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CONSIDERATIONS IN PLANNING AND LAY-OUT OF CENTRES FOR INDUSTRIAL RESEARCH AND DEVELOPMENT 1/

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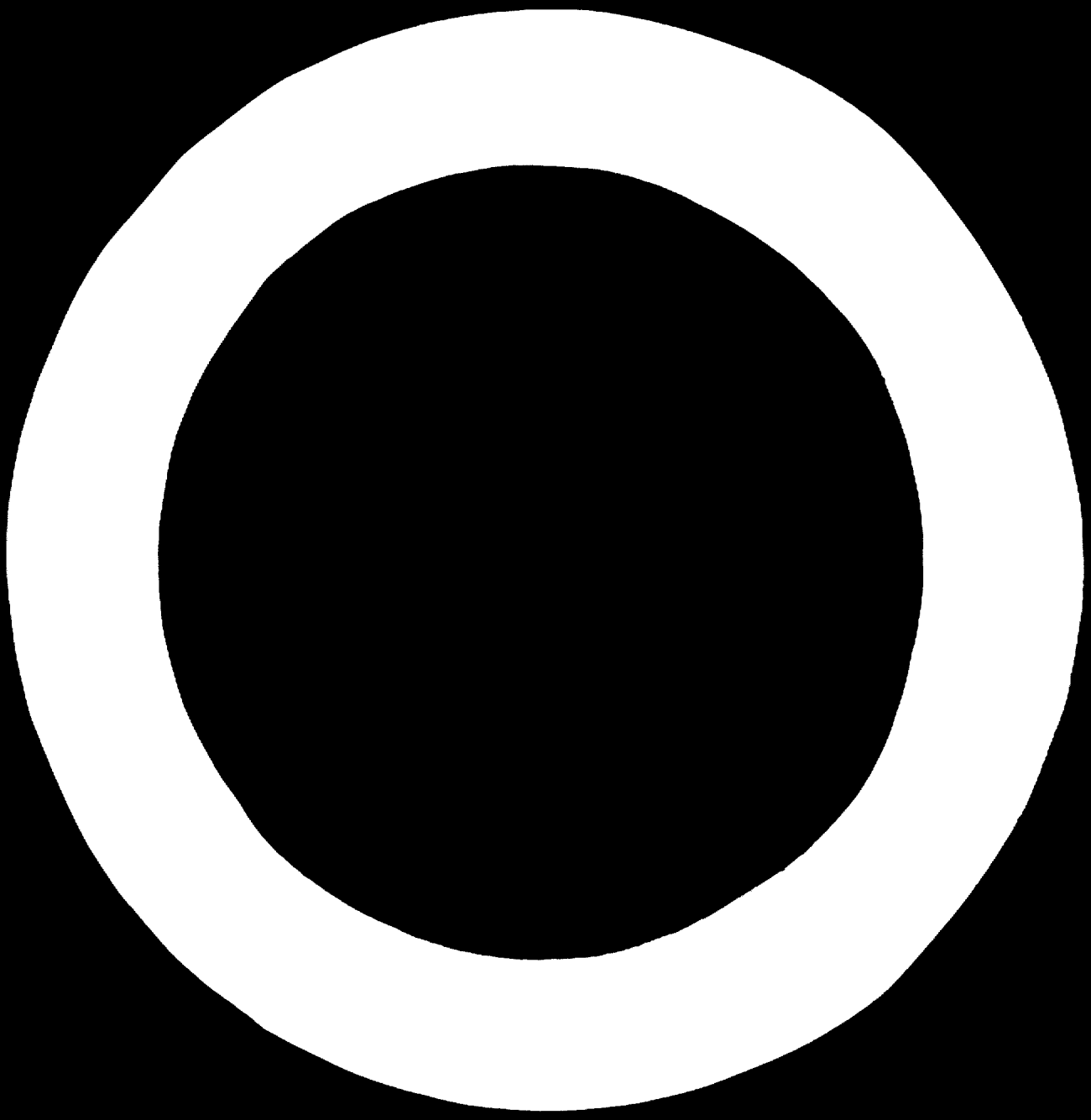


0 PREAMBLE

Planning and layout of Centres for Industrial R & D is a complex activity involving several considerations which have to be simultaneously taken into account. The extent of complexity is also influenced by the size of the R & D establishment and the nature of industrial activities to which it is related. It is therefore even more difficult than in the case of normal buildings to lay down a common system for all types of Industrial R & D Centres; each has to be considered in its own environment and situations and appropriate answers arrived at. There are however some general principles or considerations which influence major decisions relating to planning and layout of Industrial R & D Centres notwithstanding their individual specialities or variations and the attempt here is to focus attention on some of these common principles or considerations.

1 INTERRELATION BETWEEN THE MANAGEMENT SYSTEM AND PLANNING AND LAYOUT OF BUILDING

The most important consideration is to correlate the planning and layout of the building with the system of management proposed to be adopted. It is not uncommon to find this aspect totally forgotten with the result that the building layout dictates, to a large extent, the nature of management system to be adopted in an Industrial R & D Centre. It needs hardly any emphasis that R & D being the business of these centres, any management system should be such as to secure the maximum possible returns in the form of R & D results in the minimum possible time consuming the minimum possible resources. The planning and layout of Industrial R & D Centres would have to suit such a management system.

1.1 Matrix Management and Its Influence on Layout

Neither the traditional vertical bureaucratic structure suited to general administration nor the totally horizontal structure suited to fundamental and basic research work

would generally be suitable for Industrial R & D. The trend in recent years has been team work and multi-disciplinary approach leading to a system of Matrix structure for R & D Management. In this system, the infrastructure comprising R & D talent, R & D equipment, space and environment, technical and general services and management controls form the infrastructural part while the R & D operational teams and technology transfer groups form the output part. The balanced integration of the infrastructural inputs towards objective fulfilment is the main task of the management. Conceptually, therefore, there are no divisions, departments or sections as encountered in the conventional type, which have a tendency to act as sub-institutions under the main institution. The planning and layout of the building therefore has, as its basis, an integrated approach towards avoiding the creation of visible and marked geographical boundaries for the main divisions or departments.

1.2 R & D Equipment as Common Facility

The integrated approach leads to the concept of treating R & D equipment as a library of equipment available for use by all and not parts of demarcated divisions of the institute. The building layout therefore provides for installation, operation and use of the equipment on this basis, and in a manner which leads to cogent classification.

1.3 Centralization of Materials Management and Workshop Facilities

Services, such as procurement, stores and workshop need special attention to ensure that they function efficiently within the framework of the management system and the planning and layout of the building should ensure this. For example, if the layout provides for four or five main stores distributed in different locations in the building, a coordinated functioning of the stores activity will be handicapped because it would either require as many storekeepers as the number of store-rooms or the working hours of each store room will have to be restricted. Similar is the situation with workshop. The planning and building layout in Industrial R & D Centres has therefore to take this also into account.

1.4 Open System v/s Closed System

Yet another important consideration in the planning and layout of Industrial R & D centres is whether the organization proposes to adopt the open system, the semi-open system or the closed system in the seating of its employees. It is well known that an open system is a more progressive one and is being adopted by more and more organizations in view of the great advantages offered by continuous visual connections amongst the staff. But in situations where the communication systems have not developed enough to permit softness in speaking or the social practices do not permit quiet transactions so essential for an open system, the building layout will have to provide for a closed system. In most developing countries, it appears, an optimum combination of the two leading to a semi-open system, is most advantageous. Whatever the system, the layout should simultaneously ensure maximum visual connection, opportunities for frequent interaction between all levels of staff engaged in similar activities and at the same time an atmosphere round the scientists conducive to creative activity.

1.5 Environment or Climate for R & D

Every R & D organization has to give close attention to the environment and climate in which the R & D personnel are to pursue their endeavours. There are two distinct aspects of the environment and climate - one relates to the environment and climate of the organization as engendered by the attitudes and behavioural pattern of those above, below and horizontal in level to a worker; the other is the physical environment and climate. It is the direct responsibility of the managers of R & D to ensure the former, that is, the environment and climate in the management structure of the organization are conducive to healthy progress in R & D. The latter is to be secured by those in charge of building planning and layout; it also includes landscaping and horticulture and their subsequent maintenance. R & D, when sincerely pursued, is a mentally strenuous job which is why the environment and climate should be comfortable, soothing and conducive to revitalization of thinking processes. A number of studies have shown that even in manual, physical or mechanical jobs, the environment and climate in which one

works has direct relation with one's productivity. That being the case, the importance of proper environment and climate to a mentally taxing occupation like R & D should be considerably more so.

2 INCORPORATING FLEXIBILITY IN LAYOUT AT REASONABLE COST

In any dynamic and progressive R&D organization, changes will and must take place. If the layout of the building does not incorporate enough flexibility to permit these changes, the very natural growth and progress of the organization will suffer as a result of the restraints imposed by the building layout. Flexibility in the layout could mean additional cost and therefore considerable care has to be exercised to ensure that the advantages secured in terms of flexibility are worth the additional expenditure incurred in securing the flexibility. In fact, the ingenuity of the designer lies in giving a building layout with maximum possible flexibility at minimum possible additional expenditure. Some aspects of these changes are indicated in brief in the following paragraphs.

2.1 Dynamic Progress in R & D Necessitates Changes

Dynamism is a sign of progress. In any progressive Industrial R & D Organization, changes become necessary in view of the dynamism in the thinking processes of the R & D personnel involved. Since R & D men are essentially men of creativity, what an individual or a group of individuals might have considered as the best solution in a given situation might be considered by another individual or group of individuals as needing modifications, improvements or changes. As such, dynamic changes should be treated as part of the culture of the creative men involved. Those who are responsible for the planning and layout of R & D Centres should give consideration to the thoughts of not only the present individuals involved in the planning processes but also of the possibilities of another set of creative men thinking differently. This calls for an understanding in depth of the situations by the planner or designer of the building.

2.2 Changes with Time

Whilst the changes necessitated by differences in thinking of groups of creative individuals and dynamism have been as mentioned in 2.1, time factor is another which considerably influences the changes. In spite of the best thinking and exercise that may go into the finalisation of a plan or layout at the commencement of the construction of a building even before the building gets completed, it is not uncommon to find that needs for changes come up. These are the changes caused by time inasmuch as the need for them became evident in the time that elapsed between the starting and the completion of the building.

2.3 Changes Due To Technological Evolution

At the pace at which science and technology are advancing, we see how fast technologies become obsolescent. While it is true that no one can precisely predict the shape of things to come, a prudent planner or designer of an R & D Centre should take into account the fact that advancement in technology is bound to lead to changes. Accordingly, he should tailor his planning and layout providing for reasonably good foundations for the growth of the R & D Centre despite changing technologies.

2.4 Changes Flowing From Social And Economic Changes

After all, an R & D Organization is part of the society in which it functions notwithstanding its involvement with any particular industry or encompassment by any technology. For the same type of industry, for providing the same technological support, the organization of an R & D Centre in one type of socio-economic environment would have to be different from that of another socio-economic environment. This being easy to appreciate, the same concept could be extended to appreciate the changes needed in a given R & D Centre with changes in its own socio-economic environment. If changes are called for within the organization, the planning and layout of the building would have to adequately provide for for them.

3 CAMPUS SYSTEM vs SINGLE BLOCK SYSTEM

Given the objectives which have to be fulfilled by an Industrial R & D Centre, one of the early questions which the planner or designer has to face or solve is whether the building planning and layout for that Centre should be on the basis of a spread-out system which can be termed as 'Campus System' or on the basis of a concentrated system which can be called the 'Single Block System'. Here, the nature of activities as well as the type of management will influence the decision. Notwithstanding the extent of land available to an Industrial R & D Centre and its low cost, one would find that in modern Industrial R&D Centres the Single Block System is preferable unless functional considerations necessitate the spread-out system. For example, in an Industrial R & D Centre, which has hazards of radio-activity, it will be quite logical and rational to separate an activity from the rest. Similarly, activities with inherent hazards should be segregated from the rest. There can be many such cases where functional separation of certain activities would be a positive imperative. There could also be technical considerations, such as the heaviness of equipment used in an Industrial R & D Centre which would make a ground floor system or at the most one more floor preferable to making heavy floors on multi-storey basis. In general, the more the spread-out the more expensive the services will become. One has therefore to balance all aspects in arriving at a layout most suited to a given situation. For example, one of the largest Industrial R & D Centres in India, the Cement Research Institute of India, after a detailed exercise, came to the conclusion that a combination of the two systems resulting in 11 blocks, most of them of two storeys integrated by suitable connections in the form of open or closed corridors, would be the ideal solution.

4 PLANNED AND UNPLANNED EXPANSION

However generous one's planning might be, Parkinson's law holds sway, that is, there is always an expansion. An Industrial R & D Centre is no exception to this. A prudent planner or designer of an Industrial R & D

Centre building has therefore to appreciate that notwithstanding his client's feeling of adequacy of a certain size of the building, his sucessors would find need for expansion. The original planning could be such as to accommodate a necessary expansion with no infructuous expenditure. The most important requirement of such an expansion is that it should not, on the one hand, disturb the normal functioning of the existing unit and at the same time integrate smoothly with the already existing unit to give the sense of a whole. In other words, like a drop of water which is a whole by itself and can mix with another to again give a whole, a planned expansion should have an effect of wholeness at all stages. Such expansions could be planned or unplanned. The planned ones could be those which are foreseen and provided for. The unplanned ones should cater to the possibilities of future manager adding to what exists at that stage without having been provided for in the planned expansion. The layout of the Cement Research Inscitute of India given in Figure 1 will bring out how such future expansions have been provided for.

5 MULTIPURPOSING INVESTMENTS FOR BETTER RETURNS

5.1: One of the common problems faced in Industrial R & D Centres relates to creation of certain facilities which involve large investments. The R & D objectives and the objectives of those who manage the R & D, demand that such facilities be created even though they may involve substantial investments. But, on the other hand, anyone who has consideration for investment looks at it as a large investment being made for creating a facility which might be used infrequently - may be once in a year or once in two years, once in a quarter, or at the most once in a month. It is here that a considerable amount of interaction between all those who are interested in the development of an R & D Centre is required. One has to basically examine whether these very investments cannot be made multipurposed. For example, the same space can be used by different disciplines for different activities if it is so planned and designed from the very beginning. Similarly, certain facilities can be so designed that with a slightly additional investment they become multi-purposed, saving thereby additional investment of over several times. A typical example of this is the multi-purpose Heavy Test Block provided in the Cement Research Institute of India. This Hall is 20 x 70 metres with a height to the ceiling

of 10 metres, and with an overhead crane of 10 tonnes capacity moving the entire length of the floor. The floor itself is made of a heavy box girder capable of taking a load of 50 T/m^2 or 100 tonnes concentrated load at any point. Reaction point holes have been provided in the floor on a module basis. This Block is annexed to three of the engineering blocks making it possible for any of these blocks to feel that the space belongs to it - the space really is a part of it as long as it has an use for it. The floor can be used for installing plant and machinery under test or structures under test. Two more features which have been incorporated in this multi-purpose test arrangement are -

(a) A vertical reaction wall which is integrated with the test floor thereby transmitting the entire horizontal reaction to the test floor, and this has saved considerable cost while providing very convenient facility for large-scale horizontal loading, such as those of earthquakes, wind, water or earth pressure. The wall has also been provided with reaction point holes to a module.

(b) The box itself has been so designed that its inner dimensions are convenient enough to provide working space. These inner box spaces which are tunnel-like are used for various activities; one of these tunnels has, in fact, been widened at the very preliminary design stage resulting in a very convenient area for putting up a long line pretensioning bed for precast concrete work. Here again, the pretensioning bed, if separately constructed, would have involved substantial investment. But, by using the very floor as the reaction frame, a pretensioning bed has been achieved at a fractional cost of an independent pretensioning bed. These arrangements are illustrated in Figure 4. Any number of such examples can be given. In fact, multi-purpose use of space is not new in the design of school buildings, especially in developing countries. From these, one can appreciate the importance of making investments multi-purposed so as to get better returns from them. Even if such multi-purposing slightly increases the investment, the returns would be worthwhile in terms of their manifold increased usage.

5.2: Where the frequency of use is not much, one should consider first whether it is at

all necessary to invest in such a facility. If such a facility is available conveniently elsewhere, it would be best to utilize it from there. In many developing countries, however, an awkward dilemma is faced where provision of a certain facility is rather expensive and not to have the facility is retrograde. It is here that multipurposing should receive close attention.

6 LABORATORY SERVICES

Cold water, hot water, drainage, electricity for light loads and electricity for heavy loads, gas, vacuum, compressed air and steam are some of the services normally met with in Industrial R & D Centres. Sometimes, these services are provided just for the satisfaction of being able to claim that all possible services have been provided. However, considerable amount of thinking has to go into each one of them. For example, one could argue that various points in the Laboratory have to be used for analytical work and therefore they need supply of gas; a basic question which has to be asked in such situations is whether the user areas should be diffused or is it possible to concentrate them into one area so that the gas service is confined to that area. So could the other services be examined. Thus, the planning and layout of the building will also be influenced by the nature of services demanded and their points of use. Once the use of the facilities is concentrated and confined to the minimum number of points possible, the rest of the details could be worked out on the normal engineering principles leading to most economical positioning of the respective plants and a convenient and economic distribution system. Figure 1 also illustrates the layout of some of these services which have been provided in the Cement Research Institute of India.

7 SPECIAL CONSIDERATIONS FOR DIFFERENT FACETS OF ACTIVITY

Apart from the general considerations in planning and layout for Centres for Industrial R & D discussed hitherto, certain special considerations are necessary in regard to some specific functions. These are briefly discussed below, as also illustrated in Figures 1 to 6 with reference to the Cement Research Institute of India.

7.1 Industrial and Technological Research

There are two concepts generally prevalent,

one where the main scientific staff are separated from the equipment facilities and the operators; and the other where the two are integrated. In the former system, scientists of different disciplines can have a good faculty interaction if they were to be grouped together. But, in most Industrial R & D Centres, interaction along the line in the vertical sense is found to be more important than in the horizontal direction because horizontal interaction is in anycase caused by the other management processes and activities. This would lead to equipment facilities, operators and scientists to be located together. The planning and the layout of the building in such cases have to ensure an integrated layout. However, care is to be taken at the same time to ensure that the scientists and technologists are provided enough space free from noise and other disturbances so that their intellectual work is not impaired in spite of their being in the midst of their men and equipment.

7.2 Pilot Plants

Pilot plants have different definitions in different situations. The term derives from the fact that a laboratory study brings out results to be tried out on a small scale before being put on a full-scale plant. But today many plants, which are not precisely pilot plants but carry out only mini unit-operations or are mini-plants, are called pilot plants. Mini-plants, which are used essentially as an R & D equipment, not the plants proper, are also called pilot plants. The location and the system to be adopted for pilot plants cannot be generalised because of their very specialised nature. There are pilot plants in Industrial R & D which are almost manufacturing factories by themselves; there are, on the other hand, pilot plants which are no more than laboratory equipment comparable to other equipment. The two need entirely different philosophies in regard to building layout considerations. For all pilot plants, which are similar in nature to the R & D equipment within the laboratory, substantially the same yardsticks as applicable to the latter can be applied. Pilot plants, which are on a large-scale manufacturing basis, should preferably be separated as a subsidiary activity of the R & D Centre and treated accordingly in respect of planning and layout as well

as in management.

7.3 Demonstration Operations

Demonstration operations could be with reference to R & D experimentation, small pilot plants or large pilot plants. Sometimes, large-scale testing also may involve demonstration where a large number of people may assemble. In the case of each R & D activity involved, a master question has to be asked, viz, whether the activity could at any time have to be demonstrated to a group of persons. If so, within the framework of the layout, the space around such equipment incidental to such activity should be able to conveniently accommodate observers to stand or sit during demonstrations.

7.4 Industrial Information and Documentation Activity

Information is becoming more and more a creative explosion. It is being increasingly realised that an efficient and competent Industrial Information Service can often provide the industry greater service than a whole R&D Centre. Industrial information and documentation activity is no more a mere library activity of issuing books and taking them back. Information science has to be recognised as a science in its own right and the building layout should provide for not only a library and reading room but also for information science activities. These include documentation, abstracting, reprography, micro-filming, micro film reading, computer service and so on. Certain countries have national standards for library building and related infrastructures. For instance, there is an Indian standard code of practice relating to primary elements in the design of library buildings (IS: 1553-1960). There is also a specification for library furniture and fittings (IS: 1829-1961) besides a code of practice for library lighting (IS: 2672-1966). Such standards form useful guides for the functional design of these facilities. The relative extents of counter space, storage space, retrieval arrangements and reading space will depend on the nature of activity in the Industrial R & D Centre and the nature of usage of the industrial information service.

7.5 Conference Hall and Meeting Rooms

Here again, the main aim must be to make

them multipurposed as far as possible. In fact, display areas or museum activities of an R & D Centre could be combined with conference or meeting areas. If an R & D Centre has training as part of its regular programme and training courses are to be conducted throughout the year on a regular basis, provision will have to be made for regular lecture halls. Such lecture halls, meeting rooms and conference halls should be viewed together to make them, as far as possible, interchangeable and multipurposed. At the same time, they should be enough to cater to possible simultaneous activities.

7.6 Records

An Industrial R & D Centre broadly deals with the following four types of records -

(a) Personnel records
(b) Financial records
(c) Technical records
(d) General affairs records

In addition, sometimes there may be separate records relating to materials management and workshops, they being the major services, and other technical services.

The volume of records would depend upon the size of the activities involved. But, under normal circumstances, records relating to technical activities would be several times more voluminous than those relating to other aspects. Thus, centralisation of records could be viewed essentially with reference to the technical records and to conceive it as a part of industrial information activity would appear to be most rational.

7.7 Reception and Telephone Exchange and General Offices

A view of the Reception and Telephone Board in the Cement Research Institute of India is illustrated in Figure 2. Purposefulness, warmth, pleasantness and efficiency should mark the layout of the reception.

Every Industrial R & D Centre has to deal with general activities, such as Administration, Finance & Accounts and General Affairs. Provision of space for these and the planning and designing of areas for them could substantially be on the

same lines as for other organisations of the same type with one proviso that, as far as possible, these functions should not interfere or disturb the pursuit of the main R & D activities.

7.8 Workshops

The size and nature of the workshops in an Industrial R & D Centre will depend entirely on the nature of activity of the Centre and the workshop facilities available to it from outside sources. The workshops would have to conform to the regulations of the local authority. In general, it is desirable to conceive workshops as an ancillary unit unless the nature of industrial R & D is such that it gets integrated with the workshop activity.

7.9 Toilets

Standard norms exist in many countries for provision of toilets in relation to the number of users. But, quite often, in the planning and layout of Industrial R & D Centres, the decision on toilets cannot be taken in precisely the same manner as for certain other types of office, public or community buildings. The working convenience in each area has to be studied, as also the number of people involved and their location kept in view before a final decision is taken in regard to toilets. Mention may be made here of the Indian standard code of basic requirements for water supply, drainage and sanitation (IS: 1172-1971) which, among other things, lays down norms for the provision of toilets.

7.10 Social Welfare Activity

Many R & D Centres incorporate canteen as a part of their building complex. A new idea is now emerging in favour of a separate Social Welfare Block which provides for catering, recreational and guest house activities. The Cement Research Institute of India is adopting this idea. From the central catering service, a subsidiary canteen arrangement within the main building will enable serving the personnel in the Industrial R & D Centre during mid-day

lunch. The size of the catering arrangement - whether it be the main one in the Social Welfare Block or the secondary one in the Main Block - will depend on several parameters and cannot be generalised. Facilities in the neighbourhood, nearness or otherwise of the employees' residences, social customs and habits and the efficiency of catering service will all determine the size of the canteen to be provided.

7.11 Storage

One of the commonly forgotten needs is storage space, that is, space for storing the inputs meant for the R & D Centre, the samples received, those under processing and those which are finally disposed of. The nature of materials and the quantum of samples will depend upon the nature of the R & D Centre's activities. Irrespective of the magnitude, a system for storage is called for. If the material to be handled is not messy and it is small in quantity, a series of lockers or cupboards will do. Otherwise, as is common with most engineering oriented Industrial R & D Centres, special attention to receiving, handling and storage of materials as well as disposal of tested materials is called for. A liberal storage space is an important constituent in the good planning of an R & D Centre.

7.12 Safety

Depending on the nature of activities carried on, Industrial R & D Centres will have areas of hazards - radioactive, fire, chemical, mechanical, electrical, environmental and so on. Safety practices, as laid down in the relevant standards and statutes, and enforced by the local authority should be followed.

8 CASE STUDY OF THE CEMENT RESEARCH INSTITUTE OF INDIA

In order to illustrate the foregoing principles, the Cement Research Institute of India, one of the largest Industrial R & D Centres in India, is taken for case study. The details are self-explanatory from the following:

(i) Site Plan of the Cement Research Institute of India including indication of some of the services (Figure 1)

(ii) Ground Floor Layout Plan of the Cement Research Institute of India (Figure 2)

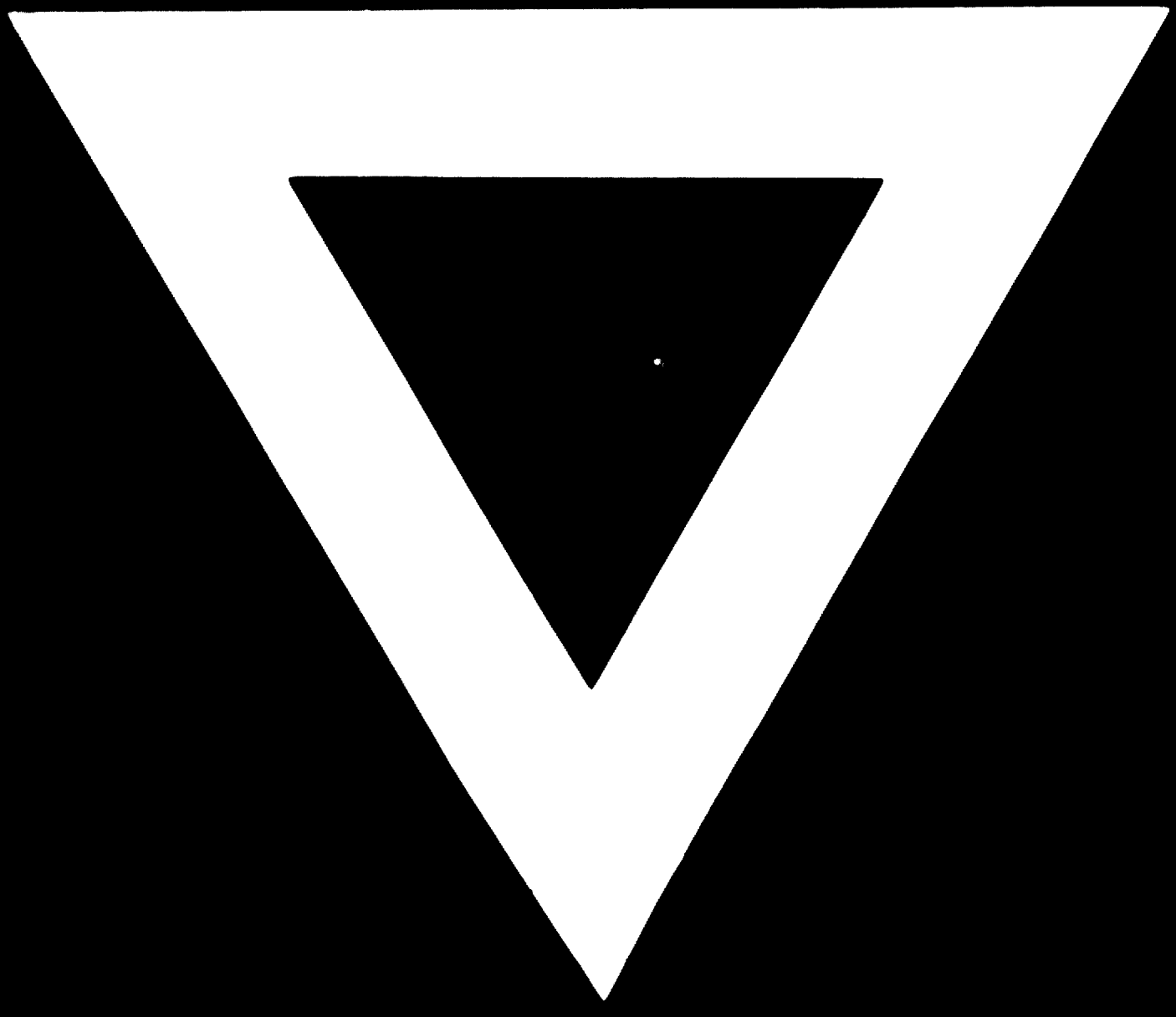
(iii) First Floor Layout Plan of the Cement Research Institute of India (Figure 3)

(iv) Layout Plan of Multipurpose Test Hall (Figure 4)

(v) Layout Plan of Process Engineering and Material Process (Figure 5)

(vi) Layout Plan of Pilot Cement Plant of Cement Research Institute of India at Muduvathur (Figure 6)

(vii) A number of photographs relating to different facets of Cement Research Institute of India (Separate coloured slides)



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