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MANAGEMENT OF INDUSTRIAL RESEARCH AND SERVICE INSTITUTES IN THE BUILDING MATERIALS AND CONSTRUCTION SECTOR IN DEVELOPING COUNTRIES

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SECTORAL WORKING PAPERS

In the course of the work on major sectoral studies carried out by UNIDO, Studies and Research Division, several working papers are produced by the secretariat and by outside experts. Selected papers that are believed to be of interest to a wider audience are presented in the Sectoral Working Papers series. These papers are more exploratory and tentative than the sectoral studies. They are therefore subject to revision and modification before being incorporated into the sectoral studies.

This paper is based on a report of UNIDO consultant Professor Dr. Gyula Sebestyén. The views expressed do not necessarily reflect the views of the UNIDO secretariat.

Preface

This paper focuses on the techniques for managing building materials and construction research in developing countries. It is addressed to those who have day to day responsibility for the management of research institutes concerned with the building materials and construction sector.

This paper was prepared in co-operation with Prof. Dr. Gyula Sebestyén, Secretary General of the International Council for Building Research Studies and Documentation, Rotterdam, Netherlands.

Contents

Acronyms and abbreviations

AFNOR	Association française de la normalisation, France
BA-GDR	The Academy of Building of the German Democratic Republic
B-IRSI	Building Materials and Construction-Industrial Research and Service Institute
BMC	Building Materials and Construction
BRE	Building Research Establishment, United Kingdom
BRS	Building Research Station; part of BRE
BSI	British Standards Institution, United Kingdom
BSRIA	The Building Services Research and Information Association, United Kingdom
CEBTP	Centre expérimental du bâtiment et des travaux publics, France
CIB	International Council for Building Research Studies and Documentation, Netherlands
CIRIA	Construction Industry Research and Information Association, United Kingdom
CSTC	Centre Scientifique et Technique de la Construction, Belgium
DIN	Deutsches Institut for Normung, Federal Republic of Germany
EGSZI	Institute for Building Economics and Organization, hungary
EIRMA	European Industrial Research Management Association
ETI	Institute for Building Science, Hungary
GOSSTROY	State Committee for Construction, USSR
I&D	Information and Documentation
IPT	Instituto de Pesquisas Tecnologicas do Estado de Sao Paulo, Brazil
IRSI	Industrial Research and Service Institute
ISO	International Organization for Standardization
IUFRO	International Union of Forestry Research Organizations
NBS	National Bureau of Standards, USA
NBS/CBT	NBS Center for Building Technology
NBS/CFR	NBS Center for Fire Research
NGO	Non-governmental Organization
R&D	Research and Development
RILEM	International Union of Testing and Research Laboratories for Materials and Structures
TRADA	Timber Research and Development Association, United Kingdom
UNCHS	United Nations Centre for Human Settlements (HABITAT)
UNESCO	United Nations Educational, Scientific and Cultural Organization

1. INTRODUCTION

This study on building materials and construction industry research and service institutes in developing countries has been prepared as one of the follow-up actions to the First Consultation on the Building Materials Industry held in Athens, Greece, from 26 - 30 March 1985. Its aim is to contribute to the process of strengthening research capabilites in the building materials and construction industry, thereby promoting the development of these industrial sectors and of industry in general.

The study is intended to serve managers of research and service institutes in the building materials and construction sector in the developing countries. It has not been possible to come up with ideal solutions with a global and time-independent validity, or to point out panacea, for every problem that a research institute's manager may encounter. The study rather describes experiences in different countries; it highlights the advantages and disadvantages of certain approaches.

2. DEFINITION AND FUNCTIONS OF INDUSTRIAL RESEARCH AND SERVICE INSTITUTES

2.1 General considerations

In industrialized countries industrial research and service institutes (IRSIs) serve an important function in technical and economic development. Some definitions from the UNIDO publication "Guidelines for the creation of industrial research and service institutes in the least developed countries"[1/] are cited by way of introducing certain terms and concepts.

IRSI, Industrial Research (in abridged form: "research") and Service Institute. Research means acquiring new knowledge by laboratory experiments and/or theoretical investigations. Service means application of existing knowledge: engineering, testing and analysis, surveys, feasibility studies, etc.

R&D, Research and Development. Research means experiments, etc. needed to create a new or improved technology. Development is short for process or product development, such as engineering, pilot plant studies, plant design, and establishment of production.

Basic or scientific research aims at discovering new phenomena and shedding light on the laws of nature without having specific uses of the knowledge as an explicit motive. It is in principle not industrial research.

Applied research aims at achieving a result that can be exploited. It can have a high content of advanced research, using the same methods as in basic research, or it can be related more to engineering and product development.

The type of IRSIs which are examined in this study are those which, at the minimum, undertake a considerable range of research activities, i.e. are not exclusively service institutes. It is to managers of this type of IRSIs that this study is addressed. This does not exclude that such IRSIs carry out substantial service activities, but IRSIs doing only such design, consulting and engineering work are not examined. However service activities will frequently be assessed in their relationship to research.

For the sake of brevity, IRSIs active in the field of the building materials and construction industry (BMC sector) are denoted as B-IRSIs independent of the actual total or partial coverage of the field by the IRSI. Some principles emanating from various UNIDO reports on IRSIs

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1/ R. H. Westergaard, Guidelines for the creation of industrial research and service institutes in the least developed countries (UNIDO/IO.555), 11 August 1983.

follow in an abridged form together with some comments on their applicability for B-IRSIs.[2/-7/]

IRSIs contribute significantly to the development of industry. Several prerequisites have to be met prior to the successful establishment of an IRSI and according to national goals and priorities, it will vary in structure, purpose, and type of activities to be undertaken.

IRSIs became common in the industrialized countries after the Second World War and these countries have over a period of time come to learn their inherent potential and limitations. Many mistakes have been made, but gradually the institutes have become more and more cost-effective and useful. Investigations found that in many instances IRSIs in developing countries (at least during the initial periods) functioned poorly. One of the reasons for unsuccessful IRSIs is that the political and economic conditions in individual countries were overlooked when the IRSIs were designed. What is sound IRSI policy in a developed country may be totally out of place in a developing country.

A small, poor and underdeveloped country that sets up an IRSI may draw too heavily on human and financial resources (including foreign currency). It is therefore important to assess the expected costs and benefits realistically. IRSIs can have widely differing activities such as research, development, architectural and engineering design, consultancy, vocational training. The most difficult IRSI undertaking is R&D. Overambitious and unrealistic projects should be avoided. Despite all these difficulties, industrial research is useful and becomes more so as the country industrializes.

2/ Report of the high-level review group on The Principal Issues or Industrial Research and Service Institutes, in the joint UNDP/UNIDO evaluation staff report (assembled by R.E. Kitchell, UNIDO/EX.94. 6 August 1979).

3/ W.R. Millager, Managing technical institutes for industrialization (UNIDO/IOD.116), 7 October 1977.

4/ Laurence L. Barber, Institutional infrastructure for industrial development (UNIDO/ICIS.36) 26 July 1977.

5/ S.N. Ndam, Institutional infrastructure for industrial technology, UNIDO informal paper, 26 March 1977.

6/ Utilization of national technological institutions in the developing countries for industrialization, Report of an expert group meeting (UNIDO/ID/WG.246/6), 9 March 1977.

7/ Report on the Meeting of Selected Heads of Research Institutes (UNIDO/ID/WG.233/21), 31 January 1977.

One of the conditions for asserting that an IRSI is operating satisfactorily is that industry and government agencies are actually making use of the services. However, the mere fact that the services of the organization are being used only indicates that they have some value, not that they are producing benefits commensurate with their cost. That some services are in fact sold leads to the idea of using willingness to pay as a possible measure of benefits but here again problems can easily arise in implementation. Willingness-to-pay for a particular service is not the same as an actual payment for it and even actual payment is not a guarantee for practical application. Therefore even actual payments can only be relied on as one indication of the effectiveness of research.

The precise need for R&D, consulting, engineering, etc. cannot be established in advance. Usually the IRSI will be built up in phases and the extent of future expansion can be based on experience gained. But the scope of the first phase should not be so small that the institute cannot be viable. In that case the needs should be met by creating or expanding various institutions such as university facilites, government testing laboratories, information centers, and vocational training organizations.

The Fourth General Conference of UNIDO held in Vienna from 2nd to 18th August 1984 discussed strengthening the scientific and technological capabilites in developing countries in order to accelerate the economic progress.[8/] In the papers of this Conference it was stated that most developing countries have established single-purpose and multi-purpose research institutions of various types and institutions for scientific education and basic research. Some countries are also planning to set up science parks. Most the research and development is carried out in government-run institutes, although in a few countries it has been introduced at the enterprise or industry level. Institutions for standardization, testing and quality control, which form part of the infrastructure for technology development, have also been established in a number of countries.

2.2 <u>Characteristics of the building materials and construction industry in relation to reserach and development</u>

Manufacture of building materials and construction are carried out in different subsectors:

(a) Informal sector;

(b) Formal sector:
  (i) Small-scale subsector;
  (ii) Medium-scale subsector;
  (iii) Large-scale subsector.

8/ Report on the First Consultation on the Building Materials Industry; Athens, Greece, 26 - 30 March 1985 (UNIDO/UNCHS/ID/335; ID/WG.434/8), 18 April 1985.

The immediate capacity for absorbing research results is smallest in the informal sector, (a), and increases in group (b) from (i) up to (iii). The practice in industrialized countries shows that it is the medium-size enterprises which are often the best clients of building research institutes; those in subsector (i) are too small and difficult to reach; those in subsector (iii) large and to a great extent self-reliant in reserach also. The manager of a B-IRSI should bear this in mind but simultaneously seek ways to reach sector (a) and subsectors (i) and (iii). In the BMC sector, small production units including the informal sector, are very important. It is thus important for B-IRSIs to focus part of their efforts on the needs of these producers.

The primary objective should be to encourage production of building materials which are durable and inexpensive and which could be produced locally, using locally available raw materials and skills. In devising construction technologies for the less affluent communities, the design and specification of the dwellings should broadly correspond to the traditional design and specifications, so that there would be no inhibition against the use or adoption of the new designs and specifications or of alternative materials or serious technical difficulties in the application of new materials and techniques involving the use of hired skills.

Building materials that deteriorate quickly are generally either organic or, if mineral, consist of soft stone or unconsolidated soil. Nevertheless, in suitably protected environments, traditional materials such as wood and dried mud can also last almost indefinitely. The wide differences in durability between the same materials in several situations relates to the configuration and details of building design or the use of protective measures to prolong the life of vulnerable components. There is considerable scope for bringing about improvement in conventional construction techniques that would reduce the use of costly materials without affecting the quality of construction.

In developing countries the building materials and construction research institute would normally include the following activities in its programme:

(a) Developing suitable building materials from locally available raw materials hitherto unutilized, such as agricultural, industrial and forest wastes;

(b) Improving the durability of traditional building materials by making suitable modifications in the composition of raw materials, by modifying manufacturing processes and by building designs which take into account the weathering and deterioration of materials;

(c) Evolving new construction techniques with a view to economizing on construction cost as well as in the consumption of building materials by the optimum use of their strength;

(d) Evolving new building techniques to improve the speed and reduce the cost of construction or to withstand earthquakes;

(e) Protection of the environment, conservation of natural resources.

2.3 Establishing and strengthening building research institutes

Organized building research is a product of the 20th century. The first major building research institute was founded some sixty years ago; this was the Building Reserach Station in the United Kingdom which is now incorporated in the present Building Research Establishment. Other institutes were founded between the two World Wars (e.g. in France and the USSR) but most research institutes in Europe and indeed in other industrialized countries came into being in the years after World War II, predominantly in the fifties.

In developing countries, such institutions were set up in subsequent periods, mainly in the seventies and the eighties. It is important to recognize that new building research institutes usually need time to "grow up" and become fully efficient. A new industrial plant should be able to reach its full planned manufacturing capacity within a few years. Contrary to this, a new building research institute usually needs at least ten but more likely some twelve to fifteen years before it becomes an important factor in the technological development of a country's building industry. However, this does not exclude significant benefits being derived earlier. A long term view as regards the development of such institutions can be a useful factor when assessing their effectiveness.

In recent years a number of governments have investigated the feasibility of abolishing building research institutes as governmental institutions and to privatize building research. Such exercises have been carried out in Australia, Sweden, the United Kingdom and the United States, and in each case the outcome was against implementing such a strategy.

Nevertheless in most instances various measures were adopted to increase industry's participation in supervision and sponsorship and management, and to reduce the state budget's financial commitments toward building research. The reasons for the decisions to retain some part of building research as a central public activity have been the same as those used when these institutions were founded: vital public interest is involved in the shaping, maintaining and improving of the built environment, and research results cannot be effectively disseminated strictly on a fee-for-service basis. The conclusions accepted in industrialized countries, are equally valid in developing countries.

Centralized institutes can be organized also by an association of contractors and manufacturers; such institutes exist in the United Kingdom (CIRIA, TRADA, BSRIA, etc.), France (CEBTP), Belgium (CSTC) and other countries. The centralized research institutes therefore can be public or semi-public. In countries with centrally planned economies, research institutes are usually state-owned organizations.

In many countries a combination of building materials and building research within the same institute has proved to be an efficient solution and such a scheme merits continuation in the future in suitable cases. If the scale of research activities calls for high specialization in different fields, then different research institutes can be recommended. Research on anorganic building materials (cement, concrete, bricks, etc.) and research on timber products can be organized in such cases in two different research institutes (as occurs e.g. in Nigeria, Ghana, India, Thailand, etc.).

International intergovernmental organizations (UNCHS, UNIDO. UNESCO, etc.) have considered it as important to lend their support to establishing and strengthening building research in developing countries. Some international non-governmental professional organizations (CIB, RILEM) also undertake activities aimed at strengthening the B-IRSIs. The manager of a B-IRSI may find it useful to study the work of the various international organizations with a view to obtaining assistance for his own institution.

3. SURVEY OF BUILDING RESEARCH AND SERVICE INSTITUTE (B-IRSI) ACTIVITIES

3.1 The sectoral coverage of B-IRSIs

The activites of a B-IRSI can be related to the following main fields:[9/-15/]

- Building materials and components;
- Building and the construction industry and their products (buildings, public works, etc.);
- Architectural and engineering design, history of architecture;
- The built environment; physical (urban and regional) planning.

The broad categories can be further broken down into specific applications within each of the main field as is shown in box 3.1.

Obviously no B-IRSI would deal with all the fields. While the specific scope of a B-IRSI affects the manager's work, the analysis in this study is generally applicable for types of B-IRSIs dealing with the range of activities shown in box 3.1.

Some institutes are components of a greater complex of research. In such cases certain areas may be taken care of by units other than the building research unit. So, for example, in the USA within the National Bureau of Standards, there is a Center for Building Technology but fire research is handled by NBS's Center for Fire Research. In Brazil within the Instituto de Pesquisas Tecnológicas do Estado de São Paulo there is a building research division but timber falls within the scope of another unit of IPT.

9/ Appropriate Building Materials for Low Cost Housing, E&F N Spon, London-New York, Volume I, 1983; Volume II, 1985.

10/ Building Materials for Low-Income Housing, E&F N Spon, London, 1987.

11/ Materials, Construction Techniques and Construction Economy in Developing Countries (Proceedings of International Conference, Paris 1986).

12/ P. Chemillier, L. Chabrel, Les évolutions technologiques dans le bâtiment: bilan et perspectives, CSTB, Paris 1982.

13/ Long-Term Research and Development Requirements in Civil Engineering, CIRIA, London 1981.

14/ Building Research World-Wide (Limited Proceedings of the Eigth CIB Triennial Congress, Oslo, June 1980).

15/ Advancing Building Technology (Proceedings of the Tenth CIB Triennial CIB Congress 1986; Center for Building Technology, National Bureau of Standards, Gaithersburg, Maryland, USA, 1986).

Box 3.1. Fields of B-IRSI activities

(a) Building materials

- Earth (mud, clay soil, laterite, adobe) and stone;
- Binders and additives (cement, lime gypsum, pozzolana, sulphur);
- Concrete (plain, reinforced, prestressed, ferrocement, fibre or bamboo reinforced);
- Bricks, blocks, mortar, masonry (use of fly-ash, rice husk, etc.);
- Timber, bamboo, leaves, husks, fibres, agricultural by-products;
- Industrial wastes and by-products (slags, etc.);
- Other and alternative materials (paints, plastics, composites).

(b) Building components

- Foundations;
- Walls and plastering (reinforced masonry);
- Floors;
- Building boards, partitions, doors, windows, shutters;
- Roofing (fibre-cement sheets, reinforced concrete plans, shells);
- Stoves for cooking and heating;
- Ventilation;
- Washing and sanitary facilities.

(c) Design of buildings

- Architectural design;
- Structural design;
- Design of equipment;
- Protection against noise, moisture, heat, cold, rain, fire, earthquakes, corrosion.

(d) Building and civil engineering works

- Housing (dwellings, houses, flats; low-, medium-, high-rise; urban, rural);
- Health and recreational buildings;
- Educational and cultural buildings;
- Offices, commercial, transport buildings;
- Industrial and agricultural buildings;
- Roads, bridges, tunnels, dams;
- Municipal services.

(e) The BMC industry

- Organization, management, economics;
- Manufacturing, transport, on-site processes, mechanization;
- Maintenance and modernization of the building stock;
- Financing;
- Labour (personnel problems, work safety, health aspects).

(f) Social and environmental matters

- Physical (urban and regional) planning;
- Protection of environment;
- Social, sociological, psychological problems (perception of environment);
- Architectural heritage and esthetics;
- Demand and supply.

Some countries have more than one independent institution for research covering the fields. In the East-European countries this solution is widespread. Thus in Hungary there is a building research institute called the Institute for Building Science (ETI) and a separate institute called the Institute for Building Economics and Organization (EGSZI) which is engaged in research on building economics.

In the USSR, China and the German Democratic Republic, the plethora of institutes has resulted in the creation of a supervisory governmental institution. In the USSR this is the Gosstroy (State Committee for Construction) and in the German Democratic Republic the Academy of Building of the German Democratic Republic.

3.2 Types of activities

The main types of IRSI activities have been listed in the first section; these are now subjected to further discussion from the point of view of B-IRSIs in developing countries. The main B-IRSI activities are:

- Research (applied and developmental research: focussed on specific problems in developing countries);

- Development work (experimental and demonstration projects; development and experimental manufacturing of new or improved building materials and components; remedial action; post-earthquake reconstruction);

- Testing (quality control, approval of new materials);

- Design and consulting engineering (studies, standards, codes, expertise services);

- Collection and dissemination of information, and

- Education (teaching, training).

In a great number of cases, the main task assigned to a B-IRSI is to execute research. In some such instances everything other than research activity is considered as secondary and the manager of the B-IRSI has to take care that other activities should not reduce the research potential. In other cases the various activities can acquire a more balanced importance with each being considered as useful yet none as dominating the others.

Some of the non-research activities are vital for generating useful research. Others are more loosely linked to research and these are the activities which must be carefully scrutinized when deciding about their share and about growth potentials allocated to various activities. The optimal allocation of scarce resources among the various competing ends is an important management task and requires the full attention of the B-IRSI's manager.

Non-research activities of building research institutes may be carried out by the staff, either as part of their normal duties, or based on separate contracts with or without financial bonuses. Professional disadvantages arise mainly if the non-research work requires excessive time thereby reducing research capacities. On the other hand, research institutes are often unable to ensure from research work alone, the income levels that are sufficiently attractive to highly qualified persons and so are obliged to compromise for this reason alone. The combination of research work with other types of activities may also enhance the reputation of leading researchers and contribute to obtaining necessary funds for research.

3.3 Research

Building research usually is applied research. There is little basic research even in the most advanced research institutes. It must be clear that the objective of building research is to see its results applied, thereby effecting a change in the industry.

"Traditional" or "classic" building research concentrates on physical phenomena: mechanics, acoustics, and the physics of heat and moisture. Some research in the field of chemistry has also been part of building research: the chemistry of cements, additives to concrete, corrosion and lately the use of plastics. In the course of the last twenty years, besides these classic branches of building research new fields of research have emerged:

- The study of economic, social and planning problems, both on a macro- and micro-economic level;
- The study of human/psychological, physiological, biological subjects in relation to the built environment.

Not all building research institutes joined this trend; some, mainly testing laboratories, remained purely technical institutions. Most institutes, however, have increased their research in these new areas. There are also housing institutes which lay the emphasis on social and sociological topics related to housing, but are B-IRSIs in the sense in which the term is used in this paper.

3.4 Development and design; experimental and demonstration projects; manufacturing of new products

Development work is the stage that follows applied research; its aim being to prepare the practical application of research results. The same is true but with certain restrictions for design work, since in many cases the application of research results involves design of structures, building and/or of manufacturing facilities of materials and components but design is not necessarily preceded by or linked to research. Research and development frequently form part of the technological innovation process and sometimes result in inventions which can be patented. Although it is impractical to list here all possible forms of development and design work some typical examples are,

- Participation in a consulting-advisory capacity in development work of construction companies with the aim of applying research results;

- Design of pilot factories producing building materials based on research results, e.g. cement or lime kilns; stabilized soil or laterite blocks, etc.;

- Establishing own manufacturing facilities for laboratory equipment such as sieves, cones, cube or cylinder forms for testing of concrete, mortar and bricks;

- Design of structures and buildings incorporating research results, e.g. ferrocement roof planks; ventilation and sun louver equipments; experimental houses.

Building research institutes frequently engage in development and design work. This usually commences with development and design aimed at practical applications of the institute's research and as such could usefully complement research. It often acquires some independence and in periods when there are no tasks coming from internal research, contracts may be accepted from external clients on topics unrelated to the institute's own research or even in some way in competition with the institute's research. As research is not by its nature an activity which could generate uniformly continuous development and design work, internal conflict and competition for scarce resources and priorities may be the outcome. The manager of the institute must monitor such developments carefully and make periodic and appropriate adjustments to resource allocations and institute policies.

Another danger is that development and design may require a staff with qualifications that are different from those needed in research. In periods when such staff cannot be occupied with development and design based on research results, there will be an inclination or even a pressure from financial necessity to take on other work not linked to research at all. If this takes place on a major scale, a distortion in the scope of the research institute will result.

3.5 Testing; quality control; approval of new materials

Laboratory and on-site testing of building materials, components and structures is an important tool in ensuring good quality construction. Laboratories for such purposes are established usually within building research institutes; in some countries, however, such laboratories form part of a university or there exist independent testing institutes. The logic for combining research and testing is grounded in the fact that the same equipment used for testing can be used, and are needed, for research. There is, however, also a somewhat similar justification to have testing facilities at univerities and polytechnics. Future civil engineers and architects should be familiar with materials testing and therefore this is a subject usually included in curriculae. As a consequence, universities and polytechnics need laboratory testing equipment for teaching and demonstration purposes; the same equipment can be used for routine testing also.

Most testing activities are commissioned by organizations active in the building process, such as manufacturers, contractors, architectural and civil engineering designers. Such testing is usually charged to those ordering it and yields an income to the institute.

The public or other authority can make it a normal task of a research or testing institute to check quality by testing without charging the contractor or manufacturer. In such cases the institution ordering the testing will pay for the work but it also has to give authority to the testing institute to enter the factory or construction site and take samples. In organizations where testing becomes a repetitive activity, it is advisable to devise price lists for the most common testings tasks.

Testing in itself does not fall within the category of research but it does give experience which can be useful in research, e.g. observations of causes of failures can be the starting point for research. The public authorities have a vested interest in an appropriate method of introducing new building materials due to considerations of safety, health and environmental aspects. For this reason in many countries there exists a system for the approval of new building materials and components. Such approvals were given in French the names "agrément" and, for the past few years, "avis technique". The government usually authorizes a public institution to implement this system. The institution can be the building research institute itself or a unit with some independence but still within the building research institute or it can be a separate organization.

In the case of developing countries with relatively new and small building research institutes, assuming that qualified manpower and funds for equipment are too limited to allow for splitting functions into two organizations, the right decision probably is to keep this task within the building research institute.

3.6 Consulting engineering and developing codes and standards

Consulting engineering activities and work related to the development and implementation of building codes and standards are often part of the B-IRSI's mandate. Most such activities fit well into the general scope of a building research institute. Some activities which can be placed in this category are,

- Preparation of state-of-art surveys on various fields of construction and building research;

- Examination of problem areas including building defects and damages and preparation of possible solutions and remedies;

- Serving as experts in legal or arbritration cases;

- Serving as advisory consulting engineers to government and industry;

- Preparation of draft standards, codes, regulations.

Consulting engineering and related activities usually are to the credit of research institutes. It is important in this respect that only appropriate topics and from suitable clients should be accepted and that the consulting, engineering, advisory or expertise work should be carried out on a high professional level. In addition ethical integrity is a requirement from which no deviation should be tolerated; a research institute could be tempted into an unacceptable attitude either by political pressure or by financial advantages offered by a client.

The development, implementation and continual monitoring of building codes and standards is important to the development of the BMC sector. This is an area in which the B-IRSI has an important role to play and one which provides scope for the institute to gain stature and importance. It is vitally important, especially in developing countries, that building regulations are based on both technical and economic considerations. Regulations must not be so strict that they rule out the use of locally available materials and interfere unjustifiably with the operation of small-scale and informal sector builders. This is important to point out because the research institute is naturally biased toward an emphasis on technical considerations and has to make a conscious effort to give proper weight to economics.

3.7 Information, documentation and publications

Activities in this area include both processing existing information and producing new information. The production of information can be based on information received or on work carried out by the institute. Information can be produced for internal and/or for external consumption. Information can be conveyed to users in its original or in some kind of processed form. The second form comprises processing in the original language (abstracts. summaries, microfilms, etc.) or in translated form.[16/] For most B-IRSIs the principal product is information about the R&D it has carried out.[17/]

Before and during R&D the organization itself makes the use of various types of information. Access to the professional literature must include literature in the country's language or leading languages and in at least English or French. Access to literature should be realized in part through traditional methods, i.e. provision of books, films, microfiche, in part through electronic access. Inter-library loan is a very well developed and efficient way of improving access to literature in most industrialized countries and international co-operation in this area is good.

The B-IRSI must formulate a policy with regard to its own information requirements. This includes the size of staff to be employed in documentation, information and publications and the extent of the finances that can be allocated for such purposes. The number of books to be purchased and periodicals to be subscribed to must be decided. This decision depends also on the language used in the country and the linguistic capabilites of researchers. Institutes may feel it necessary to employ translators on a full-time basis in the main where the language in the country is other than the language(s) in which most professional literature is published (English and French). A decision has to be taken as to the languages in which the literature should be continuously monitored; languages that are selected frequently are Spanish, Chinese, Russian, Japanese, German.

It is a permanent task to arrange for information available and newly obtained by the library and documentation service of the institute to reach those to whom it would be of potential benefit.

16/ G. Sebestyén, Information Needs and Tasks in the Building Materials and Construction Industry in Developing Countries (presented at UNIDO Expert Group Meeting in Zagreb, April 1986).

17/ The Impact of New Information Technologies on R&D and on I&D Management (EIRMA Working Group No. 31 Report, Paris 1986).

Some funds and resources should be allocated to the library and documentation service at once when establishing a research institute but it usually takes some time to develop a good library and documentation system.

One simple but effective means of making staff aware of the institute's documentation facilities is to circulate a list of the library's new acquisitions. Beyond this a computer accessible card catalog and abstracts can be helpful. When the card catalog is online it becomes unnecessary to circulate a list of new acquisitions since it can be conveniently scanned on a computer terminal.

Beyond internal requirements for information, the results of work done in the building research institute have to be made available to clients and others, through reports, leaflets, posters, articles, books, slides, films, etc. which are either produced by the institute staff or by organizations that specialize in such matters. Managers of building research institutes are faced with a number of fundamental questions in this area, which is discussed in more detail later in this report.

3.8 Education

In some countries B-IRSIs are combinations of research institutes and education institutions, both activities being accorded equal importance. This is the case, for example, in Yugoslavia.

Also, in recent years universities are themselves carrying out more applied research. In many countries, research institutes are located on university campuses either as independent institutes or under varying degrees of guidance of university professors. Research institutes themselves may organize courses, series of lectures, demonstrations and training in order to bring their own research results or those to be adapted from abroad to the attention of industry and to train workers and technicians in certain new skills.

3.9 Participation in domestic professional life; international co-operation

The staff of a research organization participates in their country's professional life. This helps them to identify the needs of the industry and to put their own results into practice. They also participate in the international professional life; this provides them with approaches, results and practices which can greatly broaden their perspective and gain exposure to ideas sometimes quite different than those current in their home country. International organizations should not be overlooked as a source of funds for staff members of research institutes in developing countries to use for attending international meetings.

International co-operation is promoted by United Nations Organizations (UNIDO, UNESCO, UNCHS, UN Regional Economic Commissions) and international organizations.

It is important that research institutes themselves be able to co-operate on their own level. Participation in the work of international non-governmental professional (NGO) organizations is important for research institutes and their researchers. Such participation provides them with a feedback of experiences from abroad and this can enhance the efficiency of their own research. CIB and RILEM are the two most active organizations in the BMC sector; others, such as IUFRO in relation to the use of wood in construction, have a more limited scope but exactly for this reason, may be important for researchers in such areas.

It is an important task of the B-IRSI manager to select the institutes with which it wishes to enter into close bilateral co-operation. Usually building research institutes restrict close bilateral contacts to some four to six foreign institutes.

Typically B-IRSIs in developing countries will wish to have close co-operative relations with institutes both in developing and in developed countries. Co-operation with institutes in other developing countries provides the opportunity to share information with organizations in similar circumstances where ideas concerning such management issues as funding and the dissemination of information to the BMC industry which one of the institutes have found effective are likely to be effective for the other. Research results and methods are also more likely to be mutually applicable between institutes who are both located in developing countries. Co-operation with organizations in developed countries facilitates access to sophisticated techniques.

It is important that, within the framework of such bilateral agreements, the rank-and-file researchers receive an adequate share of travel. At the same time, research managers themselves should use the opportunity to acquaint themselves with experiences in other countries which could have useful feedback for their own work.

Twinning of two B-IRSIs is the name frequently used to designate a higher and more permanent form of bilateral co-operation. Bilateral agreements (and twinnings) usually comprize:

- Exchange of publications;
- Reciprocal visits (for short, medium and/or long periods);
- Selection of priority topics for co-operation;
- Programmes of co-operation on selected topics; eventually division of research work.

A very desirable high-level form of co-operation can result in joint research reports. Twinning arrangements usually come into being after periods restricted to simpler forms of co-operation.

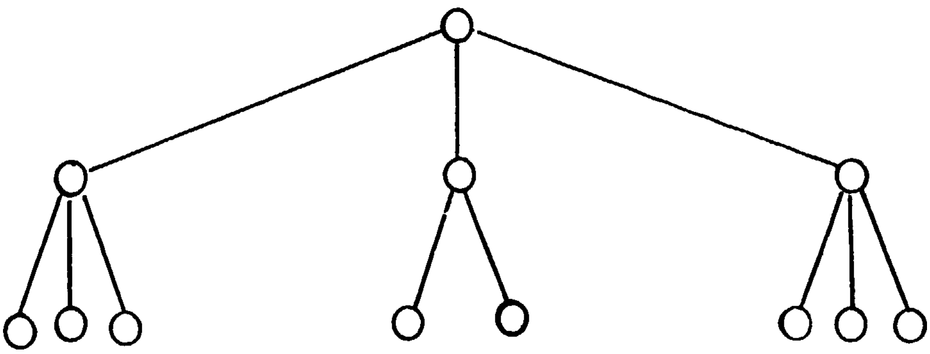
4. MANAGEMENT OF BUILDING RESEARCH INSTITUTES

Management comprises various processes of planning, decision-making, execution, controls and all this at various periods in the life of a research institute. The theory and practical experiences of management are applicable to building research institutes also and there is no need to summarize the body of general knowledge that exists on management. This section therefore is restricted to highlighting selected aspects of management which frequently have specific importance for building research institutes.

4.1 Organizational structure

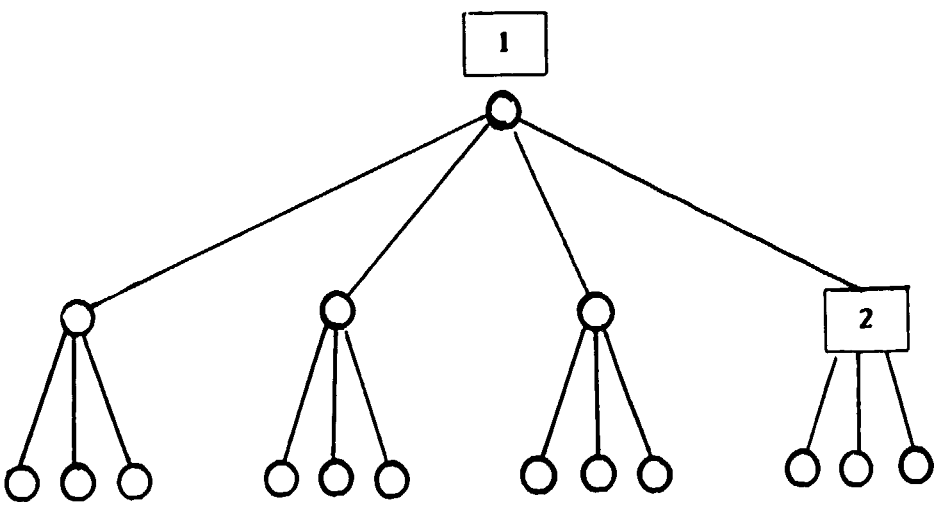
Small building research institutes can operate with a simple linear hierarchical structure in which each person can receive instructions from one individual only.

Figure 4.1. Simple linear hierarchical structure



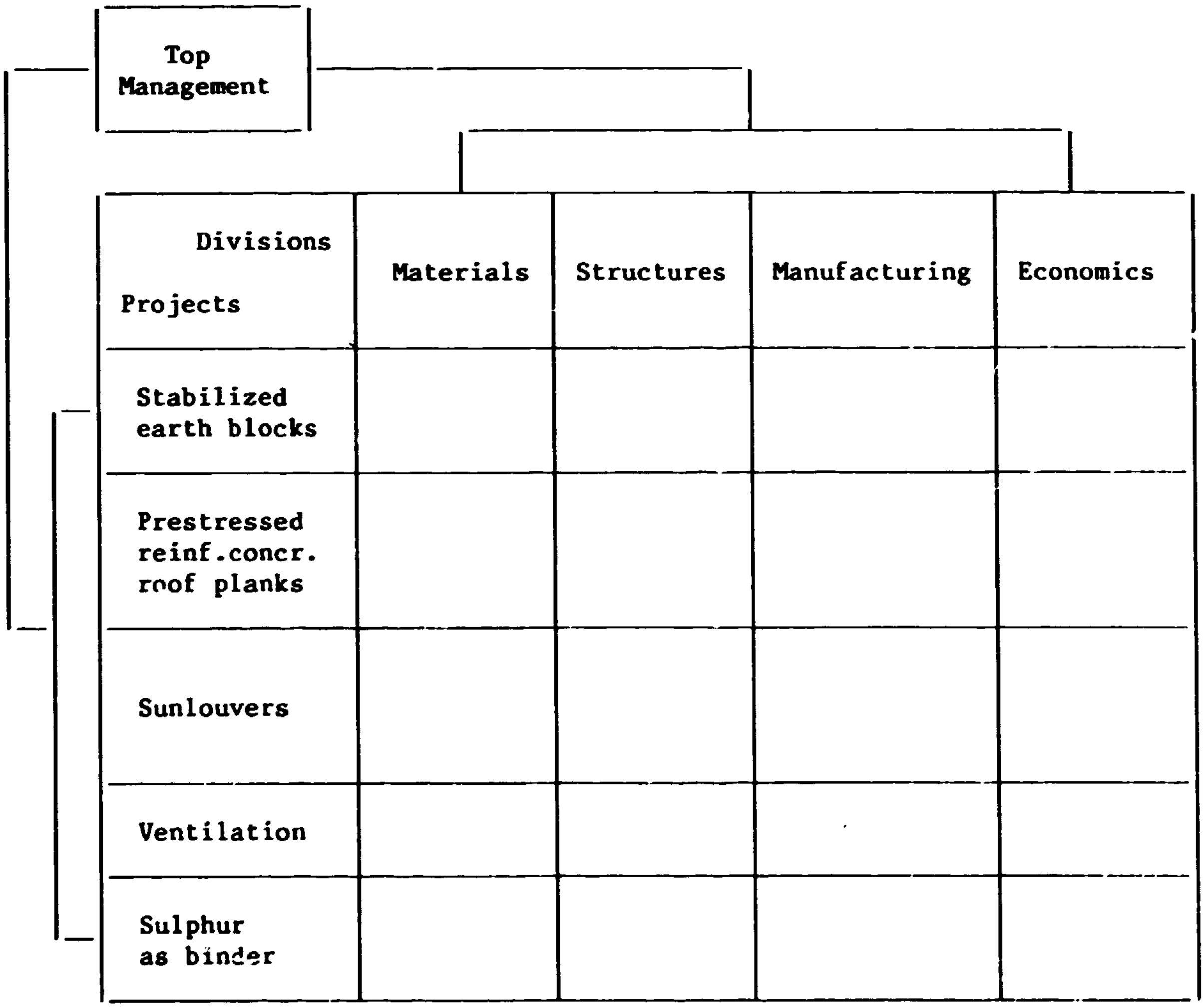
In larger institutes, in addition to the linear structure for certain specialized functions, a general staff might be established as shown in figure 4.2. The functional-linear structure is the most widely used form of organization in building research institutes.

Figure 4.2. Functional-linear structure



Recent years have seen the introduction of a new form: the matrix structure with its various alternative set-ups. All are characterized by a dual entry of responsibilities: one usually stable and based on subordination, the other often more mobile and based on tasks and processes. This type of structure is called for in institutes which carry out complex R&D projects that have requirements for different types of researchers and qualifications and have changing requirements for equipment and labour. In such a matrix structure, the execution of a project proceeds from one division to the other and each project has its supervisor; alternatively several projects have one single supervisor or project manager. An example of such a structure is illustrated in figure 4.3.

Figure 4.3. Matrix structure



Taking into account the different target dates of projects, this organizational structure requires frequent review and updating. A review (be it by meeting of members of top management or meetings with researchers, etc.) can take many forms and is a tool utilized by management in all organizations. An excessive frequency of meetings with little use for most participants, e.g. daily meetings just to review incoming mail, should be avoided. Regular but not too frequent meetings, complemented by ad hoc meetings according to needs, is probably the optimal solution.

A special form of matrix management can be introduced by appointing top researchers for certain disciplines. The appointment of a top mathematician, chemist, architect, economist, etc. confers on these persons the right to supervise research in their specialized field in any division of the research institute and, within the scope of their discipline, they are then empowered to give instructions to researchers throughout the institute. This type of structure is justified only in institutes which are engaged in sophisticated research projects requiring the work of researchers with greatly differing qualifications.

The success of such a system greatly depends on the professional expertise and skills in human communications of the top reseराchers involved. Researchers tend to resent and fight off interference from persons whom they either do not accept as professionally (scientifically) superior to themselves and/or who cannot intervene with authority without giving offense at the same time.

Apart from its advantages the matrix structure does have one drawback: the inherent conflicts between the two types of responsibilities. It demands a greater degree of care, firmness and tact on the part of top management but if it functions well, can be more efficient than other forms of structure. The matrix organizations can be recommended only for those building research institutes which have attained an adequate maturity and experience. Otherwise the functional-linear type of organization is to be preferred.

One way to achieve the optimal level of co-operation between those working in these multidisciplinary aspects of building rsearch is to promote co-operation between staff in various divisions, (independent from the form of structure: linear, functional or matrix). Another solution is to re-arrange organizational units frequently according to the research projects to be executed. This latter solution is used when there are large individual research projects which make heavy demands on co-operation and completion dates; in the case of a great number of medium-sized and small research projects a more permanent organizational structure is generally utilized. Universal patterns for the system of research divisions do not exist; what occurs in practice largely depends on the scope and the priorities of the institute concerned.

As concerns shake-ups of the internal structure managers can broadly speaking fall into one of two types:

- Those who are fond of frequent reorganizations and who are able to execute such shake-ups without difficulty;
- Those who prefer to retain problems for solution within existing internal structures.

The first type of manager inevitably has a higher profile although this does not necessarily mean that he is more efficient. A cautionary advice is to be aware of one's inclination and to resist too frequent reorganizations in the first case and to seek to overcome reluctance to reorganization in the other case.

In building materials research the broad categories of materials can serve as the basis for divisions, e.g. on:

- Cement, lime, gypsum, pozzolana, sulphur;
- Clay, laterite, dried, stabilized or burnt clay bricks;
- Stones, concrete, mortar;
- Glass;
- Wood.

In addition, for research and for testing the basic common properties of building materials, a chemical and physical research and testing division is usually established. Where specialized sophisticated equipment is present the organizational structure can be streamlined around these. In building research institutes, the different qualifications of the researchers can be an important factor in determining divisions, e.g.:

- Structures including or excluding geotechnics and foundations (requiring mainly structural engineers as researchers);

- Secondary components, e.g. doors, windows, partitions, floors, pavements, claddings (requiring architects and civil engineers as researchers);

- Mechanical equipment, e.g. water supply, sanitation, ventilation, heating (requiring mechanical engineers as researchers);

- Plastics, painting sealants (requiring chemists and chemical engineers as researchers);

- Economics and management (requiring building engineers and economists as researchers).

4.2 Physical location and institutional framework

It is not typical for the B-IRSI manager to have much control over the physical and institutional setting of the organization. Typically it is decided before he is recruited and is specified in the founding charter. However, on occasion the B-IRSI may be reorganized and given a new charter together with a new physical and institutional setting. For this reason this section provides a few observations on these topics.

Building research institutes can have their own independent land and their own buildings or they can be located together with other organizations. A widely applied practice is to concentrate various research institutes in one place; these then form a campus or a science park. This type of accommodation exists in the United States (Center for Building Technology of the National Bureau of Standards, Gaithersburg, Maryland), in the Netherlands (TNO, Delft), in the German Democratic Republic (Berlin), in Japan (Tsukuba), in Denmark (Horsholm) and in other countries. The institutes may retain their independence or they can form a complex. In some cases two or three institutes are located on adjacent sites.

Another spatial combination is when a building research institute is located within the perimeters of or adjacent to a university campus. The location of a B-IRSI near a university favours contacts between research and teaching and the institute may be able use students as interns and part-time or temporary research assistants. Faculty may also contribute on a part-time basis to the research of the institute.

B-IRSIs which serve one large construction company or a company manufacturing building materials, e.g. cement, can be located within the actual premises of the company. This occurs mainly in the case of company research institutes.

From all these spatial combinations, it is the science campus solution which promises the most advantages. It offers high-level expertise in adjacent disciplines in which a building research institute generally cannot attain a high degree of proficiency. A science campus usually strengthens the scientific level of research in all constituent institutes. Provided this does not influence the researchers in too theoretical a direction, then it yields benefits. On the other hand combinations with industrial companies tend to push institutes toward practical development work.

The solution least worthy of recommendation is to place an institute in a building of its supervisory ministry; this usually exerts an undesirably strong influence on a research institute's work and may transform it into little more than an auxiliary branch of the ministry, eventually also reducing the institute's scientific independence. Combinations with universities, as for example occurs in Yugoslavia, entail both advantages and disadvantages, with perhaps the former outweighing the latter.

4.3 Legal status and responsibilites

Legal conventions are subject to considerable local variation and the manager of a B-IRSI must be cognizant of the legal implications of the institute's activities. If the manager has acquired sufficient experience in legal matters during his career prior to having been nominated to his managerial function in the B-IRSI, he is in a better position to assess correctly the legal aspects of the B-IRSI's work. If this is not the case or if specific legal rules regulate research, development or other IRSI activities then the manager is advised to seek expert legal counsel. In most countries legal and financial responsibility for research results is limited to the correctness and accuracy of the research work. In development and design work, in demonstration projects and manufacturing, i.e. when a B-IRSI carries out normal production activity, legal and financial responsibilities are much wider and may be beyond what can be reasonably expected from a research institute. In such cases adequate insurance may protect the institute.

In many countries it is not necessary for the manager of a B-IRSI to take out liability insurance for his own person; in certain countries, however, this may be necessary. The manager is well advised to clarify this point before accepting the appointment.

When setting up an institute the legal status has to be defined and this will then remain valid for a prolonged period and will provide a permanent framework for the institute. Public building research institutes are sometimes founded by statute. Building research institutes may have their own independent legal existence or they may form part of a larger organization.

Institutes can be governmental organizations owned by the state; this is the case, for instance, with the Building Research Establishment in the United Kingdom. They can be subsidiary to industry, namely to industrial federations, e.g. CSTC in Belgium, to a group of companies (CIRIA in the United Kingdom) or to a company, such as for the research institutes of the Kajima and other companies in Japan.

The supervising authority can be a division of the supervising governmental or industrial institution; boards, councils, committees, etc. can have a supervisory or advisory function. Even in the case of state-owned institutions supervisory or advisory committees are frequently chaired by a leading personality from the industry; this could contribute to programmes and results more in tune with actual industrial needs.

The legal status and employment conditions of the staff can be regulated according to those applying to either civil servants or in private industry. Some opportunities may arise for the manager of a B-IRSI to choose or to alter the legal status of the staff. In such cases the benefits and drawbacks inherent in the various alternatives have to be evaluated. In industrialized countries, many important B-IRSIs, e.g. BRE in the United Kingdom, operate as public government supervised institutions and rules for civil servants are valid for the staff; in some others, e.g. CSTC in Belgium, employment conditions as in private industry are applied. For the manager of a B-IRSI in a developing country, nothing beyond a careful evaluation of alternatives can be recommended. In any case it is important to have a system which provides appropriate rewards for successful researchers.

4.4 Management and communications

The top mananger has to maintain good communication first of all with his direct Deputies so that they are aware of his policies and views and can fit smoothly into his management pattern. Discord and friction between the top echelons constitute a major source of failure of management.

In addition to the various management levels, good communications with all staff members of the B-IRSI is important. Internal communications include person to person contacts, informal and formal meetings, functioning of committees, internal journals, information bulletins, and management rulings and guidelines. Communications among staff members also must be effective and this should be a concern for the B-IRSI manager.

In addition to co-operation between researchers within a B-IRSI, sometimes co-operation with other IRSIs may be necessary in order to carry out some complex projects. Such co-operation may introduce complications into the execution of programmes but in certain cases it can be unavoidable or even desirable. Many research problems require multi-disciplinary contributions and this can give rise to contacts by the B-IRSI researchers with researchers in other disciplines. This can have a positive impact on the B-IRSI by broadening the horizon of researchers.

Outside committees are effective means of ensuring communication between the research institute and interested parties in industry and government. Close co-operation with outside committees or committees made up of both institute staff and outside parties help to involve potential industrial and government clients at an early stage and evince their interest and active participation. Thei can also ensure that research staff in proposing projects are aware of the necessity to take account of the needs of government and industry, and make the effort to consult these sectors before putting porposals forward.. They should involve the participation of all those concerned with the industry at some stage, but should be organized, where possible, as to require the minimum of administrative servicing.

The term "Committees" may mean quite different types of groupings of people with greatly differing terms of reference. Some of the Committees in use in B-IRSIs are:

- Supervisory and/or advisory Committees for the top management of IRSIs comprising representatives of government and industry;
- Sectorial committees comprising experts possessing specific knowledge in a given field;
- Internal Committees with representatives of the B-IRSI's various units.

There are a number of external circumstances that influence management, for example, requirements of government and industry, market conditions, investment and building management policies, new discoveries elsewhere. Good two-way communication both with those outside and within the institute can help the B-IRSI manager to beware of these developments and to react appropriately.

4.5 Research funding and financial management

Basically there are two methods for financing building research:

(a) Allocation of financial resources by a centralized authority (ministry, company), eventually broken down according to topics;

(b) "Earning" money through contracts with various clients.

A combination of the two occurs frequently. Financing according to (a) tends to be more common for small and new institutes; method (b) is frequently used in varying measures for large and well established institutes. The share of income earned from contracts often lies between 20 and 40 per cent. Financing also depends on the nature of the activities. Quality control testing for example, is customarily undertaken on a fee basis. Advisory services usually are charged for except when provided to the informal sector.

B-IRSIs financial operations can be based on two completely different sets of principles:

(a) That income and expenditures are budgeted separately; expenditures are approved with a breakdown into categories (salaries, office costs, etc.). Any surplus income and profits cannot be used as additional source for investments, bonuses, etc., and must be paid into the credit of the state budget.

(b) That the B-IRSI operates as a normal enterprise with budgetted incomes and expenditures but with some freedom to make use of surplus income and profits.

Intermediate (mixed) arrangements exist also, e.g. permission to use some part of surplus income and profits for internal purposes. The B-IRSI manager should endeavour to attain at least this last solution in order to stimulate the staff to achieve better financial results.

Whatever the financing mix of the institute, good relations have to be maintained between the financers and the B-IRSI. They can be strengthened by effective publicity activity on the part of the B-IRSI. By circulating promotional publications and substantive reports and through participation of B-IRSI staff in professional life, clients are made aware of the B-IRSI's capabilities.

In addition, it is usually necessary for the B-IRSI itself to initiate contacts by making offers, and by approaching institutions and their representatives. In larger B-IRSIs acquisition of contracts can be decentralized to some extent, so that B-IRSI divisions themselves are made responsible for collecting contracts in sufficient volume. In this respect, division heads must have a certain amount of managerial responsibility.

Such decentralization, however, does not completely relieve the B-IRSI manager from the responsibility to acquire contracts. He should closely monitor the financial position of the B-IRSI divisions and intervene where necessary. In addition, the B-IRSI manager must not be satisfied simply that each Division has sufficient orders. The quality of the orders also counts; quality being taken to mean that the B-IRSI is obtaining the type of orders which it is best equipped to fulfil and which it can execute with maximum efficiency. It is necessary to have orders which in fact yield the B-IRSI income, recognition and an assured future. The policy of a B-IRSI must be oriented towards short-term and long-term achievements.

The SMC industry experiences more seasonal and cyclic fluctuations than most sectors in the modern market economy. It is undesirable that research should also be subjected to such drastic fluctuations. Therefore financing should be reasonably constant: building research proceeds most efficiently when there are no sudden large changes in its level of activity. This can, in practice, probably be best achieved by accepting in principle, and annually updating, say a three to five year rolling budget where the budget is known with certainty for one year ahead and with decreasing precision for the rest of the period. Another mechanism frequently used in the United States is for the institutes to farm out a portion of its research work so that fluctuations can be absorbed in the work that has been farmed out without impacting on the core work.

Research must compete with other activities for funds and manpower and the B-IRSI manager in developing countries must possess the skills to persuade public policy makers and private industry decision makers to give the necessary support to research.

The costing of research projects is sometimes more a matter of convention than a reflection of the actual economics. Direct costs are typically fairly straight forward but associated with any research institute there is a certain amount of overhead which cannot accurately be attributed to any single project. For this and other reasons it may well be in the interest of the institute to accept certain projects at below cost. If the manager of the institute has complete pricing flexibility this should not pose any particular problems since the manager can then arbitrarily elect to price the project below cost. The danger arises when the institute is required to adhere to certain pricing policies and the manager attempts to bend the accounting rules to allow the project to bve accepted below cost. While a certain amount of flexibility may be inherent in the pricing fixing rules, the manager must be vigilant against letting his desire for the project tempt him into violating the rules under which he is required to operate.

The institute manager should always have some ideas for which there is no immediate outside finance available but which he considers essential for the future of the B-IRSI. To be able to carry out such research, the manager should have funds over which he alone disposes. The size of such a fund should be five to ten per cent of the total yearly turnover of the research institute. The B-IRSI can also invite researchers to apply for financing from this fund or it can use part to finance researchers' initiatives. In some cases, it might be prudent to execute some initial research from this fund even if external financing were to be obtainable, simply as a way to safeguard an element of freedom in clarifying the direction of further work and also as a vehicle for presenting in a more effective way the B-IRSI's own initiatives. If such a fund has not yet been introduced into the B-IRSI, the manager should initiate steps to do so. Naturally, when it is in existence, adequate attention must be devoted to its purposeful use.

4.6 Investment policy and new research technologies

B-IRSIs need certain fixed assets in order to be able to function efficiently: land, buildings, testing apparatus, office equipment, etc. Buildings and other facilities should be adaptable to future development.

Most B-IRSIs are engaged in testing materials and components. Suitable equipment is needed for this which can also be deployed for research and development purposes. Testing equipment comprises a wide range of machines, structures, instruments and auxiliary equipment. Some are simple and cheap; others are sophisticated and can be extremely costly. Small testing and quality control laboratories need relatively simple testing equipment enabling the laboratory to test cement, concrete, mortar, bricks, timber, soil. A vast literature is available on testing euqipment including also documentation on very special high-cost equipment.[18/]

Research institutes and quality control, or testing, laboratories usually publish leaflets containing information on their scope, internal structure, staff and equipment. Worldwide registers of specialized expensive equipment in building research organizations have been compiled and published for certain specific areas.[19/20/]

Quality control usually needs some kind of equipment. More labour-intensive procedures for materials testing are appropriate in developing countries. Such is for example the case with timber stress grading; this, however, requires careful training of persons and periodical control of visual stress grading by testing equipment. Reinforced concrete and wood beams can be tested for bending by loading them with e.g. bricks instead of making use of an expensive testing machine.

The laboratory equipment available for building research entails ever spiralling costs. Not even major institutes in large countries can afford to possess the most sophisticated and most costly equipment in every field.

18/ Testing Equipment/Equipement d'essai des matériaux (Draft Recommendation of RILEM 20-TE, 1983, Matériaux et Constructions, Volume 16, No. 92, pp.97-148).

19/ Register of World Large Scale Test Facilities for Building Research (Editors: K. Kamimura, Y. Aoki, M. Nakashima; CIB Publication 75, 1984).

20/ Survey of Laboratories Investigating Aspects of Thermal Comfort (Editor: Dr. L. Bánhidi; CIB Publication 89, 1985).

A sound solution consists in grouping together research institutes of different branches; in this way duplication of equipment can be avoided and institutes which are specialized for particular fields of research can even have very costly equipment. Such "clusters" of research institutes exist in the Soviet Union (Akademgorod), in Japan, in the United States and other countries.

A geographically isolated building research institute, that is not a member of any grouping, has to make a careful choice between the many types of equipment that are available. It is a natural tendency to endeavour to possess some basic laboratories, e.g. in mechanics, acoustics, building physics. When these already exist it becomes a delicate problem to decide in which direction to develop the institute further. A world-wide survey of unique equipment installed in building research institutes, shows that even the duplication of these would involve unrealistically high capital outlays. Some examples of such equipment are cited below:

- Large diameter turbulent wind tunnels (at CSTB Nantes, France);
- Fire testing equipment for large size components, and structures with synchronized loading equipment for rooms or groups of rooms (the National Bureau of Standards, Gaithersburg, Maryland, USA);
- Experimental high-rise building laboratory (Gaz de France, Paris).

Large institutes in a position to look back on a long and notable past (as for example the BRE, United Kingdom) can have excellent and costly equipment in several fields. Institutes which are comparatively new could try to procure unique equipment in just one or two areas. Costly equipment should be installed in the particular fields where there are eminent experts available.

Some laboratories in industrialized countries offer training facilities for those working in laboratories. Research institutes in developing countries may make use of such courses but it is sometimes preferable to offer training within the developing country itself. Though training institutions of industrialized countries are mostly prepared for holding courses in their own country, holding them in developing countries is sometimes possible.

The use of laboratory equipment is different from the use of manufacturing machinery. The latter has permanent staff for exploitation; the former can be operated by permanent staff but according to programmes of different researchers, in their presence and with their contribution. So, for example, mechanical testing machines such as presses, bending machines, etc., can be used at subsequent periods by researchers at first working in concrete then in steel, timber or plastics. Management must ensure that proper priorities are established for using such equipment.

When showing visitors around the research institute, it is the laboratory that usually gets the most attention. Whether it is elaborately or modestly equipped it can serve as a showpiece. It is after all about the only place in a research institute where it is possible to actually see, in the physical sense, the work going on. This function while it should not be allowed to interfere with the more substantive operation of the laboratory, should not be slighted. Whoever is providing the tour, and on the most important occasions it is likely to be the director, would do well to have something interesting to say about the laboratory and the work that goes on there.

5. MANAGEMENT OF RESEARCH PROGRAMMES AND PROJECTS

5.1 Preparation of research programmes; selection of priorities

The operational efficiency of a research organization to a considerable extent depends on its research programme, i.e. research projects already funded and those being developed for funding, as well as the general set of topics to be researched. For any research organization during any period, there exist endless variations of potential programmes. The topics to be selected, their relative importance, their objectives and their implementation are numerous and managers of B-IRSIs must devote much of their attention to establishing programmes.

Decisions may be taken by an individual with or without prior consultations or they can be based on teamwork. Formal analytic methods also may be applied to assist in programme development.

Both the capabilites of the institute, based on potentials of equipment and staff, and the needs of the BMC sector must be considered. The latter include wishes of potential sponsors, financing possiblities for certain activities, as well as opportunities for increasing productivity in the BMC sector through research projects whose contribution may initially be clear only to the management of the institute.

All sorts of different systems are in use in different countries to determine research budgets, decide on projects and programmes, and allocate funds. There do exist some concepts common to nearly all systems.

Projects and programmes emanate to a great extent from the members of the research organizations themselves. To ensure that the projects and programmes so proposed are realistic it is necessary to ensure that the research staff maintain adequate contact with industry and with local and national government.

Cost benefit studies, technological forecasting techniques, market research, and other techniques are employed in many countries to assist in programming. One problem with these techniques is that the data available may be too imprecise to lead to the definitive setting of priorities.

Sometimes industrial and construction companies have difficulty in defining their research needs or are constrained from divulging them due to commercial secrecy or some other reason. In other cases, a lack of inspiration on the part of academics can be observed when asking for proposals for new research. Though such difficulties can be experienced, they are not typical and one can assume that a sufficient number of candidates for research will be presented and the problem lies rather in making the optimum selection from among them. Experience and empiric methods can give satisfactory results; in the case of a great number of competing proposals for research, recourse can be had to more formal methodology. A system of criteria can be defined and this can be used as a checklist when assessing individual proposals.

Typically, many individual projects are sketched and then compared. Selecting or rejecting projects is based on the outcome of the comparisons. Mathematical models may be used when comparing a large number of possible alternatives.

Comparison of two or indeed many projects can be based on one single criterion. If only one criterion is used then the comparisons are relatively easy; they become more complex when several criteria are considered. In most cases it is necessary to take into account several factors. If a project is superior in every aspect to all others, then the selection is easy. In practice this is rarely the case; individual projects may be superior to others when matched against certain criteria, and at the same time be inferior as regards other criteria. In such complex assessment cases, methods have to be used with scoring or rating systems in order to summarize findings for individual criteria. A significant number of such scoring techniques and checklists have been introduced and applied, e.g. publications of the European Industrial Research Management Association EIRMA.[21/22/] Naturally, it is not proposed that scientific methods should be employed in every case but it is advisable to bear them in mind when arriving at decisions on research priorities. Basically, answers should be sought to the following four questions before taking the decisions.

(a) What is the importance of the proposed research subject in the country concerned?
Comment:
The answer to this question has to be evaluated and balanced against the cost of the research.

(b) What are the chances for technical success?
Comment:
Proposals for research projects should be rejected if sufficient probability for their technical success is lacking. This depends on the existence of adequately qualified personnel (researchers and assistants), availability of laboratory equipment, finances, raw materials and components and the scientific chance of success.

(c) What is the likelihood for economic feasibility and practical application?
Comment:
In developing countries, it is important that the results of the research can be applied within the technological and economic constraints of the country. Emphasis on research leading to productivity improvements that are capital saving, do not require too much engineering know-how to apply, make use of locally available materials, and do not effect substantial changes, perceived or real, in the cultural environment are most likely to find immediate application.

21/ European Industrial research Management Association (EIRMA) Working Group Reports: No. 16A - Methods for the Evaluation of R&D Projects (1976); No. 21 - Systems and Methods for Planning Research and Development in Industry (1979); No. 26 - How Much R&D? (1983).

22/ G. Sebestyén, Research priorities for the building materials industries in developing countries (UNIDO/ID/WG.434/6*), 1985.

(d) Is research justified in comparison to imports of products or know-how?
Comment:
Most developing countries do not allow unrestricted access to international markets. Thus, this criteria needs to be addressed in light of actual cost of the imported alternative. In many cases locally developed products, whether research outputs or manufacturing equipment, may be viable alternatives to imports even at cost ratios which would make them very poor buys if unrestricted access to international markets were available.

It is not sufficient to evaluate research projects individually; it is necessary to have an overall strategy on the allocation of research resources. One of the components of such a strategy is staffing policy. It is necessary when evaluating research projects not only to ensure that the overall best use of existing staff is taken into account, but also to ensure that the workplan does in fact at least approximately provide for the full employment of all the resources available to the institute. This includes not only staff but equipment, and perhaps important intangibles such as industry contacts, co-operative agreements with other institutes, governments and universities. Particularly in the case of staff this does not imply that there can be no shifting of researchers and other workers within a reasonable range of activities, but there are limits.

While a certain amount of turnover of staff can be desirable to provide scope for new ideas, the institute should be very caution about terminating researchers who are made redundant by a shift in programme focus. Because the researcher is often required to invest in the development of very specialized skills which are not always easily transferable to the job market outside the research institute, it is normal for them to expect that the institute will provide a substantial degree of employment security. The research institute which is not prepared to do so will find it difficult to recruit staff. Further its staff will be inclined to direct more of their concern to the contribution of their research curricula to its value in the outside job market often at the expense of the institute's own research agenda.

5.2 Management of individual research projects

In addition to selecting research projects for inclusion in an institute's programme, objectives, methods of work, resources, calendar planning and intended output should be defined more in detail. Progress should be reviewed periodically, as far as possible by interviewing the project-leader also. A research project has to be planned at first in more general terms for the selection process and, after its approval, more detailed planning is required. The plan should address itself to the following items:

- Title
- Objectives with target date(s)
- Background and state-of-art survey
- Operations to be carried out with chronological plan
- Equipment and staff required (available and new)
- Necessary co-operation within the institute and with other organizations
- Financial plan (planned or contracted income; expenditures)
- Form and characteristics of report(s) on work carried out.

The above is valid for applied research and/or development projects. In basic research it is usually not possible to define a chronological plan, which includes for example when certain discoveries are expected, instead the period for which funds have been made available should be fixed. Smaller projects can be planned and executed as one single operation: following their approval and commencement, a report on what was achieved should be submitted only at the end of the project. Larger projects should be phased, with professional and financial reviews being imposed at predetermined points.

If the project includes experimental testing, careful thought is necessary as regards the types and number of samples and experiments, because decisions on these may have considerable consequences on the necessary funds, equipment and scheduling. There is extensive literature available on planning experiments. Large projects require particularly careful planning. After research has been completed, the results need to be evaluated. Evaluation usually includes:

- Internal assessment concentrated on scientific and methodological acceptability;
- External assessment by the sponsor to evaluate the acceptability from its own point of view.

5.3 Control of time spent

Two diametrically opposing opinions and strategies exist concerning the recording of time spent in the execution of different tasks:

(a) The length of time needed for research tasks is not in fact predictable and the actual time used up is not really conclusive for assessing efficiency and therefore the administrative process of maintaining records of the time spent on individual tasks should be avoided or kept to a minimum. Periodical personal interviews with researchers reveal more about their work than formal records.

(b) Industrial applied research has become a regular activity. The time required for individual tasks can be planned (within certain limits of accuracy) and as a consequence should also be recorded. Comparison of planned and actual times reveal how effective the work is. Such data can be used for future programming.

The choice of strategy depends on the character and scale of research operations. Tasks within the domain of theoretical research differ from each other more widely than do those related to applied development projects. If the greater part of the work consists in the preparation of measuring equipment, e.g. ascertaining the strength of masonry walls built from stabilized soil blocks or concrete blocks, then the time can be programmed with a fair degree of precision.

In smaller institutes for top management to survey the work of researchers is practical. This is not the case in larger institutes. These larger institutes, therefore, usually apply some kind of time recording. This does not imply that no such recording should be applied in small institutes, but indicates that simpler methods might be called for. An internal regulation usually details the format of time recording.

5.4 Transformation of results into practical applications

Insuring that results of its research efforts are successfully applied in the BMC sector is not the responsibility of the research institute alone, but there is much that it can do. The viability of the institute depends on how well its work serves the building materials and construction industry. If the results are successfully implemented then its work will be perceived as beneficial by industry leaders, government officials and of course the public at large who are the ultimate consumers, albeit usually indirectly, of the research results produced by the institute.

It is important that the institute does what it can to help ensure the successful application of its work. One useful method is to involve the future applier in the research work at early stages. Frequently application is hampered by the fact that the research results are not published in a form that is readily understandable by practitioners. Some researchers are satisfied when their research work is completed and do not feel the need to publish results. Unpublished research, however, has no existence.[23/] Publications by researchers often describe in great detail the process of research which offers little if anything of interest to the practitioner. It is necessary to transform research results into publications concentrating on the aspects of application. This can be done by the researchers themselves, but sometimes persons different from the researchers can perform the task better.

Some significant points on communication and application of research results (as surfaced e.g. some years ago within CIB Working Commission W 54 - Selection and management of research projects) are summzarized below.

Many of the publications of research results in technical journals and in other media is in the wrong style and format to serve as an effective means of communication between research workers and practitioners. There is an excessive tendency for the work to be written up in far greater detail with regard to research techniques, methods and results, and too little emphasis is placed upon identifying the new information or technique which would be of value to the practitioner. The Defect Sheets published by the Building Research Establishment, United Kingdom, are one of the many good examples of simple but practical publications designed to the needs of users.

There is clearly a requirement for a detailed research report by the organization carrying out the work by other research workers who might want to check it, but this type of research report will not always serve the purpose of ensuring that the results and their implications are understood by those in the industry who put them into practice.

A publication can be counterproductive if it creates a kind of false euphoria in which it is assumed that communication has been achieved whereas, in fact, the exact opposite has happened. An example of a published standard

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23/ A. Legros, Le chercheur comme écrivain, ou le devoir de publication (CSTC Brussels, Belgium; paper submitted to the CIB Meeting of Building Research Managers, Bucharest, 1975).

showed that 75 per cent of the people who should have been using this standard were not even aware of its existence, and of those who were aware of it, only 50 per cent followed it, i.e. 12.5 per cent of the whole. Yet the assumption was firmly fixed in people's minds that, the standard having been published, matters had now been put right and there was no need for further effort in that area. There are many other examples of continual recurrence of problems in spite of the fact that their solutions have been published over and over again for many years.

A publication should be made appropriate both in its content and its presentation to the audience to which it is being addressed. This requires a substantial organizational effort to decide to whom the contents are to be addressed, the most appropriate vehicle for doing so, and the most suitable form of the message. This in turn means that research laboratories need to sharpen their professional skills in marketing and publishing to the levels previously thought of as necessary only for commercial organizations. These skills should cover not just the publications but other aids to communication, such as films, audio-visual tapes, slides, training courses, and seminars.

It is vital to try to identify what would motivate the users and to see that this is adequately reflected, not only in the presentation of information, but also in the way in which the actual research programme is conducted, and the sort of data that might be collected. This means that communication of the ultimate results has to be considered at the very early formative stage of the project and, wherever possible, potential users should be brought in at an early stage of the project and kept in touch with the project as it develops. Considerably greater use could also be made of indirect selling activity through such media as television and various programmes which, although of a popular character, could nevertheless, be used to transmit useful information.

Repetition is frequently necessary and if something is not initially understood, a different approach may often give the desired result. It must also be remembered that misunderstandings often arise because of the intrinsic courtesy of people or a wish to appear knowledgeable often leads them to indicate that they have understood something when in reality they have not. Audio-visual aids and simple guide books, making copious use of vernacular language and phrases and simple illustrations, ideally of the cartoon type and based on familiar or local concepts, are particularly effective.

The guidelines outlined above relate to communication and publications by the research institute. It should not be forgotten that other types of IRSIs might take equal or even better care of the research-application interface, for example engineering consulting firms, extension services, vocational-technical schools, and universities. Beyond this there exist the BMC companies, some of whom possess their own research facilities, and have an interest in applying the new technology. They are in an excellent position to know what is the best since they are the ones who convert the technology into its ultimate result, namely improved products and/or lower costs.

A note of caution should be added to the previous statement that what is the best can unequivocally be stated. Underlying this reservation is the fact that the building materials and construction industry has more traditional features than other sectors of industry and therefore human elements play a vital role. A given technical solution is applied successfully by one company and yet it fails for another; this also explains why e.g. in large panel techniques such a great number of competing techniques survive in parallel without any one gaining ascendance over the others (Camus, Coignet, Balency, Larsen-Nielsen, etc. systems).

Education and training for building professionals and technicians is often best achieved in the classroom, and for artisans and operatives by means of on-site workshops in the local environment where the trainees participate actively in the application of the research findings. Particular importance must be attached to regional and local factors especially in areas where transport is limited, expensive or difficult, and where language varies. A sound principle is to take the knowledge to the job rather than trying to bring those for whom the information is intended to a single centre.

Information transfer in a developing country is a much more personal business than in a developed country and therefore good human and personal relations are particularly important. In this connection it is important that B-IRSI staff make clear in their interaction with users that they recognize and respect the user's position and opinions. In some types of training situations the classroom setting is appropriate and in this situation there is the danger that the trainer may assume an air of superiority; this is of course to be avoided. Special classroom techniques are called for to ensure that the respect of the trainer for the trainees is apparent.

Building codes constitute useful transfer tools although even these are no guarantees for application. They are also needed in order to strengthen the formal sector and sometimes to improve the potential for financial assistance especially in low-cost housing.[24/] Research institutes should pay a role in preparing standards.

Direct collaboration of building research organizations with housing financing and development agencies, as well as village and town development committees, all contribute to spreading results. Student participation in research is also a useful way to establish contacts for research. Staff members of companies should be invited to visit research institutes at suitable intervals and/or should be made to feel a sense of involvement in research.

24/ J. Knocke, Elements of research needed for establishing technical building codes enjoying an effective demand in African countries with mixed or marked economies (Proceedings of Ninth CIB Triennial Congress, Stockholm 1983, Volume 5, pp. 93-99).

6. STAFFING AND PERSONNEL POLICIES

Most important resource of a successful research institute is its staff. The recruitment of good staff is easiest when the B-IRSI can offer competitive salaries, up-to-date equipment, and projects which are intellectually stimulating. Institutions in developing countries often encounter difficulties in staffing. The commendable wish to maintain professional standards usually leads to understaffing; this situation, however, is to be preferred to one of overstaffing with personnel who have inadequate qualifications. The difficulties in staffing commonly force these institutions to establish training schemes for the staff. This can take various forms such as in-service training, refresher, or upgrading, courses and study fellowships.

In a number of cases research institutes rely on expatriate specialists to fill some of the key vacancies. Any temporary use of expatriates ought to be tied closely to the recruitment and training of national replacements. This is the best way to avoid serious gaps occurring as expatriates leave.

Various methods have been introduced and are applied by research institutes in developing countries in order to attract and retain qualified staff. Some of these are:

- Use of private industry salary scales in public institutes;
- Inflating ranks;
- Tolerating or encouraging various forms of additional income such as income from teaching, consultancy, publishing, etc.

Despite all efforts, however, turnover of staff may be high, qualified staff members leaving the institute for better paid jobs in government or private industry. While this is frustrating, it does yield some benefits for the institute: highly positioned former research institute staff members can create an atmosphere of goodwill for the institute. Some degree of turnover in the staff is useful.

Staffing and personnel policies comprise:

- Writing job descriptions and classifications;
- Designing compensation and incentive policies;
- Defining employment security and career development policies, and
- Establishing policies for professional development and intellectual fulfillment.

6.1 Qualifications and skills

A given mix of projects would require a staff with certain qualifications. The staff available usually deviates more or less from the one that would be ideally suited for the execution of programmes. In such cases it is a managerial task to decide to what extent it is possible to satisfy needs by moving scientists to new areas of work. This includes human problems and requires tact but sometimes firmness also. Some scientists move easily to new areas of work; others insist on remaining in areas in which they are experienced even if these are no longer so promising and do not attract financial sponsors.

Each research organization should include some members with specialist skills but the majority should have broader industrial or scientific interests. The greater proportion of members should couple their major role - that of carrying out research appropriate to the organization - with a subsidiary role which brings them into contact with other organizations and with the industry.

Inter-desciplinary changes can usually be achieved by most research staff; it is only those with very special research skills that present problems. These latter should, therefore, be restricted to a small proportion of the total. For the rest, major changes in programme balance can be arranged rapidly without staff problems. Technical sub-groups of research organizations should be multi-disciplinary in character, that is project-oriented rather than subject-oriented. For small organizations handling many small projects, matrix management systems are the best way to ensure this. For larger organizations and larger projects, project management teams of a multi-disciplinary character can be more effective.

In some cases there may be only one eminent researcher in a given area. With his/her departure that eminence is lost. To be able to produce valuable results over a longer period, the number of research staff in a given area must lie above a critical value. This ensures continuity, the productive and creative confrontation of ideas, gathering younger, less experienced scientists around the older, more experienced ones. To contribute to the formation of such groups is an important task for the research institute's management.

Researchers in building research institutes have two types of professional qualifications which affect the pattern of their mobility:

(a) Researchers with qualifications within the basic scope of the institute; these are civil engineers, architects, urban planners;

(b) Researchers with other qualifications: mathematicians, physicists, chemists, economists, mechanical and electrical engineers.

Researchers in the first category have a restricted mobility between research institutes; they cannot, or on a limited scale at the most, find a suitable occupation in research institues outside the construction industry. On the other hand they can, without undue difficulty, find attractive offers of employment in the construction industry itself, e.g. with contractors and design practices. This in itself affects their thinking which usually is not too far removed from problems of the construction industry.

6.2 Compensation and motivation policies

In B-IRSIs it is common to make use of an approved list of work spheres. Each sphere is given a name; the required qualifications and other stipulations are described and the salary range for each sphere is defined. Despite its administrative character the content and the application of such a system requires adequate attention first of all by the B-IRSI manager.

In many B-IRSIs a formal hierarchy of researchers is also in use. While the actual titles used for the individual categories may differ, basically the following categories are applied:

- Top researcher/scientist, not necessarily with any managerial tasks; sometimes called scientific counsellors or advisors. This is the highest category reserved for the most outstanding researchers. Only a very small number of staff members receive this prestigious ranking.

- Senior research/scientist for highly qualified and experienced researchers. This like the previous category is applied to persons who are recognized for their expertise and past achievements.

- Researcher/scientist. More junior to the staff members in the previous two categories but nevertheless implies impeccable professional qualifications.

- Research/scientist assistant. This category can be reached by personnel who lack top qualifications but who have given long and outstanding service as well as by young graduates who can commence their careers in this category.

The B-IRSI manager has to introduce the grading system, approve its statutes and supervise its operation. The system must state the stipulations for each category which may comprise such items as age/length of service; qualifications; linguistic knowledge; proof of previous assessed research; publications, etc. For each category the lowest and highest salaries may be defined and it is quite in order for top salaries in the higher categories to exceed the salary of the manager of the unit in which the top scientist is working.

Depending on scientific interest the manager may personally participate in the process of assigning grades or place the system under the supervision of the B-IRSI's top scientist. The application of such grading/ranking systems should be used for the motivation of the researchers. To achieve this, great attention and consistency is required. The impact of the system on internal morale as well as on some further aspects is dealt with in the following.

Earlier studies on institutional infra-structure for industrial development[25/] have stated that the shortage of qualified personnel in developing countries leads to a competition among institutions for the persons they need. This competition stimulates efforts to attract staff from other institutions and to attempts by employees to move to other posts with higher rank and better income.

Regulations preventing transfers except with the approval of some central personnel authority would alleviate these dangers but would create other difficulties by compelling persons to remain in a job against their wishes. Research institutes within the ministerial structure frequently remunerate their staff as civil servants and at civil service rates. This may or may not be attractive, depending on the relative salary and other conditions of service as compared to those prevailing in the private sector. To meet this

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25/ Laurence L. Barber, Institutional infrastructure for industrial development (UNIDO/ICIS.36) 26 July 1977.

challenge, research institutes often try to establish themselves as an autonomous agency. By so doing, they free themselves from civil service salary restrictions and are in the position of being able to offer higher salaries.

The need to pay higher salaries can inflate top ranks for staff if the levels of salaries attached to each rank were to be set outside the institute. This results in a top heavy organization, with too many of the B-IRSI's staff holding top level positions and too few staff in the middle and lower grade levels. This is an undesirable situation. By doing this the institute may end up in having nearly all of the staff in senior ranks which is an undesirable situation.

In addition to their salary scale many B-IRSIs also use a bonus system. This can provide a good incentive for researchers but if its level is too high in relation to basic salaries, it can serve to divert attention away from basic tasks towards those activities yielding high bonuses. A bonus fund can provide the manager with a tool to orient researchers towards high priority projects. Bonus systems should strive for simplicity and assessments should be based not so much on formulae, point systems or special bonus task achievement reports but rather on broad evaluations of the researchers' work by managers. Naturally if bonuses are offered for the completion of tasks by fixed target dates, then it is compliance with these conditions that will be the prime criterion.

Special awards including a financial payment can also be granted to researchers. The main forms which awards can take are:

- Awards for research with a high scientific value; awards of excellence;
- A special category of awards for young researchers;
- Awards for publications;
- Awards or prizes or profit sharing for industrial applications, patents and innovations.

The total number and amount of the awards granted for excellence are usually fixed. Rewards for industrial applications, patents and innovations may depend on results/benefits achieved or expected. In principle, a partnership with industry in these areas is to be recommended including sharing of benefits but care must be taken against animosity arising in deciding the respective shares of research and industry. If the B-IRSI manager is faced with the problem as to whether to introduce such a system, his decision should take account of the consequences on:

- Contacts with industry;
- Income levels of researchers;
- Changes in the motivation of researchers.

Patents play a somewhat more restricted role in the BMC sector than is the case, for example, in telecommunications or bio-engineering. Nevertheless patents and innovations do mark R&D achievements and should be encouraged.

Research institutes sometimes complain that the salaries and incomes of their staff are lower than in industry. This is usually true but real comparisons are difficult and researchers may enjoy certain privileges not necessarily shared by their counterparts in the industry:

- Intellectual satisfaction of scientific research and development work;
- More flexible working hours;
- Social and financial benefits from publications and from participation in domestic and international professional life;
- Continuous updating of knowledge;
- Potentials for outside income; hopes for subsequent higher paid positions in industry.

In some countries, researchers are allowed to complement their salary by other bonuses or income (from consultancy, design work or other sources). While an appropriate income level for institute staff should be ensured, the indirect benefits also should be given adequate attention. The management of a research institute therefore should, for example, try to ensure that the institute's researchers are provided with the up-to-date research equipment. It is the duty of research institute directors to create the type of environment under which those who are assets to the institute, are content to remain there; but also to find ways to remove from the staff those who may have become something of a liability.

6.3 Career development and employee morale

The manager should encourage and support the research and engineering staff to improve its skills, expertise and knowledge. Some mechanisms for this are,

- Individual reading and learning using the institute's library and external sources;
- Meetings at which an institute's researcher or an external lecturer informs participants of new knowledge;
- Courses and training to acquire new knowledge and skills;
- Attending graduate and post-graduate courses and lectures outside the institute.

The status of a research institute naturally depends first of all on its achievements and its capability to produce tangible results. Also, high scientific qualifications and standing of leading scientists of the institute provide a sound basis for a good status image of the institute. This makes it easier for the management to acquire for the institute appropriate tasks and contracts but prestige is no more than the first step and what then really counts, are the results themselves.

Researchers should, moreover, be encouraged to acquire and renew their familiarity with problems of the industry. This can also be achieved through attending meetings and by visits to factories, building sites, company headquarters and branch offices. In some cases researchers could spend several days or even months in factories or on building sites, so as to experience industrial conditions at first hand.

Staff should be encouraged to take part in industrially-oriented associations, committees and meetings. Social interaction is a necessity for a building research institute in order to create contacts with industry and thereby make the research activites part of industrial life. Naturally, interaction has its limits. The primary duty of a research staff is to offer research results of interest to practitioners and be open to industry's problems.

Researchers should also build up good collaboration with agencies in the public sector. It is essential to break down the misunderstanding which tends to exist between research versus government and industrial personnel. An effective means for this is the involvement of research staff on industrial problems in an advisory and consultancy role, even if this means some interruption of research programmes.

Another fruitful course adopted in some countries is the use of research organizations as a linking group to foster collaboration between different parts of the industry in co-operative development and marketing of their separate skills.

Also an effective means that fosters co-operation is the use of research organizations as a source for the collection and dissemination of relevant information to the industry by publications, films and other visual aids, and meetings.

New organizations should gain the trust of industry and government by developing these types of contacts before committing to a long run research programme for the institute. It is better to let the research evolve naturally from this collaboration rather than to try to proceed too rapidly into research. Once industry has come to recognize the understanding of their problem which exists in the research organization they are more likely to have confidence in, and to apply any results which come from it.

When government or industry makes a contract with a research institute, it may pressure the institute or researcher to produce the kind of answers it expects. This undesirable influence can be even stronger when the government agency is the supervisory body for the institute. Researchers should always be objective and resist any forms of partial interference, which it must be admitted, is easier said than done. It is the duty of managers to protect researchers' integrity against such pressures. This is sometimes difficult because of the interests and positions of sponsors. As regards internal contacts between the research managers and researchers, the managers should keep in mind that many of the researchers in their own fields may well be his/her intellectual superior.

APPENDIX

LIST OF SELECTED BUILDING RESEARCH INSTITUTES

A. Forest and Timber Research Institutes

Africa

Côte d'Ivoire	Centre Technique Forestier Tropical, Abidjan
Gabon	Centre Technique Forestier Tropical
Ghana	Forest Products Research Institute, Kumasi
Madagascar	Centre Technique Forestier Tropical, Tananarive
Malawi	Forest Research Institute, Dedza
Nigeria	Forestry Research Institute, Ibadan
Upper Volta	Centre Technique Forestier Tropical, Ouagadougou
Zambia	Forest Products Research Division, Kitwe

Asia

China	Academy of Forestry Sciences, Institute of Wood Industry, Beijing
India	Forest Research Institute and College, Dehra Dun, Uttar Pradesh
Indonesia	Forest Research Institute, Bogor, Java
Malaysia	Forest Research Institute, Kepong
Philippines	Forest Products Research and Development Institute, Los Baños
Thailand	Royal Forest Department, Forest Products Research Division, Bangkok

Latin America

Brazil	Instituto de Pesquisas Tecnologicas do Estado de Sao Paulo, Divisao de Madeiras, Sao Paulo
Venezuela	Laboratorio Nacional de Productos Forestales, Merida

B. Cement Research Institutes

Asia

India	Cement Research Institute of India, New Delhi
Philippines	Cement Institute of the Philippines, Manila

Latin America

Argentina	Instituto del Cemento Portland Argentino, Buenos Aires
Colombia	Instituto Colombiano de Productores de Cemento, Bogotá
Mexico	Instituto Mexicano del Cemento del Concreto, México DF
Paraguay	Instituto Paraguayo del Cemento, Asunción

C. Glass, Brick and Ceramics Research Institutes

Asia

China	Beijing Institute of Glass and Fine Ceramics, Beijing
India	Central Glass and Ceramic Research Institute, Jadavpur University, Calcutta
Indonesia	Ceramic Research and Development Institute, Bandung

D. Materials (Building Materials) Testing Laboratories and Research Institutes

Africa

Benin	Centre National d'Essais et de Recherches des Travaux Publics, Cotonou
Congo	Laboratoire National d'Essais et des Travaux Publics, Brazzaville
Madagascar	Laboratoire National des Travaux Publics et du Bâtiment, Tananarive
Mali	Laboratoire National des Travaux Publics, Bamako
Mauritania	Laboratoire National des Travaux Publics, Nouackhott
Morocco	Laboratoire Public d'Essais et d'Etudes, Casablanca
Tunisia	Laboratoire de Contrôle et de Recherche Industriel, Montfleury

E. Building Research Institutes

Africa

Algeria	Centre National d'Etudes et de Recherches Intgrées du Bâtiment, Cité Nouvelle El Mokrani
Gabon	Centre Expérimental de Recherches et d'Etudes du Bâtiment et des Travaux Publics, Libreville
Ghana	Building and Road Research Institute, Kumasi
Kenya	Building Research Centre, Nairobi
Sudan, Rep.of	Building and Road Research Institute, Khartoum
Zaire	Institut National du Bâtiment et des Travaux Publics, Kinshasa

Asia

China	China Building Technology Development Centre, Beijing
	China Academy of Building Research, Bejing
	Shanghai Research Institute of Building Sciences, Shanghai
India	National Buildings Organisation, New Delhi
	Central Building Research Institute, Roorkee
Korea, Rep.of	Korea Institute for Construction Technology, Seoul
Pakistan	Building Research Station, Karachi
	Building Research Station, Lahore
Turkey	Building Research Institute, Ankara

Latin America

Cuba	Centro Técnico de la Construcción y los Materiales, La Havana
Guatemala	Centro de Investigaciones de Ingeniería, Guatemala
Jamaica	Building Research Institute, Kingston

F. Housing, and Building, Institutes

Africa

Tanzania, United Rep.of	National Housing and Building Research Unit, Dar-es-Salaam
Togo	Centre de la Construction et du Logement, Lomé

Asia

Bangladesh	Housing and Building Research Institute, Dacca
Iran, Islamic Rep.of	Building and Housing Research Centre, Teheran

Latin America

Honduras	Instituto de la Vivienda, Tegucigalpa
Mexico	Instituto de Fondo Nacional de la Vivienda para los Trabajadores, México DF
Nicaragua	Instituto de la Vivienda, Managua
Uruguay	Instituto Nacional de Viviendas Económicas, Montevideo
Venezuela	Instituto Nacional de la Vivienda, Caracas

G. Multisectorial Industrial Technology Research and Development Institutes, with Building Research Unit

Asia

Kuwait	Kuwait Institute for Scientific Research
Thailand	Thailand Institute of Scientific and Technological Research, Bangkok

Latin America

Brazil	Instituto de Pesquisas Tecnológicas do Estado, Sao Paulo

H. Research Institutes with Specific Scope

Asia

India	National Institute of Construction Management and Research, Bombay Structural Engineering Centre, Madras

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QUESTIONNAIRE

Management of industrial research and service institutes in the building materials and construction sector in developing countries

	(please check appropriate box) yes	no
(1) Were the data contained in the study useful?	/_/	/_/
(2) Was the analysis sound?	/_/	/_/
(3) Was the information provided new?	/_/	/_/
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