- Testing of materials including metals, plastics, fibres, yarns, etc.
- High temperature furnace (upto 1000^{o}C).
- Rheometer attachment to study the flow behaviour of plastics.
- Extensometer for measurement of strains.

Impact testing machine, Hardness testers (Vickers-cum-Brinell) including microhardness tester, and Rotating bending fatigue testing machine are also available in the laboratory.

A compocasting machine for making metal base composites, and a 150 T Hydraulic press have been added to the foundry facilities. Facilities for chemical analysis of minerals and materials have been created. Visible Spectrophotometer and flame phtometer are installed. Steps have been initiated towards procurement of IR, AAS, DTA/TGA, High temperature furnaces.

The HCL Work horse Level-4 microcomputer is installed and it is being used in the laboratory.

Workshop with Lathe, tool and cutter grinder, milling machine, drilling machine, cutting machine, power hacksaw etc. provides support to the ongoing research projects in terms of fabrication, machining and maintenance.

LIBRARY AND DOCUMENTATION

The RRL, Bhopal library now holds following stock:

Total number of books, standards and bound periodicals	1844
Total Reprints	1188
Journals subscribed	100

The library is slowly becoming a major source of information related to Materials Science, Composite materials, Aluminium, Natural resources of M.P. and Technology Forecasting. Over sixty International research periodicals are subscribed in these areas, and the library is frequently referred by academic, industrial and research institutions in the region.

PROGRESS ON ESTABLISHMENT

The Coperative Training College building complex where the laboratory is presently housed is being purchased by CSIR. This will make available, over 40,000 sq.ft. floor area permanently. The housing units purchased from the Bhopal Development Authority have been allotted to the staff of the laboratory. These are in addition to the tenements which are already occupied by the staff of RRL, Bhopal. The staff bus is put in operation to regularly commute the staff members to the laboratory.

Shri Arjun Singh, Hon'ble Chief Minister of Madhya Pradesh being taken round the Laboratory.

RESEARCH IN PROGRESS

METAL MATRIX PARTICULATE COMPOSITE MATERIALS

During the past few years, attempts have been successfully made to synthesise a variety of Al alloy based particulate composites containing dispersions of both solid lubricants such as graphite, mica and talc and hard ceramic particles like rice husk ash, zircon and silica sand. As reported in last year's annual report, various process parameters were optimised to produce these composites on a laboratory scale. During the current year (1984-85) a target was set to upscale the technology of making Al alloy-graphite composites to 130 kg melts on foundry shop floor so that the technology can be transferred to a small/medium scale industry. The second target was to develop products like bearings, bushes and pistons from Al alloy-graphite composites and also to explore avenues for utilising Al alloy-zircon and Al alloy-silica sand composites. In order to accomplish the above targets, two important industrial links were established, namely with M/s. La-Cast Metals and Components (Pvt.) Ltd., Bombay and Sah Industrial Research Institute, Varanasi. In addition M/s. Escorts Ltd., Patiala have agreed to make pistons and Automotive Research Association of India (ARAI), Pune have also agreed to evaluate the performance of Al alloy-graphite pistons.

On July 18, 1984 an agreement was signed between the Regional Research Laboratory, Bhopal and M/s. La Cast Metals and Components (Pvt.) Ltd., Bombay (Fig. 1). According to this agreement, the firm has agreed to offer their shop floor facilities to our laboratory for casting and machining of Al alloy-graphite composite pistons. Soon after the agreement was reached, a team of scientists from RRL, Bhopal was deputed to Bombay with ingots of Al alloy (LM 13) - 3 wt.% graphite and LM 13 - 5 wt.% graphite which were synthesised at RRL, Bhopal. These ingots were remelted at M/s La Cast Metals and Components (Pvt.) Ltd. at Umbergaon factory under actual shop floor conditions using one of their oil-fired furnaces. The melt was successfully degassed without any rejection of graphite particles. This is important since it suggests the possibility of a centralized facility for initially synthesising composites, which can then be remelted and cast into desired shapes at a number of other small foundries.

It was decided to cast pistons for:

(a) I.C. Oil Engine AV-I Series-II and Kirloskar single piston engine.

(b) Escort Swaraj Tractor - 37 and

(c) Ingersoll Rand Compressor.

In all, 80 pistons and four test bars were made in the first attempt. No change in the shop practice was introduced. The pistons were later heat treated using the standard heat treatment used for LM 13 alloy and machined to get the desired contours. A photograph of the pistons made in the first attempt at M/s. La-Cast is shown in Fig. 2. Test bars and pistons were subjected to a thorough metallographic examination at RRL, Bhopal to find out the graphite distribution. Attempts are underway to modify the practice to get uniform distribution of graphite within a piston, and from one piston to the next.

The same team of scientists, who were involved in the first trials at La Cast, were deputed once again for further trials with the modified practice. They have successfully cast 100 pistons with improved gating systems. These castings were heat treated and

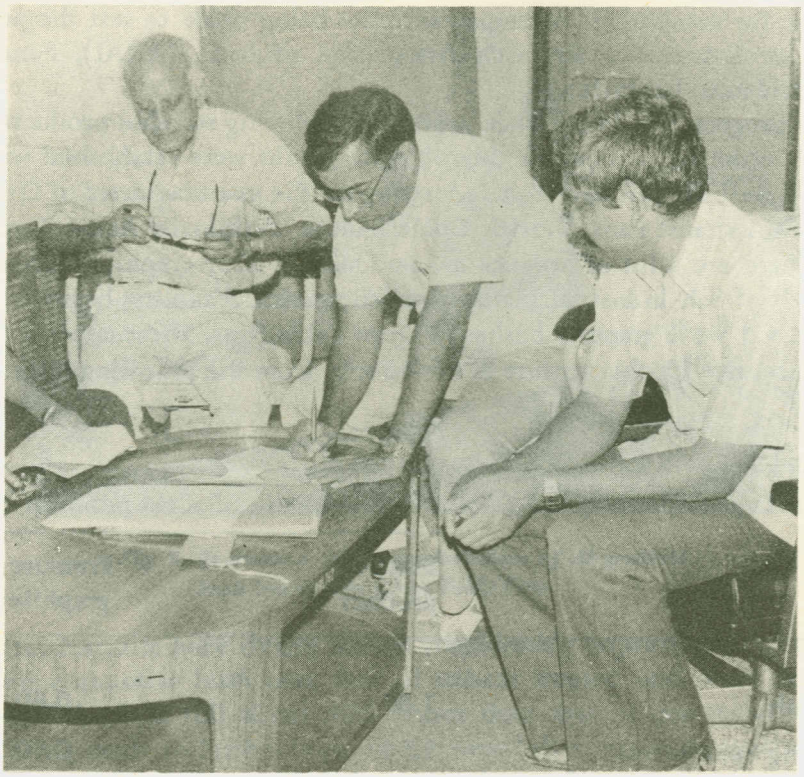


Fig. 1. Signing of agreement between Regional Research Laboratory, Bhopal and M/s. La Cast Metals and Components Pvt. Ltd.; Bombay, Prof. P.K. Rohatgi, Director, RRL, Bhopal and Shri P.N. Brahmwar, Managing Director, La Cast Metals and Components Pvt. Ltd., signed on behalf of their respective organizations.

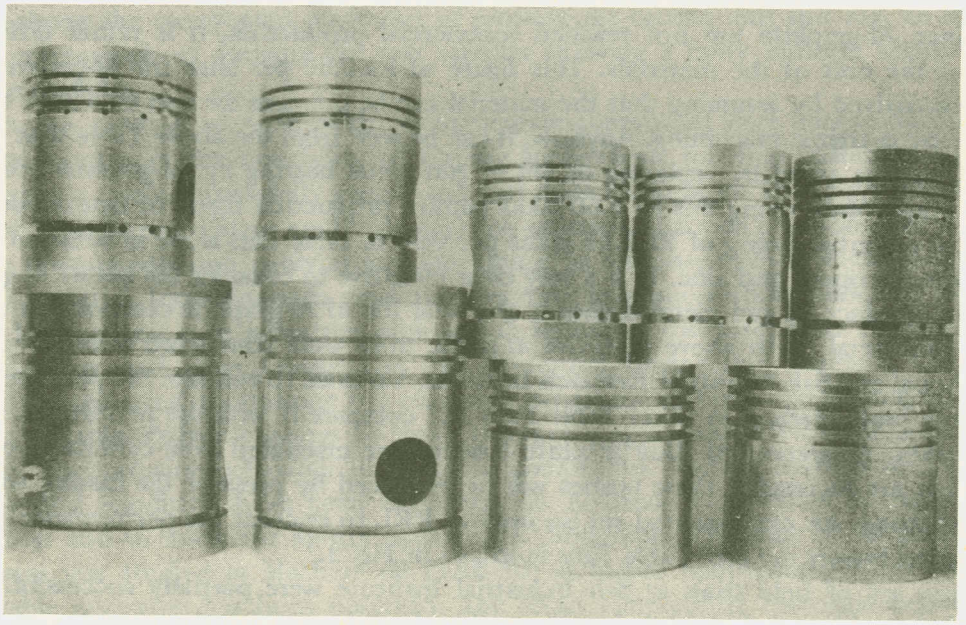


Fig. 2. Photograph showing different types of pistons of LM 13-graphite composite cast and machined at La-Cast Industries by RRL Scientists.

left at La Cost for machining. Attempts are now being made to test the performance of these pistons at Automotive Research Association of India (ARAI), Pune, and Indian Institute of Petroleum, Dehradun.

Notable progress has been made towards developing suitable products like bearings and bushes. In order to accomplish this objective, links were established with Sah Industrial Research Institute, Varanasi. Sah Industries are the manufacturers of Cinni Table Fans and Ceiling Fans, Exhaust Fans, Verticle Cooler Pumps, Peripherial Action Generator Pumps and Mixers. There are a lot of avenues to introduce Al alloy-graphite bushes and bearings if the field trials at Sah Industrial Institute are successful. A modest beginning was made to try out LM 13 + 3 wt.% graphite bushes in Cinni Table Fans. There appears to be tremendous financial incentive for this venture as can be seen from the following table:

Table-I

No. of bushes	Type of bush	Cost per bush in Rupees	
		Sintered product	Pressure die Al graphite
1	Pivot bush	1.60	0.60
1	Oscillating Spindle bush	1.30	0.60
2	Oscillating worm bush	0.80 x 2	0.60 x 2
4		4.50	2.40

Since Al-graphite has not reached commercial production, it is rather difficult to work out the cost of the materials. This figure of Rs.0.60 per bush for Al-graphite composite was arrived by assuming that the material can be pressure die cast into bush bearings followed by marginal machining. Anyhow, it can be seen from the above Table that roughly Rs. 2.10 can be saved by replacing on set of gun metal bearing by Al-graphite composite bush bearings. Multiplying this by 2.50 lakhs (annual production figure of fans in India), we arrive at a potential saving of Rs.5.25 lakhs per year in table fans alone in addition to conserving scarce copper and zinc. It is a very clear incentive to consider the use of Al-graphite composite in place of gun metal bushes if the wear life of Al-graphite composite is close to that of gun metal. With above objective in mind, trials were conducted simultaneously at RRL, Bhopal and Sah Industrial Research Institute, Varanasi to evaluate the performance of Al-graphite bush bearings in Cinni Table Fans and compare it with the performance of gun metal bushes. At present Al alloy graphite bushes were machined from cylindrical castings. If the trials are successful, these bushes will be produced by pressure die casting with very little machining. An experimental set up used at RRL to evaluate the performance of these experimental bushes in Cinni Table Fans in shown in Fig. 3.

First set of field trials at Sah Industrial Institute were partially successful. It was observed that although LM 13 + 3 wt.% graphite bushes ran without seizure, wear rate of composite bush bearings was significantly higher than that of gun metal bush. Composite bushes were later heat treated in order to improve the wear behaviour. Recent field trials

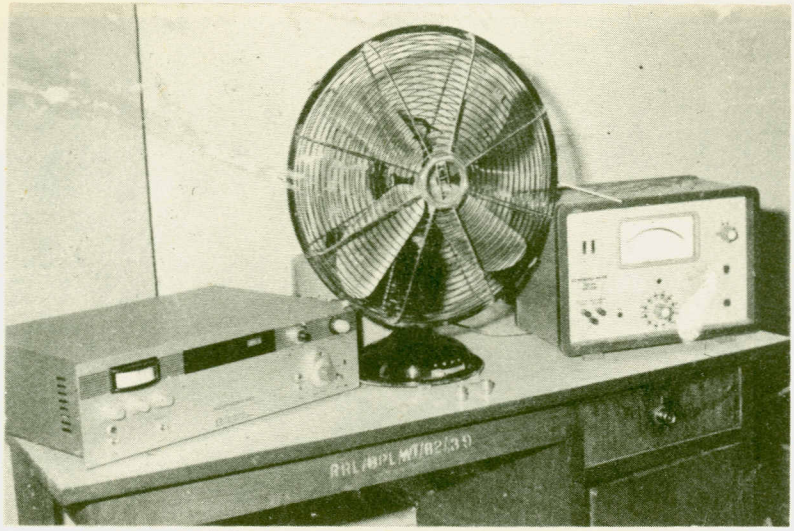


Fig. 3. Evaluation of the performance of Al-graphite bush bearings in Cinni Table Fan.

at Sah Industrial Institute have clearly shown considerable improvement in wear behaviour of heat treated composite bush over that of unheat treated one. Wear rate of the heat treated composite bush is still about 30% higher than that of gun metal bush. Attempts are currently being made to further improve the wear behaviour of composite bush and also to explore the possibility of upscaling the technology of bush making using pressure die casting technique.

A study was also undertaken to assess the casting characteristics of Al alloy-graphite composite using pressure die casting facilities available at BHEL, Bhopal. An LM 13-graphite composite was successfully pressure die cast into intricate casting like Bushing Spring Guide. Fig. 4a shows the component made out of pressure die casting unit and Fig. 4b shows the optical micrograph of pressure die cast samples showing a fairly uniform distribution of graphite particles.

A few castings of Al-alloy zircon particulate composites were sent to Sah Industrial Institute to explore the possibility of finding applications for these materials. Sah Industrial Institute could successfully remelt and cast these composites. They have indicated that some of their future designs could use abrasion-resistant Al-zircon composites in the totally die cast components not involving any machining. In response to their requirement for this kind of material, local Narmada sand particles have been successfully added to aluminium alloys. Interactions with industries such as Sah Industrial Institute, Patel Extrusion Industries, Bombay and sister laboratories like Structural Engineering Research Centre have highlighted the need to evaluate the corrosion behaviour of these composites, and also to develop suitable surface coatings to mask the spotty appearance. Work has been initiated to study the corrosion behaviour of Al-zircon composites. Various coatings such as enamel painting and anodizing have been deposited on Al-zircon composites to impart surface protection and to mask the spotty appearance. Corrosion behaviour of Al alloy-graphite composite was studied in Machine oil (SAE-30) at higher temperatures (100^{o}C), and no measurable corrosion has been observed. The room temperature corrosion behaviour has also been studied using potentiodynamic anodic and cathodic polarization measurements in different concentrations of sulphuric acid and sea water.

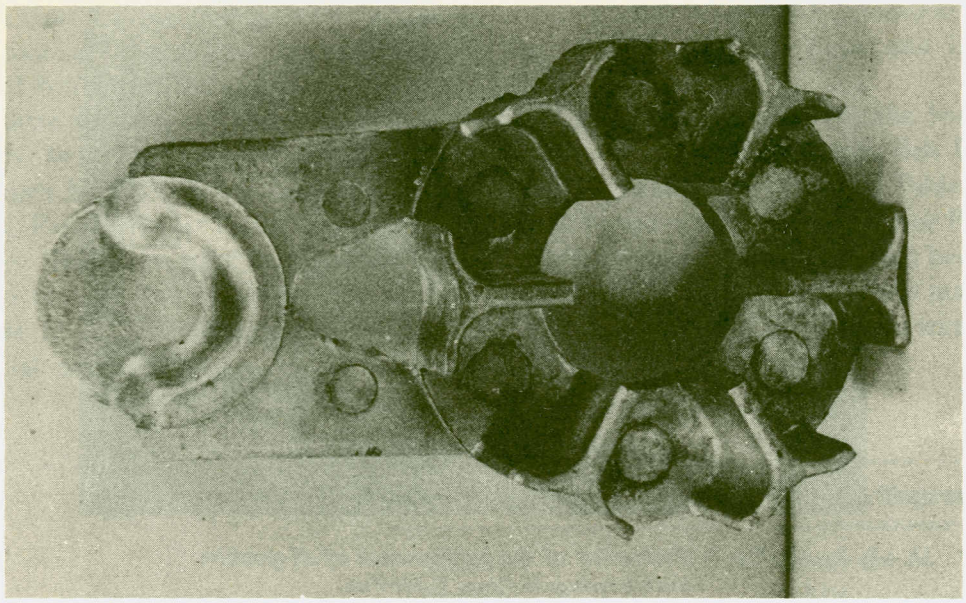


Fig. 4(a). Photograph of Al-graphite Bushing Spring Guide made by pressure die casting at BHEL.

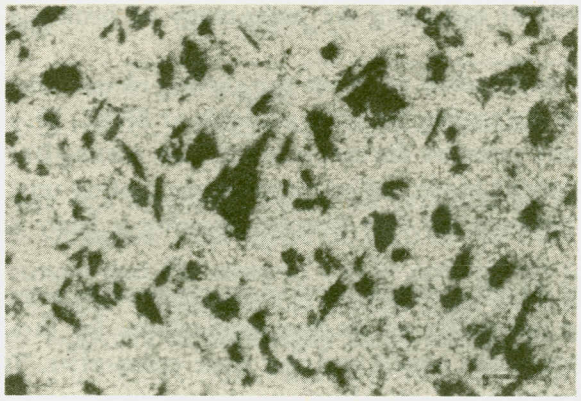


Fig. 4(b). Optical micrograph showing uniform distribution of graphite particles.

Detailed laboratory investigations are being carried out on the heat treatment and deformation behaviour of Al-graphite composites. Preliminary studies on the thermo-mechanical processing of Al-graphite composite show improvements in strength and ductility. High temperature forging and rolling were done on these composites and microstructure and mechanical properties were measured in the laboratory. It is seen that graphite particles can be deformed into stringers along the thickness plane (Fig. 5).

Al alloy-talc composites which were synthesised in 1983-84 have been tested for wear properties. A pin-on-disc machine (Fig. 6a) has been designed and fabricated at RRL to study the wear properties of composites. Studies have shown that significant reduction (upto 30%) in wear rate could be accomplished due to the addition of 2.8 wt.% of talc powder. An SEM micrograph of a worn out surface of LM 13 + 2.8 wt.% talc is shown in Fig. 6b.

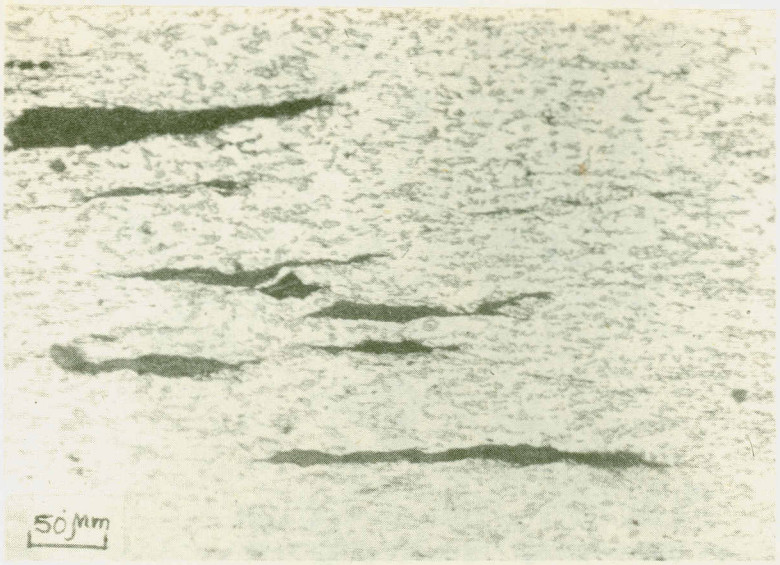


Fig. 5. Typical microstructure of LM 13-3 wt.% graphite hot rolled to 67% reduction (Photograph taken at the long transverse direction).

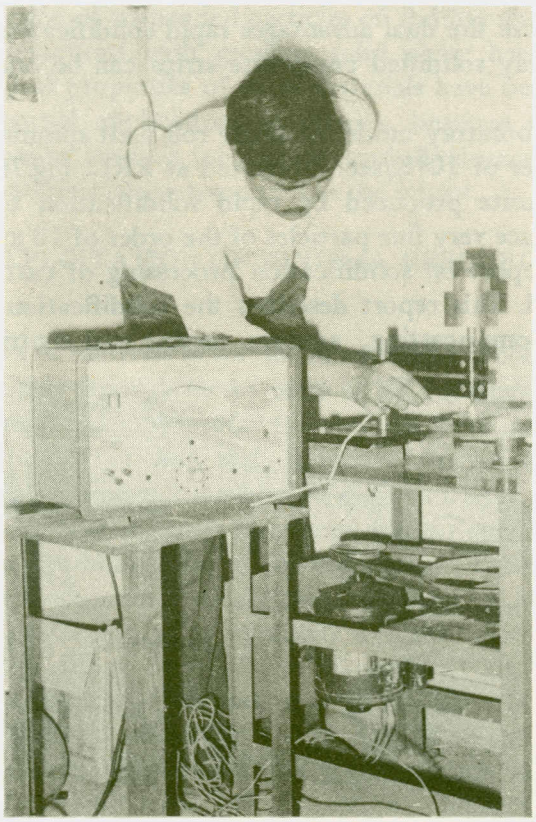


Fig. 6(a). A pin-on-disc experimental set-up designed and built at RRL, Bhopal for measuring wear rates of Al alloy composites.

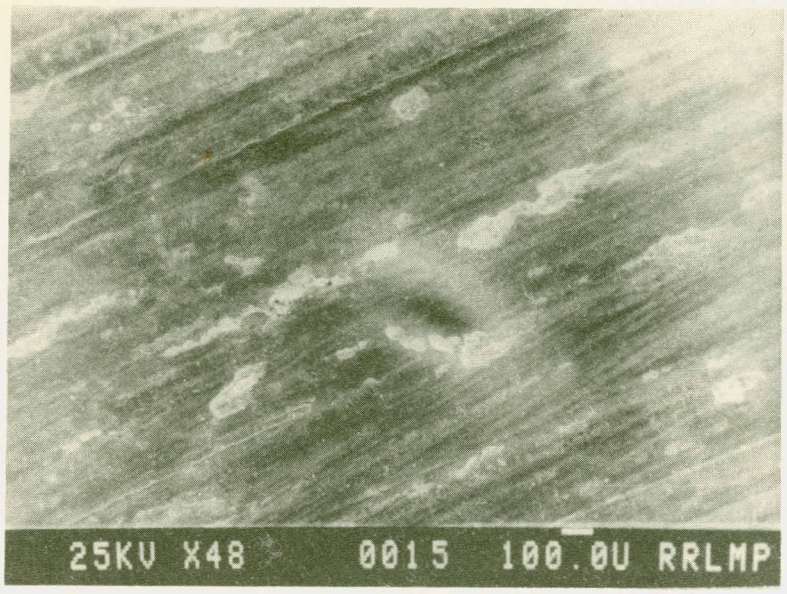


Fig. 6(b). SEM micrograph of a worn out surface of LM 13 + 2.8 wt.% Talc.

Work has been initiated on rapid solidification of Al alloys with dispersions of graphite with a view to achieve the dual advantages rapid solidification as well as lubricity of graphite. These thin rapidly solidified composite strips can be brazed on to moving parts to reduce friction.

Fig.7a shows the laboratory model of single roll melt spinning unit capable of giving a cooling rate of the order of 10^5K/sec. fabricated at RRL. Fig.7b shows the micrograph of the Al-graphite composite produced by rapid solidification technique. Attempts are now being made to introduce very fine particles of the order of 10 μm or less.

A state-of-the-art report on solidification processing of cast metal particulate composites has been prepared. This report describes the solidification techniques like gravity or pressure die casting, compocasting, squeeze casting and centrifugal casting that have

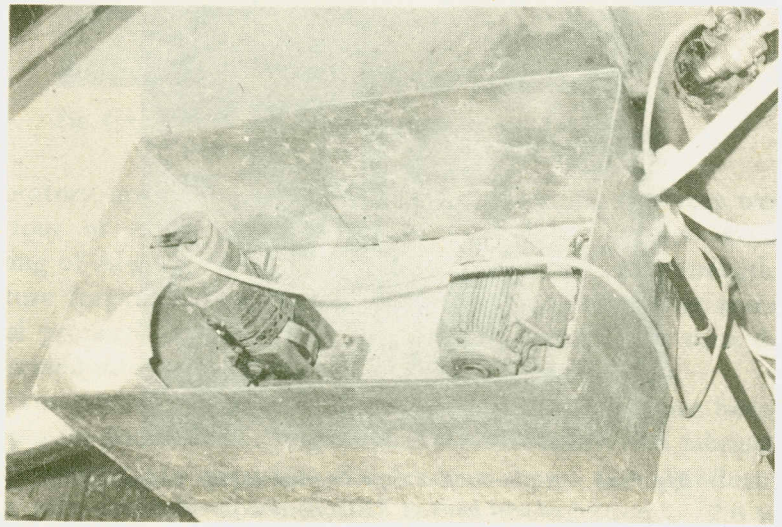


Fig.7(a). A laboratory model melt spinning unit.

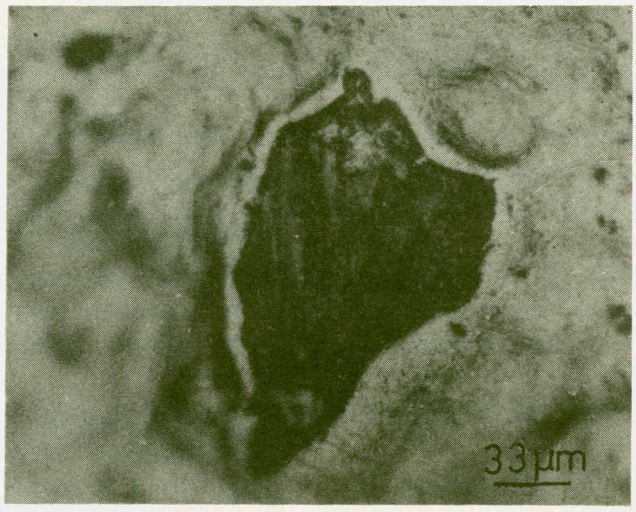


Fig. 7(b). Optical micrograph of a rapidly solidified Al-graphite composite.

been used to synthesise Al alloy-ceramic composites having controlled distribution of dispersed particles. The composite prepared by the above technique offer tailor-made materials that have the required properties such as strength, ductility, friction and wear.

In addition, influence of suspended particles on fluidity and their potential as nucleation sites and their interactions with growing solid phase have been studied. Physical, mechanical and tribological properties of these materials have been discussed in the report to emphasise their potential applications in pistons, bearings and cylinder liners. Work carried out to explore newer avenues for research and development in the area of Al alloy particulate composite materials is also presented in the report.

EVALUATION AND EXPLOITATION OF MINERAL RESOURCES OF MADHYA PRADESH

In view of large resources of minerals in MP the laboratory has collected samples of minerals like talc, mica, bauxite, clay from different parts of MP for characterisation and systematic evaluation and development of new products based on these minerals. Comprehensive reports on Mineral Resources of MP and Research Imperatives related to Bauxite, were brought out last year. These reports have been widely ciruclated during this year and have received great appreciation. Several copies have been requisitioned by different organisations and the reports are being published for wider circulation. Table-II lists the experimental work completed on characterisation of different minerals of M.P. The work under this project at RRL, Bhopal is beginning to stimulate mineral based industries in the State of M.P.

During this year considerable amount of work has been carried out on characterisation of talc bearing minerals of M.P., and a comparative study of its properties with the similar minerals available in other parts of the country has been undertaken. It has been found that talc available in M.P. is highly disordered type and, contains impurities like kaolinite, sand, and iron. Attempts are being made to find applications of locally available talc in polymers as additives, and also in aluminium alloy composites, and in ceramic industries.

Table-II

Characterization of minerals done at RRL, Bhopal using different techniques

Name of minerals	Techniques applied
Mica schist/Mica	SEM, XRD, DTA, TGA, IR, WCA*
Talc	SEM, XRD, DTA, TGA, IR, WCA
Vermiculite	WCA, TGA
Zeolite	WCA
Graphite	WCA
Limestone	WCA
Pyrophyllite	SEM, TGA, WCA
Bauxite	PGS**
China clay	WCA
Lepidolite	WCA, SEM, TGA
Soil	IR
Dolomite	WCA
Cassiterite	PGS

* WCA = Wet chemical analysis

** PGS = Petrographic study.

After analysis of beneficiated mica powder from mica schists of M.P., it had bee observed that eventhough nearly 60% of silica contained in the mica can be eliminate using water elutriation method, the mica powder so obtained contained very fine silic Attempts are now being made to further purify it by using the floatation and other techn ques. Several experiments have been completed to use beneficiated mica powder for maki mica-polymer composite, mica-natural fibre polymer hybrid composites, delaminated mi powder for aluminium mica composites, and fine mica powder for paint industries.

Optical and scanning electron microscopic studies were conducted to measure th aspect ratio and number of lamellae in individual mica particles.

For characterisation of clays available in M.P. the laboratory has taken up an e tensive programme. Experiments are going on for determining the suitability of comm clays available in the region for making bricks of standard qualities. China clay available Bairagarh (suburb of Bhopal) is being studied and some experiments have been made f removal of impurities. Its use as sanitaryware is being examined along with other ra materials of M.P. Pyrophyllite, quartz and calcite minerals of M.P. are also being assesse for production of sanitaryware.

Studies were initiated to assess the industrial potential Narmada sand. Chemical an lysis shows that this sand requires significant beneficiation for use in glass industry. It ca be used for building, foundry and for water filtration.

Chemical analysis of phosphorite from Jhabua and Saugar districts has been cor pleted. The minerals from Jhabua district were found to be fairly satisfactory for producir elemental phosphorous whereas high iron-content of Saugar phosphorite may be a proble for immediate exploitation.

Lepidolite of Bastar district is being studied for possibility of production of Li_2CO_3. The tentative flow diagram for production of Li_2CO_3 from lepidolite is being finalized. Bharat Aluminium Co., Korba has shown active interest in production of Li_2CO_3 as it is imported at present.

Successful laboratory trials were made on exfoliation of vermiculite mineral available in Jhabua district of M.P. Detailed laboratory experiments are going on to characterise it and finding its industrial applications, including the possibility of adding it to aluminium alloys and polymer to synthesise composites.

Laboratory experiments were undertaken to develop SiC whisker from rice husk (Fig. 8). It has been observed that percentage conversion to SiC is low, and attempts are now being made to further modify the process in order to achieve higher percentage of whiskers.

The minerals group has evolved an improved method for rapid chemical analysis of Aluminium-ceramic particle composites.

RRL, Bhopal actively participated in entrepreneurship development seminar at Raipur for setting up mineral based industries in M.P.

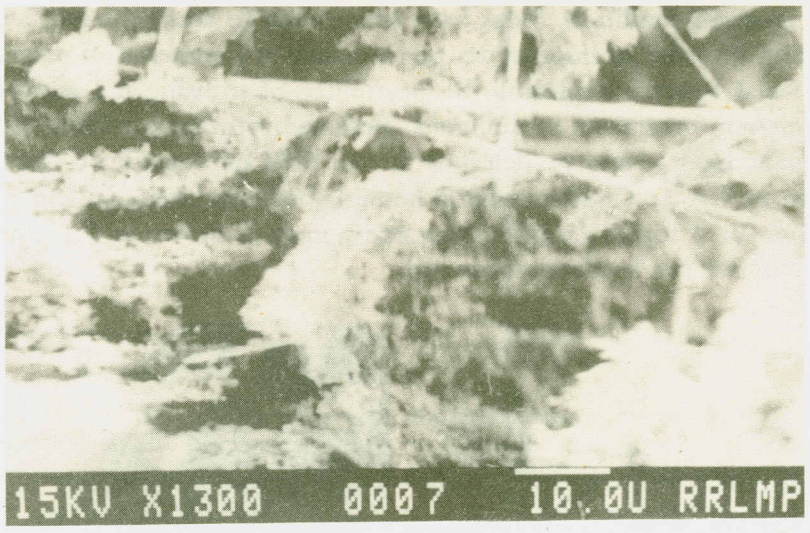


Fig. 8. SEM-micrograph of SiC whisker from rice husk.

POLYMER BASED COMPOSITES UTILISING NATURAL RESOURCES OF M.P. INCLUDING NATURAL FIBRES AND IPOMOEA STEM

A project in this area has been approved by the Research Advisory and Executive Committees, and is scheduled to commence from 1985 onwards. Prior to the commencement of the actual project, considerable amount of work has been carried out in order to demonstrate the feasibility of the proposal. A comprehensive study on "Resources, structure, properties, and uses of natural fibres of Madhya Pradesh" has been carried out and results of this study have already been published in JSIR (1984). A bibliography on natural fibres has also been prepared. Based on the above two reports, two important areas of research have emerged.

(A) PROPERTY EVALUATION OF FIBRES AND AGRO-WASTES

Before taking up any meaningful work on natural fibre composites, it was necessary t determine various mechanical and physical properties of fibres and particulate fillers. Suc properties are well documented for synthetic fibres such as glass and carbon. Unfortunatel the data on various natural fibres is relatively scant. From the limited amount of wor carried out in this direction, it was found that properties such as tensile strength and modu lus vary considerably for the same type of fibre extracted from different sources. In som cases this variation could be as high as 100-200%. This is primarily due to the fact tha there is no standard technique to extract these fibres. Secondly, mechanical properties a well as chemical composition of fibres also depend to some extent on the age. In view o the above, research was undertaken to systematically evaluate various mechanical an physical properties of natural fibres with special reference to Madhya Pradesh region.

Ipomoea (commonly called as "Besharam") is a wild growing plant in the Madhy Pradesh region. This plant grows in many other parts of India and other parts of the wor in large quantities. Despite very large quantities grown presently and much greater potentia very little scientific work has been done on this plant. It is used for fencing and low co housing in as received condition. Steps have been taken to study the mechanical behavio of Ipomoea stem in order to improve its performance as a material of construction. Maj emphasis is placed towards exploring the possibility of utilising the above mentioned n sources as fillers/reinforcements in polymers. Besharam powder has been used as a filler i polyester to make light weight particle boards. An SEM micrograph of fractured beshara board is shown in Fig. 9a. Good interfacial bonding between besharam and polyester can b noted from Fig. 9a. A higher magnification micrograph is shown in Fig. 9b where the ce structure of besharam can be clearly observed.

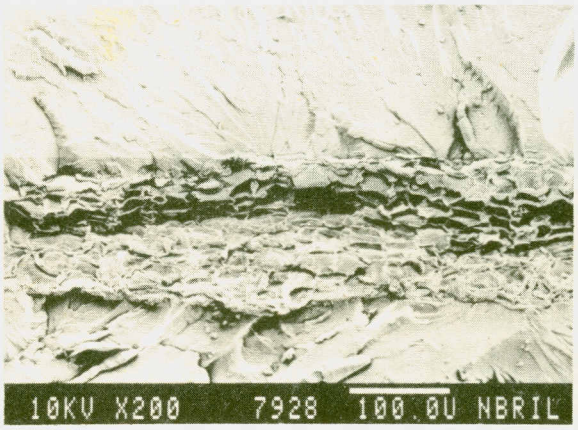


Fig. 9(a). An SEM Micrograph of fractured Besharam Powder - Polyester board: Good interfacial bonding can be noted.

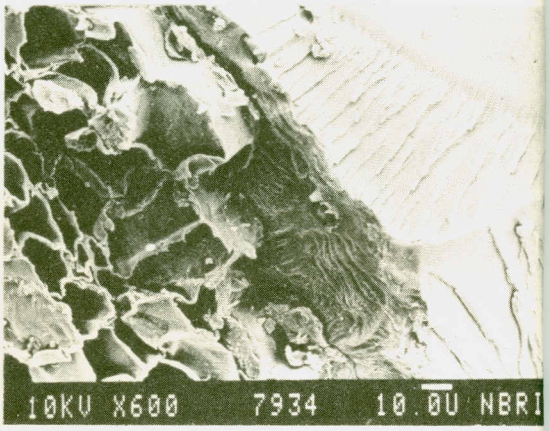


Fig. 9(b). A higher magnification micrograph Fig.9(a) showing the cell structure besharam.

(B) POLYMER-NATURAL FIBRE COMPOSITES

Some preliminary work has been carried out to evaluate the properties of polyester-su hemp fibre composites and to identify major bottlenecks in the extensive use of pol ester-natural fibre composites. It was experimentally possible to synthesise polyester-su

hemp composites containing upto 40 vol.% of unidirectionally aligned fibres. The tensile strength of these composites was found to increase linearly with increase in volume per-cent of fibres; increases in strength were close to predictions of the rule of mixture (Fig.10). It can be seen from Fig.10 that the tensile strength of polyester can be increased by 250% with the incorporation of only 20 vol.% uniidirectionally aligned sunhemp fibres. Modulus of polyester-sunhemp fibre composites was also found to increase linearly with the volume per cent of fibres. However, experimental observations showed that the increase was much higher than that predicted by the rule of mixture (Fig. 11). The discrepancy between the experimental and theoretical prediction can be due to the following reasons : firstly, due to the underestimation of fibre modulus and secondly, due to a synergistic effect when the fibre is embedded in polymer. From the experimental value (dotted line in Fig. 11) the effective fibre modulus was back calculated to be approximately 35 GPa, which is about half of fibre glass. This study has highlighted the need for extensive experimental work to develop better predictive capability in this area.

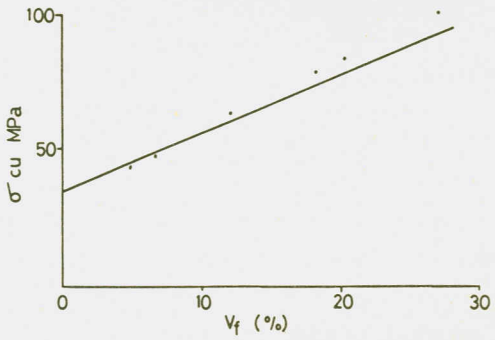


Fig.10. Ultimate tensile strength of sunhemp polyester composites versus the fibre volume fraction, solid line indicate theory (R.O.M.).

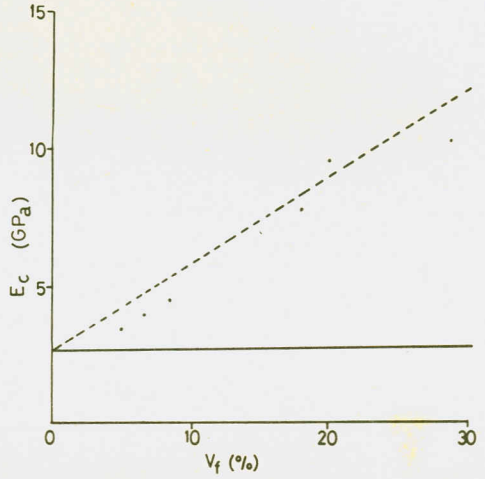


Fig.11. Composite modulus Vs volume fraction of sunhemp polyester composites, solid line indicates theory while the dotted line represents experimental trend.

Preliminary investigations on water absorption of polyester-sunhemp fibre composites have been carried out and the results are shown in Figs. 12 & 13. It is obvious from Figs. 12 & 13 that at high volume fractions, the moisture uptake will be significant, and serious thought must be given towards solving the moisture absorption problem with polymer-natural fibre composites.

Some economic aspects of polymer-natural fibre composites have also been worked out. Table-III shows the values of relative costs and relative weights of polyester composites containing 0.20 and 0.40 volume fractions of unidirectionally aligned sunhemp fibres as compared to other plastic systems. The cost and weight of polyester-sunhemp fibre composites and unfilled polyester at equivalent stiffness and strengths were computed from experimental measurements/extrapolations while the data on GRP (Glass fibre reinforced plastic) was theoretically computed. It is seen from Table-III that the polyester-0.4 V_f sunhemp fibre composite has the best stiffening efficiency. It is also predicted that the specific stiffness per unit cost of polyester-0.4 V_f sunhemp fibre composite is far more efficient than a 0.2 V_f GRP. In the light of the above, the synthesis of polyester-0.4 V_f sunhemp fibre composites at RRL, Bhopal is a significant achievement.

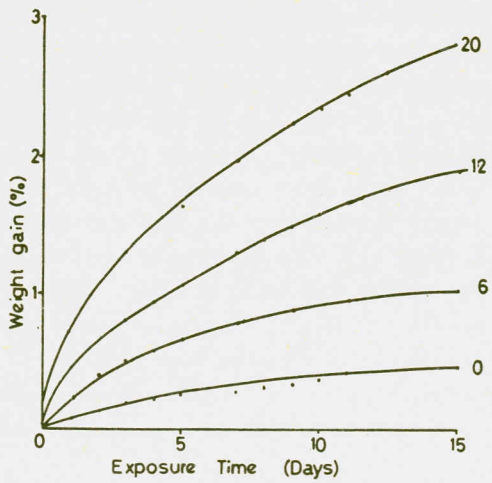


Fig.12. Percent increase in weight versus immersion period in water (the number at the ends of each curve indicate % Vf of sunhemp-polyester composites).

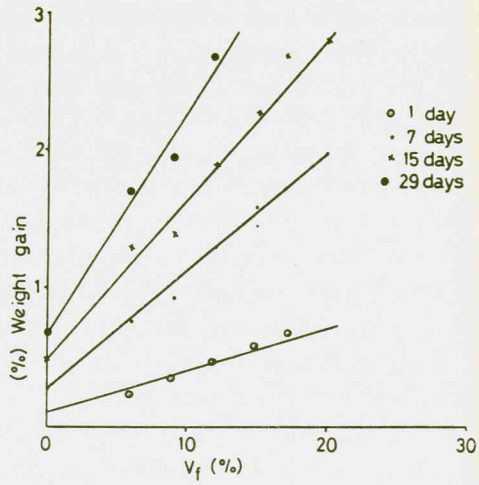


Fig.13. Percent gain in water after immersion water versus volume fraction (%) of su hemp polyester composites after vario periods of water immersion.

Table III

Efficiencies of filled and unfilled polyester resin

	Equivalent Stiffness			Equivalent Strength		
	Relative cost	Relative wt.	Specific stiffness/ unit cost	Relative cost	Relative wt.	Specifi strengt unit co
Polyester	100	100	0.01	100	100	0.01
0.2 V_f sunhemp polyester	23.5	26.8	0.16	34.4	39.3	0.07
0.4 V_f sunhemp polyester	11.6	15.6	0.55	17.7	23.8	0.24
0.2 V_f GRP	18.8	20.6	0.25	13.2	14.6	0.52

ACTIVITIES IN BUILDING MATERIALS RESEARCH

The major thrust during the year has been research on wall/roofing element from loc plant material for low cost housing and building bricks from wastes from Aluminiu industry.

USE OF IPOMOEA CARNEA AS BUILDING MATERIAL

Ipomoea carnea (Besharam) which grows extensively in MP has been identified as a usef material for several applications including housing. Problems associated with this mater as a low cost housing material were identified, and attempts initiated to solve these pro lems. A systematic study of structure and its properties, microstructure, mechanical b haviour and thermal behaviour has been conducted. Ipomoea carnea is a ligno-cellulo

plant material having 57.7% cellulose, 16.59% lignin and 17.3% Pentosan. Its tensile strength is 15-25 MPa. Ipomoea carnea chips and its powder mix readily with cement and mud. The bond strength of Ipomoea carnea with Mud Plaster + 2.5% cement was 0.7 Kg/cm^2. The ultimate load bearing capacity of 2.5% cement stabilized Mud Plastered panel having 14 vol.% Ipomoea was 300 Kg/m^2 giving a factor of safety of 3 for wind loading 100 Kg/m^2 (Fig. 14a & 14b).

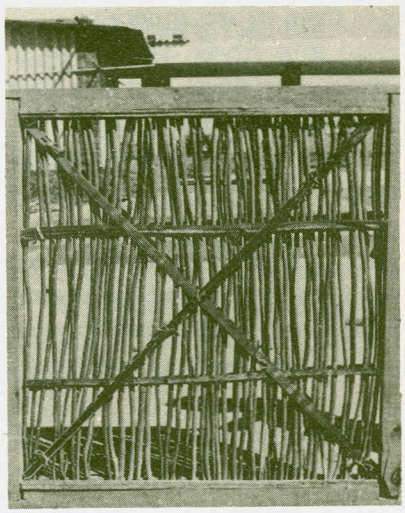


Fig.14(a). Ipomoea wall panel.

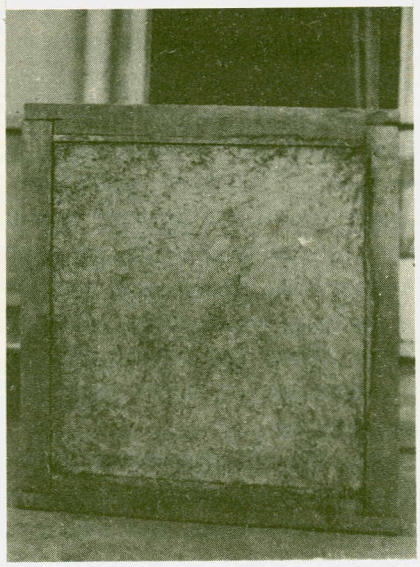


Fig.14(b). Mud-plastered Ipomoea wall panel.

CEMENT FIBRE SHEETS ROOFING ELEMENT

Study of cement sunhemp fibre corrugated roofing sheets was undertaken to investigate the possibility of making inexpensive roofing element for low cost houses. It was also hoped that natural fibres like sunhemp can replace Asbestos fibres which present health hazard. Various types of coatings have been deposited on the fibres to improve the property-performance relationship of the fibre and the sheets. High flexure strength in cement-sunhemp fibre composite was observed indicating that this is a promising material for buildings.

BUILDING BRICKS AND CEMENTITIOUS BINDER FROM WASTES FROM ALUMINIUM INDUSTRIES (RED MUD)

Casting of full size building bricks were undertaken since 50 mm briquetts were cast using red mud and local soil and gave good results as per ISI as reported last year. A small manual compaction machine has been fabricated and full size bricks have been successfully cast. These are under trial for firing in furnaces.

The use of red mud to make cementitious binder using local clay, paddy husk as fuel is also under investigation.

ACTIVITIES IN BIOMATERIALS SCIENCE

The carapace of the turtle was analysed for its chemical constituents. Carapace powder ha been added to polyester resin and the properties of this Biomaterial composite are bein investigated. Thermal degradation studies on the carapace have been completed. Studie on microbial degradation of the carapace to extract fibres from it, are underway.

Collagen has been dissolved out and reassembled into fibres, from several anima tissues. Attempts are underway to make collagen sheets, and to develop it as a material fo biomedical use, in the manufacture of artificial skin, from waste animal tissues.

Sections of the turtle heart have been fixed and observations are underway to stud the collagen deposition patterns in a comparative manner with the human heart so that significant clue can be provided on ageing of the human cardiac tissue.

Anatomical, Histological and Histochemical methods have been developed and uti lized for studying the structure of the tissue of the heart, brain and endocrine system.

Nerve Fibres from Anatomic Nervous system have been isolated and further studie will be undertaken to throw more light on how electrical energy is transmitted throug Biological systems.

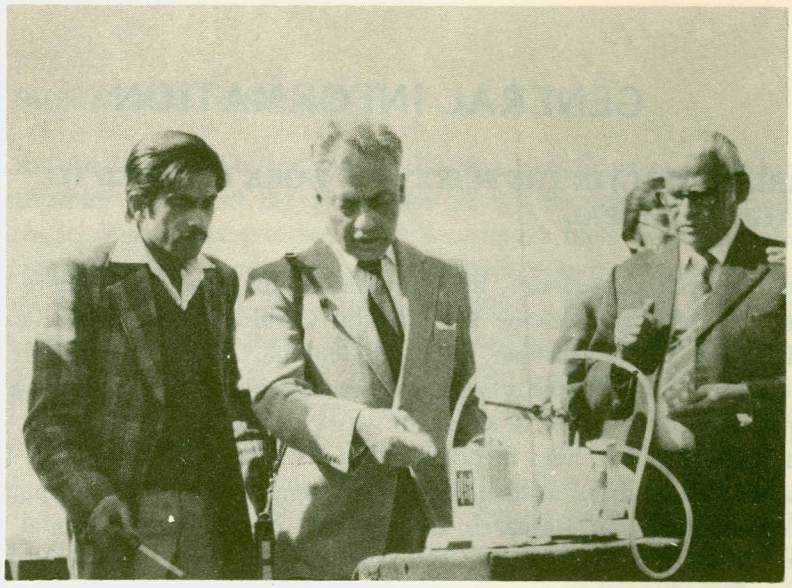
During the MIC gas leakage period and when Operation Faith was underway, the tea from Biomaterials Division undertook various surveys to determine the extent of damage o plant and animal tissues, and assisted high powered scientific teams from ITRC, NEER CIFE, NIO and other laboratories. Histopathological studies on the MIC affected fishe animals and human tissue are underway at the Division.

GENERAL INFORMATION

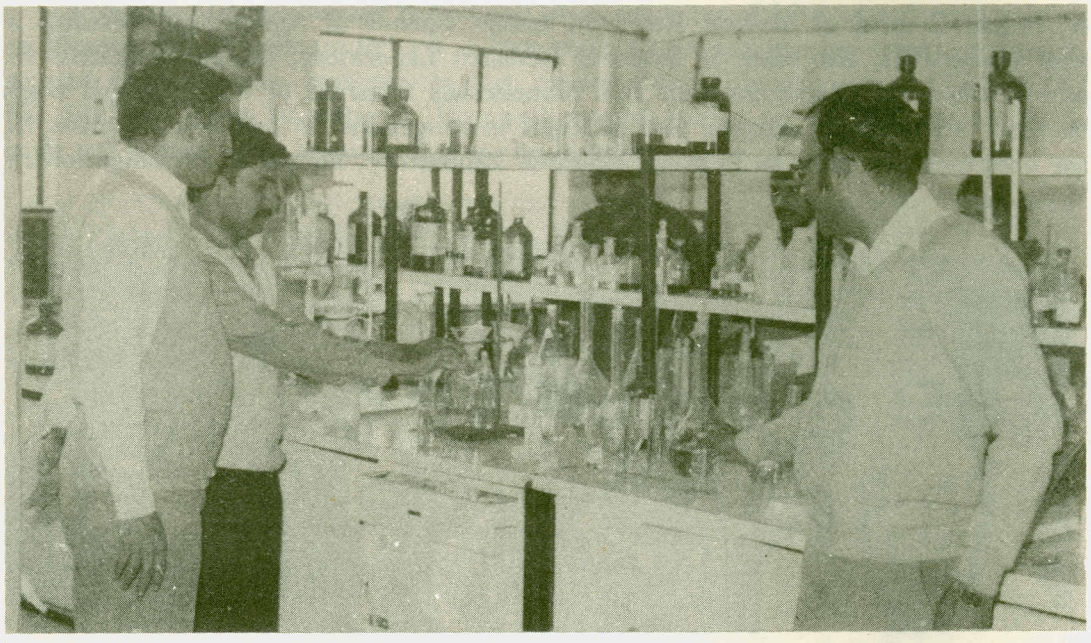
ROLE OF RRL(BHOPAL) IN THE SCIENTIFIC WORK RELATED TO MIC LEAKAGE AT BHOPAL

The Regional Research Laboratory, Bhopal acted as the base from where scientific investigations related to MIC gas leakage from Union Carbide, Bhopal were carried out under the leadership of Dr. S. Varadarajan, Director-General, CSIR. Over hundred scientists from all over the country from different organisations assembled at the Regional Research Laboratory, Bhopal and participated in scientific work as one group to check the environment after the gas leakage and to help in neutralisation of the remaining MIC. Several scientists came from sister CSIR laboratories including National Environmental Engineering Research Institute, Nagpur, Regional Research Laboratory, Hyderabad; National Chemical Laboratory, Pune; Industrial Toxicology Research Centre, Lucknow; National Institute of Oceanography, Goa. Scientists from other sister organisations including Indian Petrochemicals Limited, Baroda, Hindustan Organics Limited, Bombay, National Institute of Occupational Health and Safety, Ahmedabad, Defence Research and Development Organisation, Indian Council of Medical Research, Indian Council of Agricultural Research and several Universities, also came to Regional Research Laboratory, Bhopal. Scientists from Minerals, Chemical Characterization and Biomaterials Divisions of RRL, Bhopal worked with these scientists in carrying out different investigations. In addition scientists from other countries also came to Regional Research Laboratory, Bhopal to exchange scientific

Dr. S. Varadarajan, DGSIR with the team of scientists participated in the scientific investigation related to MIC leak at Union Carbide, Bhopal.



Dr. S. Varadarajan, DGSIR examining the analysis of MIC in air.



Chemical analysis of MIC in progress.

information. On several afternoons seminars were held at the Regional Research Laboratory, Bhopal under the leadership of Dr. Varadarajan, to exchange scientific information and to do brain storming to find solutions to the problems related to gas leakage and neutralisation of the remaining gas. It was indeed one of the finest hours of Regional Research Laboratory, Bhopal in having to respond to the unprecedented call of the society in terms of fulfilling its charter of a Regional Research Laboratory responding to a critical regional crisis.

Specifically the scientists assembled at the Regional Research Laboratory, Bhopal examined samples of air, water, animal and vegetable tissues to look for residual toxicity. Scientists from Indian Metereology Department were recording air velocity and temperatures round the clock to determine the vulnerable zone in the event of another gas leakage. Their work also led to the understanding as to why people in certain parts of Bhopal were affected more than in other parts. Several scientists worked towards understanding of what could have triggered the leakage of the gas, what should be done to prevent similar leakage in the second MIC tank, and what precautions should be taken during neutralisation of remaining MIC. The co-operation between scientists from different organisations was indeed exemplary.

PUBLICATIONS AUTHORED BY STAFF OF RRL, BHOPAL

1. S.V. Prasad and T.H. Kosel, "A study of carbide removal machanisms during Quartz Abrasion. II : Effect of Abrasive particle shape", Wear 95 (1984), 87-102.

2. Annie George, L.G. Radhika, Kelukutty, P.N. Mohan Das and P.K. Rohatgi, "Rutile from ilmenite using coconut pith as reductant", Journal of Materials Science (UK), 19 (5), May, 1984, p.1522-1529.

3. P.K. Ghosh, S. Ray and P.K. Rohatgi, "Incorporation of Alumina particles in Aluminium-Magnesium Alloy by stirring the melt", Transactions of the Japan Institute of Metals, Japan, 25(6) 1984.

4. T.H. Kosel, Y.Z. Mao and S.V. Prasad, "Observations of Erosion Debris Particles Produced by Micromachining", Proc. ASLE Annual Meeting, Chicago, May, 1984.

5. K. Rohatgi, J.P. Trivedi and P.K. Rohatgi, "Research Imperatives in Microbial Leaching of Bauxite and other silicate bearing minerals using Heterotrophic bacteria", JSIR, 43(6), 1984, pp.302-305.

6. Navin Chand, S. Sood, P.K. Rohatgi and K.G. Satyanarayana, "Resources, Structure, Properties and Uses of Natural Fibres of Madhya Pradesh", JSIR, 43(9), 1984, pp.489-499.

7. B.N. Keshavaram, K.G. Satyanarayana, B. Majumdar, B. Dattaguru and P.K. Rohatgi, "Studies on Fracture and strength behaviour of Al-glass and Al-fly ash particle composites", Proceedings of International Conference on Fracture (ICF-6) vol.4, 1984, pp.2979.

8. Navin Chand, "A new relationship of Tg with interchain spacing", Pop. plastics, Dec. 1984.

9. B.S. Majumdar, A.H. Yegneswaran and P.K. Rohatgi, "Strength and fracture behaviour of metal/matrix particulate composites", Materials Science and Engg., 68 (1984), pp. 85-96.

10. A.K. Jha, G.S. Upadhyaya and P.K. Rohatgi, "2014 Al-alloy Metglass sintered composites" Sintered Metal-Ceramic composites, Edit. G.S. Upadhyaya, Elsevier Science Publishers B.V. Amsterdam, 1984, pp.259-260.

11. M. Patel, "Structural study in some vermiculite Minerals using DTA and TGA techniques" Trans. India Ceram, Soc. 43(2) 31-34 (1984).

12. M. Patel, "Preparation of oriented clay mineral samples", Canadian Clay and Ceramics, 57(3), 4-6, p.12 (1984).

13. V.K. Mahesh, M. Maheshwari and R. Sharma, "Compounds analogous to cannabinoids : Synthesis of 2-alkyl-3-hydroxy-6, 6-dimethyl-6H-benzofuro (2,3-c) (1) benzopyrans and 2alkyl-3-hydroxy-6, 6-dimethyl-6H-naphtho (1,2-b) furo (2,3-c) (1) benzopyrans", Indian J. Chemistry, 486, 23B(1984).

14. S.V. Prasad and T.H. Kosel, "The Design and some Applications of In-Situ SEM scratch Tester", J. Mater. Sci. Letters. 3 (1985) 133-136.

15. Navin Chand, K.K. Verma, Mohini Saxena, A.C. Khazanchi and P.K. Rohatgi, "Materials science of Plant based materials of Madhya Pradesh (India) for Housing", Proceedings of International Conference on Low Cost Housing for developing countries (March, 9-15, 1985), Roorkee, pp. 191-201.

16. C.K.S. Pillai, M.A. Venkataswamy, K.G. Satyanarayana and P.K. Rohatgi, "Laminated leaf composites as low cost substitutes for wood and wood based materials", Proceedings of International Conference on Low Cost Housing for developing countries (March 9-15, 1985), Roorkee, pp.211.

17. B. Vijayalakshmi, V.S. Prasad, C.K.S. Pillai, K.G. Satyanarayana and P.K. Rohatgi, "Fire retardent cum life extended coconut Leaf-Thatch as Roofing Material", Proceedings of International Conference on Low Cost Housing for developing countries (March 9-15, 1985), Roorkee, pp.151.

18. R. Prakash and R. Mathur (1984) Nerve fibres in the turtle heart. Acta Anat. 120 : 1-2/84.

19. R. Prakash, G.K. Lehri and Rekha Nigam (1984) "Urophysis and caudal neurosecretion in a Major Carp Labeo rohita" Acta Anat. 120: 1-2/84.

20. S. Kumar, P. Rao, S. Saxena and A. Hundet (1984) On the structure of corpus cerebelli in some Fishes. Acta Anat. 120 : 1-2/84.

21. R. Prakash and U. Banerji (1984) Nerve fibres in the testes of turtle. Proc, Sixth All India Congress of Zoology 190 : 98/84.

22. R. Prakash, S. Kumar and A. Hundet (1984) Neuroanatomy of the Cerebellum of Lissemus puctata Proc. Sixth All India Congress of Zoology 104-53/84.

23. R. Prakash and Savita Gulati (1985) Nerves in the heart of Lissemus punctata Proc. 72nd Indian Science Congress.

24. R. Prakash, A. Deshmukh and U. Banerji (1984) Bhopal Lakes : A study on plankton control and Bio Productivity Proc. Nat. Conf. Environmental Awareness Ed. and Management 36/28.

25. F. Zafar and A. Deshmukh (1984), Geological and Bio-medical studies on certain Environment aspects in and around Bhopal region. Proc. Nat. Conf. Environ. Awareness Ed. and Management 38/28.

26. S.V. Prasad and T.H. Kosel, "A comparison of carbide fracture during Fixed - Depth and Fixed-Load Scratch Tests", Proc. Int. Conf. on Wear of Materials - 1985, Vancouver, Canada, 1985 (Also accepted for publication, Wear).

27. P.K. Rohatgi, R. Asthana, and S. Das, "Solidification processing of cast metal-ceramic particles composites", Proceedings of seminar on Solidification, San Jose State University, California, USA, Nov. 1983 (Proc. to be published by American Society of Metals), accepted.

28. M. Patel, Beneficiation of montmorillonite mineral from bentonite, J. Indian Ceramics (Accepted).

29. M. Patel, Structural study in some Vermiculite minerals by X-ray diffraction method, Indian Ceramics (Accepted).

30. Mohini Saxena, O.P. Modi, A.H. Yegneswaran and P.K. Rohatgi, Corrosion characteristics of Cast Aluminium alloy-3 wt.% graphite particulate composites in different environments. Materials Performance (Communicated).

31. Mohini Saxena, A.H. Yegneswaran and P.K. Rohatgi, Surface Finishing of aluminium alloy ceramic particulate composites., Plating and Surface Finishing (Communicated).

32. O.P. Modi, A.H. Yegneswaran and P.K. Rohatgi, Hot Deformation Behaviour of Cast Aluminium Alloy Graphite Composite, to appear in Proc. Int. Conf. on Progress in Metallurgical Research : Fundamental and applied aspects, IIT Kanpur, 1985.

33. S. Das, A.H. Yegneswaran and P.K. Rohatgi, Characterisation of LM 13 and LM 13 Graphite composite - Rapidly quenched from the melt, to appear in Proc. Int. Conf. on Progress in metallurgical Research : Fundamental and applied aspects, IIT Kanpur, 1985.

34. S.C. Arya, T.K. Dan, B.K. Prasad and P.K. Rohatgi, Study on the suitability of LM 13-Graphite composite for pressure die casting, J Materials Science (Communicated), 1985.

35. A.R. Sanadi, S.V. Prasad and P.K. Rohatgi, Natural Fibres and Agro-wastes as fillers and reinforcements in polymer composites, J. of Composites (U.K.) (Communicated), 1985.

36. Navin Chand, A.C. Khazanchi and P.K. Rohatgi, Ipomoea Carnea, its structure properties and performance in polymer, clay and cement based composites, J. of Composites, U.K. (Communicated), 1985.

37. M. Patel and V. Ramakrishnan, Effect of temperature on adsorption behaviour of alumina from two binary liquid mixtures, J. Chem. Engg. Data, accepted (1984).

38. C.B. Raju, M. Patel and P.K. Rohatgi, "R&D imperatives on bauxite mineral, J. of Sci. & Indl. Res., accepted (1985).

39. M. Patel, "Identification of unconverted oxide phases in a synthetic clay mineral by scanning electron microscopy and X-ray microprobe", J.X-ray Spectrom. accepted (1984).

40. V.K. Mahesh, M. Maheshwari and R. Sharma, Analogs of Cannabinoids : Synthesis of some 7H - Indolo, 5 H-Imidazolo., 7 H - Benzimidazolo (1,2-c) (1,3) benzox zines - Novel ring systems, Canadian J. Chemistry, in press (1984).

41. P.K. Biswas, E.S. Dwarakadasa, and P.K. Rohatgi, Effect of internal chill on piping and soundness of Aluminium castings, submitted to British Foundrymen, 1984.

42. C.B. Raju, M. Patel and P.K. Rohatgi, Minerals Resources and R&D imperatives on minerals of M.P., J. Sci. Ind. Res. submitted.

43. A.K. Jha, G.S. Upadhyaya and P.K. Rohatgi, "Properties of 2014 Aluminium alloy metallic glass (Ni-Mo based) particles composites", Submitted to Journal of Materials Science, Feb. 1985.

44. C. Pavitran, P. Guruswamy, S.V. Prasad and P.K. Rohatgi, "Physical and Mechanical Properties of a Particulate Composite developed for Dental Filling Applications", J. Ind. Dental Assoc. (Accepted) (1984).

45. S.V. Prasad, P.K. Rohatgi and T.H. Kosel, "Mechanisms of Material Removal during Low-Stress and High-stress Abrasion of Al-Zircon Composites". Communicated Wear 1985.

46. A.K. Jha, T.K. Dan and S.V. Prasad and P.K. Rohatgi, "Preparation and Properties of Al-Talc Composites" Communicated to J. Mater. Sci. 1985.

PAPERS PRESENTED IN SEMINARS/SYMPOSIA/CONFERENCES

1. Seminar on Solidification and Casting of Metals-Future Trends, April, 1984, RRL, Bhopal.

   - Future Trends in metals and solidification processes; P.K. Rohatgi.

   - Cast Metal Ceramic composites for antifriction and antiabrassion application in industry; P.K. Rohatgi.

2. International Conference on Case Histories in Geotechnical Engg., St. Louis, MO, USA, May 6-11, 1984.

   Stability of Slopes - a case history; G. Ramaswamy, Gopal Ranjan, Bhawani Singh, U.N. Sinha and A.C. Khazanchi.

3. EPCO Bhopal Conference on World Environment Day, June 5-6, 1984.

   - Autonomous Shelter with improved in-built environment; A.C. Khazanchi.

4. Seminar on Environment, organised by Society of biospheres, June, 1984, RRL, Bhopal.

   - Evaluation of minerals in Bhopal water (Ca, Mg), M. Patel.

5. "Metals Congress" of American Society for Metals, Detroit, USA, Sept., 1984. "Recent Advances in Cast Metal Ceramic Particle Composites", P.K. Rohatgi.

6. Seminar on Solidification and casting of Metals, Univ. of Roorkee, Oct. 12-13, 1984.

   - Heat and fluid flow during solidification of particulate composites; R. Asthana and P.K. Rohatgi.

   - The Microchill Technique for the Improvement of Castings and Ingots; P.K. Biswas, E.S. Dwarakadasa and P.K. Rohatgi.

   - Characterisation of LM-13 alloy Rapidly quenched from the melt; S.Das, A.H. Yegneswaran and P.K. Rohatgi.

   - Recent Advances in Cast Metal-Ceramic Particle Composites (Invited talk), P.K. Rohatgi.

7. Annual Technical Meeting of Indian Institute of Metals, Nov., 1984, IISc., Bangalore.

   - Deformation Characteristics of hot worked Aluminium alloy Graphite particulate composites; O.P. Modi, A.H. Yegneswaran and P.K. Rohatgi.

8. International Symposium on Land slides, Canada, December, 1984.

   - Stability analysis and protective measures for building complex on slopes; Gopal Ranjan, Bhawani Singh, Swami Saran, K.N. Viladkar and A.C. Khazanchi.

9. International Conference on Progress in Metallurgical Research : Fundamental and Applied aspects IIT, Kanpur, Feb, 1985.

   - Solidification of cast metal matrix composites; R. Asthana and P.K. Rohatgi.
   - Al alloy-Talc composites : Preparation and some properties; A.K. Jha, T.K. Dan, S.V. Prasad and P.K. Rohatgi.
   - Low stress abrasion resistance of Al alloy Zircon particulate composites; S.V. Prasad, and P.K. Rohatgi.
   - Characterisation of LM-13 and LM-13 Graphite Composites Rapidly quenched from Melts; S. Das, A.H. Yegneswaran and P.K. Rohatgi.
   - Deformation behaviour of hot worked Al alloy Graphite composite; A.H.Yegneswaran, O.P. Modi and P.K. Rohatgi.
   - Potentio-dynamic Study and Electroplating of Al Alloy-3 wt. % of Graphite particulate composite; O.P. Modi, M.Saxena, A.H. Yegneswaran and P.K. Rohatgi.

10. Seminar on Building Materials and Allied Technologies Feb., 1985, RRL, Bhopal.

    - Possibility of implementation of a new energy saving process in Cement industries of M.P.; M.Patel.
    - Development of housing materials using indigenous resources of M.P. Navin Chand, A C. Khazanchi, P K Rohatgi.
    - Development of cements from Red mud; C.B. Raju.

11. Annual Convention of Indian Ceramic Society, March, 1985, RRL, Hyderabad.

    - Chemical Analysis in Metal Ceramic Composites; A.K. Ray, C.B. Raju and M. Patel.
    - Evaluation of mica and talc minerals from M.P. for utilization in composite making; M.Patel, C.B. Raju and S. Raman.

12. International Conference on Low Cost Housing, Roorkee, March 9-15, 1985.

    - Natural Fibres and agro-wastes in Low cost composites for Housing; A.R.Sanadi, S.V. Prasad and P.K. Rohatgi.

- Structure property and performance evaluation of Ipomoea carnea; Navin Chand, A.C. Khazanchi and P.K. Rohatgi.

- Materials Science of Plant based materials of Madhya Pradesh for housing; Navin Chand, K.K. Verma, Mohini Saxena, A.C. Khazanchi and P.K. Rohatgi.

- Economic viability and bottlenecks in the development of building materials industries; Navin Chand.

SEMINAR/SYMPOSIUM/WORKSHOP/CONFERENCE ATTENDED BY LABORATORY STAFF

1. Mr. A.C. Khazanchi attended the EPCO Bhopal Conference on World Environment Day, June, 1984.

2. Mr. Navin Chand, Mr. K.K. Verma, Dr. Mohini Saxena, Mr. A.C. Khazanchi, Mr. Pati and Mr. Sanadi attended the International Conference on Low Cost Housing, Roorkee, March, 1985. Dr. Navin Chand was panelist of a session on Development of new materials for mass housing.

3. Mr. R. Asthana, Dr. P.K. Rohatgi, Mr. S. Das and Dr. A.H. Yegneswaran attended the Seminar on Solidification and Casting of Metals, University of Roorkee, October, 1984. Dr. P.K. Rohatgi also chaired a session on Composites.

4. Dr. P.K. Rohatgi, Dr. S.V. Prasad, Dr. A.H. Yegneswaran, Mr. A.K. Jha, Mr. O.P. Modi, Mr. S. Das and Dr. Mohini Saxena attended the International Conference on Progress in Metallurgical Research; Fundamental and Applied Aspects, I.I.T., Kanpur, February, 1985. Dr. P.K. Rohatgi also chaired a session on Phase Transformations.

5. Dr. A.H. Yegneswaran attended the Annual Technical Meeting of Indian Institute of Metals, Bangalore, November, 1984.

6. Dr. M. Patel, Dr. C.B. Raju, Dr. A.K. Ray attended Annual Convention Indian Ceramic Society, Hyderabad, March, 1985.

7. Dr. T.K. Dan and Shri S.C.Arya attended the Annual Convention of the Institute of Indian Foundrymen at Bombay, January, 1985.

8. Dr. P.K. Rohatgi attended the Metals Congress ASM-AIME Annual Meeting, Detroit, USA., September, 1984.

9. Dr. P.K. Rohatgi chaired a Session on the National Seminar on 'Phonon Physics' at Bhopal in February, 1985.

10. Udayan Banerji attended the Sixth All India Congress of Zoology from 19-22 October, 1984 and presented a paper "Nerve Fibres in the Testis of Turtle".

11. Dr. Navin Chand, Udayan Banerji, Anwar Desmukh and Ajit Hundet attended the National Conference for Environmental Awareness, Education and Management, at Regional College of Education at Bhopal, October, 1984. They were also organizing Committee members.

12. Dr. R.N. Yadava attended five day Training Course in Fortan-IV at Hindustan Computer Ltd., New Delhi.

13. Dr. A.H. Yegneswaran attended the National Symposium on 'Magnesium - its status and prospects in India' at NML, Jamshedpur, 15-16 February, 1985.

14. Dr. M. Patel attended the Indian Aluminium Association Meeting in New Delhi.

15. Dr. A.H. Yegneswaran attended the INCAL-85 meeting preparatory to the International Conference on Aluminium to be held during October-November, 1985 in New Delhi.

16. Dr. R.N. Yadava, Dr. Navin Chand, Mr. A. Sanadi, attended the International Conference on Fracture, ICF-6 at New Delhi, December, 1984.

17. Dr. P.K. Rohatgi attended the National Symposium on Industry-Academia Interactions, INDAC-85 at I.I.T., Kanpur.

18. Shri A.C. Khazanchi, Dr. M. Patel and Shri P.D. Ekbote represented the RRL, Bhopal in UGC and M.P. State Uchha Shiksha Anudan Ayog Sponsored meeting on Higher Education in Madhya Pradesh.

TECHNICAL SERVICES/ADVICE GIVEN

S.No.	Party	Regarding
1.	M/s Indigenous Engg., Co. (Pvt.) Ltd., 89, Shakespeare Colony, Calcutta.	Measurement of mesh sieve size.
2.	M/s R.J. Clad Metals Ltd., D1-D4 Phase-I, Industrial Area, Agra Bombay Road, Dewas 455 001 (M.P.).	Tensile testing of Copper strips.
3.	M/s. Premier Brass & Metal Works (Pvt.) Ltd., 8, Industrial Estate, Govindpura, Bhopal - 462 023 (M.P.)	Ultrasonic testing of brass bars.

4.	M/s Hindustan Aluminium Co. Renukoot (U.P.).	Failure of milk cans.
5.	M/s Gajra Gears, Dewas (M.P.)	Advice on gear materials.
6.	M/s National Fertilizers Ltd., Guna (M.P.)	Tensile test of welded steel plates.
7.	M/s Super Cement (Pvt.) Ltd. Bhopal (M.P.)	Limestone samples for cement.
8.	Food Corporation of India, Bhopal.	Analysis of rice, wheat and sugar samples.
9.	PHE Dept., Bhopal	Water samples.
10.	M/s La-Prenca Industries (Pvt) Ltd., Bombay.	- Testing of pistons - Ultrasonic testing of bonding between piston rings. - Measurement of porosity defects in piston castings and possible remedies. - Identification of inclusions in piston castings and remedial measures.
11.	M.P. Electricity Board	Low Cost Building Materials,Pistons and Bearing Materials, Energy Policy Studies.
12.	Govt. of Himachal Pradesh	Forecasting studies of HP.
13.	M/s Malik Electrochemical Industries, Bhopal.	Testing of Airgun Components.
14.	M/s Hindustan Electrographite Ltd., Mandideep, Bhopal.	- Microscopic study of graphite.
15.	M/s Neelam Sanders Ltd., Bhopal.	- Testing of Narmada Sand for foundry.
16.	M/s B.H.E.L., Bhopal	- Testing of Sand for water filtration plant.

TECHNICAL REPORTS

S.No.	Title of the Report	Report No.
1984-85		
1.	Solidification processing of Cast Metal Ceramic Particle composite.	RRL(B)/TR/M01(85)-1
2.	2014 Al-alloy met glass sintered composites.	RRL(B)/TR/M01(85)-2
3.	Upscaling of technology of Al-graphite composite.	RRL(B)/TR/M01(85)-4
4.	Development of Al-alloy graphite composite fan bushes/field trials at Sah Industrial Research Institute, Varanasi.	RRL(B)/TR/M01(85)-4
5.	Trials of Cast Al-Ceramic Particulate composites as Fan and Pump components in industries.	RRL(B)/TR/M01(85)-5
6.	Preparation and properties of Al-alloy Talc composites.	RRL(B)/TR/M01(85)-6
7.	Corrosion characteristics of Al-alloy (LM-13)-graphite particulate composites in different environments.	RRL(B)/TR/M01(85)-7
8.	Surface finishing of Aluminium alloy Ceramic particulate composites.	RRL(B)/TR/M01(85)-8
9.	Study on the suitability of LM-13-Graphite composite pressure die casting.	RRL(B)/TR/M01(85)-10
10.	Project report for setting up a medium scale industry to make Cast Aluminium based composites (as per NRDC proforma). Shop floor tests to check presence and distribution.	RRL(B)/TR/M01(85)-11
11.	Heat treatment of Cast LM-13-3 wt.% Graphite composite.	RRL(B)/TR/M01(85)-12

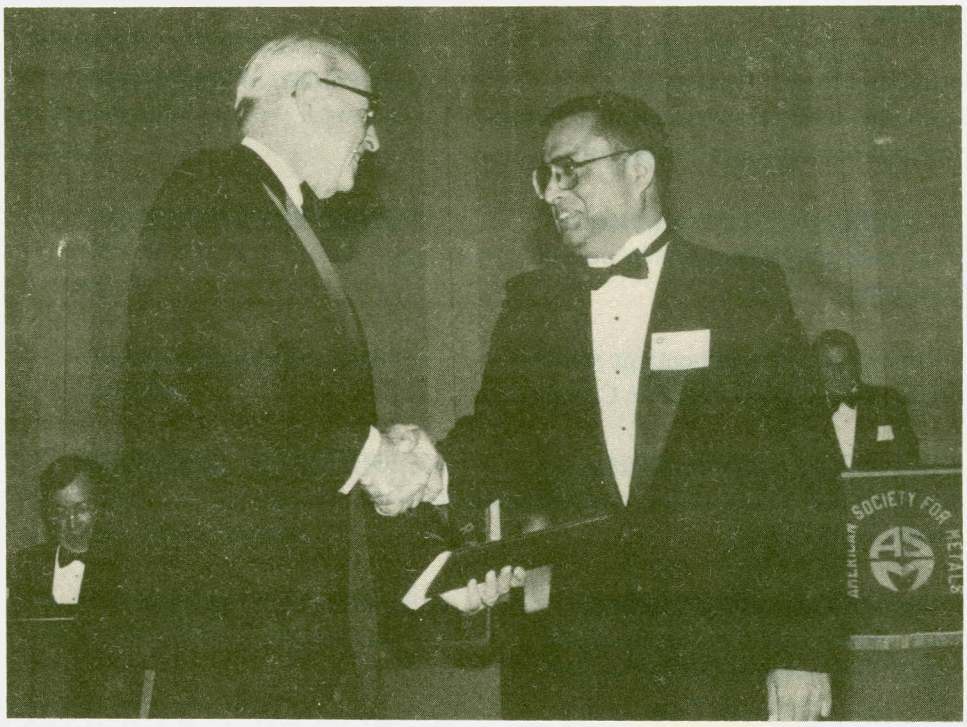
12.	Hot deformation behaviour of Cast Al-alloy graphite composite.	RRL(B)/TR/M01(85)-13
13.	Characterisation of LM 13 and LM 13 Graphite composite - Rapidly quenched from the melt.	RRL(B)/TR/M01(85)-14
14.	Modelling Vortex Technique of making Cast composites using aqueous medium.	RRL(B)/TR/M01(85)-15
15.	Materials Science of plant based materials of Madhya Pradesh (India) for Housing.;	RRL(B)/TR/M02(84)-1
16.	Resources, structure properties and uses of Natural Fibres of Madhya Pradesh.	RRL(B)/TR/M02(84)-2
17.	Ipomoea Carnea, its structure properties and performance in polymer, clay and cement based composites.	RRL(B)/TR/M02(84)-3
18.	Natural Fibres and Agro-wastes as fillers and reinforcements in polymer composites.	RRL(B)/TR/M02(85)-4
19.	A Rapid method of chemical analysis of Cast Aluminium Ceramic Composites.	RRL(B)/TR/M02(85)-5
20.	Mica and Talc mineral powders from Madhya Pradesh for Metals and Polymer Matrix Composites.	RRL(B)/TR/M02(85)-6
21.	Computer usage at RRL, Bhopal and other Indian Institutions; prepared by Ms. Leslie Ayres visiting under NSF-CSIR Exchange Programme.	RRL(B)/TR/SP (85)-1
22.	Physico-chemical and bacteriological quality of water samples collected from different parts of water distribution system of Bhopal city and RRL, Campus; Prepared by NEERI (for limited circulation).	RRL(B)/TR/Misc.(84)-1

HONOURS AND AWARDS RECEIVED BY STAFF

(1) Prof. P.K. Rohatgi, Director, was elected the Fellow of the American Society for Metals, in recognition of his distinguished contributions to the field of metals and materials. He was conferred the Fellowship on September 19, 1984, in Detroit, USA.

(2) Prof. P.K. Rohatgi, Director, received the Certificate of Appreciation and Distinguished service Award from the American Society of Engineers from India on September 21, 1984.

(3) Dr. Mahendra Patel, Assistant Director, received the Malaviya Award for "Basic Sciences" from the Indian Ceramics Society, Calcutta, for the year 1982-83.



Dr. P.K. Rohatgi, being conferred the Fellowship of the American Society for Metals by Dr. D.J. Blickwede, President of ASM, during the Metals Congress in Detroit in Sept., 1984.

DISTINGUISHED VISITORS TO THE LABORATORY

1. Dr. G.P. Dodeja, Group General Manager, BHEL, Bhopal, April 25, 1984.
2. Dr. R.K. Bisarya, Mayor of Bhopal June 1984.
3. Shri Arjun Singh, Hon'ble Chief Minister of Madhya Pradesh, September 4, 1984.
4. Dr. P.M. Bhargava, Director, Centre for Cellular & Molecular Biology, Hyderabad, October 9, 1984.
5. Dr. Shamsher Prakash, Director, Central Building Research Institute, Roorkee, October 19, 1984.
6. Prof. Rais Ahmed, Vice Chairman, University Grants Commission, New Delhi, September 24, 1984.
7. Dr. S.Z. Qasim, Secretary, Department of Ocean Development, New Delhi, October 29, 1984 and December, 1984.
8. Dr. R.W. Cahn, Chairman, Editorial Board of Journal of Materials Science, U.K., November, 1984.
9. Dr. S. Varadarajan, Director General, CSIR, New Delhi, December 5-20, 1984.
10. Dr. Lata Singh, Joint Secretary (Admn), CSIR, New Delhi, December 5-20, 1984.
11. Dr. G. Thyagarajan, Director, RRL, Hyderabad and CLRI, Madras, December 13, 1984.
12. Shri Digvijay Singh, Hon'ble Union Minister of Environment, December 13, 1984.
13. Dr. P.K. Ray, Director, Industrial Toxicological Research Centre, Lucknow, December 8, 1984.
14. Dr. K.R. Bulusu, Director, NEERI, Nagpur, December 18, 1984.
15. Dr. S. Shriramachari, Additional D.G., ICMR, New Delhi, December 1984.
16. Dr. S.K. Kashyap, National Institute of Occupational Health, Ahmedabad, December 6, 1984.
17. Dr. M. Shivaram, Chief R&D Manager, HOCL, Bombay, December, 1984.
18. Dr. Sriram, IPCL, Baroda, December 7, 1984.
19. Dr.(Ms) Leslie W. Ayres, Veriplex Corporation, Pittsburgh, USA, January 1, 1985.
20. Prof. Robert Ayres, Carnegie Mellon University, Pittsburgh, USA, January 1, 1985.

21. Dr. P.K. Iyengar, Director, Bhabha Atomic Research Centre, Trombay, Bombay, February 7, 1985.

22. Prof. M.G.K. Menon, Planning Commission, New Delhi, February 11, 1985.

23. Prof. I. Minkoff, MIT, Cambridge, USA, February 18, 1985.

LECTURES DELIVERED BY OUTSIDE SPEAKERS AT RRL, BHOPAL

	Lecture delivered by	Subject
1.	Dr. G. Nath, DST, New Delhi on May 18, 1984	Changing Society and Technological innovations
2.	Dr. (Sister) Marie T. Dimond on June 21, 1984.	Bioethics and environment
3.	Dr. K.S.G. Doss, Ex-Director CECRI, Karaikudi. on July 2nd and 3rd, 1984.	(a) Basic Electrochemistry, Mechanism of electrolysis.
4.	Dr. Y.N. Trehan, Ex-Deputy Director, NML, Jamshedpur on July 16, 1984.	Integral colour anodizing of aluminium and its alloys with special reference to recent work in Japan.
5.	Dr.P.M. Bhargava, Director, CCMB, Hyderabad on Oct. 9, 1984.	Method of Science.
6.	Dr. Shamsher Prakash, Director, CBRI, Roorkee on Oct. 19, 1984.	(a) Innovations in low cost housing. (b) Science and Yoga
7.	Prof. R.W. Cahn, Chairman, Editorial Board of Journal of Materials Science, U.K. on Nov. 23, 1984.	Recent Advances in Solidification and Alloy development
8.	Dr. (Ms) Leslie W. Ayres, Veriplex Corpn. Pittsburgh on Jan 3, 1985.	Use of spreadsheet program on small computer
9.	Dr. Robert Ayres, Carnegie Mellon University, USA on Jan 4, 1985.	The next Industrial Revolution

Dr. S.K. Gupta, DSMRDE, Kanpur. on Jan. 21 to 23, 1985.	Modern Techniques of Surface Characterization (Series of three lectures).
Prof. I. Minkoff, MIT, Cambridge USA, on Feb. 19, 1985.	(a) Solidification in ferrous and non-ferrous foundry. (b) Recent developments in foundry metallurgy.
Dr. P.C. Chaturvedi, IIT, Kanpur, on Feb. 6, 1985.	Structure of laterite soils and their applications in building materials.
Dr. N.C. Goel, Dept. Mech. Engg., Metallurgical Science Lab. Univ Manitoba Winnipeg, Canada	A model for deformation behaviour of two phase materials.
Dr. R.V. Tamhankar Sangli, on March 28, 1985	Setting up of DMRL and MIDHANI, Hyderabad.

LECTURES IN OUTSIDE ORGANIZATIONS BY STAFF OF RRL, BHOPAL

Prof. P.K. Rohatgi

"Industry Academia Interactions in Future", at National Symposium of Industry Academia Interactions, INDAC-85 at I.I.T., Kanpur, January, 1985.

"Technology Forecasting" at Thapar Corporate R&D Centre, Patiala, January, 1985

"Environmental Dimension of Technology Assessment" in the National Seminar on Education, Awareness and Environment at Regional College of Education (NCERT), Bhopal.

"Use of Technology Forecasting for long range Planning,", Invited lecture under the auspices of Bhopal School of Social Sciences.

Formulation of Research Programmes for the Seventh Five Year Plan, Inaugural Address at MACT Mechanical Association, MACT, Bhopal.

Recent Advances in Cast Metal Ceramic Particle Composites, Metal Congress, Detroit, USA.

Recent Advances in Solidification of Cast Metal-Ceramic Particle Composites, Invited talk at International Seminar on Solidification and Casting.

Dr. M. Patel.

1. R&D Imperatives on chemical industries, at Thapar Corporate R&D Centre, Patiala, January, 1985.

2. Mineral based industries in MP, at AKVN, Raipur, in Entreprenuership development programs, March 1985.

Dr. S.V. Prasad

1. Micro abrasion studies inside the scanning electron microscope, May 1984, at RRL, Trivandrum.

2. Carbide removal mechanisms during quartz abrasion, June 1984 at RRL, Trivandrum.

INTERNAL SEMINARS DELIVERED BY STAFF

1. Mr. O.P. Modi on February 5, 1985.

   Potentiodynamic study and electroplating of LM 13 3% Graphite particulate composites.

2. Mr. A.K. Jha on February 5, 1985.

   Fabrication and properties of aluminium alloy talc composites.

3. Dr. A.H. Yegneswaran on February 4, 1985.

   Deformation characteristics of hot worked aluminium alloy-graphite composites.

4. Ms. Anju Gupta on November 12, 1984.

   Fibrous Ceramics.

5. Dr. S.V. Prasad on January 18, 1985.

   Mechanisms of material removal during abrasion of aluminium alloy-ceramic particulate composites.

6. Dr. Ram Narayan on February 21, 1985.

   Use of Microcomputers in R&D

7. Mr. A.C. Khazanchi on November 1984.

   Concept of Low Cost Housing.

8. Mr. S. Das on September 20, 1984.

   Characterization of LM 13 and LM 13-graphite composite rapidly quenched from melt.

9. Dr. M. Patel on March 6, 1985.

   Evaluation of mica and talc minerals from M.P. for utilization in composite making.

10. Dr. A.K. Ray on March 6, 1985.

    Chemical analysis in metal-ceramic composites.

SEMINARS ORGANISED BY RRL, BHOPAL

I. A two day seminar on 'Solidification and Casting of Metals - Future Trends' was held at Regional Research Laboratory, Bhopal on April 25 and 26, 1984. The seminar organised by the Institute of Indian Foundrymen, Bhopal Chapter, jointly with Regional Research Laboratory (CSIR), Bhopal, was inaugurated by the Group General Manager of BHEL, Bhopal, Shri G.P. Dodeja. The seminar attempted to bring out the present status and future trends in solidification and casting of materials.

II. A seminar on Building Materials and Allied Technologies was organised on 22-23 February, 1985, in collaboration with M.P. Council of Science & Technology, Polytechnology Transfer Centre, Bhopal to review on the development of Building materials and also problems and performance of buildings construction in M.P. Various CSIR laboratories i.e. CBRI, Roorkee, SERC, Roorkee and Madras; RRL, Jorhat; National Building Organisation, New Delhi; local P.W.D.; Bhopal Development Authority and M P. Housing Board, Bhopal participated in the seminar spread over three sessions : viz. Building Materials; Civil Engineering problems of Buildings in M.P.; Cement and Concrete.

MEMBERSHIP OF COMMITTEES OR SCIENTIFIC SOCIETIES IN INDIA OR ABROAD

1. *Dr. P.K. Rohatgi*

   - Fellow, American Society for Metals.
   - Director, M.P. Urja Vikas Nigam Ltd., Bhopal.
   - Fellow, The Institution of Engineers (India).
   - Fellow, Institute of Ceramics (India)
   - Life Member, Indian Institute of Metals.
   - Member, Board of International Editors, Technological Forecasting and Social Change International Journal, USA.
   - Member, ASM Historical land mark Selection Committee, USA.
   - Member, Editorial Board, ASIA 2000.

- Member, Editorial Advisory Board, Current Literature Science of Science, CSIR.
- Member, Solidification Committee, American Institute of Mining and Metallurgical Engineer, USA.
- Member, Editorial Board of "Composite Materials Science", U.K.
- Member, Editorial Board, Journal of Scientific Research, Bhopal.
- Member, National Steering Committee on Composite Materials.
- Member, Academic Council of the Roorkee University.
- Co-opted member of the Academic Council of the Bhopal University.
- Member, Technical Committee, "International Conference on Aluminium," 1985.
- Member of the Metals and Materials Committee of CSIR.
- Member, Institute of Indian Foundrymen.

2. *Dr. Ravi Prakash*

- Life Member, Zoological Society of India.
- Life Member, Zoological Society of London.
- Life Member, Indian National Science Congress Association.
- Fellow of the Association of Zoologists (Ind)
- Fellow of the Zoological Society of London.

3. *Dr. S.V. Prasad*

- Member, Alpha Sigma Mu
- Member, Sigma Xi
- Member, Metallurgical Society of AIME.

4. *Dr. M. Patel*

- Member, American Clay Minerals Society.
- Member, Electron Microscopic Society of India.
- Member, Indian Ceramic Society.

5. *Dr. Ram Narayan*

- Member, Computer Society of India.
- Member, Institute of Indian Foundrymen.

6. *Dr. T.K. Dan*

- Member, Indian Ceramic Society.
- Member, Institute of Indian Foundrymen.

7. *Dr. A.H. Yegneswaran*

- Member, Aluminium Association of India.
- Associate Member, Institute of Indian Foundrymen.
- Life Member, Metallurgical Society, Indian Institute of Science, Bangalore.

8. *Dr. C.B. Raju*

- Member, Indian Ceramic Society.

9. *Mr. A.K. Jha*

- Member, Powder Metallurgy Association of India.

10. *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.

11. *Mr. O.P. Modi.*

- Member, Society for Advancement of Electrochemical Sci & Tech., Karaikudi.

12. *Mr. S. Das*

- Member, Institute of Indian Foundrymen.

13. *Mrs. Savita Gulati*

- Member of the Indian National Science Congress Association.

14. *Mr. Udayan Banerji*

- Member of Zoological Society of India.
- Member of International Anatomical Congress Association.

15. *Mr. Anwar Desmukh*

- Member, International Anatomical Congress Association.
- Member, Zoological Society of India.

RESEARCH ADVISORY COUNCIL, R.R.L. BHOPAL

1. Dr. R.V. Tamhankar, — Chairman
   362/2A, Vishrambag,
   Sangli-416 415 (Maharashtra)

2. Dr. T.P. Ojha,
   Director,
   Central Institute of Agricultural Engineering
   Nabi Bagh Berasia Road,
   Bhopal-462 010

3. Dr. G.P. Dodeja,
   Group General Manager,
   Bharat Heavy Electricals Ltd.,
   Bhopal - 462 0222

4. Prof. T.S. Murthy,
   Director,
   M.P. Council of Science & Technology
   E3/3, Arera Colony,
   Bhopal-462 016.

5. Prof. K.L. Chopra,
   Professor of Physics,
   Indian Institute of Technology
   Hauz Khas,
   New Delhi - 110 016

6. Prof. K.P. Gupta,
   Head, Advanced Centre for Materials Sciences,
   Indian Institute of Technology
   Kanpur-208 016

7. Dr. Anil Sadgopal,
   C/O Kishore Bharati,
   P.O. Bankheri,
   Dist. Hoshangabad-461 990 (MP)

8. Prof. V. Raghavan,
   Department of Metallurgy,
   Indian Institute of Technology,
   Hauz Khas,
   New Delhi-110 016

9. Dr. D. Chakravorty,
Advanced Centre for Materials Sciences
Indian Institute of Technology,
Kanpur-208 016

10. Dr. P. Ramachandra Rao,
Department of Metallurgy,
Banaras Hindu University,
Varanasi-221 005. (U.P.)

11. Prof. (Miss) P. Bajaj,
Department of Textile Engineering,
Indian Institute of Technology,
Hauz Khas,
New Delhi-110 016

12. Shri P.K. Pal,
Technical Manager,
MECON,
Hinoo, Doranda,
Ranchi-834 002

13. Director-General
CSIR
or
His nominee

14. Director,
RRL, Bhopal.

15. Chairman,
Coordination Council for Engineering Sciences.

EXECUTIVE COMMITTEE R.R.L., BHOPAL

1.	Director,	Chairman
2.	Dr. G.P. Dodeja, Group General Manager, Bharat Heavy Electrical Ltd., Bhopal.	Member
3.	Dr. K.L. Chopra, Professor of Physics, Indian Institute of Technology Hauz Khas, New Delhi-110 016	Member

4.	Dr. Anil Sadgopal, C/O Kishore Bharati, P.O. Bankheri, Hoshangabad-461 990 (MP)	Member
5.	Dr. C.B. Raju, Scientist, RRL, Bhopal	Member
6.	Shri P.D. Ekbote Scientist, RRL, Bhopal.	Member
7.	Shri K.K. Verma, Scientist, RRL, Bhopal	Member
8.	Administrative Officer RRL, Bhopal	Member (ex-officio)
9.	Finance & Accounts Officer RRL, Bhopal.	Member (ex-officio)

STAFF AT RRL, BHOPAL

	Name/Designation	Area of Interest
Director		
1.	Prof. P.K. Rohatgi B.Sc. (Met), BHU D.Sc. (MIT, USA)	Materials Science, Metallurgy 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. S.V. Prasad M.E. (I.I.Sc. Bangalore) D. Phil (Sussex)	Composite Materials, Interfaces, Friction and wear of materials.
4.	Dr. M. Patel Ph.D. (IIT-Delhi) D. Sc. (Univ. of Paris, France)	Ceramics, Surface Science Industrial and Mineral Chemistry

Scientist-C

5.	Dr. Ram Narayan Ph.D. (IIT-Bombay)	Maths, Fracture, Systems Analysis.
6.	Dr. T.K. Dan, Ph.D.(Calcutta Univ.)	Ceramics, Composite Materials
7.	Dr. A.H. Yegneswaran Ph.D. (I.I.Sc. Bangalore)	Metal Processing, Deformation and Texture.
8.	Dr. B.S. Majumdar (upto Sept.84) M.Sc. (I.I.Sc., Bangalore) Ph.D. (Rochester, USA)	Deformation and Fracture
9.	Dr. C.B. Raju,	Ceramic Materials
9.	Dr. C.B. Raju, Ph.D. (LPI, USSR)	Ceramic materials
10.	Dr. C.S. Narendranath M.E. (I.I.Sc, Bangalore) Ph.D.(I.I.Sc., Bangalore)	Solidification of S.G. Iron sand systems and die casting.

Scientist-B

11.	Shri K.K.S. Gautam B.E. (Raipur)	Electronics, Instrumentation
12.	Shri P.D. Ekbote, M.E. (Nagpur Univ.)	Chem, Engg. Metallurgy, Management.
13.	Dr. Navin Chand Ph.D. (IIT-Delhi)	Polymers, Composites, Natural Fibres
14.	Shri A.K. Jha M.Tech (IIT-Kanpur)	Powder Metallurgy
15.	Shri S. Das M. Tech. (IIT-Kanpur)	Rapid Solidification
16.	Shri K.K. Verma B.E. (Durgapur)	Civil Engineering
17.	Shri Rajiv Asthana M. Tech (IIT-Kharagpur)	Metallurgy, Process Modelling
18.	Shri O.P. Modi, M.Tech. (IIT-Kanpur)	Corrosion and Deformation
19.	Shri. A. Sanadi M.Sc (Univ. of Toronto)	M.Sc Reinforced plastics.

Scientific Assistants

20.	Sh. A. Banerjee B. Tech (BHU) (on leave)	Materials Science, Composites
21.	Shri S.S. Amritphale M.Sc. (Vikram)	Chemistry
22.	Shri B. Kujur B.Sc. (Ravishankar Univ.)	Chemistry

Technical Assistants

23.	Shri Venkateswarlu Karodi L. Met. E.	Metallurgy
24.	Shri Prakash K. Khade, Dip. Elect. Engg.	Elect. Engg.

Consultants

25.	Dr. Ravi Prakash M.Sc. Ph.D. D.Sc.	Zoology, Biological Materials
26.	Shri S.C. Arya, B.Sc. (Eng) (BHU)	Metallurgy
27.	Shri U. Mohan Rao, B.Sc. (Engg)(BHU)	Metallurgy

Research Officers (On DST Sponsored Project)

28.	Shri S. Sarangi (Upto May, 1984) M. Tech. (BHU)	Ferrous Metallurgy
29.	Shri B.K. Prasad (Upto Oct. 1984) M. Tech. (IIT, Kanpur)	Physical Metallurgy
30.	Shri G. Char B. Tech. (Raipur)	Metallurgy

Pool Officers

31.	Dr. A.K. Ray Ph.D (Calcutta University)	Inorganic Chemistry
32.	Dr.(Mrs.) Mamta Maheshwari Ph.D. (Roorkee University)	Organic Chemistry
33.	Dr.(Ms.) Pushpa Agrawal Ph.D. (Ravishankar University)	Microbiology, Industrial Pollution

Research Associates

34.	Dr.(Ms.) Mohini Saxena (CSIR quota) Ph.D.(Bhopal University)	Electrochemistry
35.	Mr. A.K. Gupta M.Tech. (BHU)	Metallurgy
36.	Dr.R.K. Tiwari (Upto Dec. 1984) Ph.D.(Patel Univ., Gujarat)	X-ray, Crystallography
37.	Mrs. Savita Gulati M.Sc. (Meerut University)	Zoology

Jr. Research Fellows

38.	Shri Udayan Banerji M.Sc. (Bhopal university)	Zoology
39.	Shri Ajit Hundit (Upto Jan. 1985) M.Sc. (Bhopal University)	Zoology
40.	Shri Anwar Desmukh M.Sc. (Bhopal University)	Zoology
41.	Shri Avinash C. Karera M.Sc. (Bhopal University)	Chemistry
42.	Ms. Anju Gupta M.Sc. (Bhopal University)	Chemistry
43.	Shri Ajay Gawhad, B.E. (Raipur)	Metallurgy
44.	Shri B.R. Pati, B.E. (Kharagpur)	Civil Engineering
45.	Shri Rajesh Gupta BE(Bhopal University)	Mechanical Engineering

Graduate Trainees

45a.	Shri J.K. Jain M.Sc. (Bhopal University)	Geology
46.	Shri A. Khare M.Sc. (Bhopal University)	Geology

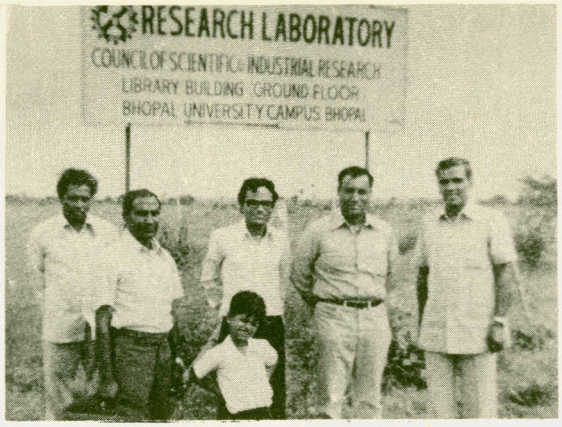
Technical Staff

47.	Shri S.K. Tiwari B.Sc. (Library Science)	Jr. Librarian

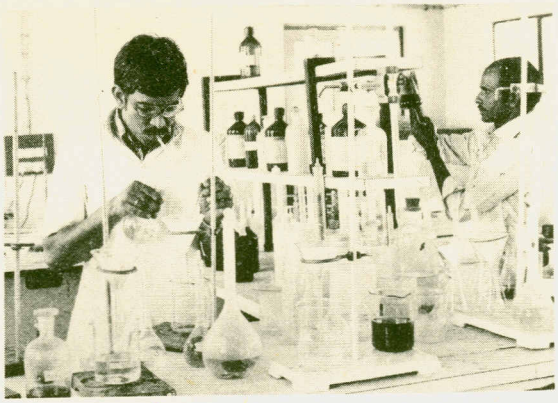
48.	Shri N.Saha B.Sc., P.G. Diploma in Mech. Engg.	Draughtsman
49.	Shri R.K. Gurjar	Laboratory Assistant
50.	Shri Abhay Kumar	Roneo Operator

Administrative Staff

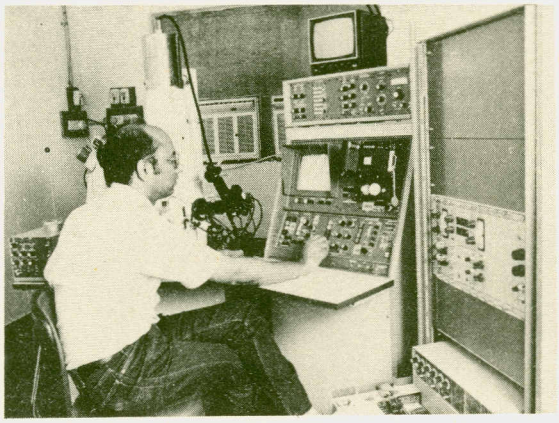
51.	Shri K.L. Jain B.A.	Administrative Officer
52.	Shri M.A. Baig Dip. Com (Govt.)	Fin. & Accounts Officer
53.	Shri N.C. Chakravarty B.A.	Section Officer
54.	Shri R.K. Bajaj B.A.	Stores & Purchase Officer
55.	Shri Omman Panicker B.A.	SPA to Director
56.	Shri T.P. Prasannan B.A.	Sr. Stenographer
57.	Shri A. Kulshreshth B.Sc., LLB., Diploma in Hotel Receiption & Book Keeping	Receptionist
58.	Shri M.L. Sharma, B.P. Ed.	Security Assistant
59.	Shri R.N. Ram	Assistant (Admn)
60.	Shri Dhirendra Kumar	Assistant (F&A)
61.	Ms. Shyamala. K.	Jr. Stenographer
62.	Shri R.P. Kapoor	U.D.C.
63.	Shri A.N. Malla	U.D.C.
64.	Shri P.K. Sathyanesan	U.D.C.
65.	Shri Girish Chand	Telex Operator
66.	Shri D.M. Chilbule	Purchase Assistant
67.	Shri Ashok Tayade (Upto Feb. 85)	Store Assistant
68.	Shri R.N. Sharma	Store Attendant
69.	Shri N.S. Jadav	Messenger
70.	Shri Vijay Kumar	Messenger
71.	Shri Harihar Singh	Watchman
72.	Shri Rafiq	Driver



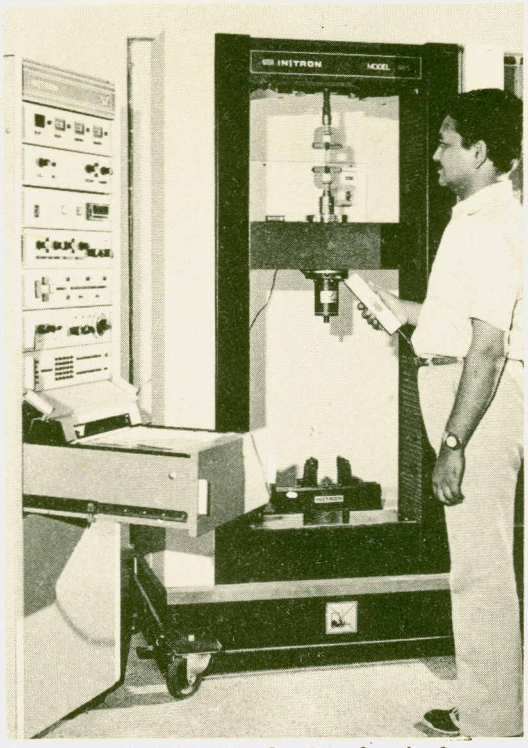
A small begining in 1981



Chemical characterization Laboratory



Scanning Electron Microscope



INSTRON, for Mechanical testing of materials

Laboratory Staff