Building Research in India

Review and Future Trends

Prof. Dinesh Mohan, Director,
and
P. L. DE, Scientist Coordinator,
CENTRAL BUILDING RESEARCH INSTITUTE,
ROORKEE (U.P.)

Introduction

Though building industry has been in existence, in some form or the other, since the advent of civilization, the application of science towards improvement of this industry is more recent in origin. "Building Science" has been recognised as a science only in the present century and research in this field came in only recently. It is little over fifty years since the first building research organisation was established in U.K. This was soon followed up by USSR and thereafter several building research institutes were established in various parts of the world. Most of these have developed, over the years, along lines reflecting changes that have occured in the building industry in each country.

History and Growth of Building Research in India

Systematic research in the field of building science started in India in 1947 with the establishment of a Building Research Unit at Roorkee under the Council of Scientific and Industrial Research. It grew into a National Laboratory in 1951 when it was named as Central Building Research Institute. The initial objective was the improvement of traditional materials and construction methods and to develop new ones. The Institute, therefore, started research in early fifties mainly in the fields of building materials and soil engineering, with only a few Chemists and Civil Engineers. It was however soon realised that, besides materials and construction techniques, building science covers a wide range of other fields like management at site, building equipment, architectural design taking into consideration efficiency of buildings dealing with problems of thermal comfort, lighting, ventilation and acoustics. The need for proper dissemination of useful information and fostering the role of a scientific spirit and outlook in the building industry in India was also felt at this stage. The Institute, therefore, expanded during late fifties and early sixties with the opening of new Divisions of Structural Engineering; Efficiency of Buildings (Building Physics); Building Practice, Plant and Productivity; Architecture and Information. For efficient functioning of these Divisions the Institute recruited qualified engineers, physicists, mechanical engineers, architects and Information Scientists.

These Divisions carried out, during the two decades of fifties and sixties, considerable research and investigations on building materials, engineering and structural aspects of buildings and their foundation, problems of comfort in buildings and their durability. Its activities also included basic research and fundamental studies coming within its purview such as X-ray studies and differential thermal analysis of clays and their electro-chemical and rheological properties, stress and strain in structures. The Institute afforded facilities for training of men for diverse types of construction and helped various construction agencies in adopting new techniques and materials of construction. It also carried out industrial surveys and dissemination of scientific and technical information through a well-organised information service.

Fresh Objectives

In spite of all these, it was realised that till the beginning of the seventies the actual utilisation of the results of research was not to the extent desired, except in a few cases like under-reamed piles, precast building elements, improved bricks, etc. In order to improve the situation and also to cover further developments, the objectives of the Institute were redefined in early 1973 as follows:

- To assist the building industry in solving problems of planning, foundation, materials, design and construction with a view to achieving better comfort, functional efficiency, speed, economy and productivity in building materials.
- To carry out research and investigation into problems of fire in buildings with a view to reducing loss of life and materials.
- To adopt all possible means to bring results of research to the notice of potential users and to ensure through appropriate measures that they find expeditious and efficient application.

Further Expansion

Realising the importance of research into problems of fire in buildings and in view of the colossal loss of money, material and men due to fire hazards, a new Division of Fire Research was added to the Institute in September, 1968, with the appointment of a senior scientist for planning, organising, equipping, and staffing the Division. This Division has grown considerably during the past eight years and is now fully equipped with facilities and expertise, to take up full scale experimentation and research on all problems of fires in buildings.

Research on rural buildings, though started about the same time as the birth of CBRI, was somehow neglected during the sixties when attention was diverted towards urban buildings. However, with the increased emphasis being laid on the development of rural section and greater plan outlays being provided in the Fifth Five Plan for this purpose, systematic research on rural buildings was revived with the creation of a Rural Building Division in 1972. During

the first two years this Division conducted surveys on the present practice and trends with a view to rationalise and improve the traditional materials and methods of construction of rural buildings. Subsequently, it developed two types of construction viz., "Skeleton System" and "Brick Panel System" which have been well received for large scale adoption in rural and in semi-urban areas.

The success of CBRI in developing low-cost construction techniques attracted the attention of several large construction agencies, particularly in the public sector. These agencies were eager to adopt these techniques in a big way with a view to substantially reduce the cost of buildings, specially repetative types like schools, health centres, etc., which were to be constructed in large numbers all over the country. This offered an excellent opportunity to the Institute to get some of its findings implemented in a big way. It was, however, demanded that the Institute should give a large scale demonstration of its low-cost construction techniques. The Government of Uttar Pradesh came forward to entrust the construction of 5000 primary school buildings in rural areas to the CBRI. The Institute took up this challenge and diverted a considerable portion of its manpower to this School Building Project, involving an outlay of the order of Rs. 50 million. It completed the constructions establishing a saving of the order of 20 per cent in cost and 50 per cent in the time of construction. Similarly, for health buildings for U.P. under the World Population Project the Institute has designed and assisted in the construction of a large number of primary health centres, family planning centres sub-centres and allied buildings.

With the successful completion of the two major sponsored projects on school buildings and health buildings the Institute has gained the confidence of many major construction agencies in the public and private sector and they are approaching the Institute for help in demonstrating the new low-cost construction techniques and training their engineers by undertaking a sizeable portion of their construction programme. This has necessitated the creation of a separate Construction Unit which has started functioning towards the end of 1975. The four Extension Cells of the Institute located at Calcutta, Bhopal, Ahmedabad and Delhi, which were set up a few years back have also been put under this Construction Unit.

Present Organization and Management

Thus, the work of the Institute is now organised in 9 Divisions, namely (1) Building Materials, (2) Soil Engineering, (3) Effciency of Buildings (Building Physics), (4) Building Processes, Plant and Productivity, (5) Architecture and Physical Planning, (6) Fire Research, (7) Rural Buildings, (8) Information, Survey and Planning, and (9) Construction and Extension Unit.

The Central Building Research Institute is a national laboratory of the Council of Scientific and Industrial Research and is managed by a Director. In the selection of research projects and framing of annual research programmes, the cooperation of the building and construction agencies is sought. The Institute is guided in this respect by a Scientific Advisory Committee consisting of 17 members representing the industry, profession and construction agencies. This Committee visits the Institute twice a year to have detailed discussion with scientists about the progress of work and future research programmes. The comments and suggestions of the members are further examined by an Executive Committee which looks into other policy matters of the Institute besides the research programme. Modern concepts of management techniques like SWOT analysis, selection of Key Result Areas, allocation of Project Merit Index, Cost-benefit Analysis, etc., are applied in the selection and management of research projects. After the research programme is finalised, the progress on each project is monitored at intervals of 2-3 months. After the completion of a project, necessary follow-up action is taken for early implementation of the results.

Important Achievements

Some achievements of the Institute during the last decade are highlighted here —

Under-reamed Piles for Foundations

Economical and safe foundations in expansive black cotton soil and other poor-bearing soils are achieved by short-bored under-reamed and compacted concrete piles. Already over 40,000 buildings have been constructed on these foundations. Besides giving stable foundations to the buildings, these piles cut down conventional foundation cost by 20 to 50 per cent. Working at an average economy of Rs. 500/- per building, this technique alone has saved the country a sum of Rs. 20 million. The technique of under-reamed pile foundation has now been included in the National Building Code of India as well as in the specifications of CPWD, State PWDs and several other construction agencies. The technique has also been adopted for foundations of transmission line towers, antenna towers, high-rise buildings, etc.

Good Quality Bricks from Inferior Soils

Black cotton soils are not suited for brick making. Bricks moulded from such soils develop cracks during drying and firing and possess very low strength. The Institute has found a solution to this problem where about 20 per cent of 'grog' (partially calcined soil) is added as an opening material. This reduces the plasticity of the soil, prevents cracking of bricks and also improves its strength. Brick kilns, using this techniques, are successfully operating at Indore and Bhopal with the co-operation of the Madhya Pradesh Housing Board and Capital Project Authorities. Several private industries have also adopted the process.

Mechanised Brick Production

Bricks moulded by conventional manual methods are not uniform in quality. Their production is also low. To meet the huge demand for bricks, the Institute has developed a semi-mechanised brick making machine which produces 2,500 bricks per hour. Besides bricks, this machine can also manufacture other forms of structural clay units which are useful for roofing and flooring purposes. These brick plants are being sold commercially by 4 firms in the country and several of these plants have been set up in India. They have also been exported to Nepal and Iran.

Flyash Concrete

Thermal power plants in the country produce very large amounts of flyash which is wasted at the moment.

It is a good pozzolanic material. A study of flyash from different power plants carried out at the Institute has revealed that 20 to 30 per cent of cement can be saved in concrete structures by using flyash concrete. Besides, this could also lead to an overall economy in the cost of concrete. It is estimated that cement to the tune of 2.4 to 3.6 million tonnes can be saved by using flyash. Other processes for the use of flyash developed at the Institute are clay bonded flyash bricks, lime flyash cellular concrete and light weight aggregates from flyash.

Bloated Clay Aggregates

Clays of suitable composition can be bloated for being used in concrete. It makes a lightweight concrete of the same strength as normal concrete. It could prove very useful in areas where natural stone is not available in large quantities and where multi-storeyed buildings are coming up in good numbers. The use of light-weight concrete, will lead to overall economy in the cost of buildings in these areas. The Institute has surveyed several sites in Kanpur, Lucknow, Calcutta, etc. where clays suitable for bloating exist. It has also put up a pilot-cum-demonstration plant at Roorkee for producing bloated clay aggregate.

Solar Water Heater

Solar energy is abundantly available in the country. With a view to utilizing it, the Institute has designed and fabricated solar water heaters for domestic uses and for use in large establishments such as canteens, hospitals, etc. The tests carried out have proved the efficient performance and usefulness of solar water heaters. Domestic solar water heaters designed by the Institute are now being commercially manufactured in the country.

Prefabricated Building Components

Roofs constitute nearly 25 per cent of the cost of buildings. They also consume two of the scarce materials namely steel and cement. Furthermore, roofs and floors constructed by in-situ conventional methods consume lot of time. Prefabricated roofing/flooring elements on the other hand can help to save both time and money. The Institute has designed and developed a number of prefabricated roofing and flooring units which lead to economy in cost and time. Besides, they consume less cement and steel as compared to conventional R.C.C. slabs. These prefabricated roofing schemes have been adopted in several large projects in Bhopal, Delhi, Ahmedabad and other places.

The Institute has also developed a prefabricated brick panel system for low cost housing. The wall panels are unreinforced with only lifting hooks at the end but the roof panels are nominally reinforced. The system has been used by the U.P. Rural Engineering Department for constructing 14 single roomed demonstration houses in villages under the State Government Schedule Caste/Scheduled Tribes Housing Scheme. About 1500 houses with this system are being put up by the Ghaziabad Improvement Trust. It provides a very economical and speedy system of construction.

Another system of prefabrication (Holopan System) was developed for housing. It is a concrete frame and cored rectangular filler type unit of construction. There are only five different types of precast elements in the system. It was adopted by U.P. P.W.D. for constructing 128 industrial labour houses at Ghaziabad in double storeyed blocks.

A low cost housing scheme incorporating several C.B.R.I. processes has been completed at Ahmedabad for the Gujarat Housing Board. 216 houses, one primary school and a block of 6 shops were constructed by the Institute. Compared to conventional methods about 23 per cent reduction in construction cost was achieved.

School Buildings

With the increase in population of school going children, educational activities in the country are also increasing. This requires a very large number of school buildings. A scientific study on the utilization of spaces in conventional primary school buildings was carried out by the Institute. It has shown that an economy upto 40 per cent in space requirements can be effected by using improved plans and suitable adjustment of the time-table. The Institute has constituted Development Groups on Educational Buildings in various States and its scientists are working in close cooperation with these groups with a view to bringing down the cost of construction of school buildings. The Institute has put up 2,500 primary school buildings in rural areas of U.P. as a large demonstration project. By extensive use of prefabrication and rationalised specifications a substantial economy in cost and time has been achieved over traditional designs.

Daylight Illumination in Buildings

The Institute has developed methods by which daylight availability in buildings, based on Indian clear sky conditions can be predicted. Ready reckoners have also been prepared for the use of architects and engineers. On behalf of UNESCO, studies have been carried out in the countries of the South East Asian Region for daylighting of school buildings.

Skeleton System

Greater stress is being laid on housing for the economically weaker section of the society under the rural development programme. Since most of housing schemes for such people envisage the use of aided self-help, the concept of construction in stages with durable support and roof in the form of skeleton is more suitable. The concrete skeleton system consists of precast pocket footing, hollow column, beams, joists and D.C. tiles.

The system was adopted for construction of 42 houses with a room, kitchen and verandah in Karimnagar district of Andhra Pradesh.

Stone Masonry Blocks

A scheme of producing precast stone masonry blocks of 30 cm x 20 cm x 15 cm using stones upto 12 cm size and lean cement concrete mix has been developed at the Institute. These blocks have one face with stone texture and weight about 21 kg. These can be easily produced at factory or at site in timber or steel moulds with ordinary labour. This technique has been adopted by the Delhi Development Authority for 26 Janta Houses; by the U.P. Housing Board for 28 EWS houses; by the A.P. Police Housing Corporation for 40 houses.

Waterproofing of Mud Walls

Mud walls are common feature in rural houses

and a number of them get eroded and a few even fall down during rains every year. The Institute has worked out an effective and economical method of waterproofing of the existing mudwalls in villages. It consists of a bitumen based composition which can be sprayed on mud walls with the help of a manually operated sprayer.

Fire Retardant Treatment of Thatch

A soaking treatment with a mixture of salts of the type used as fertilizers has been developed for rendering thatch used in rural houses, fire-retardant. Another spray coat of water-resistant paint is applied to prevent leaching out of the first treatment and provide resistance to rains.

Diaphragm Walling for Foundations

A full scale trial on diaphragm walling using a simple jetting technique developed by the Institute was carried out recently on the Sarda Sahayak Project in U. P. A reniforced concrete diaphragm wall, 70 m long, 8 m deep and 20 cm wide was put down in the ground successfully. The technique effected a saving on sheet-steel piles which have to be sometimes imported.

Single Stack System of Plumbing

The conventional two pipes system with anti-siphonage pipe consumes much labour and material. A single stack system of plumbing which needs no anti-siphonage and does away with separate drainage for w. c. and kitchen has been introduced in the National Building Code as a result of intensive studies by CBRI.

Current research activities

The Institute has at present 128 research projects in hand out of which 22 are sponsored by the industry. The disciplinewise break-up of the projects is as follows:

Building Materials	33
Soil Engineering	24
Efficiency of Buildings (Building Physics)	18
Building Processes	16
Architecture and Physics Planning	11
Fire Research	10
Rural Buildings	7
Inter disciplinary	9
TOTAL	128

The research results are published in the form of research papers in Indian and foreign journals while the new ideas of design, construction techniques and materials are popularised through Data Sheets, Building Digests, Building Materials Notes and Technical Notes published by the Institute. Advance summaries of papers sent for publication are brought out in the quarterly CBRI Abstracts.

Services to the building industry

Besides undertaking sponsored projects, the Institute renders testing and consultancy services to the industry and construction agencies. The newly started Construction Unit and the four Extension Cells (Ahmedabad, Bhopal, Calcutta and Delhi) attached to it are particularly geared to undertake sizeable demonstrations for the construction departments in the public as well as private sectors and to train their field staff and engineers in the adoption of new techniques. The Institute maintains excellent Information, Documentation, Reprography and Library Services not only to serve the scientists of the Institute but to extend it to the Industry. Training facilities are also provided to nominees from the industry as well as students and teachers from technical institutions.

Future Trends

Out of the total plan outlay of over 53,000 crore rupees in the Fifth Five Year Plan about 4,600 crore rupees will be spent on housing alone. Besides this, huge amounts will be spent on other types of buildings like educational buildings, storage buildings, etc. It can be roughly estimated that out of the total plan outlay about half goes to constructions of one type of building or the other. Particular stress is being given in the Fifth Five Year Plan towards rural housing. Building Research must, therefore, of necessity, be concerned with the problems which are expected to be of interest to the industry and the users even ten to fifteen years hence. With this end in view, a perspective plan for research at the Institute for the next ten years has been formulated after discussions with experts comprising architects, engineers and builders. The areas of study are broadly classified into: Environmental Research, Materials and Fire Research and Engineering Research.

Under Environmental Research major projects will deal with the influence of environmental conditions on the thermal sensation of human being and utilisation of solar energy. Studies will also include spaces and their inter-relationship in residential buildings, modular coordination and building bye-laws. Urban planning studies will include formulation of density patterns and land use pattern of new housing developments.

Under Materials Research a wide range of materials will be covered with the main objective of improving the quality and productivity of conventional materials and developing new ones. Special emphasis will be given to the development of light weight materials, utilisation of agricultural and industrial wastes and use of plastics.

Fire Research will be considerably strengthened with the installation of large furnaces for testing full scale building components.

Engineering Research will include major projects on soil-structure interaction, soil anchors, chemical grouting, industrialised building techniques, cellular and lightweight concrete construction, method studies on building operations and various types of rural construction.

Alongside with the development of research activities, auxillary scientific services like Extension, large size demonstrations, Information and Survey, Industrial Liaison, etc., and general technical services like workshop facilities, procurement of equipment and stores, will have to be expanded to meet the increased need of the scientists and to realise better and quicker utilisation of the results of research for the benefit of the Nation.