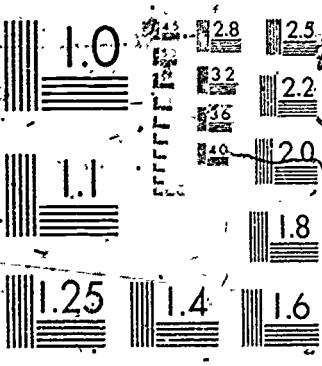

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ABSTRACT

The Central Building Research Institute (CBRI) is one of the national laboratories of India's Council of Scientific and Industrial Research. CBRI has applied the techniques of partial prefabrication to school building programs in Uttar Pradesh, the state having the largest population in India. The plan provides that the elements of a basic shelter--foundations, supporting columns and a roof--be furnished in places where primary schools are needed. The local community is to provide the wall panels, windows, doors, and floor, using local materials and at its own expense. The criteria for the design of the prefabricated elements included (1) simplicity in assembly, (2) ease of transport using lorries or bullock carts, and (3) weight low enough to permit easy handling. This case study details the school designs and the development of the organizational structure to meet the total building program for 5,000 or more schools in a period of three years. (Author/MLF)

INNOVATION IN MANAGEMENT OF PRIMARY SCHOOL CONSTRUCTION

– a case study –

R.D. SRIVASTAVA

Educational Building Report 3

UNESCO REGIONAL OFFICE FOR EDUCATION IN ASIA

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CHAPTER ONE

INTRODUCTION

Background

The enrolment of children in primary schools in India has risen from 14 million in 1950-51 to 37 million in 1965-66 - a three-fold increase in 15 years. By 1981, at the end of the Sixth Five-year Plan period, enrolment is expected to reach 80 million children. In 1966 only about 30% of primary schools were stated to have been housed in satisfactory buildings.[1] The majority of primary schools were, and many still are, accommodated in rented or rent-free buildings, most of which are unsuitable for school purposes, as they are ill-lighted, ill-ventilated and unhygienic.[2] (see Plate 1 opposite).

An approach to the improvement of this situation was outlined in the Report of the Education Commission as follows:

i) Provision of necessary funds;

ii) Reduction of the building costs to the minimum level possible;

iii) Devising of a suitable machinery to implement the programme expeditiously and economically.

It so happened that a member of the Commission's Working Group on Educational Buildings was Sri Dinesh Mohan, Director of the Central Building Research Institute (CBRI), Roorkee, India. Aware of the need to build very large numbers of schools, Sri Mohan had, in 1963, already initiated a modest programme of research in the field of school building design and the Education Commission Report was to result in a sharp increase in the importance he assigned to this work at Roorkee.

The Central Building Research Institute is one of the national laboratories of India's Council of Scientific and Industrial Research. Located at Roorkee in the State of Uttar Pradesh, the Institute, founded in 1947, adjoins an engineering university with traditions extending back for 150 years.

Functionally, the Institute is required:

a) To assist the Indian building industry in solving problems of planning, design, construction and materials, with a view to achieving greater functional efficiency both in design and construction;

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1. India. Ministry of Education. *Education and national development, Report of the Education Commission 1964-66.* New Delhi, 1966.

2. S.N. Mukerji. *Education in India today and tomorrow.* Baroda, Acharya Book Depot, 1969.

Plate 1. Examples of existing schools in need of more adequate accommodation.

b) To carry out research in the problems of fire in buildings;

c) To bring the results of research to the notice of potential users and to ensure that these results find expeditious and efficient application.

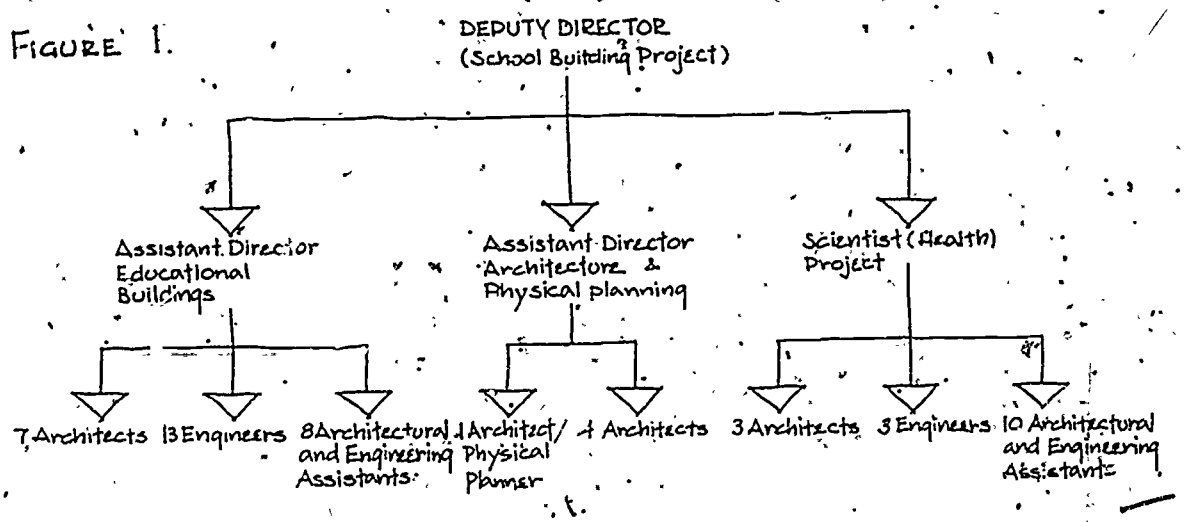
The realization of these broad objectives is achieved through the Institute's seven research divisions:

1. Building materials
2. Soils engineering
3. Efficiency of buildings
4. Building process - plant and productivity
5. Architecture and physical planning
6. Fire research
7. Rural buildings

There are also information and extension services to meet the research needs of the Institute's scientists and to ensure that the results of research are disseminated to and utilized by the building industry.

Educational building, including primary school research and development programmes in the CBRI, is the responsibility of the Architecture and Physical Planning Division, the 1973 organization and staffing of which are shown in Figure 1. Naturally the division also uses the output of the other divisions in

FIGURE 1.



its design and construction work. Thus, for example, the design of windows for schools is based on the methodology developed by illumination scientists of the Efficiency of Buildings Division, while building material problems are solved on the basis of advice from the Building Materials Division, and so on. In short, those directly engaged in research and development programmes for educational buildings at the CBRI, Roorkee, are supported by a group of more than 200 scientists specialising in almost all aspects of building from adhesives to acoustics and from soil stabilization to ceramics.

School building research at CBRI

In early 1963, the author, an architect in the Division of Architecture and Physical Planning, was assigned to start programmes of school building

research. As the import of the Education Commission's findings placed such stress on the need for national development in field of school building, the response of the CBRI in the years that followed was to increase its research effort and recruit more staff to work on the new programmes.

These programmes were initially focussed on the classroom environment. The results of the large scale survey by CBRI of the body sizes of children were used to assist the Indian Standards Institute to formulate standards and the data also formed the basis for studies of space needed in classrooms and the design of furniture.[3] Other topics that received early attention included storage requirements for primary schools, the single-teacher school and the relationships between the primary school curriculum and space needs. In the context of this monograph, this latter topic is worth more detailed explanation.

It has long been realized that if economy is to be achieved in buildings for education, every part of the building should be of minimum area, the use of every part of the building should be optimized and the construction of every element of the structure should be as cheap as possible.

In 1966, CBRI school building research programmes included studies on the second of these aspects, namely the optimization of the use of space in Indian primary schools. A study of the primary school curriculum in Uttar Pradesh showed that covered space was only necessary for some activities while others could be better accommodated on the school site in the open. In this way, the area of the primary school could, it seemed, be reduced by 40%.[4]

It was obviously important to apply this concept to school building design in real situations and, in 1968, work was started on the design of a school incorporating these ideas. This work culminated in the design and construction of the Uttar Pradesh schools, a description of which forms the subject of this monograph. (See Plate 2).

Concurrently with the studies on the more effective use of space, work was also commenced in CBRI on the application of techniques of partial prefabrication to school building programmes. It was thought that if the elements of a basic shelter, namely foundations, supporting columns and a roof, could be provided in places where primary schools were needed, the local community anxious to have a school would be willing to provide the wall panels, windows, doors and floor, using local materials and at their own expense.

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3. Indian Standards Institution. *Indian Standard: 4838. Anthropometric dimensions for school children; part I-1969: age group 5-11 years; part II-1968: age group 12-16 years.* New Delhi, I.S.I., 1968.

   Indian Standards Institution. *Indian Standard: 4837. Recommendations for school furniture, classroom chairs and tables for use in junior schools; part I-1968: age group 5-11 years; part II-1969: age group 12-16 years.* New Delhi, I.S.I., 1969.

4. Srivastava, R.D., B.M. Gupta, and D.J. Vickery. *A method of reducing classroom requirements in primary schools in Asia.* Occasional Paper No. 13. Colombo, Asian Regional Institute for School Building Research, 1967.

Plate 2. An early prototype of the new primary school.

The criteria for the design of the prefabricated elements included (a) simplicity in assembly, (b) ease of transport using lorries or, if necessary, bullock carts, and (c) weight low enough to permit of easy handling. Prototypes of partially prefabricated schools designed using these criteria, were first built in the CBRI and subsequently in Maharashtra and Kerala and provided sound experience for application of the partial prefabrication concept on which the design of the Uttar Pradesh schools was subsequently based. (Refer to Plate 3).

Other educational-building research programmes of the Architecture and Physical Planning Division of CBRI have included a study on the design of university hostels[5] and, more recently work on second-level schools.

Educational Building Development Groups

The primary school building research programmes outlined above showed promising results, and suggested that it might be possible to obtain important reductions in the cost of educational buildings through rational use of space, improved construction techniques and cost analysis and planning at the design stage. The developments evoked considerable interest in the Union Ministry of Education at New Delhi as they offered a means by which the serious shortage of primary school buildings in the country might be reduced. The

5. India. Central Building Research Institute. *University hostels; planning considerations*, Roorkee, CBRI, 1969.

main concern of the Ministry was, naturally, that the new ideas be disseminated to the State Governments and other agencies concerned with the construction of school buildings throughout India.[6]

The need to communicate promising developments in school building design and construction to the States had, however, already been foreseen by the Education Commission, as indicated in the quotation which follows:

> "... to continually introduce improved and economic techniques, we recommend the adoption of the following additional measures:
>
> i) Formation of Educational Building Development Groups
>
> Each State should have an Educational Building Development Group ... consisting of an architect, an educationist, an administrator and a cost accountant .... to improve the planning and construction of government school buildings ..."

The Commission suggested that, in addition to a Development Group in each State, there should be a Group at Union level, one of the functions of which might be to highlight "the latest techniques of construction and researches at home and abroad ..." for the benefit of the State Groups.[7]

The Development Group at Union level was accordingly formed in 1967 with the Education Adviser to the Government of India as its Chairman and the author - the architect in charge of the school building research programmes at CBRI - as its member-secretary. The promotional work of the CBRI and the activities of the Group at the Centre have resulted in the formation of development groups in the States of Maharashtra, Kerala, Punjab, Uttar Pradesh, Tamil Nadu and the Union Territories of Goa, Daman and Di and Arunachal Pradesh.

In collaboration with CBRI and the National Development Group, the State development groups have constructed a number of prototype buildings but as ad hoc bodies having neither finance nor permanent staff, the main value of the groups to the present time has been to provide a point of contact at State level to which the clearing house and other activities of the National Development Group and the CBRI can be directed.

The primary school building programme in Uttar Pradesh

Uttar Pradesh, as is explained more fully in Chapter Two of this monograph, is the State having the largest population in India - in 1971, 88,341,144

6. Note: India comprises a Union of States. Whilst the Union Government is concerned with the co-ordination of educational facilities, determination of standards of higher education, scientific and technical education, research, promotion of Hindi and development of all Indian languages and is responsible for five Central Universities and other institutions of national importance as Parliament may by law declare, education in India is primarily the responsibility of the State Governments.

7. India. *Report of the Education Commission.*

persons. In 1965, Atmanand Misra, writing in the (Union) Ministry of Education's periodical 'Education Quarterly' described Uttar Pradesh as having very low ability to support education (total revenue divided by population), a fairly low degree of educational effort (% educational expenditure per capita of State revenue per capita).[8] Accomplishment in Education in Uttar Pradesh has also been very poor compared with that in other States (accomplishment is percentage total enrolment at all levels to the educable population at those levels). Finally, Uttar Pradesh shared with two other States the lowest educational level of adult population as measured by the percentage literacy of the total population.[9]

Primary education in Uttar Pradesh is managed through Zila Parishads,[10] municipalities and notified town areas and private agencies. Privately managed schools appear to have few building problems but schools managed by local governments, especially by Zila Parishads, experience considerable difficulty with their accommodation (Plate 4). During 1968-69, a survey by the State Department of Education showed that only 36% of the public primary schools had satisfactory buildings.

The background to this situation is worth briefly describing here. After independence, an intensive programme for the expansion of primary education was planned and new schools were opened wherever temporary accommodation could be found. At the same time, programmes for the construction of new school buildings were commenced. Table 1 shows how the position developed during the first three of India's five-year plan periods.

During the 4th Five-year Plan, a further 990 primary schools were constructed in urban and rural areas. At the present, statistics show that, of the primary schools opened in Uttar Pradesh, about 42,000 still lack satisfactory buildings.

To the backlog of 42,000 buildings that need to be constructed to house the present population of primary school children has to be added a further 25,000 buildings to house additional enrolments foreseen in the subsequent five years. The total number of primary school buildings that thus need to be built in Uttar Pradesh by 1978 is of the order of 67,000 - a tall order indeed.

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8. Atmanand Misra. *Educational balance sheet of States.* Education quarterly, Ministry of Education, India. Vol. 17, no. 66, June, 1965. p. 64-8, 83.

9. Paradoxically, Uttar Pradesh has the highest number of universities and higher education institutions of any State in the country.

10. *Zila Parishad* is a District Board, responsible for functions which, in a rural context, are similar to those exercised by a Municipality in an urban situation.

Table 1. Progress of primary school building construction in Uttar Pradesh during the first three five-year plan periods

Plan period	Programmed for construction	Actually constructed	Backlog of unconstructed schools
First Plan, 1951-1956	6 925	6 002	923
Second Plan, 1957-1961	9 662	7 130	2 532
Third Plan, 1962-1966	50 126	11 578	38 548
Total, 1951-1966	66 713	24 710	42 003

Note: From data provided in a paper by Dr. A.P. Malhotra, then Deputy Director Elementary Education, U.P., presented at a Seminar at CBRI, Roorkee, 5 October 1971.

Plate 4. Zila Parishads often experience difficulty in providing accommodation.

Although discussed in greater detail below, it is appropriate to summarize here the main reasons for the increasing gap between school building needs and the provision of buildings in the State. These are:

a) community participation falls below the expected levels;

b) the State construction agencies are not fully utilized;

c) allocations of money prove inadequate in the face of rising prices of labour and materials;

d) cost control techniques are not applied;

e) funds allocated for local development are applied to projects having greater priority than school building.

In 1968, as is mentioned above, a school building development group was established in Uttar Pradesh and studies were made leading to the design of primary schools for the State. In 1971, representatives of the State Department of Education and CBRI met at a seminar to discuss the outcomes of the design work and it was decided that State funds would be provided to undertake experimental construction of the design material and, in particular, to check the costs of the new prototypes. The seminar also recommended that the findings of the CBRI studies be incorporated in a revision of the School Building Code. More important perhaps, the participants suggested the formation of a school building consortium to take advantage of the new techniques which formed a feature of the designs and recognized that future school building programmes should be oriented to provide avenues for employment - especially for skilled building technicians of which many were unemployed at the time.

These recommendations were subsequently approved by the State Education Minister and CBRI was authorized to start construction of 12 prototypes in three Districts of Uttar Pradesh.

The outcome of the prototype construction programme showed that the design was cheap to build, - Rs. 8,100 (about US $1,080) or Rs. 101 (US $13.50) per place - and that construction time was short. As a result, the State Government decided to construct 5,350 of the new schools - roughly 105 in each of 51 of the 54 administrative Districts of Uttar Pradesh. At the date of preparation of this Report, the construction programme was more than half completed.

CHAPTER TWO

THE DEVELOPMENT OF THE NEW PRIMARY SCHOOL

Education in Uttar Pradesh

Of the population of the State of Uttar Pradesh - 88,341,000 - 13% live in urban and 87% in the rural areas. There are some 111,722 villages, 257,468 hamlets and 486 towns in the State. The population density is 300 persons per square kilometre.[11]

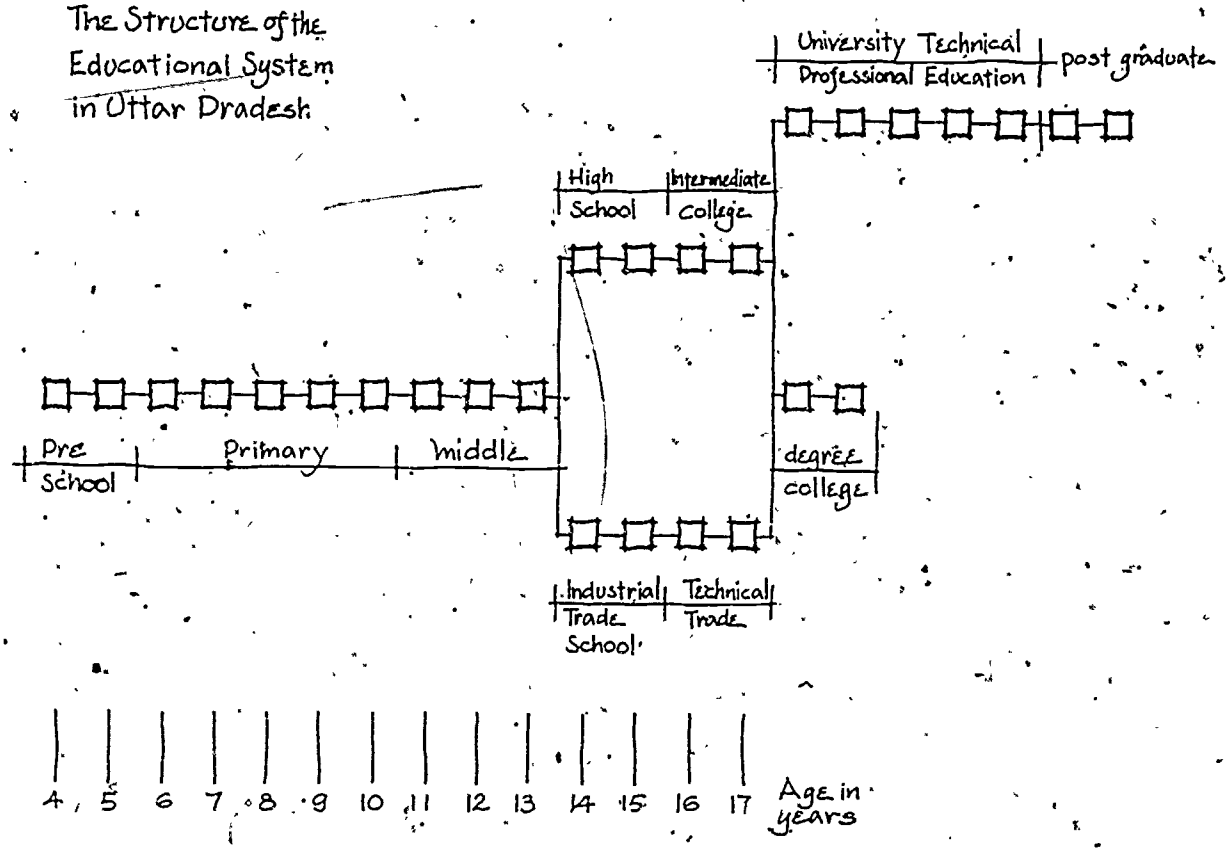
Educationally, the State is divided into 54 districts, (Figure 2) and for better supervision, inspection and control, the districts are grouped into eight

FIGURE 2.

11. Statistics in this paragraph are taken from statistical publications of the Ministry of Education and Social Welfare, Government of India.

regions for boys and seven for girls. The structure of education is shown in Figure 3. Data concerning the numbers of pupils, percentage enrolment to

FIGURE 3.
The Structure of the Educational System in Uttar Pradesh



corresponding age group, percentage enrolment in rural areas, pupil/teacher ratio, numbers of primary schools and percentage of primary schools in rural areas of Uttar Pradesh, are given in Table 2. Figure 4 indicates the relationship between population by age groups and the population of children enrolled at the different levels of education.

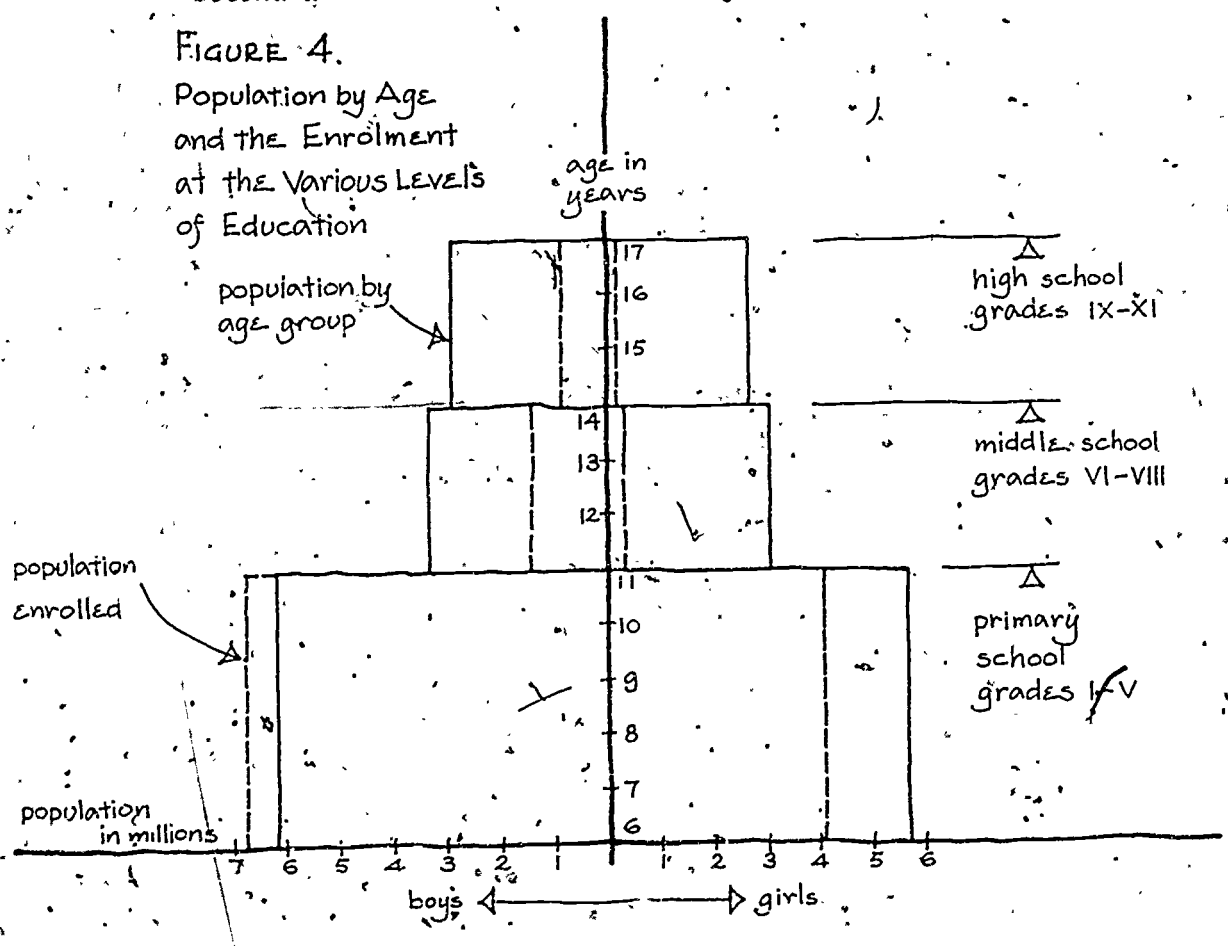
Although primary education is of five years' duration in Uttar Pradesh, the population distribution in the rural areas is such that only about 10% of the school buildings require five classrooms. Figure 5, which is of considerable importance in relation to the concept of phased construction, described below, shows the percentage distribution of primary schools, by enrolment, in the rural areas and, superimposed on it, is an indication of the classrooms required. (Figure 5 appears on page 18).

Table 2. Annual enrolments, pupil/teacher ratios and numbers of primary schools in Uttar Pradesh for the period 1962-71

Year	Number of pupils enrolled (in thousands)			Percentage enrolment to corresponding age group	Pupil/teacher ratio	No. of primary schools	Percentage primary schools in rural areas
	Boys	Girls	Total				
1962-63	4 041	1 300	5 341	53.8	44	49 812	
1963-64	4 422	1 575	5 997	59.2	41	52 645	
1964-65	5 291	2 470	7 761	74.0	50	57 905	
1965-66	5 469	2 547	8 016	74.3	50	58 438	
1966-67	5 927	3 004	8 931	80.3	53	60 238	
1967-68	5 921	3 259	9 180	80.4	53	60 564	
1968-69	6 064	3 300	9 365	79.2	56	61 127	
1969-70	6 514	3 786	10 300	85.4	51	61 959	
1970-71	6 804	4 024	10 828	91.5	53	61 959	90.5

Source: India. National Council of Educational Research and Training. *Second all-India educational survey.* New Delhi, 1967.

FIGURE 4.
Population by Age and the Enrolment at the Various Levels of Education



The primary school curriculum for Uttar Pradesh is summarized below:

Regional language	45	minutes per day
Second language	40	" " "
Social studies	40	" " "
General science and agriculture	45	" " "
Mathematics	45	" " "
Craft	40	" " "
Games and physical education	45	" " "
Prayers	10	" " "
Total	310	minutes per day.

A typical time-table is shown in Figure 6. From this, it will be seen that by planned use of the site for certain lessons it is possible to reduce the number of teaching spaces needed in the building. Such an arrangement would not, of course, be possible if the climate made outdoor teaching unfeasible. Reference to the section of this report concerning climate will, however, indicate that it is usually sufficiently clement to permit lessons to be held outdoors (Plate 5).

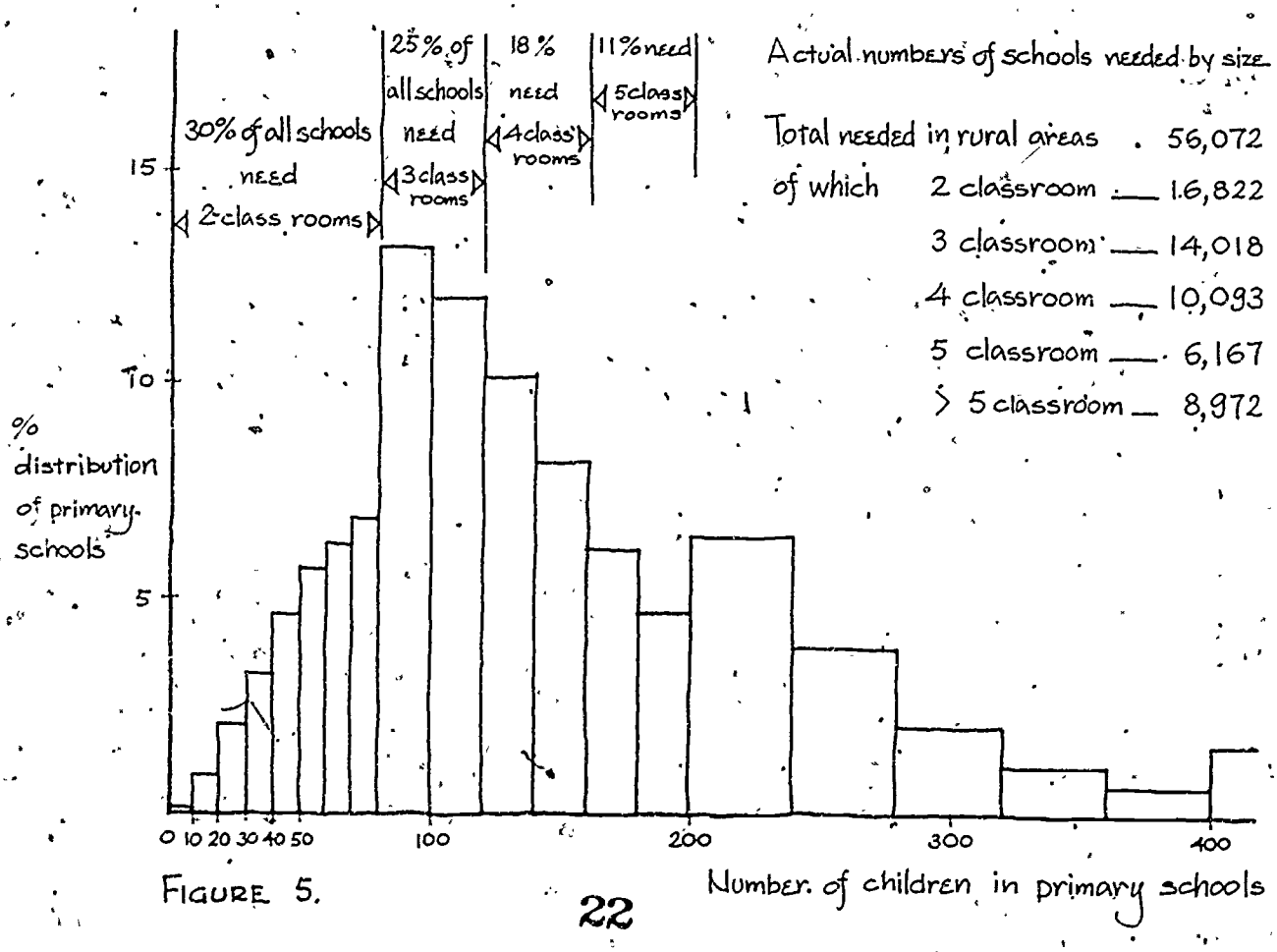


FIGURE 5.

Figure 6. A TYPICAL PRIMARY SCHOOL TIME TABLE (winter)

Period		1st	2nd	3rd	4th		5th	6th	7th
Time / Class	10 a.m. 10.10	10.10 10.55	10.55 11.40	11.40 12.25	12.25 1.10	1.10 1.50	1.50 2.30	2.30 3.10	3.10 3.50
V	PRAYERS	Hindi	G. Sci. & Agri.	Maths	Craft	LUNCH * BREAK	English	Games	Social Study
IV		Hindi	Craft	English	Games		Maths	Social Study	Gen. Sci.
III		Social Study	Games	Hindi	Maths		Craft	English	Gen. Sci.
II		Games	Maths	Craft	Hindi		Social Study	Counting and tables	
I		Games	Hindi	Social Study	Hindi writing		Craft	Maths	

Periods on the site and out of the building

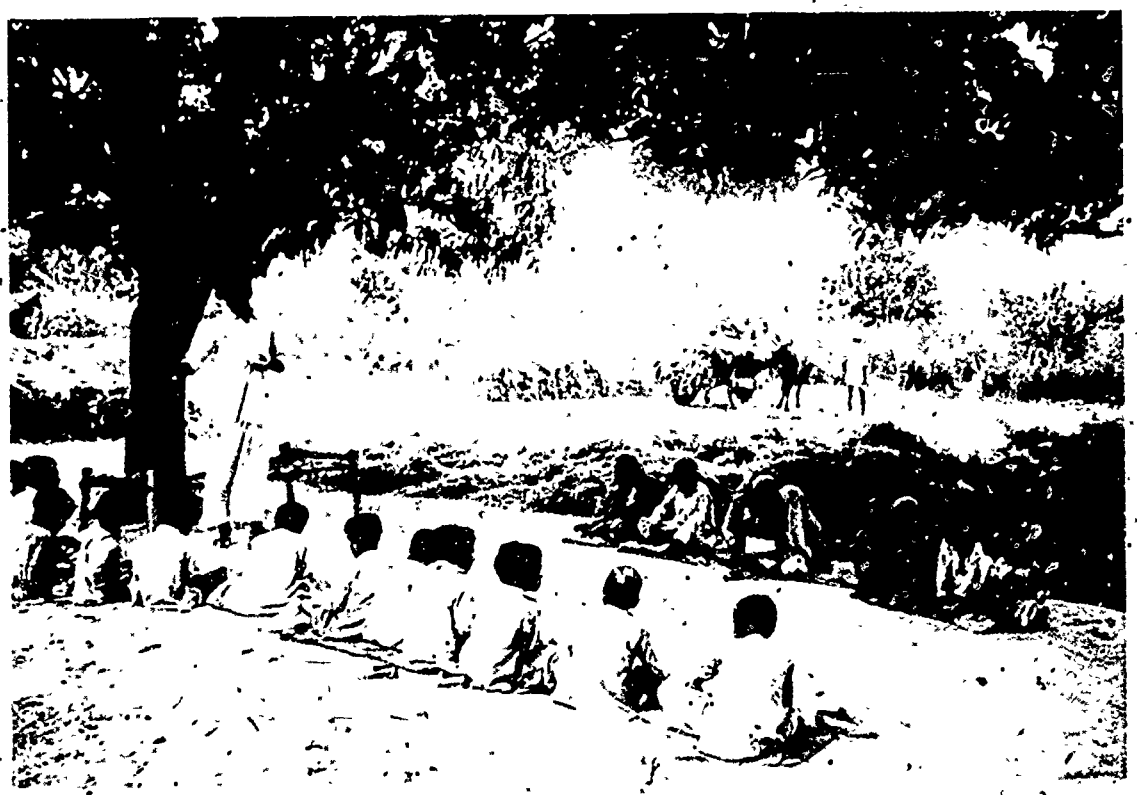


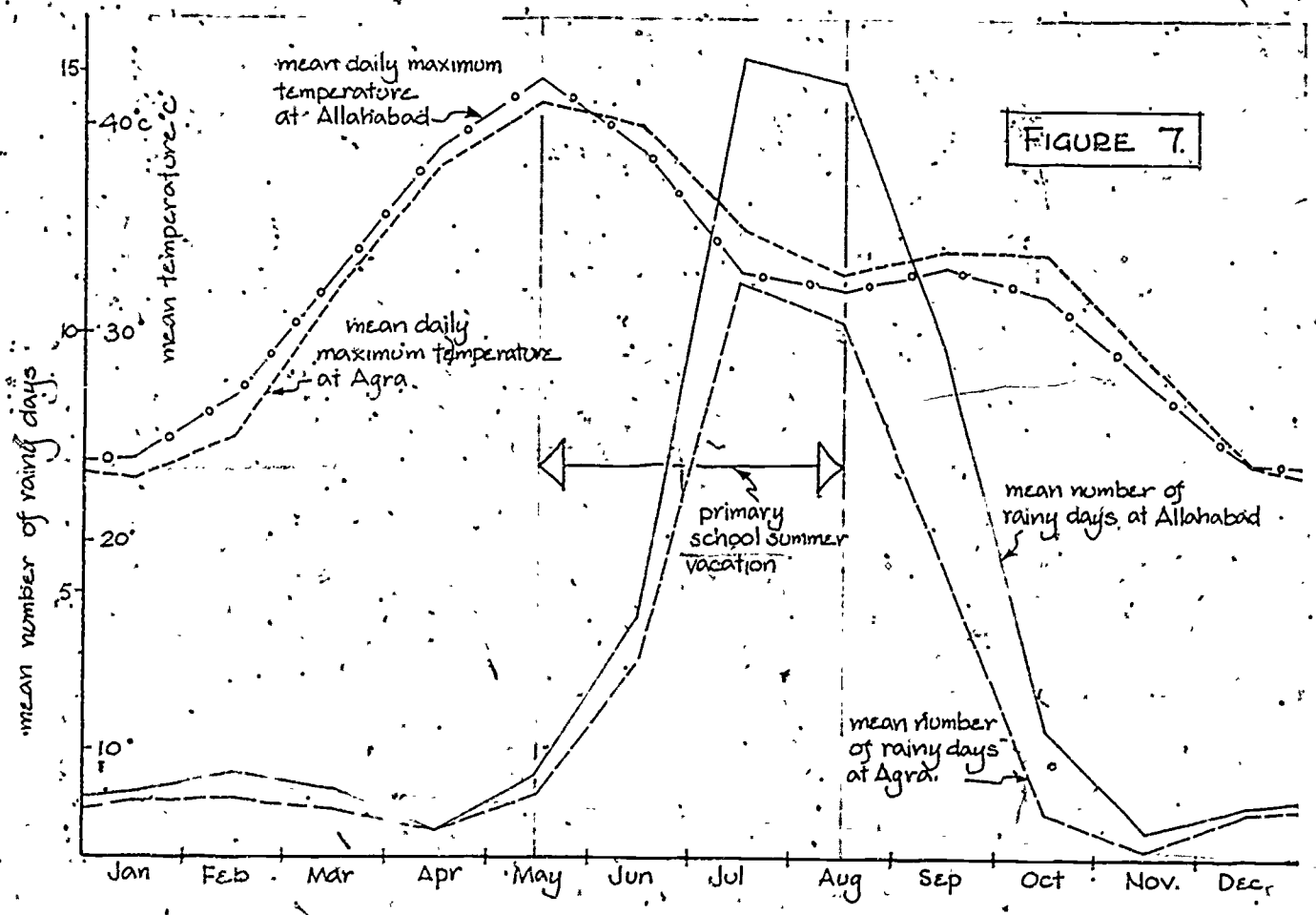
Plate 5. The climate of Uttar Pradesh is usually sufficiently clement to permit lessons to be held outdoors.

The topography and climate of Uttar Pradesh

The largest area of the State is level, well drained and cultivated. In the north, it rises into the Himalayas and includes such famous peaks as Nanda Devi (7,300 m). Many of the schools, the design of which is described below are built at elevations of 1,000 m or more. Where the State borders central India, the land becomes rough and broken.

A characteristic of Uttar Pradesh is its numerous villages, many of which are crowded high on the debris of older sites, making it difficult to find space for the primary school within the village setting. New schools are thus sometimes built just outside the older village sites.

The climate, except for the Himalayan areas of the State, is hot and dry. Temperature in the plains ranges from 30-46 degrees centigrade and annual rainfall from 762 to 1,118 mm. The rainfall is monsoonal and heaviest in the months of June, July and August. Data on the mean number of rainy days for a few selected stations are given in Figure 7, on which are also



marked the school holidays in the State. Figure 7 also indicates the mean maximum daily temperatures for each month of the year. It will be concluded that for those months of the year during which schools are not on holiday, teaching and learning outside the building on the school site is quite practicable - a conclusion that is well borne out by local practice as indicated in Plates 1, 4 and 5. The clement climate during the school year was thus a significant factor considered while developing the new schools.

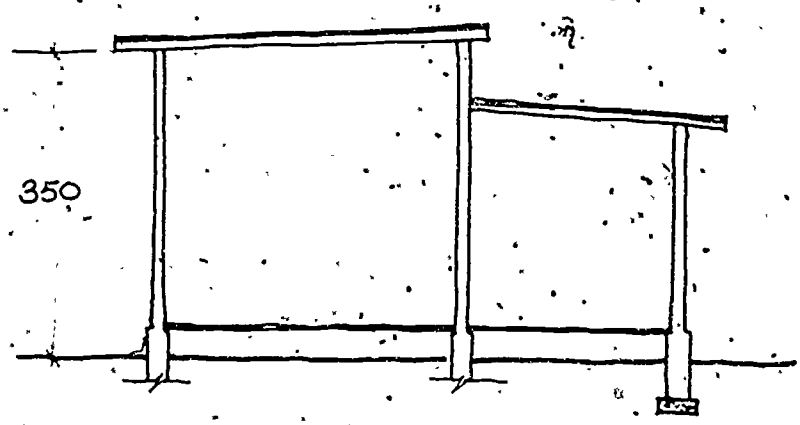
Existing school building

Standard plans for school buildings were developed in Uttar Pradesh as early as 1931. There were two basic plans which differed only in regard to their roofing pattern. In the year 1948 the designs were revised. The new plans had larger teaching spaces and no longer included a teacher's residence, store-room and kitchen as did the previous standard designs. For reasons of cost and scarcity of materials during the immediate post-war years, mud walls and local clay tile roofs were adopted as a common pattern. Certain other modifications were also introduced to suit local conditions. For example, in western and central U.P., mud roofs were found cheap and convenient to construct. In the hilly regions of the State, galvanized iron roofs were found suitable and stone-in place of mud walls - were easy to construct. The width of classrooms was also reduced by two feet in the new design due to scarcity of wooden rafters in lengths of more than 3.05 m. Later it was found difficult to maintain these resulting temporary buildings and, with the passage of time, many such schools deteriorated and became unserviceable.

In 1957 the standard plans prepared in 1948 were revised in consultation with the Chief Engineer of the Public Works Department of Uttar Pradesh and, as a result, six types of design came in use. These schools have one or two teaching spaces. They usually comprise:

1. A classroom space 3.66 m. wide;
2. A circulation space 2.44 m. wide in the front of classrooms;
3. External brick walls 35 cm. thick;
4. In the plains a roof in re-inforced brick or re-inforced cement concrete and in the hilly regions stone walls and pitched roof with galvanized iron sheets;
5. The foundation depth is usually a metre with a 30 cm. thick concrete base.

A typical example of one of these schools is illustrated in Figure 8. The teaching space in the example shown is 58.7% of the area of the building while the circulation space is 30%. Though the windows provided in the school are adequate, their disposition is not judicious and the lighting in the teaching spaces is not uniform.



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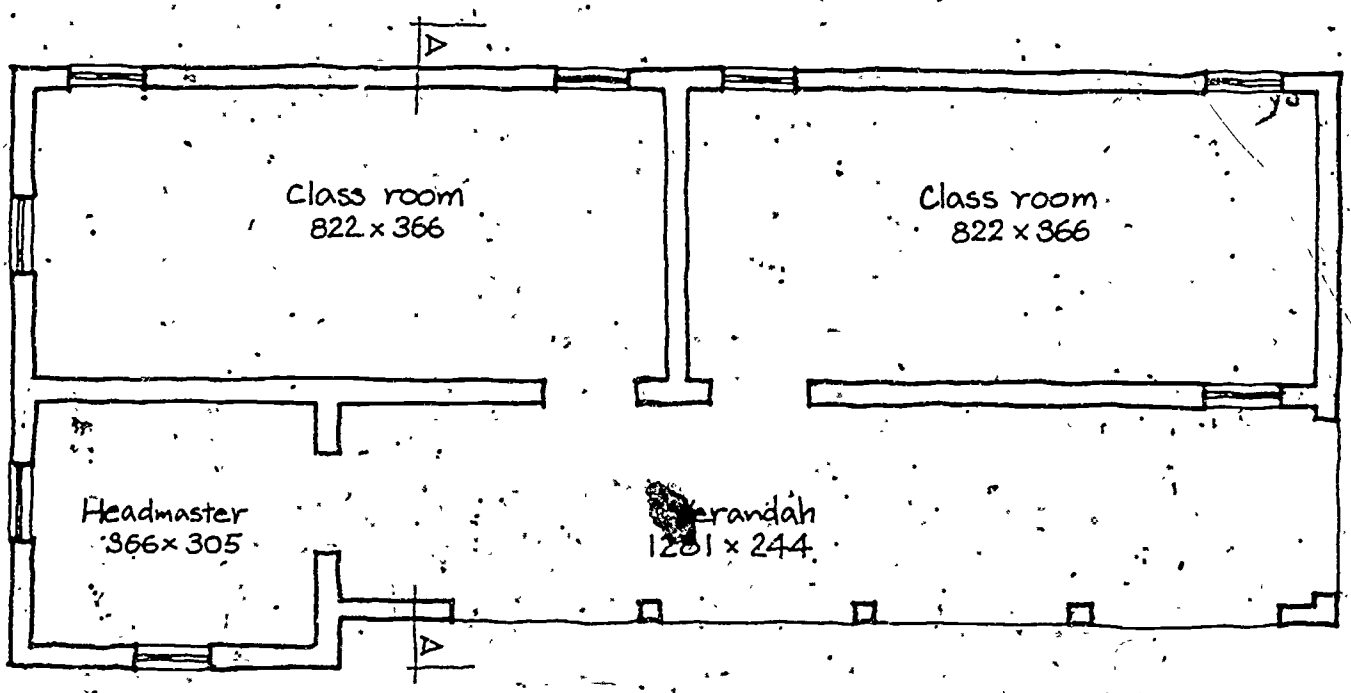


PLAN

FIGURE 8. A Typical Example of an Uttar Pradesh Primary School, Designed in 1957

These schools are 'basic' schools. Craft work and education-through-activities are the main objectives of the curriculum, which requires group work in various group sizes in addition to occasional formal teaching. The 3.66 m. span of the teaching spaces restricts the performance of such activities. The length of the classrooms also creates problems such as difficulty in seeing the chalkboard for children at the back of the class. Audibility also is a problem due to the distance between the teacher and the farthest child. The height of the classroom is generally about 3.5 metres which could conveniently be reduced to 2.9 metres without affecting thermal comfort.

The school in the rural area is the main centre for community functions and activities. It is used as a meeting place by the village Panchayat, as a reading room and as an adult education centre. It is also often used as a place for accommodating marriage parties. These various functions need flexible spaces which the schools lack.

In practice the schools have survived in their present form because the methods of teaching are by 'chalk and talk', and because there is no other place for community activities in the villages. Future schools need to provide functional facilities in order to help improve the quality of education and to meet the varied community needs.

In recent years the cost of material, labour, and thus construction has risen rapidly while the financial allocation for construction of schools has remained the same during this period of rising prices. The result has been that a number of schools on which construction has started have remained incomplete - often roofless or lacking doors, windows, floors and sometimes walls. Where schools have been completed, the materials have often been poor and the workmanship hurried. The result is heavy maintenance costs every year. As there is usually no money for maintenance, the buildings deteriorate very quickly.

To summarize, it may be concluded that the design of the older schools:

1. Does not adequately serve the educational purpose;
2. Does not motivate the teachers to adopt new teaching methods;
3. Does not provide the sort of facilities for the students to learn through activities;
4. Does not have a rational distribution of area as between teaching and non-teaching spaces;
5. Does not serve community needs;
6. Is not such that they can be built cheaply.

Research and development

An assessment of the situation outlined above led to the conclusion that a new approach to the design and construction of primary schools was needed in Uttar Pradesh and, moreover, in view of the scale of the construction programme, that its management would require very careful planning if there was to be any real hope of successful implementation.

It was thus decided to prepare new primary school designs and, in view of the repetitive nature of the programme in which over 5,000 similar school buildings were to be constructed, to evaluate all design ideas through the construction of full-size, prototype school buildings. The Central Building Research Institute with its design specialists, various building science resource personnel and workshops for prototype construction, was an agency obviously eminently suited to undertake this work.

The Uttar Pradesh Education Authority set out its ideas for the new primary schools as follows:

1. Initially, each school would have two teachers and later five;
2. There would be 80 children in each school in the first place but later the school would be able to expand to 200 places;
3. The internal space should be adequate for the basic education foreseen in the curriculum;
4. Internal space should be supplemented by outdoor teaching space;
5. A cooking space should be provided for mid-day meals;
6. There should be facilities for a teacher to stay overnight in the school.

No cost limit was prescribed, but the Education Authority was emphatic in its requirement that the new school should be as cheap as possible and certainly cheaper than the old designs. In the Central Building Research Institute, after a preliminary study of planning specification and cost analysis Rs. 8,500 was regarded as a reasonable target cost for the building and site works.

Because of the requirement that the initial building should comprise two classrooms with a possibility, if the school-going population justified it in future, of expansion to a three or five classroom school, it was decided to design a building that could be built in stages (Figure 9). The plan of the first prototype is shown in Figure 10. Each teaching space is sufficient for 40 children and two of the spaces are separated by a movable partition. Chalkboards, display areas and storage spaces are provided as well as a deep cupboard-cum-kitchen for the teacher to use during an overnight stay in the school. Ventilation is ensured through the provision of pierced grills in the walls. At those parts of the rooms farthest from the windows, a desk top illumination of 150 lux was calculated.

On the site, a double-sided chalkboard is provided for outdoor teaching and there is a small open kitchen, a hand operated water pump and a urinal.

Constructional design of the prototype

The need to complete a construction programme of over 5,000 two-classroom schools in a period of three years, and at a variety of sites of either easy or difficult access, suggested the use of constructional techniques which permit of very rapid building. Equally important was the need to use local materials, skills and labour.

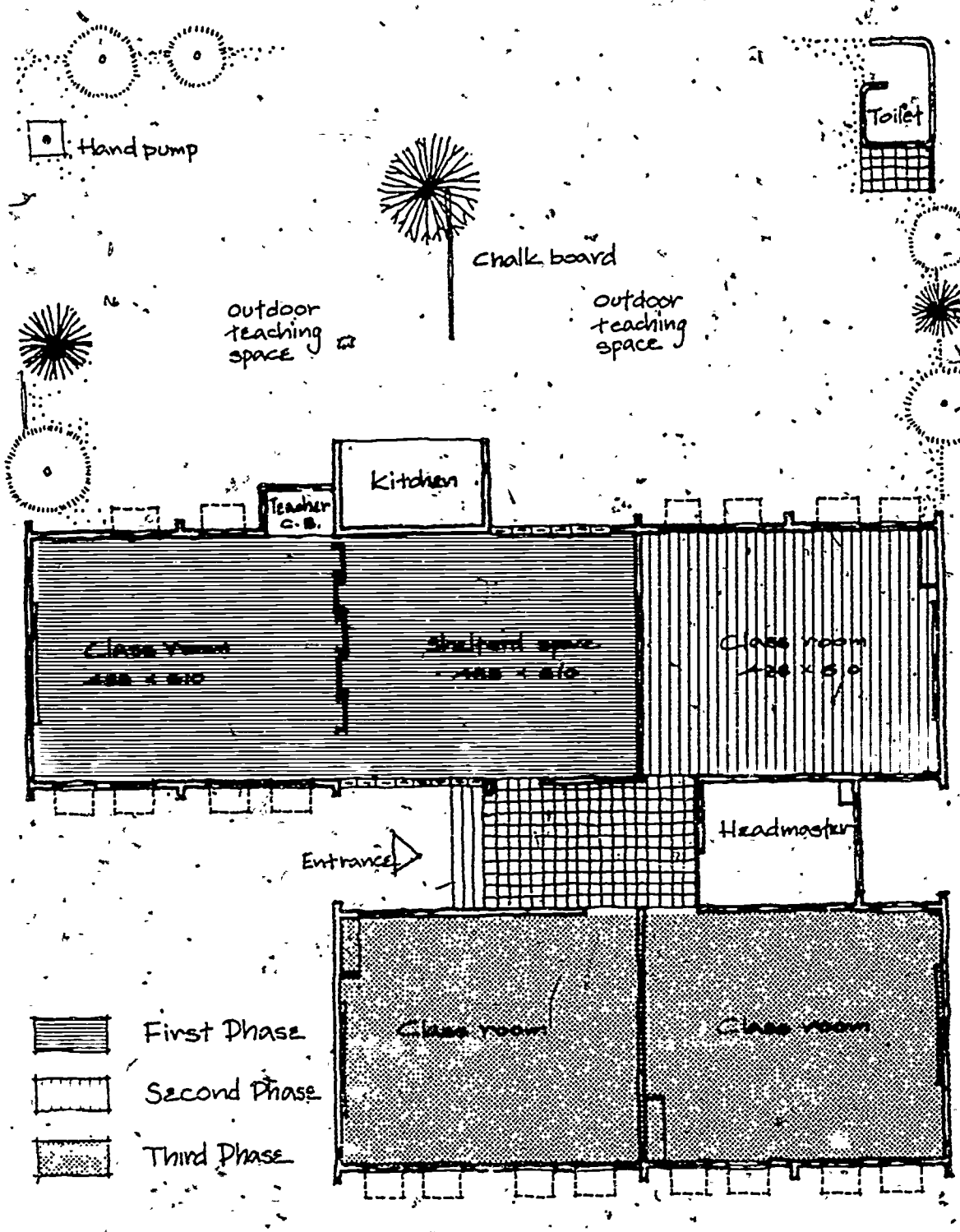


FIGURE 9. The Five Classroom, Primary School Designed to be built in phases

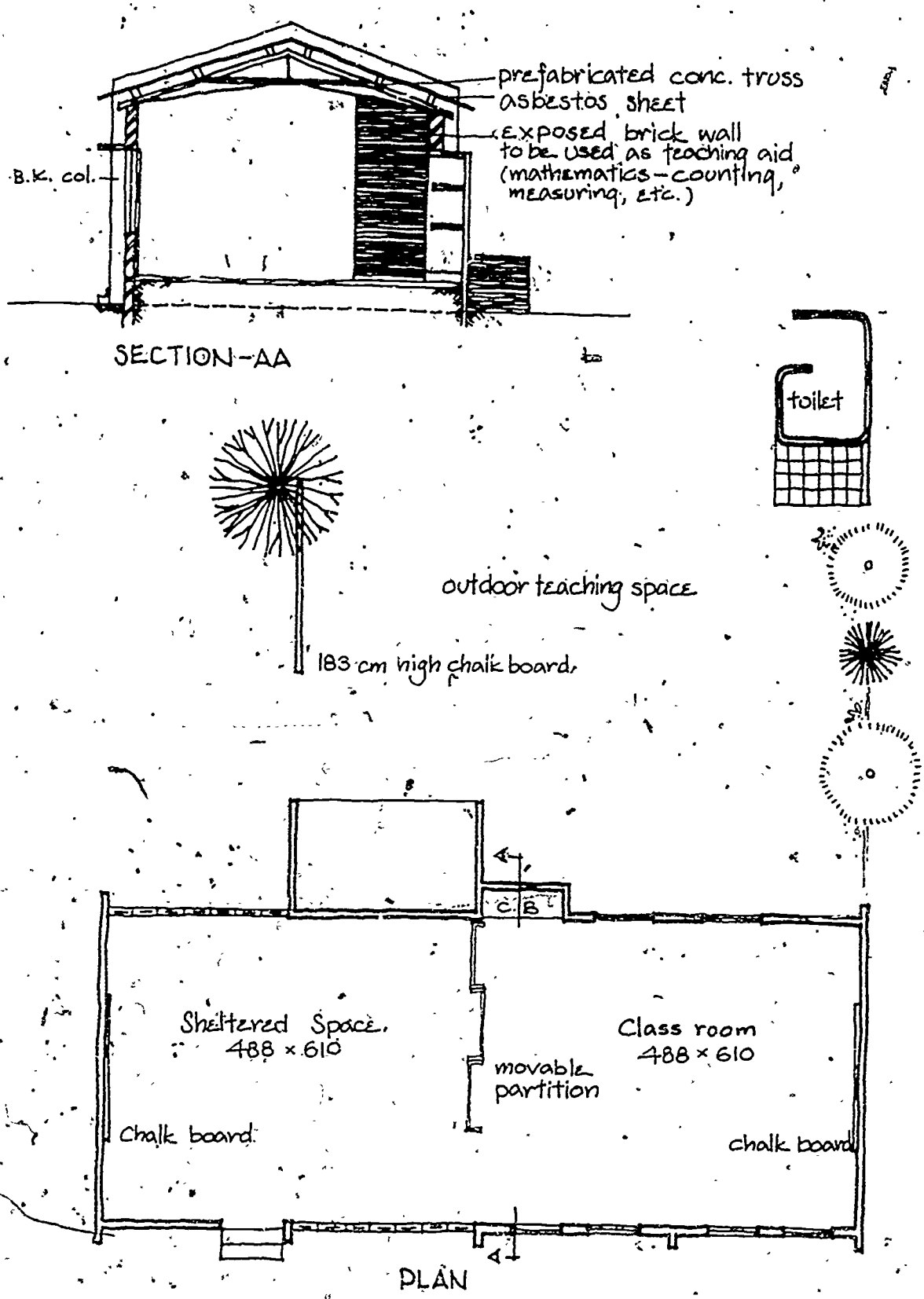


FIGURE 10. Plan of the First Stage of the First Prototype

Partial prefabrication seemed to provide a possible answer. Although the prefabricated construction technique is not an unknown concept, in the context of developing societies, the importance of such techniques lies in simplification of costing methods, joint details, and erection methods, thus minimizing the use of skilled labour. The techniques were tried, guided by the following considerations.

1. There should be a minimum number of standard components;
2. Where concrete components were to be used they should be simple to cast, thus reducing the need for skilled labour;
3. As many sites were accessible only by bullock cart, the components should be designed to fit this mode of transport;
4. The components should be light enough for manual handling into position in the building;
5. Joints between components should be as simple as possible.

The initial design of the first prototype is shown in Figure 11 and Plate 6, and the following is an outline of the specifications:

Foundation	: Pre-cast concrete pocket footing to column with strip foundations to external walls
Damp-proof course	: 1" cement concrete
Columns	: Pre-cast, reinforced concrete
Superstructure	: 9" brick wall in mud mortar and cement plaster both sides
Floor	: Concrete or brick
Doors and windows	: Prefabricated steel frames, wooden doors and window shutters
Roofs	: Pre-cast truss with asbestos sheet covering
Finishing	: Painting on wood work, white wash/colour wash/brick pointing.

Plate 7 illustrates the method of roofing.

The above constructional techniques and specifications were arrived at after a detailed analysis of cost and specifications of various alternative schemes. For example, Table 3 shows the cost comparison of roof trusses with sheet as covering material. Likewise, a comparative cost analysis of various alternatives for different elements was made to arrive at the most economical solution.

The cost of the school at each of the three stages of construction was estimated and is given in Table 4. (Tables 3 and 4 appear on page 30).

Plate 6. The first prototype.

Plate 7. The method of roofing the first prototype - an early trial. The pitch adopted for the prototype was lower.

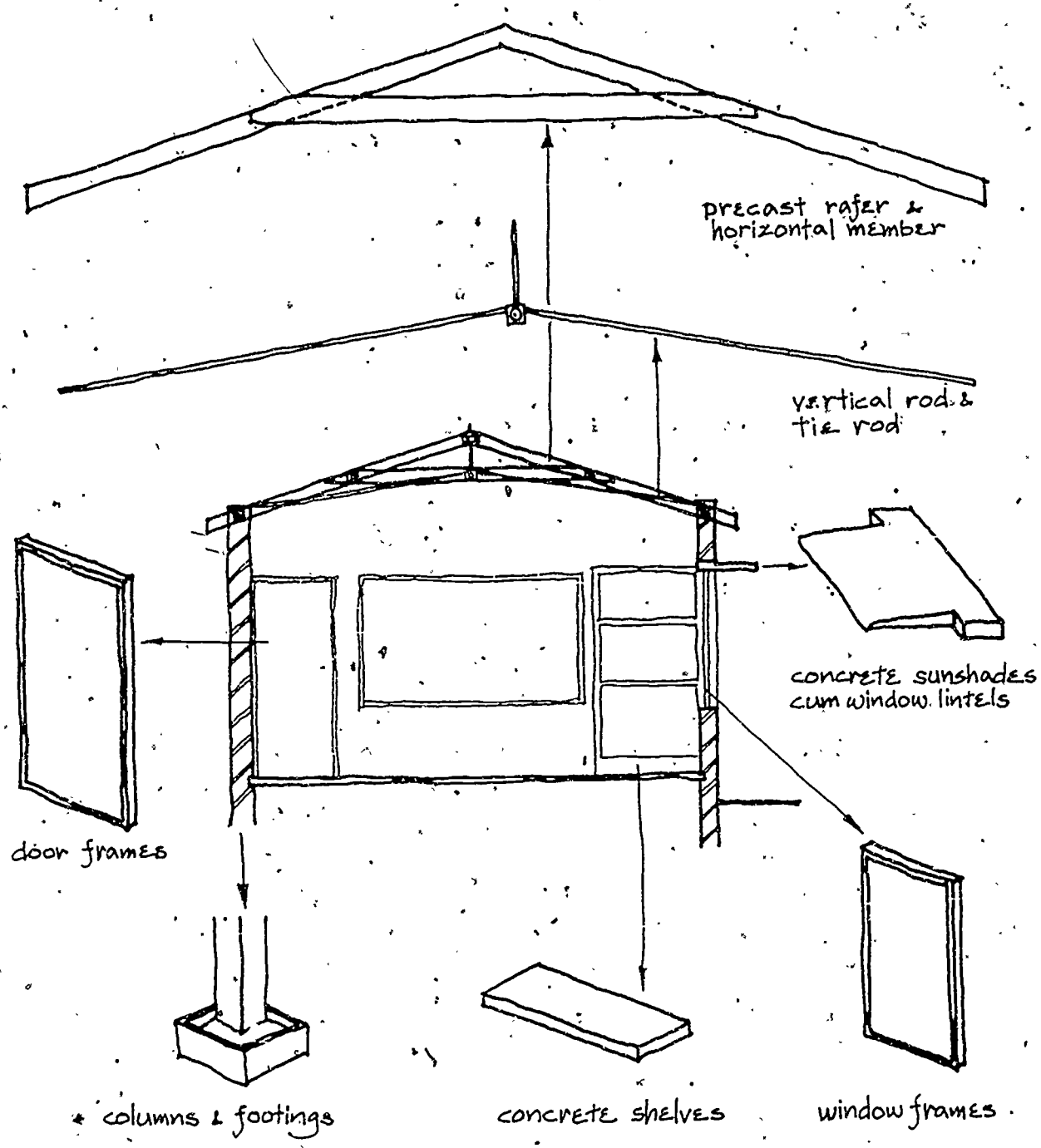


FIGURE 11. Constructional Design of the First Prototype

Table 3. Cost comparison of roof trusses with sheeting as covering material (span 6.56 m)

Trusses	Purlins/ Reapers	Spacing of trusses	Cost in (Rs) of Each truss.	Purlins/ Reapers per Bay	Cost/M^2 (in Rs)	% saving compared to wooden kingpost truss
Wooden kingpost truss	Wooden	2.44 m (8' 0" c/c)	334.11	494.22	44.10	-
Wooden truss (Kerala type)	Wooden	0.61 m (2' 0" c/c)	127.22	28.48	36.15	18.1
Pre-cast RCC scissors truss	Pre-cast RCC	2.44 m (8' 0" c/c)	247.17	294.86	26.38	40.2
Composite truss	- do. -	2.44 m (8' 0" c/c)	230.46	294.86	25.80	41.6

Table 4. Estimated costs of each phase of construction and cumulative costs of first prototype schools

Stage	Estimated cost (Rs.)	Total cost (Rs.)
First stage	8 500 ($1,080)	8 500 ($1,080)
Second stage	4 000 ($ 540)	12 500 ($1,620)
Third stage	10 500 ($1,417)	23 000 ($3,037)

Note: Figures in brackets are the cost in US dollars at the time of drafting this report.

The final cost for a 200 place school would thus be Rs. 115 ($15.52) per place.

Prototype construction

Twelve school buildings, four in each of the districts of Lucknow, Unnao and Rai Barely, were constructed as the first prototypes. The pre-casting work was done at district headquarters, the schools were located within a radius of 16 km. from each of the casting yards. The construction was organized departmentally. On an average, each school was completed within 35 days and the average cost was Rs. 8,100.

Adverse reactions were recorded from the villagers, teachers, students, officials and other general public and are given in Table 5.

Table 5. Comments on the first prototypes

Source	Nature of comments
Teachers	Thermal discomfort; noise disturbance through the top of the partition 6' 2" high; independent access to each classroom desired; asbestos roof was considered temporary structure. The built-in cupboard, it was suggested, should be replaced by a storeroom, which could be used as school storage space also.
Students	Thermal discomfort; noise disturbance through top of partition. Independent access required to each class.
Officials	Asbestos roof not liked as they looked temporary, and liable to be damaged by students thus requiring more maintenance.
Villagers	The same comment as officials

The other constructional design criteria had, of course, already been met. Plate 8 shows that the roof components could easily be carried by bullock cart, while the ease with which the roof components could be manhandled into position is shown in Plate 9.

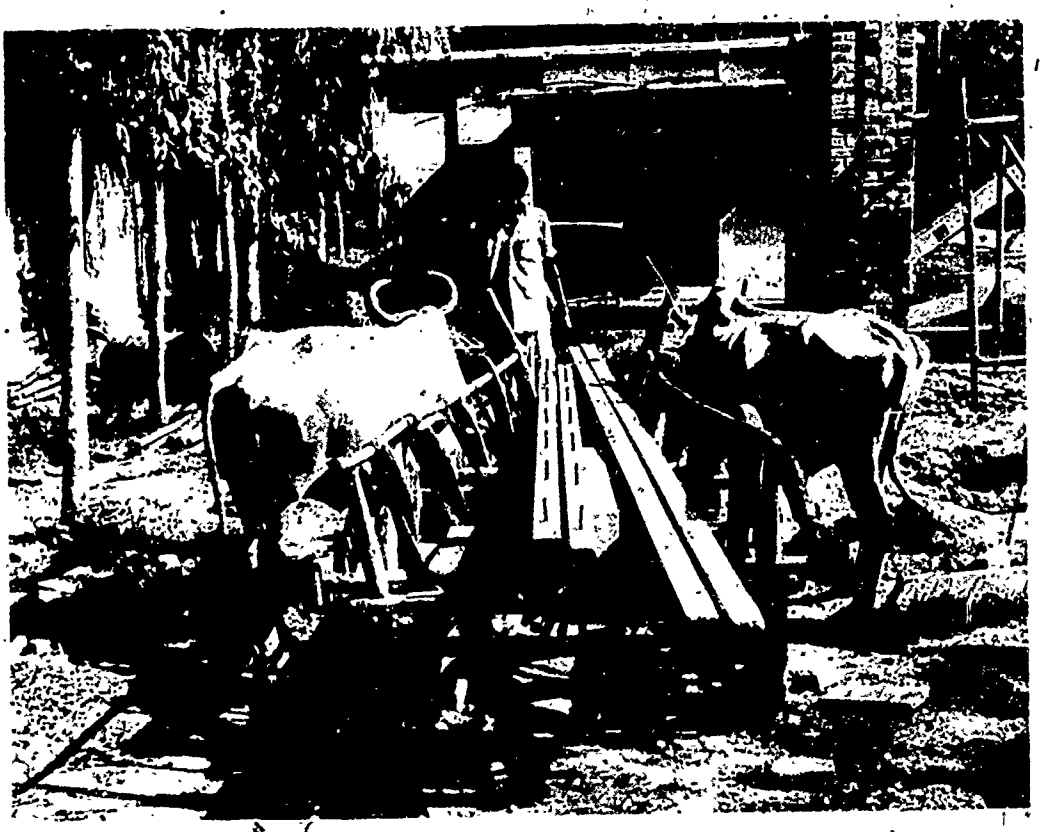


Plate 8. Roof components could easily be carried by bullock cart.

Plate 9. Man-handling the roof components into position.

Adjustment of the prototype

There followed, as a result of the initial experience with the 12 prototypes, two further adjustments. The first took into account the comments made by the local people using the school. A concrete flat roof was provided, a separate entrance was arranged to each classroom and a larger storage room replaced the small space and kitchen.

The complaints about noise over the movable partition were resolved in a way which were well illustrated how the research resources of the Central Building Research Institute could be brought to bear on problems. In the first prototypes, as has been seen in Figures 9 and 10, the chalkboards were placed at opposite ends of the two classrooms. The acoustics specialists of the Institute, after taking a series of measurements, found that interference, as between one class and the next, would be considerably reduced if the chalkboards, and thus the teachers, were arranged back to back on the partition dividing the spaces.[12] This adjustment was thus also incorporated in the second prototypes of which the arrangement is shown in Figure 12 and Plate 10.

12. Choudhury, N.K.D. *Sound diffraction around movable partitions in teaching spaces.* Educational Building Report No. 1. Bangkok; Unesco, 1973.

FIGURE 12.
Plan of First Stage of the Second and Third Prototype

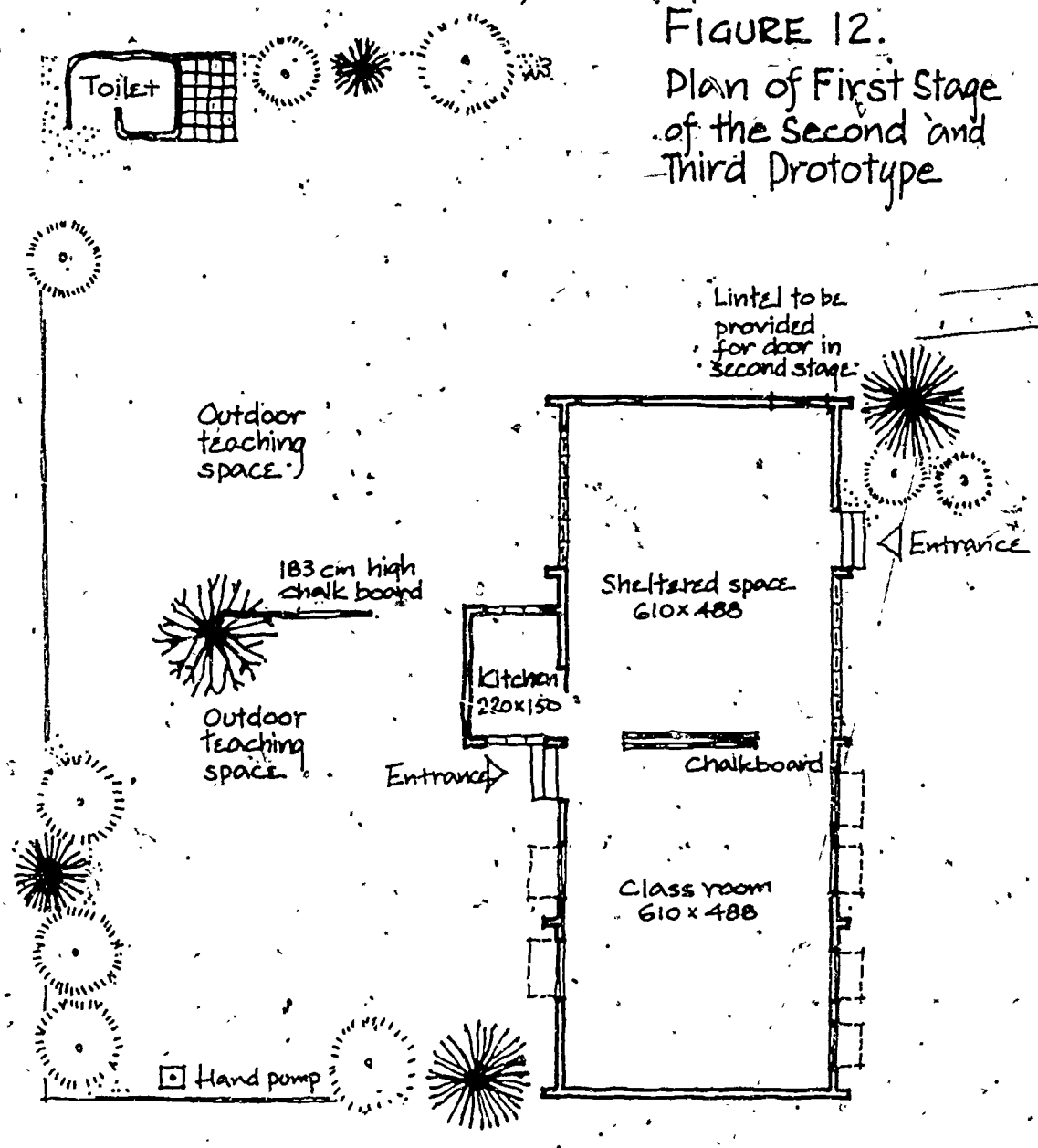


Plate 10. Interior view of second prototype showing central, back-to-back chalkboards and flat roof.

But a study of the roof construction using inverted composite trusses, each with two steel tension and three concrete compression members showed that erection was an excessively time consuming activity, adding substantially to the costs of what, otherwise, was a very cheap way of spanning the classroom space. Efforts were therefore made to reduce the erection time and thus the cost of this element of the roof. The result, which is shown in Plate 11, is an extremely neat, light-weight, welded steel truss which, hoisted into place by four labourers in half an hour, reduced by $5\frac{1}{2}$ hours the time taken to scaffold for and assemble the composite truss.

The third prototype, in fact, incorporated the following changes from the first:

i) asbestos pitched roof replaced by a flat, pre-cast concrete channel roof on prefabricated welded trusses.

ii) the pre-cast reinforced concrete columns and column bases where dispensed with in favour of brick, block or stone work - as locally available.

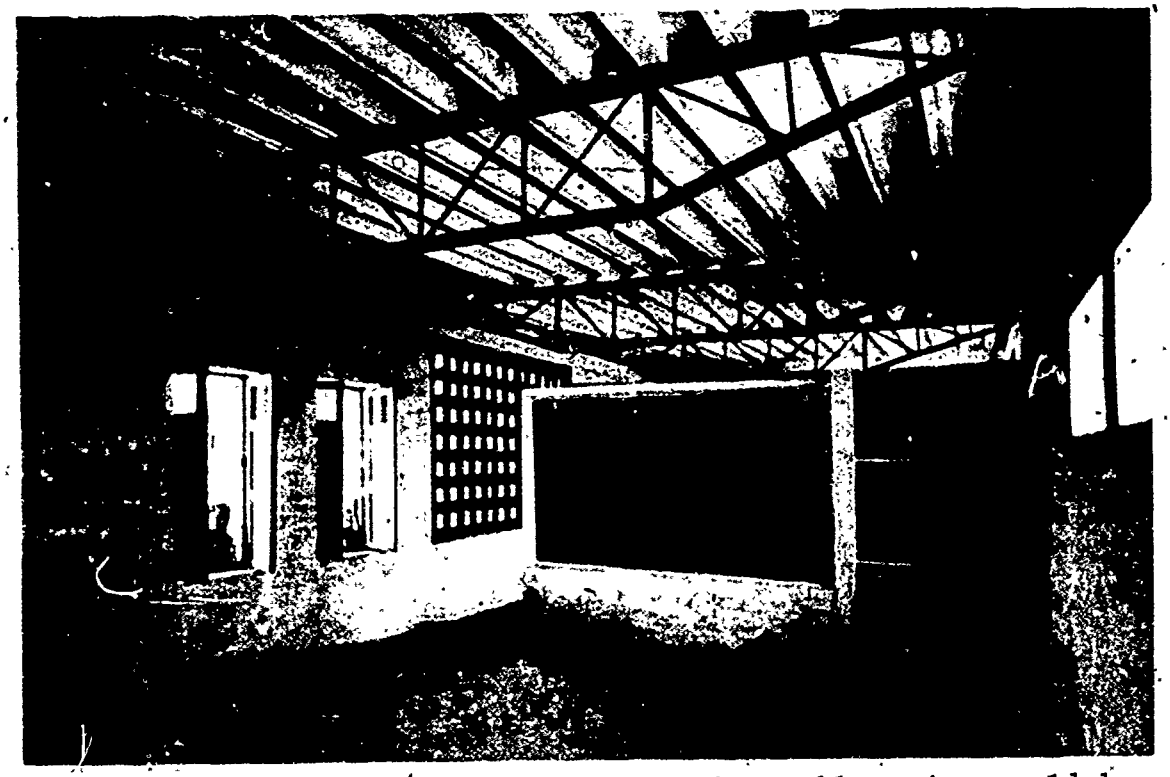


Plate 11. The final solution to the roofing problem using a welded, light-weight, prefabricated steel truss.

iii) the movable partition was replaced by a free-standing brick partition with chalkboards on both sides thus changing the quality of the building from 'flexible' to 'adaptable'.[13] (this was due to the very high cost of timber and the comparatively low cost of brick work in Uttar Pradesh).

iv) a large internal store was provided in lieu of an external kitchen.

v) two doors were provided instead of one.

The details of the third prototype are shown in Figure 13 (page 36).

The quantities of materials and labour for one such school building is shown in Table 6. This forms about 85% of the building cost. The remaining 15% of the cost is consumed in transportation, casting platform and moulds for the pre-cast components and other minor materials.

The costs of the third prototype varied, of course, slightly from place to place and the costs at eight selected districts representing eastern, central and western zones of the State are given for purposes of comparison in Table 8. Annex I indicates the way in which these costs have been built up as, for example, a channel unit. (Annex I appears on pages 68 and 69).

From Table 8, it will be seen that the average cost per school is Rs. 8,319 or Rs. 104 (US $14) per student place of 0.74 m^2.

13. Definitions suggested by OECD. "Adaptability" is essentially, large magnitude/low frequency change while "flexibility" is defined as low magnitude/high frequency change.

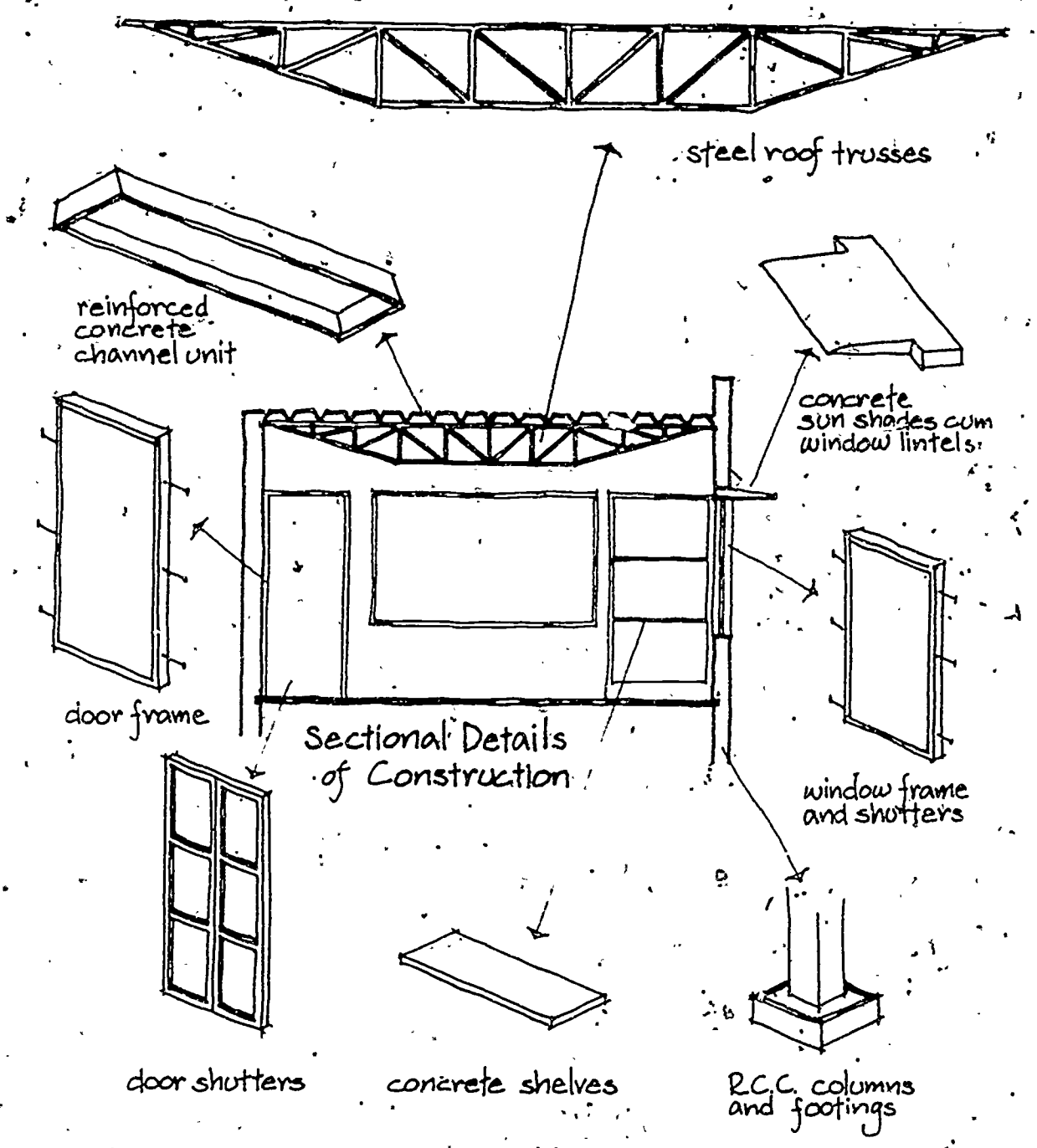


FIGURE 13. The Prefabricated Elements of the Third Prototype

Table 6. Quantities material/labour per school

Item	Unit	Qty
Material		
Bricks	no.	19 000
Cement	tons	5.1
Steel	quintal (100 kg)	6.91
Cement aggregate	cu. m	12.45
Sand	cu. m	6.80
Unslaked lime	quintal (100 kg)	7.62
Surkhi	cu. m	3.44
Timber	cu. m	0.2
Labour		
Skilled	man days	97
Unskilled	man days	204

It is useful to compare this cost with that for the construction of primary schools in other countries of the region such a comparison is shown in Table 7.

Table 7. A comparison of the cost per unit area of primary school buildings in the Asian region

Country	Cost per sq. metre of primary school construction in U.S. $
India - Uttar Pradesh 3rd Prototype	14.10
India - Kerala State	18.10
Iran	70.00
Indonesia	21.30
Malaysia	52.00
Pakistan	32.30
Sri Lanka	53.30
Thailand	60.00
Mean cost for region	$40.14

Table 8. Comparative costs of third prototype in eight selected districts

District	Prefabricated components															Reinforcement and stone grit	Door/window	Cartage	Local material in walling etc. - labour and contractor's profit	Total (Rs.)
	Channel unit			Steel trussed beam			Sun shade						Shelves							
							Door			Window										
	Q	R	A	Q	R	A	Q	R	A	Q	R	A	Q	R	A					
Bareilly	76	24.75	1881	3	203	609	2	24	48	4	18	72	6	10	60	117	510	530	4 604	8 431
Ballia	76	27.25	2071	3	209	627	2	27	54	4	20	80	6	9.0	54	112	640	468	4 006	8 112
Deoria	76	28.50	2166	3	210	630	2	27	54	4	19.5	78	6	9.3	55.50	126	510	475	4 270	8 361
Ghazipur	76	26.50	2014	3	210	630	2	25	50	4	18	72	6	8.5	51	121	520	478	4 298	8 234
Gorakhpur	76	28.25	2147	3	210	630	2	27	54	4	19.5	78	6	2.3	36.60	126	510	470	4 496	8 547
Muzaffarnagar	76	24.00	1824	3	204	612	2	20	40	4	18	72	6	12	72	112	497	423	4 639	8 291
Moradabad	76	25.50	1938	3	205	615	2	20	40	4	14	56	6	10	60	120	550	350	4 620	8 349
Varanasi	76	24.50	1862	3	210	630	2	22	44	4	16	64	6	8	48	99	510	478	4 489	8 224

Q = quantity
R = rate in rupees
A = amount in rupees

Comparisons of this sort, must, of course, be qualified. Different costs of labour, different standards of construction and of finishes, all affect the cost-per-unit area. The Table may at the very least show that it is possible to build a brick school with a sound concrete roof very cheaply indeed - provided that costs are analysed and through successive development of prototypes, reduced to a level compatible with the target budget.

An internal comparison, with an equivalent building using traditional methods of construction is, of course, valid from all viewpoints. Table 9 compares the costs of the construction of the third prototype with a similar school built using the traditional construction of Uttar Pradesh.

Variations in the final design.

Two factors have led to a considerable number of variations in the final design depending upon the site at which each school is constructed. The first and major type of variation is that connected with climate. As has been mentioned on page 20, the State of Uttar Pradesh, while in the main comprising level, though often rough and broken land, includes along its northern border some of the mountainous Himalayan country where schools are often built at elevations of 1,000 m. or more. In these mountainous regions, not only are temperatures much lower, but in winter, there is usually heavy snowfall. The type of construction used in such situations has thus to differ from that of the plains. Figure 14 illustrates how, while retaining the main features of the plains school, the school for the mountainous areas has been adapted wi[illegible] sloping roof, more effectively to drain away the water from melting snow a[illegible] with thick walls to help retain heat in cold weather.

The second type of variation is found in almost all schools in the construction programme. As is explained more fully in Chapter Three below, those responsible for construction on individual sites are required to keep the cost of each building within a prescribed limit. Sometimes where mud bricks for wall panels are not readily available, concrete blocks, stone or burned bricks may be used.

The open grille work in the classroom as well as the large grille in the sheltered space may also vary, depending on the materials available locally, but whatever variation is made must be such that the cost limit is not exceeded. The only constant features of the buildings thus, are the prefabricated elements.

Plate 12, taken on a typical, misty day, shows the design variation for the mountain regions, while Plate 13 shows a school in the Himalayan foothills of Uttar Pradesh in which concrete blocks have been used for wall panels. Plates 14, 15 and 16 show the completed primary school in its (more normal) village setting in the plains.

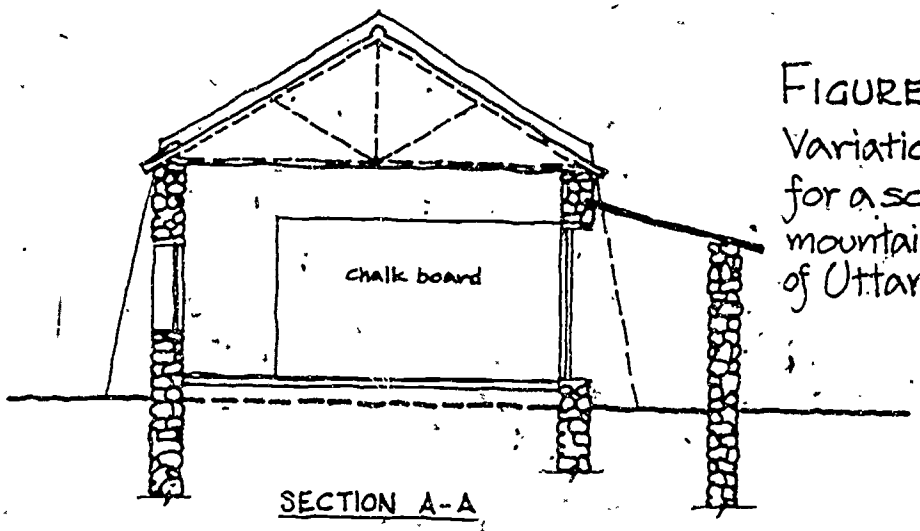
Table 9. A comparison of traditional building costs in Uttar Pradesh with those of the prototype design

Element	Traditional Construction		3rd Prototype Construction		Percentage savings over traditional cost	Factors contributing to economy
	Specifications	Cost Rs.	Specifications	Cost Rs.		
1	2	3	4	5	6	7
Foundation	Excavation in ordinary soil. Lime concrete (23-30 cm thick) 100:16:32 with brick ballast, white lime and surkhi;[1] brick work in cement mortar; 3/4" thick DPC of cement mortar 1:3 with water proofing compound.	1 290	Excavation in ordinary soil; lime concrete (15 cm thick) 100:16:32 with brick ballast, white lime and surkhi; brick work in cement mortar in pillars and in mud mortar in panels. DPC of cement concrete 1:2:4 with water proofing compound.	970	24.8	Reduction in thickness of base concrete and in the section of foundation.
Walling	Brick work in cement mortar 1:6; reinforced concrete lintels and sunshades.	2 163	Brick work in cement mortar 1:3 in pillars and in mud mortar in panels; reinforced concrete lintels and sunshades.	1 930	10.8	Use of load bearing pillars and mud mortar in panels.
Roofing	Reinforced brick slab with reinforced T-beams. Lime concrete terrace (average 10 cm thick) having bitumen coating below.	4 600	Pre-cast channel units supported in steel truss; lime concrete terrace (average 7.5 cm thick) having bitumen coating below.	3 490	22.8	Use of pre-cast plank scheme instead of reinforced brick slab.

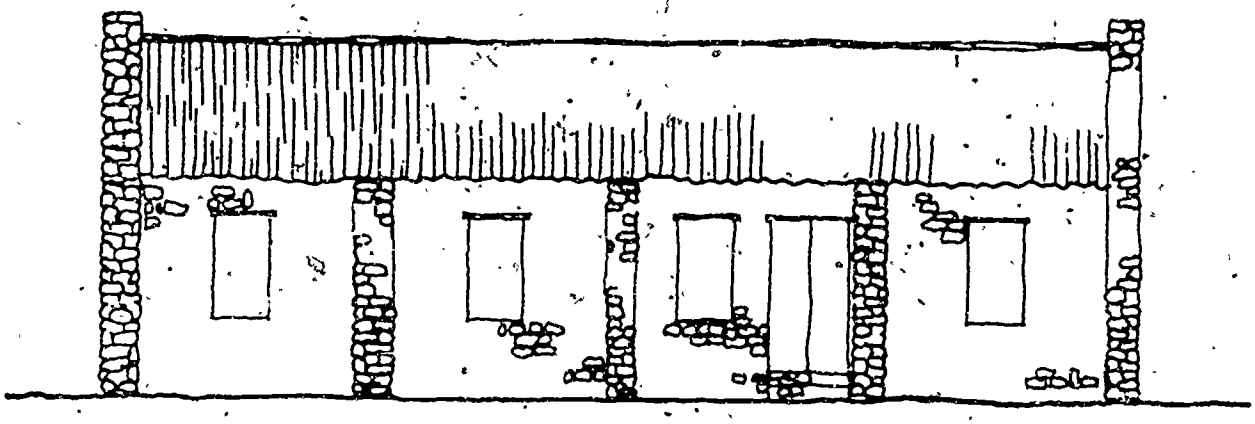
1. 'Surkhi' is crushed brick powder.

1	2	3	4	5	6	7
Floor	1½" cement concrete 1 : 2 : 4 laid on 3" thick lime concrete 100 : 16 : 32.	551	1½" cement concrete 1 : 2 : 4 laid on 3" thick rammed brick ballast	420	23.8	Use of rammed brick ballast base instead of lime concrete.
Doors and windows	40 mm thick pannelled shutters for doors; and glazed for windows and ventilators; sal wood frames for doors and windows	591	19 mm thick kail wood battened shutters with 25 mm thick ledges and braces. Timber glazed shutters for windows and ventilators; steel frame for doors and windows.	482	18.7	Omission of frames and use of battened shutters for doors.
Finishes	Levelling top of wall surfaces with cement mortar 1 : 3; 12 mm thick cement plaster 1 : 6 outside and inside; walls white washed internally and colour washed externally. Painting wood work with oil paint. Ceiling plaster to reinforced brick slab in cement mortar 1 : 3.	982	Levelling top of wall surfaces with cement mortar 1 : 3; 12 mm thick cement plaster 1 : 6 outside and inside walls white washed internally and colour washed externally. Painting wood work with oil paint.	776	21.0	No plaster on ceiling.
Fittings and fixtures	Pre-cast reinforced concrete shelves; blackboards in rooms.	120	Pre-cast reinforced concrete shelves; blackboards in rooms.	120	Nil	
	Total	10 297		8 188	20.5	
	Add 3% contingencies	309		246		
		10 606		8 434		

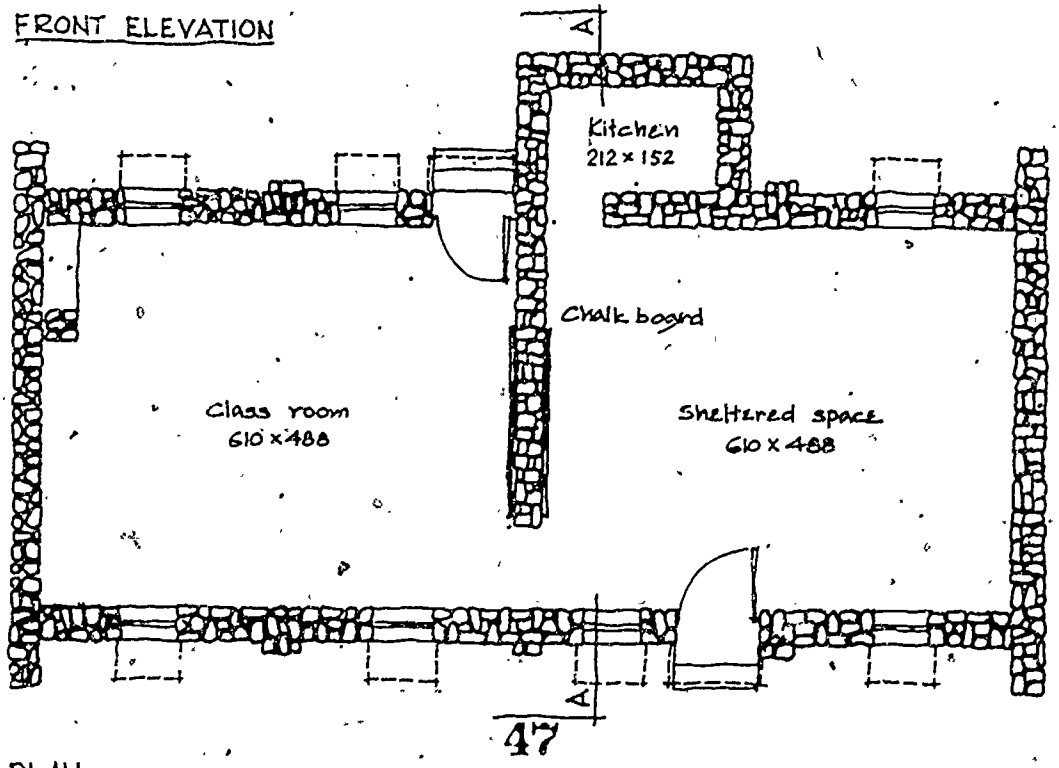
FIGURE 14.
Variation in design for a school in the mountainous regions of Uttar Pradesh



SECTION A-A



FRONT ELEVATION



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PLAN

Plate 12.

The design variation for the mountainous regions of Uttar Pradesh.

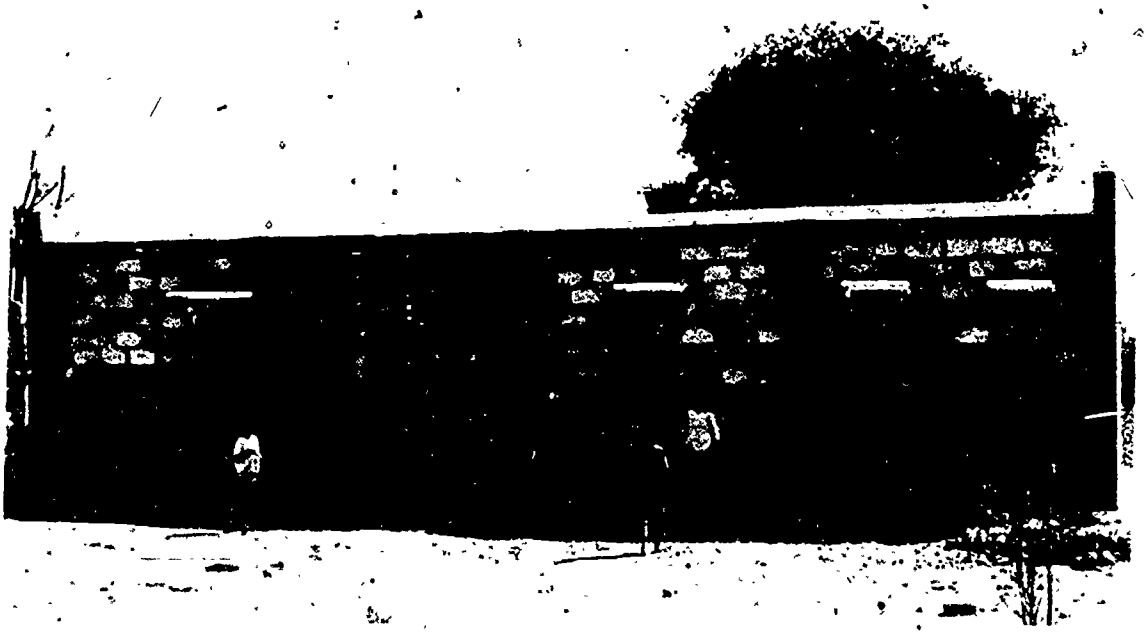


Plate 13. Concrete blocks used for wall panels in a school in the Himalayan foot hills.

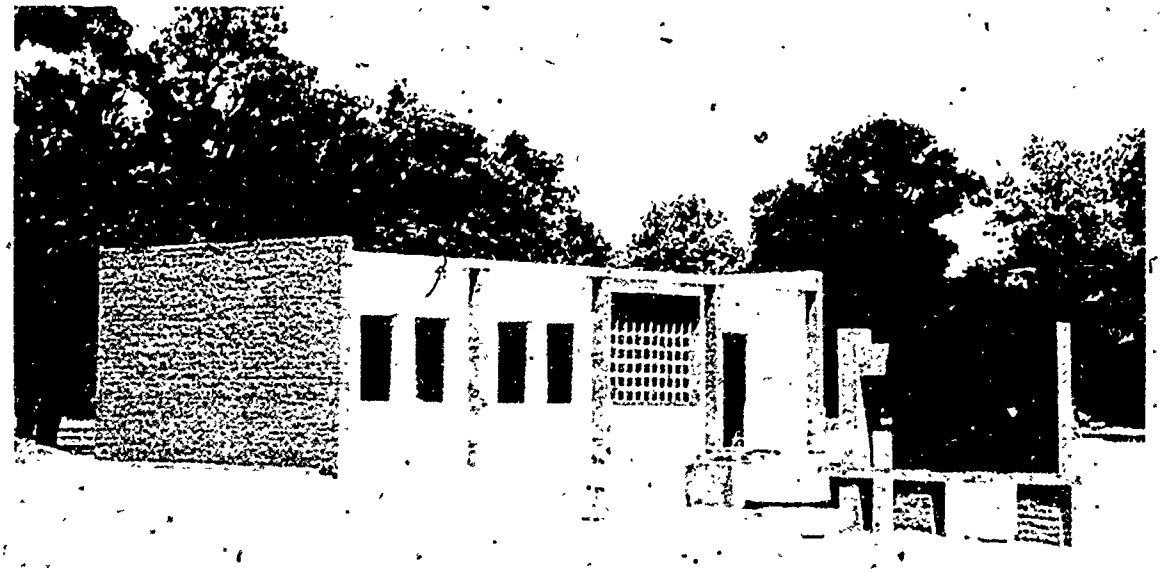


Plate 14. The more normal setting for the school in the plains.

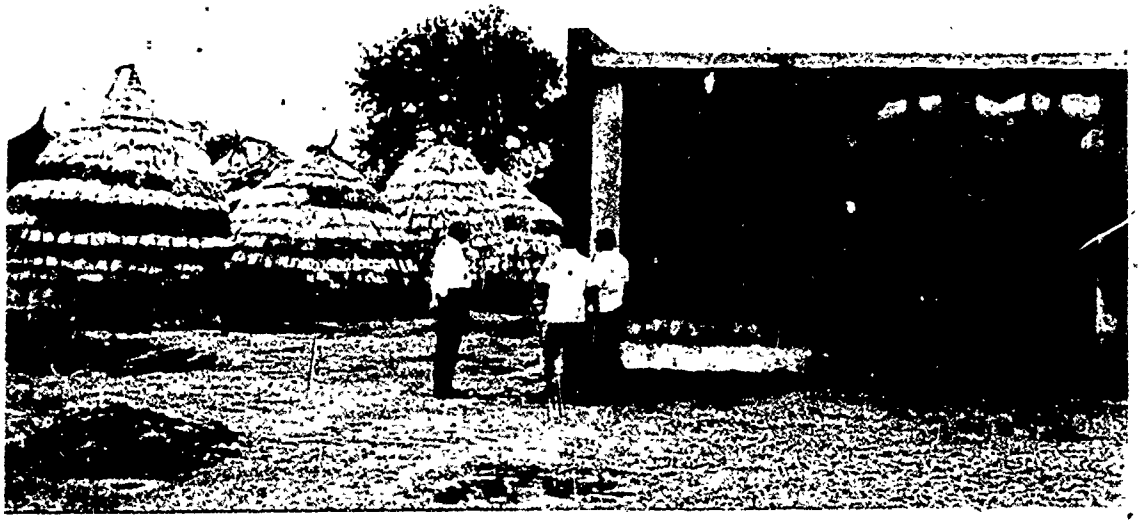


Plate 15. Detail of the 'back' of the building showing large storage space and screen to sheltered space.

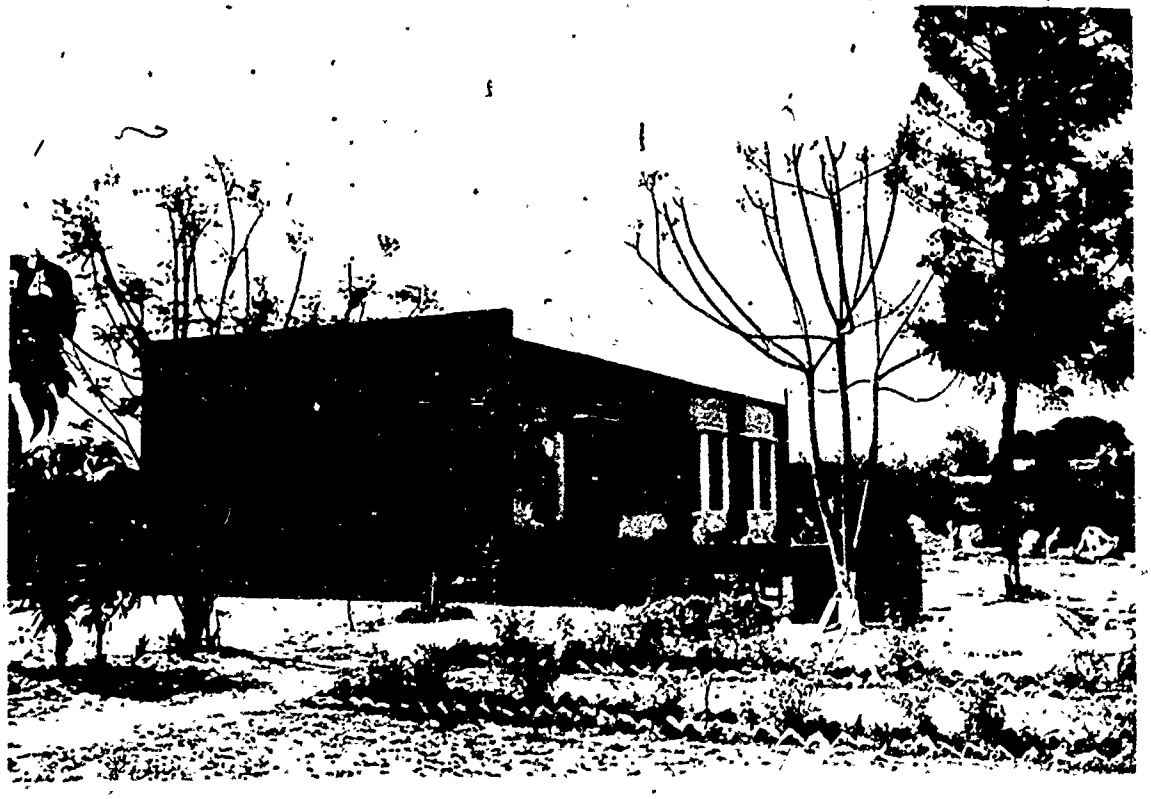


Plate 16. School in the plains with developed site and landscape.

CHAPTER THREE

MANAGERIAL ASPECTS OF THE CONSTRUCTION PROGRAMME

Background

After the adjustment of the prototype, the Government was satisfied that the design and cost criteria had been met. The problem then faced was that of arranging for the construction of 5,500 schools in a three-year period with a budget of Rs. 50,000,000 (US $6.75 million) available for the purpose. The Government released the funds to the Zila Parishads (the agency responsible for the construction of schools in the districts) with the instructions to adopt the plan and cost ceiling of Rs. 8,500 set by CBRI. The Zila Parishads found it difficult to construct schools within the cost ceiling. The cost of the schools ranging, on an average, 25 to 40 per cent more than the prototypes. The other specific difficulties faced by Zila Parishads were:

a) They were not geared to take up time-targeted construction on a mass scale due to time-consuming administrative, financial and constructional procedures and non-availability of adequate technical staff.

b) They were still not fully convinced of the economy of large-scale design and construction technology evolved by CBRI.

c) There were many priority projects already in hand.

It is worth mentioning that the procedural aspect of project implementation was one of the main reasons for large backlog in primary school construction (Table 1, page 13). It was, therefore, implied that the Project could not be carried through by Zila Parishads successfully. Even if these problems could be solved, it was clear that due to the cost of construction, the physical targets will be reduced by 25% to 40%.

Under the circumstances, the alternatives were (a) to defer the project - this was not desirable due to pressing need for school buildings; (b) to allow the schools to be constructed, as in the past, with all possible risks that the previous experiences would be repeated; (c) to involve the CBRI in the planning, programming and execution of the project. Though it was clear that CBRI is not a construction agency, it was realized that unless the challenge of constructing schools was taken up by CBRI, the benefits of research would not be available. The solution to these apparently insuperable difficulties was found by arranging for the CBRI Roorkee to undertake the work.

Managerial aspects

The CBRI is a Research Institute under the Council of Scientific and Industrial Research (C.S.I.R.) which is an autonomous body financed by the Government of India. Funds for the activities of the Institute are received from the CSIR and the Institute functions within the framework of the policies, rules and regulations of the CSIR. The programme of research activities and the budget of the Institute are controlled by an Executive Council, the members of which are appointed by the CSIR. The recommendations of the Executive Council are considered and approved by the CSIR before the programme of the CBRI is implemented. The Institute is headed by a Director, who has been delegated adequate financial and administrative powers to run the Institute effectively and to implement its research programmes.

What is of great importance in the present context, however, is that the CSIR has provision to accept schemes financed by outside agencies including Government Departments and State Governments, if these relate to research or development activities being carried out in any of its constituent National Laboratories or Institutes and for which facilities exist in these organizations. The fundamental condition of acceptance of such schemes of work financed by outside agencies is that they should have a bearing on the research and developmental activities of the Laboratory/Institute concerned. There should, moreover, be no financial involvement of the Laboratory/Institute where such schemes are undertaken, all expenditure being met from the funds received from the agency. In incurring expenditure on such projects, rules, regulations and instructions issued by CSIR from time to time have to be followed and accounts maintained according to CSIR rules and procedures. Any variations that need to be adopted for the effective execution of a particular project require the approval of the CSIR.

The request of the Government of Uttar Pradesh to the CBRI to undertake the construction of primary school buildings in the State with funds to be provided by the Government of U.P. was considered by the Executive Council of CBRI at its meeting held on the 5 September 1972. The Executive Council recommended acceptance as a sponsored project in view of the fact that it would introduce the development work of the Institute to the interior villages of the State with possible extension subsequently to cover the entire country. It also approved the creation of necessary posts for the project. The recommendations of the Executive Council of the Institute were subsequently approved by the CSIR and the Director of the CBRI was authorized to accept and start the project.

The specific difficulties to be overcome were as follows:

i) The normal Government rules and procedures for construction programmes were time-consuming, especially those rules relating to finance and administration of projects, and in no case could the basic principles of the rules be ignored.

ii) There was no set procedures or rules to administer projects with limited funds for which time targets had to be achieved.

iii) Government building projects were by rule, required to be undertaken by contractors on the basis of competitive tendering yet, as most of the building sites were likely to be in remote and often almost inaccessible villages, with difficulties of procurement and transport of materials and labour, few contractors would be willing to tender for the works and then only at prohibitive prices.

iv) Suitably experienced personnel to control projects within a time limit were not readily available.

Objective of the project

The project as is clear from the preceeding chapters is the end-product of research, carried out by the CBRI, on the major aspects of buildings, and hence it is mainly an implementation of research on a large scale, rather than a construction project per se.

In view of the nature of the project and its socio-economic impact the broad objectives of the project include:

a) To create awareness in the public and the professionals in the cost control techniques of the CBRI, so that they become a construction practice.

b) To create agencies at State and local level who could continue the activities after the CBRI has withdrawn from the construction work.

c) To plan, programme and execute the project in such a way that the local population obtains benefit of employment opportunities.

d) To create opportunities for local unskilled or semi-skilled people to improve their skill while working with trained staff of the project, thereby adding to the stock of skilled personnel at local level.

e) To create general interest and to associate the people with developmental activities in rural areas.

The project was planned with the above objectives.

The management committee

In view of the direct involvement of the State Government of Uttar Pradesh in the building programme as well as the very large sums of money that it was planned to invest, and in order to have a better co-ordination with the State Government, the Director of the Central Building Research Institute decided that the project should be managed by a 'Management Committee' comprising the following members:

The Secretary, Education Department, State Government of Uttar Pradesh.

The Director of Basic Education, Education Department, Uttar Pradesh.

The Director, Central Building Research Institute, Roorkee, U.P.

The Co-ordinator of the School Building Project (SBP) - the author of this Report.

The Committee's functions, which are subject to the overall approval of the Executive Council of CBRI and of the CSIR, are to exercise proper control and check on the activities of the project. All policy, executive and administrative matters connected with the project are reported to and considered by the Committee. As the project developed, the Committee met for consultations as and when needed.

Planning the project

Planning involved, in the first instance, consideration of the ways in which the total building programme for the 5,000 or more schools could be implemented in a period of three years. What organizational structure was needed at the executive and operational levels to achieve the programme target? What would be the hierarchy of control to ensure not only that large numbers of buildings were constructed according to pre-determined time schedules but, equally important, that they did not exceed the very vigorous cost targets which, experience with a very limited number of prototypes had shown, was feasible?

In the event, the decision problem was solved by use of the 'working-backward' procedure.[14] Over 5,000 schools had to be constructed in a period of three years for a sum of Rs. 50,000,000. The schools had, moreover, to be built in 51 of the 54 educational districts of the State.[15]

On an annual basis, this would have meant either working in about 17 districts per year for three years or constructing over 1,785 schools per year in selected districts for a three year period. A combination of these two targets which took into account the terrains, the location of CBRI (near to which it was possible to build more easily than in remote places difficult to control) and several other reasons which necessitated the construction of schools simultaneously in all the regions of the State resulted in a plan for construction as follows:

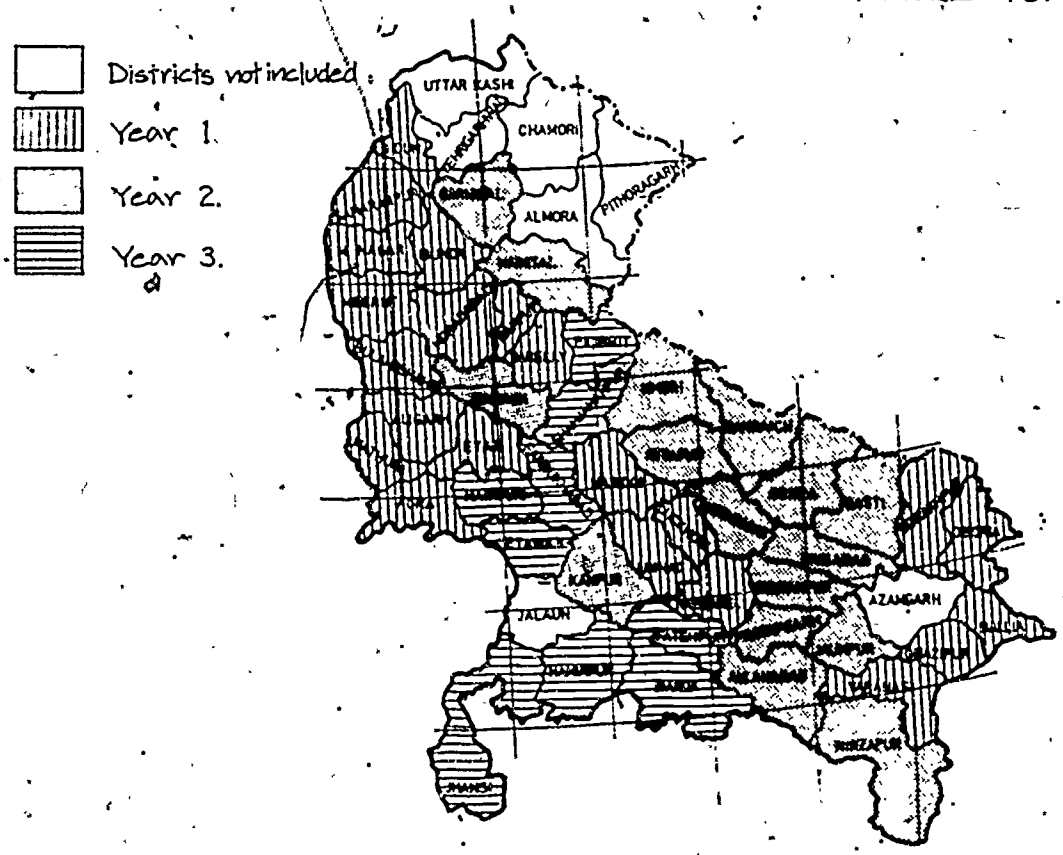
Year I	: Work in 20 districts	(about 2,000 schools)
Year II	: Work in 18 districts	(about 1,900 schools)
Year III	: Work in 13 districts	(about 1,200 schools)
Total	51 districts	(about 5,000 schools)

The phasing by districts is shown in Figure 15.

14. Julian Feldman. "Organizational decision making". In: *Handbook of organizations*. Ed. James G. March. Chicago, Rand McNally, [1972] p. 614-649.

15. The programme did not extend to the inner Himalayan districts of Uttar Kashi, Chamoli, and Pithoragarh which are remote, have a distinctive population distribution and include the highest of the peaks in Uttar Pradesh - these districts require unique solutions to their educational building problems.

FIGURE 15.

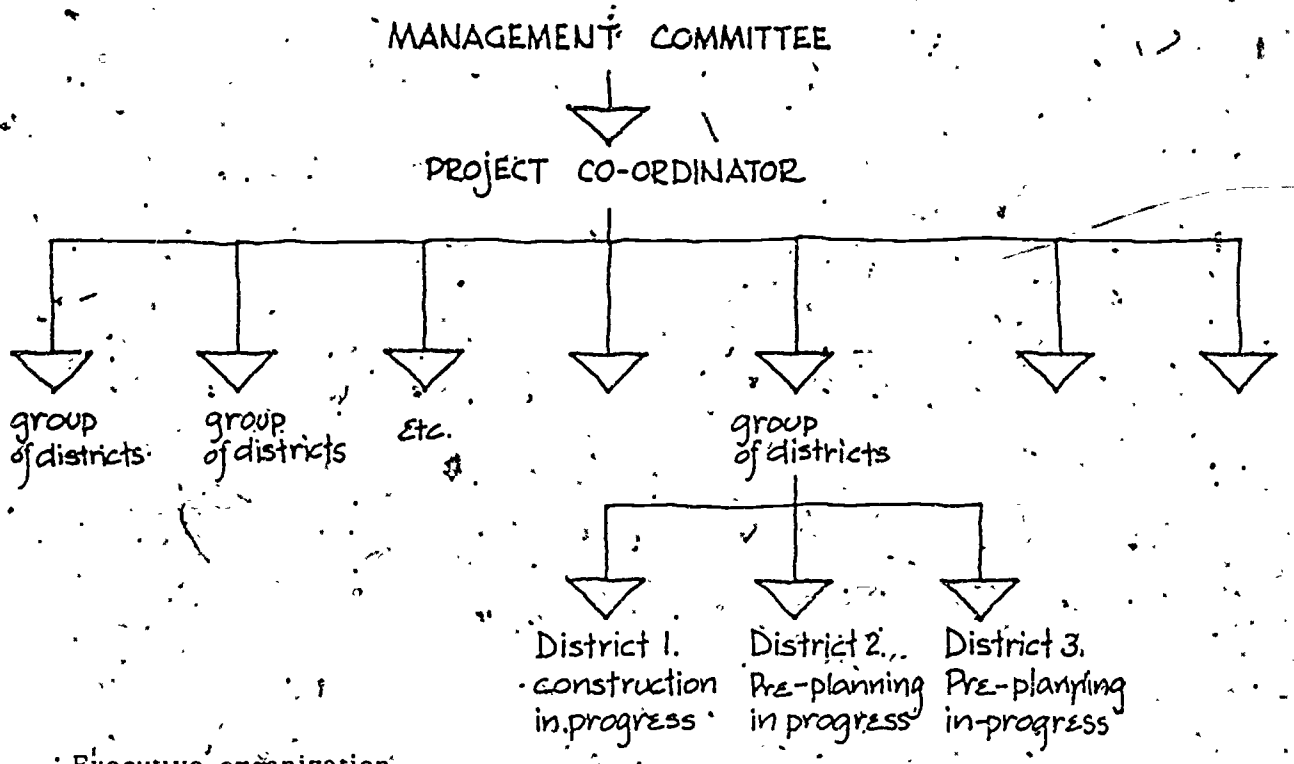


Phasing of Construction Programme over 3 years on an Education district basis

Once the programme had been divided into phases and the quantum of work to be achieved annually had been established, it was possible to work further forward and design the organizational structure to deal with a single year's programme.

The first phase of about 2,000 schools in 20 education districts meant an average of about 100 schools per district and a district programme of over three quarters of a million Rupees. ($115,000 roughly). This, it was decided, could be handled by one team and the district thus became the organizational unit on which the entire operation was based. However, as it seemed likely that work could not commence simultaneously in all districts at once, they were grouped in threes such that, while construction was to be in progress in one district of the group, pre-planning for construction was to be in progress for the other two. The skeleton of the organizational hierarchy was thus developed as shown in Figure 16. The next question to be considered was its staffing and organization at the executive level.

FIGURE 16. The Organizational Hierarchy



Executive organization

Although the project now formed one of the Central Building Research Institute's research and development activities, its interdisciplinary character, coupled with its very large budget and separate Management Committee, suggested the need to deal with it through a new, albeit temporary, Division of the Institute. It was thus decided to create a new establishment within CBRI headed by the Deputy Director who was designated Project Co-ordinator. The project co-ordinator is responsible for planning and directing the execution of the works in the districts and for looking after the day-to-day administration of the project. He is assisted on the technical side by an Assistant Director and on the administrative and accounts side by an Administrative Officer and Accounts Officer, with a minimum complement of supporting administrative and accounts staff. It was also decided that funds received for the establishment and supervision charges of the project should be maintained in a separate account in the State Bank of India, University of Roorkee Branch, Roorkee, to be operated by two Officers of the project. This enables quick payments to be made and facilitates the maintenance of accounts for the project.

Under the control of the Project Co-ordinator, Senior Scientists from the Institute were placed in charge of groups of districts with the necessary administrative and financial authority delegated to them. Each Senior Scientist was assisted by an accountant and clerk to maintain the accounts at the headquarters office of the group of districts. Each district was in charge of a scientist.[16]

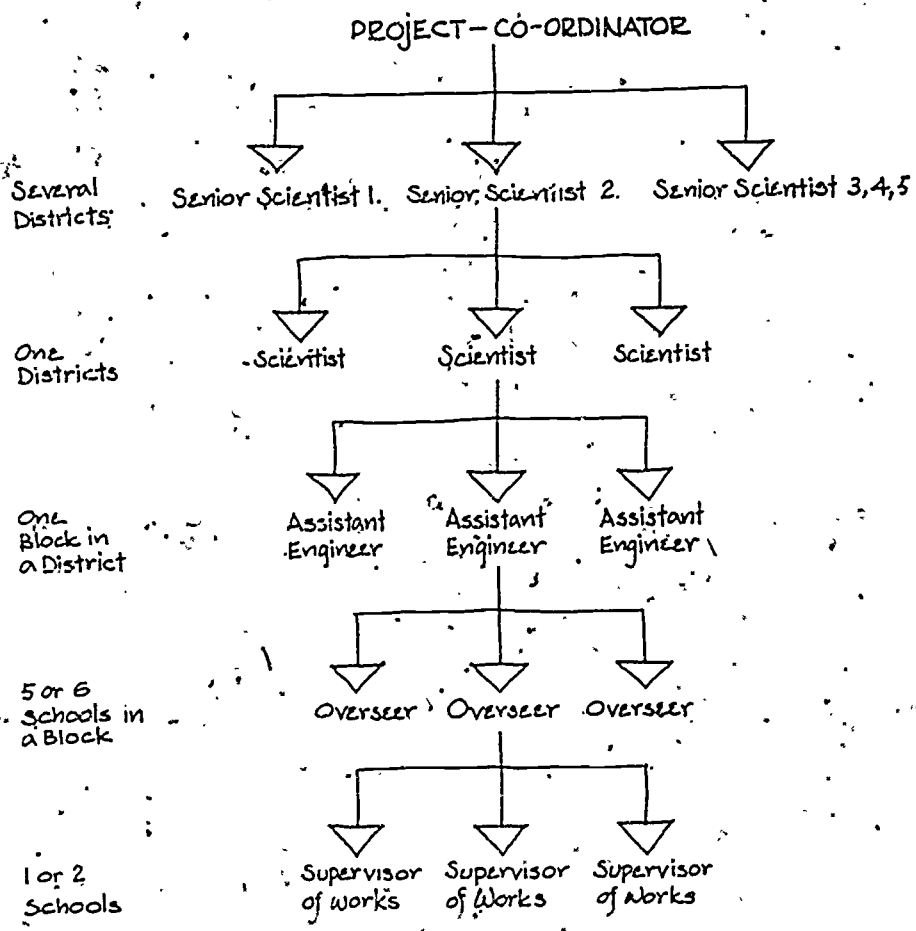
16. The staff of the Central Building Research Institute are organized hierarchically downwards as follows: Director, Deputy Director, Assistant Directors, Senior Scientists, Scientists etc.

The organization at district level was as follows:

Scientist	- responsible for the district construction programme.
Assistant Engineers	- one in charge of each 'block' in the district, each district having several 'blocks'.
Overseers	- one in charge of from five to six schools in a block, each block having several overseers.
Supervisor of Works	- one in charge of one or two schools, there being several responsible to each overseer.

The staffing situation is summarized in Figure 17. The figure represents, of course, the theoretical organizational concept and its realization had, as will be shown below, to be modified depending on the staff that could actually be recruited.

FIGURE 17. The Executive Organization



Development of the operational organization.

The Project Office opened in September 1972, the Project Co-ordinator assuming duty with one Administrative Officer and one Assistant for the Office. Work at once commenced on:

i) the planning of priorities;

ii) location of districts to be dealt with in the first year;

iii) fulfilling staff requirements;

iv) preparation of guidelines for supervisory staff and instructions to be followed in relation to work activities in the districts;

v) preparation of a scheme for preliminary training of staff in the methods of construction;

vi) liaison with the State Government and District authorities for assistance in the procurement of building materials and handing over of sites for construction;

vii) preparation of the project budget with reference to staff requirements and funds receiving;

viii) formulation of guidelines for observance of financial rules and regulations;

ix) compilation of a simplified manual for works and purchase procedures;

x) drafting service conditions of staff service;

xi) opening of bank accounts for the project funds.

These were herculean tasks and were completed by the end of October 1972 by the nucleus of the Project Staff with the assistance and co-operation of a few members of the CBRI scientific and administrative staff. The guiding principle in all these activities was the time target of the project. Urged by the need to observe the basic rules and procedures of the Government of India as adopted by CSIR and having regard to the limitation of funds, the emphasis was placed on the simplification and the rationalization of the rules and procedures to maintain the speed of progress needed to complete the project.

The first major problem, after the organizational aspects had been considered, was that of recruitment of staff.

Immediately it was decided to undertake the project and the posts, required to man the project, were created by the Director, on the basis of works to be started in the first stage, and having regard to the funds earmarked for establishment and supervision charges. It may be added that the strength of the Supervisory and Administrative Staff for the project were subsequently constantly reviewed and regulated on the basis of the quantum of work and available funds to effect efficiency and economy.

Recruitment was in accordance with the basic rules and procedures of the CSIR, which required the advertisement of the posts and the selection of candidates through duly constituted Selection Committees consisting of specialists in the fields in which the candidates were to be appointed. The procedural formalities were completed as expeditiously as possible. The first batch of candidates for the posts of Scientist were selected in November 1972 and offers of appointment made to them immediately. Most of them joined by the end of December 1972. There was, at that time, a shortage of experienced technical personnel suitable for taking up such a high priority, time-targetted project, hence it was not possible to recruit the required number of suitable candidates. The junior posts, such as Overseer and Work Supervisor, were filled through the Selection Committee by the end of January 1973 and the beginning of February 1973. The administrative posts were filled some time in November/December 1972. By the end of January 1973, sufficient staff had been recruited to start work in the field. In the meantime, the senior staff appointed were busy in planning at the Headquarters and in the Districts so that construction could start in February 1973.

The magnitude of the task of selecting candidates and the speed at which this was done is illustrated in Table ~~8~~ 10, which includes posts for supporting staff not mentioned above.

Most of the staff appointed had been posted to their districts by February 1973. There remained, however, vacant posts for overseers and works supervisors and these were filled locally, the appointees being employed on a daily wage basis. As a matter of policy, all staff recruited at the level of overseer and works supervisor and shown in Table ~~8~~ 10 were, where possible, posted to their home districts so that their familiarity with local conditions would help speed up the work.

Table ~~8~~ 10. Recruitment of staff for the project

Description of post	Number of applications received	Number of applicants called for interview	Dates of selection committees	Number of applicants selected	Remarks
Scientist	283	105	13.10.72 14.11.72 10. 1.73	19	
Assistant Engineer	476	194	21.11.72	36	
Overseers	1 251	831	Nov. '72, June '73	74	
Supervisors of works	1 330	762	30.11.72 & 1,2.12.72	209	

The posts above are those shown in Figure 17. The posts below are for supporting staff.

Table 8. Recruitment of staff for the project (cont'd)

Description of post	Number of applications received	Number of applicants called for interview	Dates of selection committees	Number of applicants selected	Remarks
Administrative Officer	36	11	14.11.72	1	
Accountants	103	36	30.10.72 & 6.11.72	10	
Clerks	71	40	30.10.72 & 28. 7.73	11	
Stenographers	37	12	29.10.72 & 5. 1.73	4	
Drivers	13	13	3.11.72	4	
Others; cleaners, peons etc.	247	58	Feb./Apr. '78	19	
			Total recruited	387	

Orientation and training of staff

Both scientists and assistant engineers were briefed by the Project Co-ordinator at CBRI for a two week period before assuming duty at their districts. The briefing included:

i) critical examination of the primary school designs, specifications and estimates;

ii) discussions on the methods to be used to execute the works;

iii) technical scrutiny of the prefabricated elements;

iv) review of the administrative procedures relating to the management of staff and to the award of contracts and control of expenditure.

The overseers and works supervisors were also given practical training in construction and supervision. This took place initially at CBRI and was completed at nearby Saharanpur, the Headquarters of a district where prototype units had been erected and a yard for the manufacture of prefabricated units had been established.

The staff were thus given the background for effective discharge of their duties and an understanding of their responsibilities in the districts. It was, however, expected that, as the training period at the disposal of the project

authorities was very short, any difficulties faced by the staff, in the course of execution of the works, would be resolved by the Scientist in charge of the district. In special cases, problems could be referred to Headquarters for the issue of necessary instructions and guidance.

The staff were very clearly given to understand that the project was of vital importance to the State and that it was to be a success. To help achieve their targets, they were required to seek co-operation and assistance from local bodies and people. They were urged also to inculcate in the village people an interest in undertaking such simple construction work by themselves so that in future they could meet their own requirements for buildings in their villages.

Work flow and issue of directives

As already stated, the source of all planning and directives for the execution of the project is the Project Co-ordinator, who is responsible for the proper guidance and direction for all project activities. His instructions and directives to the Scientists in charge of the districts and Assistant Engineers cover such subjects as:

i) the design and details of the buildings to be constructed;

ii) changes considered necessary for the improvement of the designs of the buildings and their surroundings;

iii) the technical estimates for the work to be undertaken;

iv) the methods of choosing contractors for the award of contracts;

v) the procedure for staff placement in various centres according to the requirements of the works;

vi) public relations that should be maintained by the field staff for the success of the project;

vii) adherence to rules and procedures adopted for the project;

viii) periodical reports about the progress of the works to be furnished to Headquarters and outlining any difficulties being faced in the achievement of targets.

The Co-ordinator also invites suggestions for improvement in works procedures or designs and other administrative matters from the Scientists in charge. Besides this, he visits the sites in the districts periodically to acquaint himself with problems at site and district levels and issues instructions to solve difficulties or improve situations. Periodical meetings are held at the Headquarters with the scientists in charge and assistant engineers to discuss their problems to arrive at reasonable solutions. Such meetings are also addressed by the Director who gives broad guidelines to the staff for effective execution of works. The scientists in charge and the assistant engineers are always free to bring up their problems to the Project Co-ordinator, either through post or telephone or by personal visits to the Headquarters.

Managerial aspects

The scientists in charge are also free to discuss with their counterpart colleagues in other districts, problems of mutual interest and the discussions at such meetings are reported to the Project Co-ordinator for his information. In fact a cordial team spirit has been developed amongst the scientists of the project and the Project Co-ordinator, as a result of which all problems connected with the project are expeditiously tackled through mutual discussion. The administrative officer acts as a channel for communication of instructions from the Project Co-ordinator to the scientists in charge and vice versa and he advises the scientists in charge on all administrative problems.

The Project Co-ordinator with the assistance of his Headquarters staff maintains communication with the State Government and the district authorities and all records are maintained in the Headquarters.

Preparations for the commencement of construction

The preparations for the commencement of construction were complex. Essentially four preliminary activities were involved as follows:

i) selection and acquisition of sites for the schools;

ii) selection of central sites for prefabricating building components (roof, window frames, door frames and concrete sunshades);

iii) selection of contractors or organization of direct labour for the prefabrication work;

iv) selection of contractors or organization of direct labour for construction of the schools on the selected sites.

It will be noted that all of these activities had to be undertaken initially to get the project started but also that they are continuing activities in the sense that, once they have been completed in the first district and construction work commences, the senior scientist in charge of a group of three or four districts would move on to the second district to pre-plan for construction to commence there as soon as work in the first district was finished. When work has commenced in the second district, the senior scientist would move into the third and so on. The total activity may be conceived of as 'rolling' smoothly forward at the rate of about one district - that is about 100 schools - every three months. As initially, there were five senior scientists in charge of groups of districts, it will be seen that the completion rate of construction was 500 schools per quarter - a target that had been well maintained up to the time of writing of this Report.

But in order to understand what was involved in the preparations for construction, it is necessary to consider each of the four preliminary activities in somewhat greater detail.

Selection and acquisition of sites for schools

The first activity was negotiation for sites on which to construct the schools. The State Government had already indicated the numbers of schools

to be built in each district but the District Education Authority was responsible for indicating a precise location for every unit.

The Education Authority, in turn, had to negotiate for land through the village Pradhan (headman or leader). Normally there was not too much difficulty in obtaining land for construction but occasionally local disputes arose over the location of sites. The District Education Authorities, in most cases gave a list of selected sites greater than that actually needed and the scientist in charge of the district would then have to make a choice from the list. In so doing he had to consider:

a) suitability for construction purposes;

b) access for delivery of materials.

and also whether safe storage facilities were available for materials, whether local lodgings could be found for supervisory staff and whether local contractors or labour were available to assist with construction. Over and above all this, the Scientist has to be sure that the construction of every school on every site could be completed for Rs: 8,500 or less. This meant carefully checking the availability and prices of all materials that were to be provided from the locality, other than those of the prefabricated units.

Most sites, it transpired, were found on the fringes of villages. It will be recalled that the villages of Uttar Pradesh, as of many other parts of India, comprise mud brick buildings, usually on very ancient sites. As time passed and old mud buildings collapsed, the new buildings were constructed on the debris of the old and, slowly, the level of the land on which the village stood rose in the form of a low debris mound, with the newest buildings on top of it. No space is available on these mounds for extra buildings such as schools and thus sites for the new primary school buildings had to be found on the fringe of the village, usually in a no-man's land of waste between the village proper and the surrounding agricultural land. Many sites, in consequence, were rather small and one of the problems facing those responsible for site selection was that of assessing whether there were likely to be enough children living within walking distance of the school (2 km) to necessitate the eventual construction of the second or third stages of a five classroom school and whether the site in question was large enough.

Centralized prefabrication of components

The prefabricated components of the building are illustrated in Figure 13. They comprise pre-cast concrete roofing channels, welded steel roof trusses, welded steel door and window frames, pre-cast concrete lintel-cum-sunshades and wooden door and window shutters. (Figure 13 appears on page 36).

Specialized techniques are involved in prefabricating the units. No contractor with expertise in prefabrication work according to the specification

and within the estimated cost were available in the beginning. The availability of suitable land, electric power and a good supply of water was another problem. In most of the districts, the authorities made land available to project authorities to start manufacturing prefabricated units. The number of such casting units depend upon the size and terrain of the district. In few of the districts more than one casting yard was necessary. Generally casting yard at district headquarters is preferred. This being the headquarter of Scientist in charge, facilitates better supervision for quality control and better liaison with district officials.

Award of contract

The normal way of awarding of a construction contract is through open tenders on a competitive bases. This is time consuming and experience showed that with the introduction of the new technique of using prefabricated components, this system of contracting led to high rates of construction.

It was thus decided to award contracts through negotiations. The Scientist in charge after a local market-survey prepares a cost analysis of each prefabricated element and through a detailed estimate of the school building verifies that the cost of the school is within the cost ceiling. The cost analysis and estimated rates of each prefabricated element is examined and approved by the Project Co-ordinator. The Scientist in charge is then asked to negotiate within the rates provided in the analysis. By and large, the contractors have found the procedure acceptable and workable and obviously it is time-saving for project officials.

In the beginning the project staff demonstrated the techniques to local entrepreneurs to stimulate interest in them for this sort of work. Where entrepreneurs remained uninterested, the project administration set up casting yards with its own staff and started manufacturing the units to show the way. Slowly one or two entrepreneurs started work, and contracts were awarded to them after negotiating rates and other terms. Gradually other parties have begun to come forward to contract for prefabrication in almost all the districts. Contracts have been awarded under a variety of circumstances to

i) Parties who are local entrepreneurs and have resources to finance prefabrication contracts; or

ii) Unemployed engineers or local co-operative ventures of engineers and contractors, having potential resources for carrying prefabrication contracts; or

iii) Contractors through open tenders on a competitive basis.

In most of the cases, the work has to be awarded by negotiation of rates and terms. Strict supervision by the scientific and technical staff of the project is maintained to control the quality of the products according to specifications. It has been noticed with satisfaction that the techniques for manufacture of these prefabricated units are gaining popularity among contractors and a fairly good number of contractors are now available.

Some idea of the scale, complexity and, thus, the importance of good organization of the prefabrication programmes in each district is given by Plates 17, 18, 19, 20.

Preparation for work on the site

Contracts for work at the site were normally awarded to rural entrepreneurs having some experience of construction work. The basic intention is to encourage the rural economy through employment of local labour. The value of the contract for each school is small and does not exceed Rs. 3,000. The building materials such as cement, bricks and prefabricated units are supplied to the contractor who constructs the building by supplying labour. Each such contractor is awarded a contract to construct 3-4 schools in a block at a time. Their work is supervised by the staff of the project, who provide the necessary technical guidance at every stage of construction so that the work is complete according to specifications and within the time schedule.

In the beginning, there were difficulties in finding rural contractors willing to undertake school building construction work. Rural skilled labour for construction was also scarce. The project staff made all possible efforts to interest the local people by demonstrating how these simple buildings could be constructed by they themselves. The terms of payment for such contracts were also liberalised in comparison to conventional terms to attract the local entrepreneurs. The methods used for constructing the new schools in the villages have now gained popularity with the local village people and they are now coming forward and are more willing to undertake the work. In the context of this background, most of the work is now awarded on the basis of negotiation instead of conventional open tender methods, keeping in view that the rates have to be within the approved technical estimates and the time of completion for each building fits the programme.

In the matter of award of contracts both for manufacture of prefabricated units and construction works, the project authority has to maintain a correct balance between local influential parties and their technical and physical capabilities by assessing their worth through discussion with them and by obtaining relevant information about them from local sources, as far as is practicable.

Supply of materials to sites

The fundamental factor, on which the progress of the work depends, is the efficiency of the transport facilities for carrying building materials and prefabricated units and the transport of supervisory staff to the sites. Materials such as cement, bricks and sand have to be carried from the stores of the stockists to each site, while prefabricated units, which are manufactured at centres in the district towns are to be similarly transported from the town to sites in villages. Transport poses difficulties in most of the districts and it is, moreover, an expensive item. However, the scientists in charge in the districts have made every effort to enlist local assistance in minimizing transport costs.

Plate 17. The simple jig used for manufacturing welded steel roof-trusses.

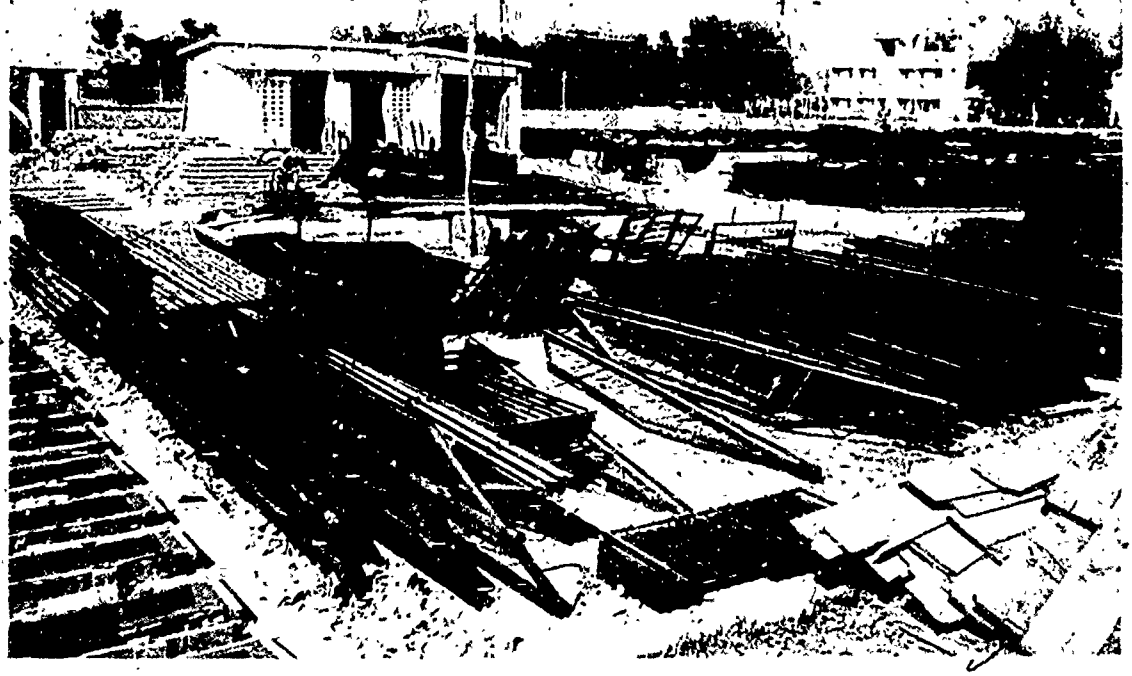


Plate 18. Welded steel trusses, door and window frames stacked ready for despatch to the school sites.

Plate 19. Precast reinforced concrete lintols-cum-sunshades, ready for stacking prior to despatch to the school sites.

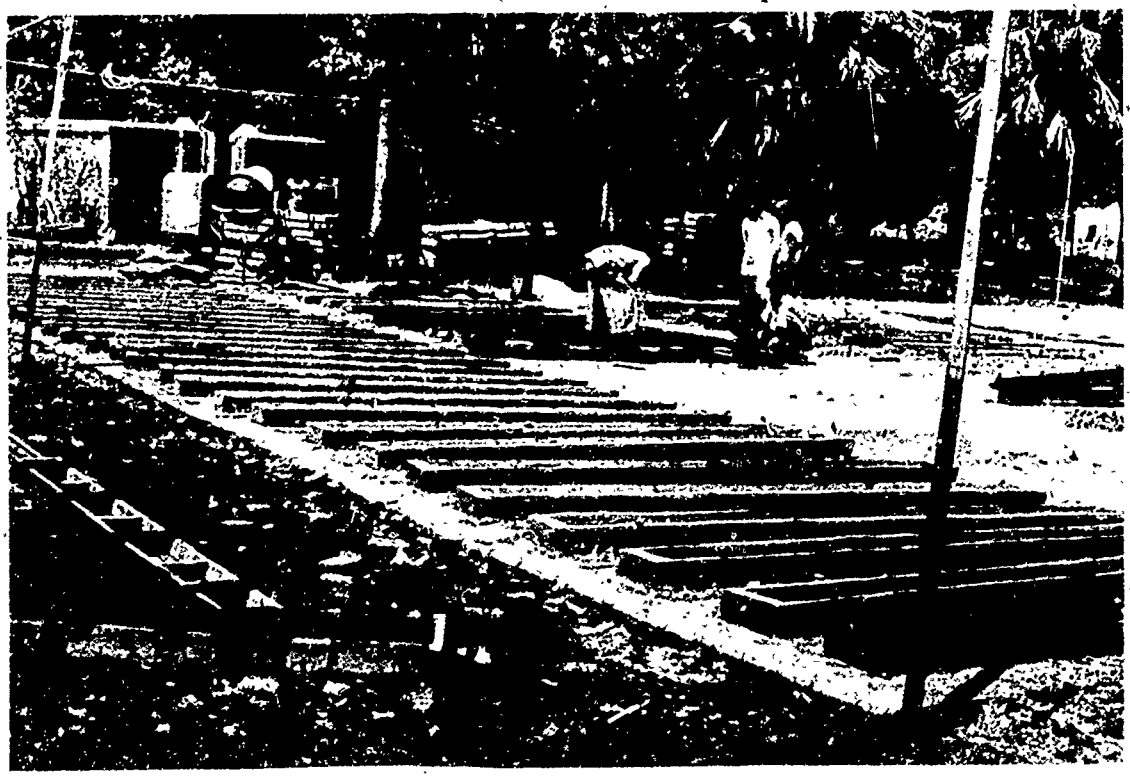


Plate 20. Precast concrete roof channels from which the formwork has just been stripped.

For quick transport of the supervisory staff, arrangements have been made to hire taxis or jeeps which are placed at the disposal of the scientist in charge of the district. Where the prefabricated units are manufactured and supplied from a distant district town, these are booked to the sites and transported in trucks, bullock carts, as the case may be.

Careful planning in this respect has been made in all districts by the scientists in charge to avoid delay in the works due to non-delivery of materials. They have been given full authority in the matter, with the stipulation that the element of cost of transport should be covered within the cost ceiling fixed for construction of each building. In special cases, as in one or two districts, where abnormal difficulties were faced, delivery vehicles have been purchased and maintained at the cost of the project.

Financial management

One of the unseen costs of building in many countries of the Asian region is the interest payable on money loaned by banks to building materials suppliers and contractors. It will be realized that contractors are not normally paid until the work they have contracted to build is completed (in whole or in part depending on the size of the building). Thus, while the building is under construction, the contractor has to find from his own resources, or to borrow from a bank, sufficient money to pay for plant hire, transport, labourers' wages, materials and the like. He will not be able to repay his bank loan (and thus continue to pay interest on it), until he has been paid for the work he has completed. Payment on completion of work involves inspection by the paying agency to ensure the work is complete as claimed and then certification for payment. These procedures may, through Government administrative channels, take at best weeks and at worst months to complete, and all this time the contractor is paying interest on a loan which itself represents the very capital he needs to finance his next contractual venture.

In tendering a price for a contract the building contractor thus uses his local knowledge of how long he is likely to have to wait for payment of his bill on completion and adds the costs of the wait in terms of interest to his contract price. Thus, the quicker contractors are paid, the lower will be their prices and the slower they are paid, the higher their charges.

As a pre-requisite for successful completion of the project, it was realized that quick payment of bills of contractors and suppliers and dues of staff, was the first and the most essential condition to be fulfilled. With this in mind, rules and procedures for payment were modified and streamlined in such a way that the bills of contractors and other parties against works or supplies could be paid within a period of three days from the date of receipt of such claims. Very clear instruction in this respect were issued to the scientists in charge of the district and the officers in charge of the works at the sites.

Broad financial rules and the powers to be delegated to the scientists in charge for expenditure sanction and payments were adopted for the project and

approved by the Director. The scientists in charge were instructed to follow these rules and regulations scrupulously to avoid irregularity in expenditure and also to expedite payments in the manner indicated by the rules.

In order to facilitate direct payments by the scientist in charge at the district levels, bank accounts in the name of the School Building Project were opened in each of the districts where work was in progress and the scientist in charge, along with an officer under him were authorized to operate these accounts. The funds for construction received as an advance from the district authorities, are placed in the bank accounts of the districts, against which all payments relating to construction are made by the scientist in charge directly and with the assistance of the accountant under him. Accounts are maintained by the accountant in the standard forms prescribed by Headquarters. To meet contingent expenditures connected with the supervision of the works, adequate funds are placed at the disposal of the scientist in charge of the districts as advances and these funds are replenished, as and when necessary, on the submission of accounts and vouchers in the prescribed form to the Headquarters. The accounts and vouchers are then scrutinized by the Accounts Officer in accordance with the financial rules and procedures adopted for the project and the advances adjusted and funds replenished accordingly. The scientists in charge are required to furnish by the 15th of every month the statement of expenditure against the funds at their disposal, maintained in the State Bank of India, in the prescribed forms which have been issued to them. The monthly statement of expenditure on the project is thereafter compiled at the Headquarters and set against the provision of funds received by the project. A careful watch is kept to see that the expenditure does not exceed the limit of provisions from the State Government. The monthly statement of expenditure is placed before the Project Co-ordinator for his information by the end of the month.

To rationalize quick payments to the contractors for works, a number of measures have been taken to simplify and streamline procedures:

i) The conventional method of recording measurements of works in the Standard Measurement Books prescribed by the Government of India has been modified to a certain extent to avoid detailed entries for each contract as the work is of a standard and repetitive nature. These modifications have saved the time of the overseers and the assistant engineers in maintaining the measurement books and certifying payments of the bills of the contractors.

ii) Running payments against materials supplied or work in progress are allowed to the extent of 75% to 90% of the value of the supplies or the work done and this enables the small contractors to sustain themselves to the end of the work.

iii) Very strict instructions have been issued to the scientist in charge and the accountants to see that the bills of the contractors are not delayed for more than a week for payment under any circumstances.

iv) The 'period of defects and liabilities' which determines when the final payments of contractors' bills are made, have been reduced.

Salaries and allowances of the staff are paid directly from the Headquarters. The salary bills are prepared at the Headquarters by the 25th of every month on the basis of the staff on the establishment roll maintained at the Headquarters and the amount remitted to the respective scientists in charge of encashment through the District Bank accounts. Payments are made on the first of every month. When any member of the staff is on leave, his leave salary is adjusted in the same month in which the salary is drawn, if the report of leave sanctioned is received at the Headquarters by the 15th of the month.

The travel allowance bills of the staff are prepared at the Headquarters in accordance with the standard travel allowance rules of the Government, on the basis of particulars of tours forwarded by the scientist in charge. The travel allowances drawn are also remitted to the scientist in charge for payment to the respective payees. This arrangement is working satisfactorily and ensures necessary check and control in the payment of the dues of the staff.

Expenditure is under the audit control of the Accounts Officer of the project. He receives all bills for payments at the Headquarters pre-audited. The bills at the district levels are pre-audited by the accountants posted in the districts in accordance with rules and procedure adopted for the project. All bills are paid by the scientist in charge after getting the bills checked by the accountant. Registers for maintaining cash and bank accounts, vouchers and classified accounts, works accounts etc. are maintained both at Headquarters and at the district level. The district accounts are periodically audited by the Accounts Officer to check their correctness.

It has been agreed by the State Government that the expenditure on the construction works against the advances drawn by the scientists in charge from the district authorities for the purpose, will be in accordance with the rules and procedure adopted by the project authorities and such accounts duly certified by the Accounts Officer of the school building project will be furnished by the scientists in charge to the District Authorities after completion of the works in the district, for audit by the district authorities.

Regarding the funds and the expenditure for establishment and supervision charges which have been received at the Headquarters from the district authorities, the matter of audit has been taken up with the Council of Scientific and Industrial Research.

Personnel management

The present complement of staff in the project number about 387 ranging in the cadre from a Deputy Director to labour. The major portion of the staff are in the field in remote rural areas. Rules and regulations and the service conditions of the staff were framed with the nature of their tasks and their residence in remote rural areas in mind and were approved by the Director before the appointments of staff were made.

The staff are, in general, governed by the disciplinary rules of the Government of India. Clear instructions were issued to scientists in charge of the districts to exercise proper control over the field staff under them. While they were advised that the human aspects should not be overlooked, they were required to control, to the best of their ability, the attendance of the staff and the discharge of duties entrusted to them in their places of work. The assistant engineers in the districts were required to keep a periodic check of the attendance of the staff in the field and this was to be further checked by surprise periodic visits of the scientist in charge to sites. The discipline and conduct of the staff are major factors to be looked after by the supervising officers at the higher level. The rigidity of hierarchy has however been relaxed and almost eliminated by personal example set by the senior staff. The Project Co-ordinator himself briefs the scientists in charge of districts in these respects periodically. Reports of indisciplinary attitudes and negligence received from District Officers are, nevertheless, dealt with sternly and expeditiously, so as to remove undesirable elements from the organization before they demoralize others and affect the project adversely.

Records of work and conduct of all staff in the project are prepared periodically in the standard confidential form prescribed by the CSIR and reviewed by the Project Co-ordinator. Adverse reports are communicated to the staff members with a warning to correct themselves in their work and conduct. By and large, the morale and the discipline of the staff are commendable and no serious personnel problems have been experienced. But day-to-day problems are numerous and are dealt with at appropriate level.

Publicity

As this is a high priority project for the benefit of the rural population, the co-operation and the assistance of the local people and authorities in the execution of the project is essential. The senior staff and all other members of the district staff have been advised to seek all possible co-operation and assistance from village Pradhans, local members of the State Legislative Assembly and Members of Parliament, District Officers and officials and other important personalities at the village or district level. The project has so far received unstinting support from them. The scientist in charge at the district and the site engineer keep close touch with the village people and other personalities mentioned above and take their view points into consideration before embarking upon the works. The village people have shown, in most of the districts, keen interest in the project and have offered assistance to Project Officers by helping them with labour, accommodation and other necessities. Project Officers have also given the villagers encouragement by demonstrating the techniques of construction and employing local unskilled rural labour and contractors.

The Ministers of the State Governments of India and Central Ministers have been taking an interest in the development of the project and some of them have visited the construction sites and addressed the rural people on the importance of the project, soliciting their co-operation to assist the Project Officers in the execution of the works. The Chief Minister and the Governor of

Uttar Pradesh have given encouragement to the project staff by regular expression of their appreciation of the work of Project Officers.

The press in India have been quick to realize the importance of the project and the expeditious way in which it is being executed. It has been very generous in giving wide publicity to the activities of the project for the information of the rural population. This has created a good reaction in the minds of the people and also the State Governments. There have been a number of requests from the other State Governments to take up similar works on a mass scale in their States.

All India radio has also given prominence to news on the project in their broadcasts. The Films Division of India has made and released a film on the development and activities of this project.

The project authorities and the Director maintain constant touch with the State Governments, public and Press to apprise them of the activities and development of the project. These media are being consciously utilized both to educate the public on the project as well as its extensions into such related fields as low-cost rural housing and to build and maintain the morale of the Project Officers, contractors and workers.

Other outcomes

The project has made a good impact on the people in the State. The approach of the CBRI to the execution of this time-bound project being somewhat different from the conventional methods and procedures for construction adopted by the Government Departments and established construction firms in the country, there has, no doubt, been a little reaction both in the political lobbies and Government construction departments as regards the soundness of both the technical aspects of the construction and the administrative methods employed. It has taken the successful construction of about 1,000 schools over a period of about eight months in the State of Uttar Pradesh to have turned the wind in favour of the techniques and methods adopted.

Government construction departments and private contractors are now coming forward to study critically the basis of the methods used and the rules and regulations framed for the project. This means that the institute has been able, through this project, to accomplish one of its primary objectives, namely to demonstrate the feasibility of low-cost construction in remote rural areas. The Government of Uttar Pradesh has, recently, decided to entrust the construction of schools in a few districts of the State to the Public Works Department on the basis of the CBRI techniques of construction.

Project authorities are encouraging local entrepreneurs to establish industries to manufacture prefabricated units. It is hoped such units would be available in the market for people to use it in the construction of their houses and other buildings. Besides catering to the social needs of providing maximum number of primary school buildings within the limited financial resources, the project provides employment not only to engineers and technicians, but also to unskilled village labour. It will provide employment opportunity for about 2.3 million man-days of which about 671,000 man-days will be for skilled workers and about 1.6 million man-days for unskilled village labour.

COST ANALYSIS OF CHANNEL UNITS

Timber mould

a) Material	Qty	Rate (Rs)	Amount (Rs)
Deodar wood	2.80 c. ft.	22.00 per c. ft.	61.60
Angle iron	12.57 kg	1.90 per kg	23.88
Screws, nails and sawing charges	lump sum		11.00
b) Labour			
Carpenter (skilled labour)	3 working days	8.00 per day	24.00
Unskilled labour	3 " "	4.00	12.00
Fitter (skilled labour)	1 working day	8.00	8.00
Welding charges	lump sum		2.50
			142.98
		Total say	143.00

Assuming 100 uses, cost per use $\frac{143}{100} = 1.43$

Casting platform

Area of platform required to cast 100 units/day	3 000 sq. ft.	
Cost of cleaning the area		200.00
Cost of brick floor laid dry; joints filled with sand		1 650.00
Cost of concrete floor finish		1 950.00
	Total	3 800.00

Cost of using platform per unit Rs. 3800/6840 Rs. 0.50 per unit

Analysis for channel unit

Materials	Qty	Rate	Amount
Cement	0.3 bags	13.00	3.90
Coarse aggregate	1.35 c. ft.	1.40	1.89
Coarse sand	0.72 c. ft.	0.50	0.36
M.S. reinforcement	4.21 kg	1.75	7.37) A
M.S. wire	0.28 kg	3.00	0.85)
Labour			
Casting			
Mason (skilled)	1/8 w. day	8.00	1.00
Unskilled labour	1/4 w. day	4.00	1.00

Making of cages	Qty	Rate	Amount	
Bar bender (skilled)	1/10 w. day	8.00	0.80	
Unskilled labour	1/10 w. day	4.00	0.40	
Other charges				
Mould as per details above			1.43	
Plateform as per details above			0.50	
Handling of units in the casting yard			0.38	
Mould oil			0.25	
Binding wire			0.10	
Vibrator and power charges			0.20	
		Total	20.43)	
Add for breakage of units at 3% except marked 'A' above			0.37)	) 20.80
Water charges 2%			0.41	
			21.21	
Overhead charges 2.5%			0.53	
			21.74	
Contractor's profit 10%			2.17	
			23.91	
		Say	Rs 24.00	