A SUSTAINABILITY IMPACT-ASSESSMENT TOOL FOR SELECTED BUILDING TECHNOLOGIES IN RURAL INDIA: THE CASE OF THE ANDHRA PRADESH PRIMARY EDUCATION PROJECT

VOLUME – II OF II

APPENDICES

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OF THE REQUIREMENT FOR
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VOLUME – II

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APPENDIX I

DATABASE FOR EMBODIED ENERGY AND CO_2 EMISSION

The process of data collection, described in chapter 7 and chapter 8, shows that the construction of different walls and roofs depend upon different materials and processes used at different stages of manufacturing, processing and fabricating, which have been categorized under the following heads.

- Level-1 Primary Manufacture, e.g., aggregate, random and course rubble stone, bricks, clay tiles cement, steel, lime, etc.
- Level-2 Secondary Processing- based on primary level materials to manufacture of micro concrete tile, pre-cast reinforced cement concrete planks, joists, channels etc.
- Level-3 Tertiary Fabrication – walls, roofs, doors, windows etc.

The above three levels were adopted by Development Alternatives (Energy Directory of Building Materials, 1995) while calculating the embodied energy of different materials in the process of completing a building as a product.

The different combinations of walling and roofing systems, which are level-3 products, require inputs from the Level-1 materials and for the pre-cast technologies from the level-2 materials. The costs of materials, labour and transportation of the Level-1 materials have been adopted from the Standard Schedule of rates of 1995-96 published by the government of Andhra Pradesh. The embodied energy contents of the Level-1 materials have been primarily from Development Alternatives' data book.

The Level-2 and Level-3 data are primarily based on the government of Andhra Pradesh approved analysis of rates of both conventional and cost effective items. One of the important targets of Andhra Pradesh Primary Education Project was to get these items approved by the government and then include in the schedule of rate analysis. The data on rate analysis for level-2 and level -3 items shows the quantity of labour, materials, equipment etc. required per unit , e.g., for the production of one micro concrete tile, for the construction of 1 square meter of roof complete in every respect etc. Such data will be used for calculating costs (labour and materials), embodied energy and emission of CO_2 per unit area of the finished walls and roofs per square meter of elevation and plan areas.

This section is on the database on

- Embodied energy and CO_2 emission (production + transportation) of level-1 materials.
- Embodied energy and CO_2 emission (transportation only) of level-2 products.

The scaffolding and shuttering in Ranga Reddy district were made with of the locally available jungle wood. These have been assumed to be level-1 materials and the following calculations show their embodied energies.

EMBODIED ENERGY 1.00 CUBIC METER OF SCAFFOLDING

Density of timber 850 kilograms/cubic meter (IS 875 (Part-1) – 1987)

It has been assumed that 100 millimetres diameter eucalyptus poles will be used for making the scaffold. It has been assumed that the cutting etc. will be done manually and hence the only energy and emission of CO_2 will be due to the transportation of the materials from the jungle to the site. The eucalyptus poles are manually tied with handmade ropes. The cost of eucalyptus poles is Rs.2000 per cubic meter, i.e., Rs.2.35/kilograms.

The number of bricks consumed per cubic metre of masonry work is 480. For 100 square meter of floor area construction 30,000 bricks are required (Rai and Jaisingh, 1986), i.e., 62.5 cum of brickwork. Total weight of wood calculated in the following table is 462.64 kilograms, which has been assumed to be used for the construction of two buildings

Embodied energy in eucalyptus = 4500 kilocalorie / kilogram

Table I.1 The consumption of timber required for the making of scaffolding.

Description	**Quantity**	**Unit**			
			Non renewable	**Renewable**	Waste
A. Materials eucalyptus 100 mm diameter					
Horizontal 8 numbers 3m long	160.221	kilograms	0.00	838.37	0.00
Vertical 6 numbers 3m long	120.166	kilograms	0.00	628.78	0.00
Cross 12 numbers 2m long	160.221	kilograms	0.00	838.37	0.00
Add 5 as wastage	22.03	kilograms	0.00	115.28	0.00
5% cost for ropes etc			0.00	0.00	0.00
B. Labour 2 numbers @ 1.5hrs/cum					
Un-skilled labour for 1 cum	0.38	mandays	0.00	0.00	0.00

Table I.2 Data for 1 cubic metre of brickwork by using it for two buildings

Description	Quantity	unit
Non renewable	0.00	Kilo Watt hours/cubic metre
Renewable	19.37	Kilo Watt hours /cubic metre
Waste	0.00	Kilo Watt hours /cubic metre
CO_2	0.00	kilograms/cubic metre
weight	462.639	kilograms
weight/ cubic metre of brick work	7.40	kilograms /cubic metre

EMBODIED ENERGY OF 1.00SQM OF SHUTTERING INCLUDING PROPS.

The cost and method shuttering props are same as that of scaffolding. As shown in the following table, the total weight of wood is **83.91** kilograms, which has been assumed to be used for the construction of five buildings.

Table I.3 The consumption of timber required for the making of 1 square metre of shuttering.

Description	Quantity	Unit			
			Non renewable	Renewable	Waste
A. Materials eucalyptus 100 mm dia					
Horizontal 4 numbers 1 m long	15.021	kilograms	0.00	78.60	0.00
Vertical 4 numbers 3m long	64.890	kilograms	0.00	339.54	0.00
Add 5 as wastage	4.00	kilograms	0.00	20.91	0.00
5% cost for ropes etc			0.00	0.00	0.00
B. Labour 2 numbers @ 1hrs/sqm					
Un-skilled labour	0.25	mandays	0.00	0.00	0.00

Props will be used 5 times (1m x 1m), i.e. 2m x 2m influence area

Non renewable	0.000	kilo Watt hours / square meter
Renewable	21.952	kilo Watt hours / square meter
waste	0.000	kilo Watt hours / square meter
weight	20.976	kilograms / square meter

Table I.4 The quantities of different types of fuels for production of level-1 materials, which have been converted to the embodied energies and CO_2 emission.

Energy of materials in kWh	Coal/ petrol	Electricity	Renewable		waste	Environmental impacts			
			wood	non-wood		non-renewable	re-newable wood	non-wood & Waste	CO_2emission
Aggregate /kg	0.0544	0.0105			0.00003	0.065	0.00	0.0000	0.029
CRS stone/kg	0.0000	0.0000	0.0000	0.0000	0	0.000	0.00	0.0000	0.000
Sand/kg	0.0000	0.0000	0.0000	0.0000		0.000	0.00	0.0000	0.000
Soil- dry compacted /kg	0.0000	0.0000	0.0000	0.0000	0	0.000	0.00	0.0000	0.000
Cement / kg	1.0521	0.0840	0.0000	0 0000	0.000080	1.136	0.00	0 000080	1.006
Structural steel/kg	9.2060	0.8620				10.068	0.00	0.0000	4.190
Reinforcing rods /kg	7.5010	0.91				8.411	0.00	0.0000	3.558
Lime (unslaked) /kg	1.4150	0.00011			0.00006	1.415	0 00	0 0001	1.337
PVC /kg	32.0000	11.0000				43.000	0.00	0.0000	20.127
Bricks/ number, fuel-rice husk	0.0000	0.0025	0.0000	1.3939	0.0000	0.003	0 00	1.3939	0.545
Bricks/ number, fuel-coal	1.0674	0.0025	0.3265	0.0000	0.0000	1.070	0.33	0.0000	0.545
Burnt clay tiles / number	0.0005	0.0752	1.0885	1.0105		0.0757	1.09	1.0105	0.871
Flush door / sqm (35mm thick)	75.7500	4.61	72.43	0	2.58	80.3600	72.43	2.5800	33.758
Shuttering wood/ sqm (19mm thick)	0.0000	0.922	8.182	0	0.516	0.9220	8.182	0.5160	0.842
Scaffolding in jungle wood/ cubic metre of brickwork	0	0	19.37			0.0000	19.37	0 0000	0.000
Props to the shutters/ sq. m.	0.000	0	21.95	0.00	0.0000	0.0000	21.95	0.0000	0.000
Bitumen /kg	12.27	0				12.268	0.00	0.0000	4.785
Paint/ kg	25.15	0				25.147	0.00	0.0000	9.809
Rubber based waterproofing /kg	18.78	0				18.777	0.00	0.0000	7.324
Polyethelene sheet (1 5mm thick) / sq m.	38 305	0	0			38.305	0 00	0.0000	14.942

kWh – kilo Watt hour, kg – kilogram, sq. m. – square metre , mm- millimetres

Sources:

Energy Directory of Building Materials. 1994, Development Alternatives. Sponsored by Building Materials and technology Promotion Council, New Delhi, India.

NCCBM (National Council for Cement and Building Materials), (2002-03), Energy Performance Achievements in Indian Cement Industry, Haryana, India

GOI (Government of India) , (2001-02), Generation Report, Central Electricity Authority.

Alcorn, Andrew, (1998), Embodied Energy in New Zealand Materials, ATLA NEWS, Newsletter Issue 7 No 4 November, 5/28/2001

Basic information on the different sources, distances from the source to the site and mode of transportation of the level-1 materials. Based on this, the embodied energies and CO_2 emissions will be calculated for the transportation only.

- Diesel
    - Transported from Bombay to Hyderabad by rail locomotive a 651 km.
    - From Hyderabad to the site by 12.5 tons capacity TATA truck 35 km (by road).
- Cement
    - By road transportation (12.5 tons capacity TATA truck) from Nalagonda at a distance of 100 kms from Hyderabad, where the dealers have their shops and stores.
    - From Hyderabad to the site by 12.5 tons capacity TATA truck 35 km (by road).
- Steel
    - By road transportation (12.5 tons capacity TATA truck) from mini steel plants at a distance of 100kms from Hyderabad, where the dealers have their shops and stores.
    - From Hyderabad to the site by 12.5 tons capacity TATA truck 35 km (by road.
- Rest of the distances from the sources to the site are shown in the table below, which are calculated from Ranga Reddy District of Andhra Pradesh

According to Energy Directory of Building Materials (1995) / Tata Energy Data Directory Yearbook (1993) the transportation energy by diesel operated

Rail Locomotive consumes	39.78	kilocalorie / ton /kilometre
12.5 ton TATA truck consume	0.26	kWh(thermal) / ton / kilometre

Table I.5 The quantities of embodied energies and CO_2 emissions of the level-1 materials due to the transportation from the production unit to the site.

Energy of materials in kWh	Density	unit	Distance travelled by (Kg)		Non -renewable energy (Mega Joules)	CO_2 (kg)
			Diesel rail	Diesel truck		
Aggregate / cum	2240.0	kg/cum	0.0	12.00	25.123	2.726
Coursed rubble stone	2400.0	kg/cum	0.0	8.00	17.945	1.947
Sand/kg	1840.0	kg/cum	0.0	80.00	137.580	14.929
Soil dry compact	1440.0	kg/cum	0.0	15.00	20.188	2.191
Cement / kg	50.0	kg/bag	0.0	135.00	0.1262	0.0137
Structural steel	7830.0	kg/cum	0.0	135.00	0.1262	0.0137
Steel rods/kg	7830.0	kg/cum	0.0	135.00	0.1262	0.0137
Lime (slaked)/kg	1020.0	kg/cum	0.0	120.00	0.1122	0.0122
PVC /kg	1350.0	kg/cum	0.0	35.00	0.0327	0.0035
Bricks /no	2.5	kg/no	0.0	8.00	0.019	0.002
Clay tiles / piece	2.4	kg/no	0.0	8.00	0.018	0.002
Flush door/sqm (35 mm thick)	21.0	kg/sqm	0.0	35.00	0.6870	0.0745
Shuttering plywood/ sqm 19mm thick	11.4	kg/sqm	0.0	35.00	0.3729	0.0405
Scaffolding in eucalyptus wood 100mm diameter /cum of brick work	7.40	kg/cum	0.0	20.00	0.1384	0.0150
Props to the shutters	20.976	kg/sqm	0.0	20.00	0.3921	0.0425
Bitumen kg/cum	1120	kg/cum	0.0	135.00	0.1262	0.0137
paint kg/cum	960	kg/cum	0.0	135.00	0.1262	0.0137
Rubber based waterproofing kg/cum	940	kg/cum	0.0	135.00	0.1262	0.0137
Polyethelene sheet (1.5mm thick) / sq.m.	925	kg/cum	0.0	135.00	0.1751	0.0190
Diesel/ kg	960	kg/cum	651	35	0.1410	0.0153

kWh kilowatt hours
kg kilogram
cum cubic metre
sqm square metre
mm millimetres

Table I.6 The data on total embodied energies and CO_2 emissions of the level-1 materials inclusive of production and transportation from the production unit to the site

Embodied energy of materials	non-renewable (MJ)	re-newable wood (MJ)	Non-wood and recycled waste (MJ)	CO_2 emission (kg)	unit
Aggregate /cum	547.721	0.0000	0.2416	66.631	/cum
CRS /cum	17.945	0.0000	0.0000	1.947	/cum
Sand /cum	137.580	0.0000	0.0000	14.929	/cum
Soil dry compact /cum	20.188	0.0000	0.0000	2.191	/cum
Cement / kg	4.210	0.0000	0.0003	1.019	/kg
Structural steel /kg	36.319	0.0000	0.0000	4.204	/kg
Steel rods/kg	30.362	0.0000	0.0000	3.572	/kg
Lime (slaked)/kg	5.199	0.0000	0.0002	1.349	/kg
PVC /kg	154.609	0.0000	0.0000	20.131	/kg
Bricks / number	0.028	0.0000	5.0108	0.547	/no
Bricks / number	3.865	1.1737	0.0000	0.547	/no
Solid conc block 290x190x140 / number	10.602	0.0000	0.0000	1.358	/no
M'lore tiles / number	0.290	3.9129	3.6325	0.873	/no
MCR tiles / number	3.813	0.0000	0.0032	0.476	/no
Flush door/sqm (35 mm thick)	289.565	260.3714	9.2746	33.833	/sqm
Shuttering + prop wood/ sqm 19mm thick	4.079	108.3261	1.8549	0.925	/sqm
Scaffold-propos-eucalyptus wood 100mm dia	0.138	69.6179	0.0000	0.015	/cum of brickwork
Bitumen kg/cum	44.226	0.0000	0.0000	4.799	/kg
paint kg/cum	90.526	0.0000	0.0000	9.823	/kg
Rubber based waterproofing kg/cum	67.626	0.0000	0.0000	7.338	/kg
Polyethelene sheet (1.5mm thick) / sq.m.	137.875	0.0000	0.0000	14.961	/sq.m.
Diesel /kg	44.553	0.0000	0.0000	2.803	/sq.m.
For timber (same as shuttering) per cum	194.0700	1548.0344	97.6272	46.4491	/cum.

kWh kilo watt hours
kg kilogram
cum cubic metre
sqm square metre
mm millimetres
MJ Mega Joules

Table I.7 The quantities of embodied energies and CO_2 emissions of the level-2 materials due to the transportation only from the building centre to the site.

	Weight	unit	Distance travelled by (KM)		Non - renewable energy (MJ)	CO_2	Non - renewable energy (MJ)	CO_2 (kg)
Reinforced cement concrete planks- weight/ no (kg)	54.35	kg/ number	0.0	2.00	0.001869	0.0002	0.102	0.011
Reinforced cement concrete joists- weight/ no (kg)	135.87	kg/ number	0.0	2.00	0.001869	0.0002	0.254	0.028
Reinforced cement concrete channel- weight/ no (kg)	142.66	kg/ number	0.0	2.00	0.001869	0.0002	0.267	0.029
Ferrocement channel- weight/ no (kg)	424.03	kg/ number	0.0	2.00	0.001869	0.0002	0.793	0.086
Cement stabilised mud block	3.6	kg/ number	0.0	2.00	0.001869	0.0002	0.007	0.001
Interlocking cement stabilised mud block	7.5	kg/ number	0.0	2.00	0.001869	0.0002	0.014	0.002
Micro concrete tiles	2.3	kg/ number	0.0	6.00	0.005608	0.0006	0.013	0.0014

kWh	kilo watt hours
kg	kilogram
cum	cubic metre
sqm	square metre
mm	millimetres
km	kilometre
MJ	Mega Joules

APPENDIX II

SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS OF THE BUILDING COMPONENTS OTHER THAN WALLING AND ROOFING SYSTEMS

Table II.1Calculation for money that goes out of the district. Rs80 = £1.

Description of materials	Electricity	Diesel	Coal	Rupees	
6 millimetres , 20 millimetres , 40 millimetres aggregate/metal	0.0105	2.6832	0.0219	120.728	/ cubic metre
Random/ Course Rubble Stone	0.0000	1.7888	0.0000	7.818	/ cubic metre
Sand for filling	0.0000	2.236	0 0000	7.493	/ cubic metre
Stone dust	0.0000	2.236	0.0000	7.493	/ cubic metre
Brick coal as fuel	0.0025	4.4720	0.0000	0.016	/ number
Wire-cut brick-rice husk as fuel	0.0025	4.472	0.0000	0.016	/ number
Clay tiles	0.0752	4.293	0.0002	0.234	/ number
Soil dry compact	0.0	3.3540	0.0000	8.796	/ cubic metre
Shuttering	0.9220	183.023	0.0000	3.099	/ square metre
Scaffolding	0	33.1027	0 0000	0.06029	/ cubic metre
Timber door	4.6100	164.346	30.4772	38.51	/ square metre
Timber for general use	48.5263	411.895	0.0000	146.33	/ cubic metre
Eucalyptus poles					
diesel/litre					
		electricity	coal		
		3.000	0 8		
		Rs/ kilo Watt hours	Rs/ kilogram		

LEAD STATEMENT FOR CONSTRUCTION OF PRIMAY SCHOOL BUILDINGS AT JAGGAMGUDA

AT RANGA REDDY EAST,

Main source of stone is Turkapally

Lead chart showing cost of transportation and materials

Table II.2 Socio-economic and environmental data of the materials used for construction of the schools in Ranga Reddy district. Rs80 = £1.

SL.NO	Material	Distance from source	Rate Rs	Unit	Money to local traders	Non-renewable	Renewable	Waste	CO_2	Cost of coal/diesel +electricity	Skilled worker	Unskilled worker
											Factor of column- rates	
		Km	Rs		Rs	Mega Joules	Mega Joules	Mega Joules	Kg			
1	20mm hard granite metal/ cum	12.00	411.50	/cum	245.51	547.7210	0.0000	0.2416	66.6312	120.73	0.04	0.07
2	6mm hard granite stone chips	12.00	246.90	/cum	99.01	547.7210	0.0000	0.2416	66.6312	120.73	0.04	0.07
3	40mm hard granite metal	12.00	278.40	/cum	127.05	547.7210	0.0000	0.2416	66.6312	120.73	0.04	0.07
4	Random Rubble Stone	8.00	148.65	/cum	111.10	17.9452	0.0000	0.0000	1.9472	7.82	0	0.2
5	Course Rubble Stone	8.00	281.75	/cum	203.49	17.9452	0.0000	0.0000	1.9472	7.82	0	0.25
6	Sand for mortar	80.00	264.70	/cum	39.71	137.5802	0.0000	0.0000	14.9288	15	% As agency charges	
7	Sand for filling	10	148.65	/cum	111.43	17.1975	0.0000	0.0000	1.8661	7.49	0	0.2
8	Stone dust	12	132.35	/cum	91.77	20.6370	0.0000	0.0000	2.2393	7.49	0	0.25
9	Bricks coal based	8.00	0.88	/no	0.74	3.8647	1.1737	0.0000	0.5475	0.02	0.0569	0.08
10	Wirecut bricks- rice husk	8.00	1.30	/no	1.13	0.0277	0.0000	5.0108	0.5475	0.02	0.0385	0.0814
11	40mm thick Tandur stone	120	45.00	/sqm	9.00	11.6644	0.0000	0.0000	1.2657	20	% As agency charges	
12	Lime	120.00	3.00	/kg	0.75	5.1992	0.0000	0.0002	1.3492	25	% As agency charges	
13	Cement	135.00	2.28	/ kg	0.34	4.2102	0.0000	0.0003	1.0195	15	% As agency charges	
14	Steel reinforcement	135.00	17.20	/kg	2.58	30.362	0.000	0.000	3.572	15	% As agency charges	
15	Steel structural	135.00	20.00	/kg	3.00	36.3186	0.0000	0.0000	4.2038	15	% As agency charges	
16	Binding wire	135.00	25.00	/kg	3.75	30.3620	0.0000	0.0000	3.5721	15	% As agency charges	
17	Clay tiles	8.00	3.50	/no	2.57	0.2899	3.9129	3.6325	0.8731	0.23	0.04	0.16
18	Soil for Cement Stabilised Mud Block	15.00	150.00	/cum	103.70	20.1884	0.0000	0.0000	2.1906	8.80	0	0.25

x

SL.NO	Material	Distance from source	Rate Rs	Unit	Money to local traders	Non-renewable	Renewable	Waste	CO_2	Cost of coal/diesel +electricity	Skilled worker	Unskilled worker
											Factor of column-rates	
		Km	Rs		Rs	Mega Joules	Mega Joules	Mega Joules	Kg			
19	Wooden shuttering	35.00	73.75	/sqm	54.21	4.0794	108.3261	1.8549	0.9251	3.10	0.13	0.10
20	Wooden scaffolding	20.00	23.32	/cum	9.08	0.1384	69.6179	0.0000	0.0150	0.06	0	0.61
21	Rubber based waterproofing compound	0	25.00	/kg	2.50	67.63	0.00	0.00	7.34	10	% As agency charges	
22	Enamel paint	0	80.00	/litre	8.00	86.905	0.000	0.000	9.430	10	% As agency charges	
23	Bitumen	0	7.00	/kg	0.70	44.226	0.000	0.000	4.799	10	% As agency charges	
24	100 PVC pipe 2.39 kg/	0	49.21	/m	4.92	369.83	0.00	0.00	48.15	10	% As agency charges	
25	Polythene sheet 1.5mm thick		44.00	/sqm	4.40	137.88	0.00	0.00	14.96	10	% As agency charges	
26	Timber door	0	1000	/sqm	731.49	289.565	260.371	9.275	33.833	38.51	0.15	0.08
	Timber for structural use	35.00	10000	/cum	8153.67	194.070	1548.034	97.627	46.449	146.33	0.12	0.05
27	Eucalyptus poles		2.35	/kg	1.13	0.000	5.233	0.000	0.000	0.05	0	0.5
28	Latex based waterproofing for mixing with cement	0	118.00	/kg	11.80	67.50	0.00	0.00	0.00	10	% As agency charges	
29	Latex based waterproofing for mixing with water	0	345.00	/kg	34.50	67.50	0.00	0.00	0.00	10	% As agency charges	
30	Diesel/litre	960	15.00		1.50	44.55	0.00	0.00	2.80	10	% As agency charges	

1st class Skilled mason/ carpenter	Rs 71.5	per day
2nd class Semi skilled\ bar bender	Rs 55	per day
labour\helper\coolie\visti	Rs 37.8	per day

Analysis of rates of the building components other than walling and roofing

Table II.3 Summary of the Socio-Economic and Environmental Impacts of the Building Components other than Walling and Roofing as complete element. Rs80 = £1.

Impacts / Materials	Socio-economic impact					Environmental impact			
	Unit cost	Retained	Skilled	Semi skilled	Unskilled	Non renewable	Renewable	Waste	CO_2
	Rs /sq m.	Rs / sq m.	Rs / sq m.	Rs / sq m.	Rs / sq m.	MJ/ sq m.	MJ/ sq m.	MJ/ sq m	Kg / sq m.
Excavation	24.68	0.00	0 00	0 00	24 68	0 00	0.00	0 00	0.00
Back fill	12.34	0 00	0 00	0 00	12 34	0.00	0 00	0 00	0 00
1.00 CUM CC 1:5:10	847 21	188 30	14 98	7.70	139 67	1173 87	0 00	0 27	212.07
1.00 CUM CC 1:3 6	1131 48	282 09	37 07	7 70	150 15	1506.55	207.30	4.74	295.39
1 00 CUM CC 1:2:4 DPC	1656.14	373.90	23.72	15 40	238 18	2407.94	0 00	0 32	454 26
1.00 CUM CC 1:2:4	1531.14	357.40	23 72	15.40	238.18	1961.60	0 00	0 32	405 82
CRS +RR	762.07	216 62	53 63	96.25	121 13	387.11	0.00	0 02	85.22
Fush pointing crs/bk	29 22	3.31	3 43	6.16	9.31	12 98	16 01	0 00	3.03
Impervious coat	61.17	4 81	4.72	8 47	13 99	59 53	0 00	0 00	12.13
Impervious coat pyramid	58.15	3 94	5.19	9 32	15 38	48 92	0 00	0 00	9 56
Plastering with sponge fin	45 39	4.42	4.50	8 09	14 98	23 52	16 01	0 00	5 41
Brickbat coba	220 02	64 19	9 83	0.00	22.47	255 85	0 00	192 29	71.03
Mud plaster	33.31	3 89	4.50	8 09	12.42	7 83	16 01	0 00	1.77
Cement pointing-stone flooring	10 56	0 41	1 72	3 08	3 02	4 32	0 00	0 00	1 01
Tandur stone flooring	81 27	9 80	6 86	12.32	12.47	15 98	0 00	0 00	2.20
Black board	81.44	8.10	3 32	5.97	11.72	83 23	0 00	0 00	17.47
painting on new wood	17.19	1 00	2.57	0 00	4.62	10 86	0.00	0 00	1.18
lime washing	12.13	2.28	1.29	2.31	5 68	1 33	16 01	0 00	0.34
Brick arch	2350.48	1453 57	229 89	96 25	323 99	389.41	1756 64	2435.26	347 89
Skirting	40 21	3.29	7.15	0 00	11.11	35.27	0.00	0 00	8.26
Khurra	144 52	11 54	18 18	0 20	40 84	357 04	0 00	0 00	45 42
PVC	70 37	4.92	8 94	0 00	4.73	383 45	0 00	0.00	49 73
Tandur stone roof cover	107 92	13 10	14 30	0 00	21 92	48.13	0 00	0 00	7.90
sailo-xe-crete	50 07	4.76	3 29	0 00	3 71	25.41	0 00	0 00	0 43
Second class brick	885.53	422.85	55 66	53.90	156 06	2288 83	670.57	0 02	350 42
timber door	1000	731 49	150	0	80	289 57	260 37	9 27	33 83
supply of wood/ cum	10000	8153 67	1200	0	500	194 07	1548.03	97 63	46 45
shuttering	73 75	54 21	9 39	0	7.06	4.08	108.33	1 85	0 93
finishing soffit of pyramid	221.78	16 39	35 75	0 00	127.58	69 02	69 62	0.00	15 59

APPENDIX III

WALLING SYSTEMS

III.1 Solid brick

III.2 Rat-trap

III.3 Cement Stabilised Mud Block 5%

III.4 Interlocking Cement Stabilised Mud Block 10%

III.5 Stone Concrete Block

III.6 Coursed Rubble Stone

III.1 SOLID BRICK WALL

Solid brick wall in English Bond is used widely in India and the brick and mortar specifications are same as that of rat trap. The detail of this type of brick work is available in the Central Public Works Department's Specifications (CPWD, 2002). Therefore, the description of this system has been excluded in this section.

Table III.1 Analysis of rates for 1.00 cubic meter 230-thick solid brickwork in 1:6 cement-sand mortar

							Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
Bricks	480.00	No	1.14	/No	549.17	541.66	13.29	0.00	2405.16	262.79
cement-sand (1.6) mortar	0.27	Cum	821.80	/Cum	221.89	32.88	309 97	0.00	0.02	70 09
Scaffolding - material	1.00	cum	23.32	/Cum	23.32	9.08	0.14	69.62	0.00	0.02
Less off site labour					-80.03					
B. LABOUR										
Off site										
Skilled worker-brick making					21.14					
Unskilled - brick making					44.71					
On site										
1st class mason	0.42	MD	71.50	/day	30.03					
2nd class mason	0.98	MD	55.00	/day	53.90					
Labourer	2.80	MD	37.80	/day	105.84					
Scaffolding labour					14.18					
curing t&P 5%					10.20					

Table III.2 Summary of socio- economic and environmental impacts of 230mm thick solid brick masonry wall for new construction

Unit cost	228.70	Rs. /square metre
Retained	134.23	Rs./ square metre
Skilled mason	11.77	Rs./ square metre
Semi-skilled	12.40	Rs./ square metre
unskilled	40.23	Rs./ square metre
Non-renewable	74.38	Mega Joules/ square metre
Renewable	16.01	Mega Joules/ square metre
Waste	553.19	Mega Joules/ square metre
Emission of CO_2	76.57	Kilogram /square metre

III.2 RAT-TRAP BONDED BRICK MASONRY

Bricks placed on edge in 1:6 cement mortar as in the sketches below is a rat-trap bond.

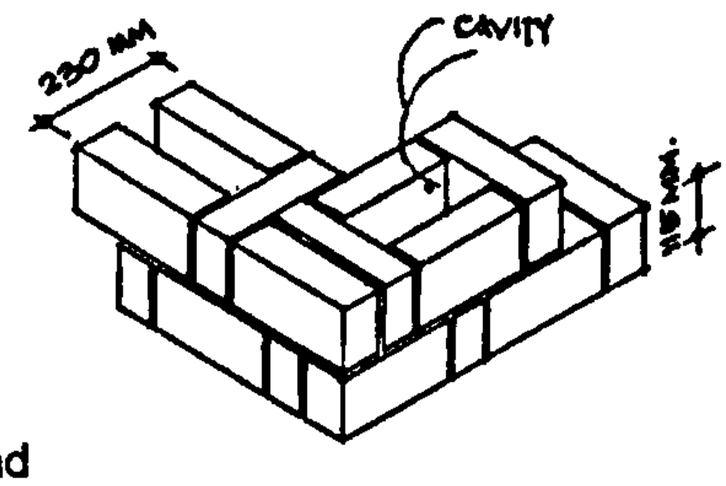


Figure III-1 Rat trap bond

Rat-trap bonded brick masonry may be used if bricks are available, that have a compressive strength of at least 50 kilograms per square centimetre and the other properties as per Bureau of Indian Standard code IS1905-1987.

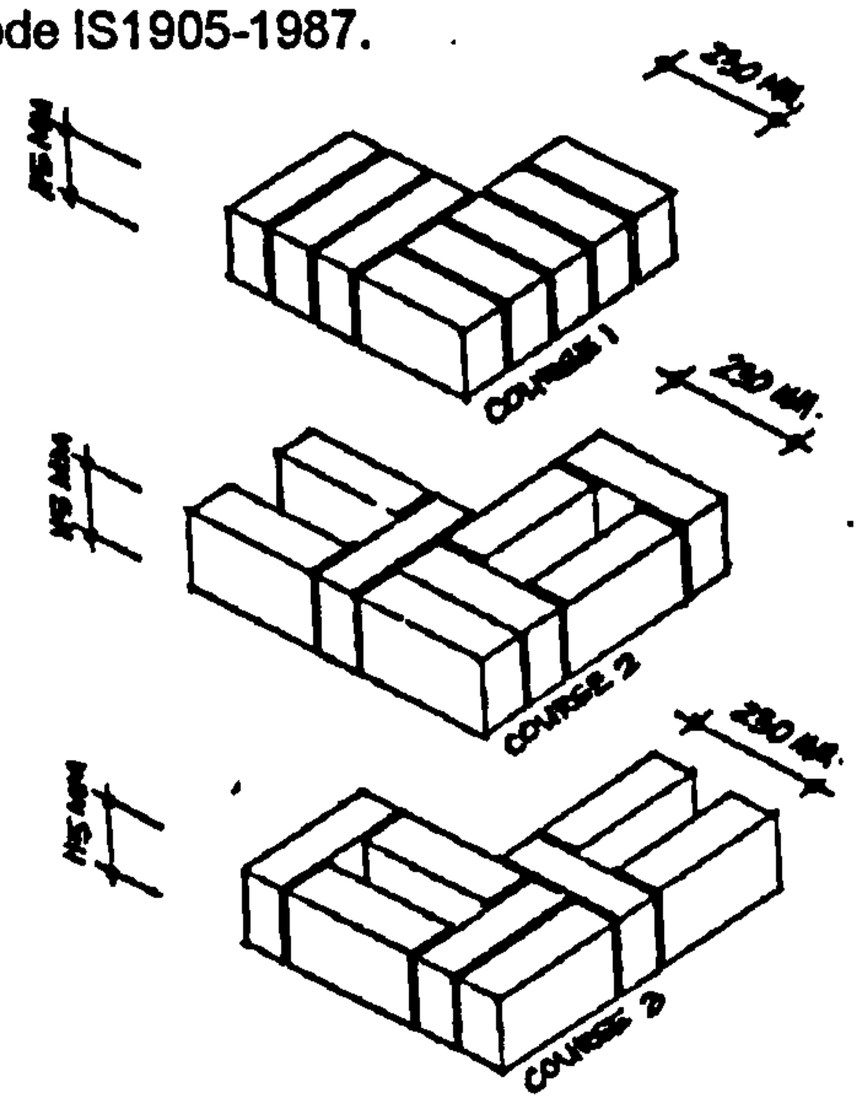


Figure III-2 Courses of rat trap bond

Method of Construction (refer to the above sketches)

1. The first course is laid with brick on edge in 1:6 cement mortar.
2. The second course is laid as shown in the above sketch and the same is repeated in course number 4,6,8,10 etc.
3. The third course is laid and repeat the same is repeated in course number 5,7,9,11 etc.

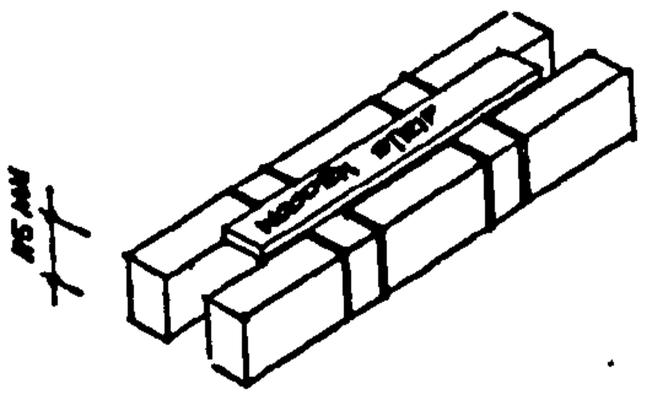


Figure III-3 Method of construction

As the mortar is laid on each course, a wooden strip may be used to prevent mortar from falling in to the cavities. Care must be taken so that the strip is not left within the brick work

Table III.3 Data for one cubic metre of rat-trap brick masonry wall (250mm thick) with 250mmx125mmx75mm kiln burnt bricks in 1:6 cement mortar.

							Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
Bricks	400 00	No	1.30	/No	520.00	451 39	11.07	0 00	2004 30	218 99
Sand (1 6CM)	0 15	Cum	264 70	/Cum	39 71	5 96	20 64	0 00	0.00	2 24
Cement (1 6CM)	36 00	Kg	2.28	/Kg	82 08	12 31	151.57	0 00	0 01	36 70
Scaffolding	1.00	cum	23 32	/Cum	23 32	9 08	0 14	69 62	0 00	0 02
Less off site labour					**-76.53**					
B. LABOUR										
Off site										
Skilled worker -brick making					20 02					
Unskilled workers-brick making					42.336					
On site										
scaffolding labour					14.18					
Skilled mason	0.56	MD	71.50	/day	40 25					
Semi-skilled mason	1 00	MD	55 00	/day	55 00					
Belder	3 36	MD	37 80	/day	126 89					
Curing /T&P 5%					11 82					

Table III.4 The summary of socio- economic and environmental impacts of rat-trap brick masonry wall for new construction

Unit cost	206.79	Rs. /square metre
Retained	110.11	Rs./ square metre
Skilled mason	13.86	Rs./ square metre
Semi-skilled	12.65	Rs./ square metre
Unskilled	44.90	Rs./ square metre
Non-renewable energy	42.19	Mega Joules/ square metre
Renewable energy	16.01	Mega Joules/ square metre
Waste	460.99	Mega Joules/ square metre
Emission of CO_2	59.33	Kilogram /square metre

III.3 CEMENT STABILISED MUD BLOCK MASONRY

Cement stabilised mud block is made by compacting a mixture of soil and cement in a block making machine that is usually 100% manually operated.

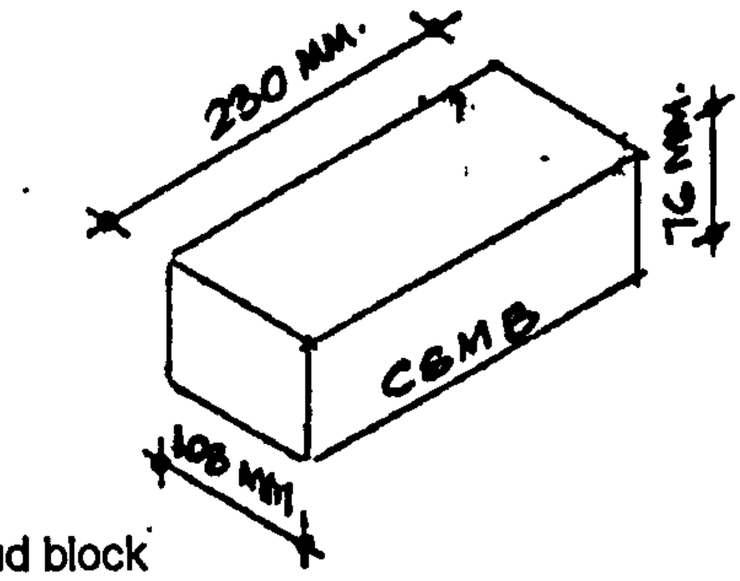


Figure III-4 : Dimensions of cement stabilised mud block

Cement stabilised mud blocks are used in masonry in a manner similar to solid brick work, but the mortar used in such masonry is stabilised soil.

Cement stabilised mud block masonry is used if other walling materials are expensive or of poor strength, if cement stabilised mud blocks are available from the local market, and/ or if it is a medium to low rainfall area. Cement stabilised mud block is suitable in a place provided that the local soil has the following range of particle distribution:

Gravel	0 – 10%	20mm – 2mm
Sand	40 – 70%	2mm – 0.02 mm
Silt	15 – 25%	0.02mm – 0.002mm
Clay	8 – 25%	0.002mm – 0.00mm

In India, there are many institutions disseminating this technology at the village level. Their block making machines and the percentage of stabilisation differ and they produce blocks of the following sizes:

Name of the Institution/ Block making machine	Length (mm)	Breadth (mm)	Height (mm)
Balram	230	108	76
Development Alternatives, New Delhi			
Astram	305	190	100
Application of Science and Technologies for Rural	200	143	100

Areas, Bangalore			
Auram	240	240	90
Auroville Building Centre, Pondicherry	290	140	90
	240	240	50-100
	240	175	50-100
	240	115	50-100
	215	140	50-100
	140	140	50-100

The Balram machine was used in the prototype school construction. Following are the properties of the Balram block.

Dry weight of one block	3.6 kilograms
Density of masonry	1860 kilograms per cubic metre
Dry strength of one block	40.0 kilograms per square centimetre

Method of cement stabilised mud block production

1. Soil as specified above is to be prepared and mixed with cement. For making 1000 blocks, 3.5 cubic metres of soil is to be mixed with 212 kilograms of cement, but not in one batch. This process is divided into preparing enough soil/ cement that will be comfortably used in 30 minutes.
2. Water is added to the dry mix to make it homogeneous.
3. Optimum moisture content is tested by dropping a lump of the prepared mix from a height
   Splits into several pieces - mix too dry
   Hardly splits - mix too wet
   Splits into 3-4 pieces - optimum water content
4. The mould is filled to the top, and the lid is closed and lock.

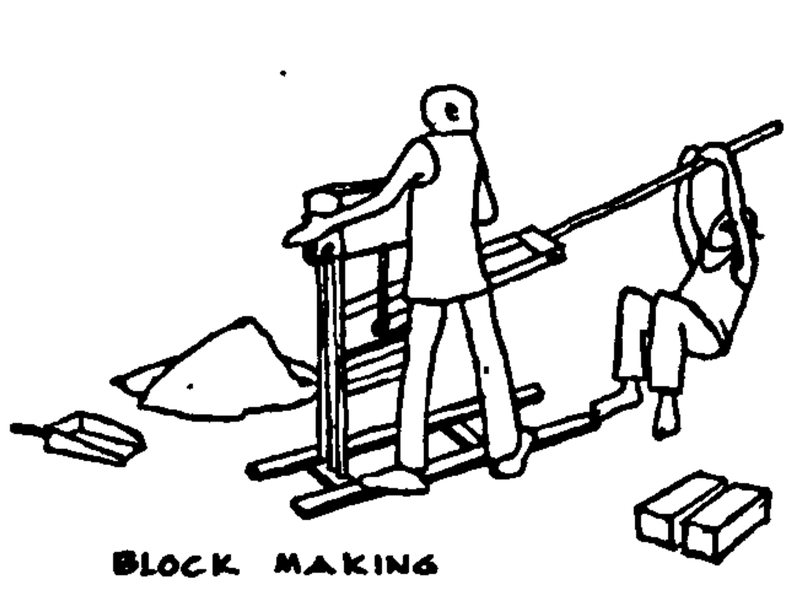


Figure III-5 The process of block making

5. The yoke is moved through 180 degree for compacting.
6. The yoke is moved up, the lid is unlocked and the blocks are ejected by pressing the yoke.
7. The blocks are laid in rows for an initial drying period of 5-7 days.
8. The blocks are stacked carefully and water cured for 2-3 times per day for fourteen days.
9. Blocks will be ready for construction purpose after a dry curing period of at least 28 days.

Method of cement stabilised mud block masonry construction

1. The method is exactly the same as conventional brickwork, except that breaking the block is not permitted. Therefore, for the purpose of attaining staggered joints, queen closers are produced by using steel slits.

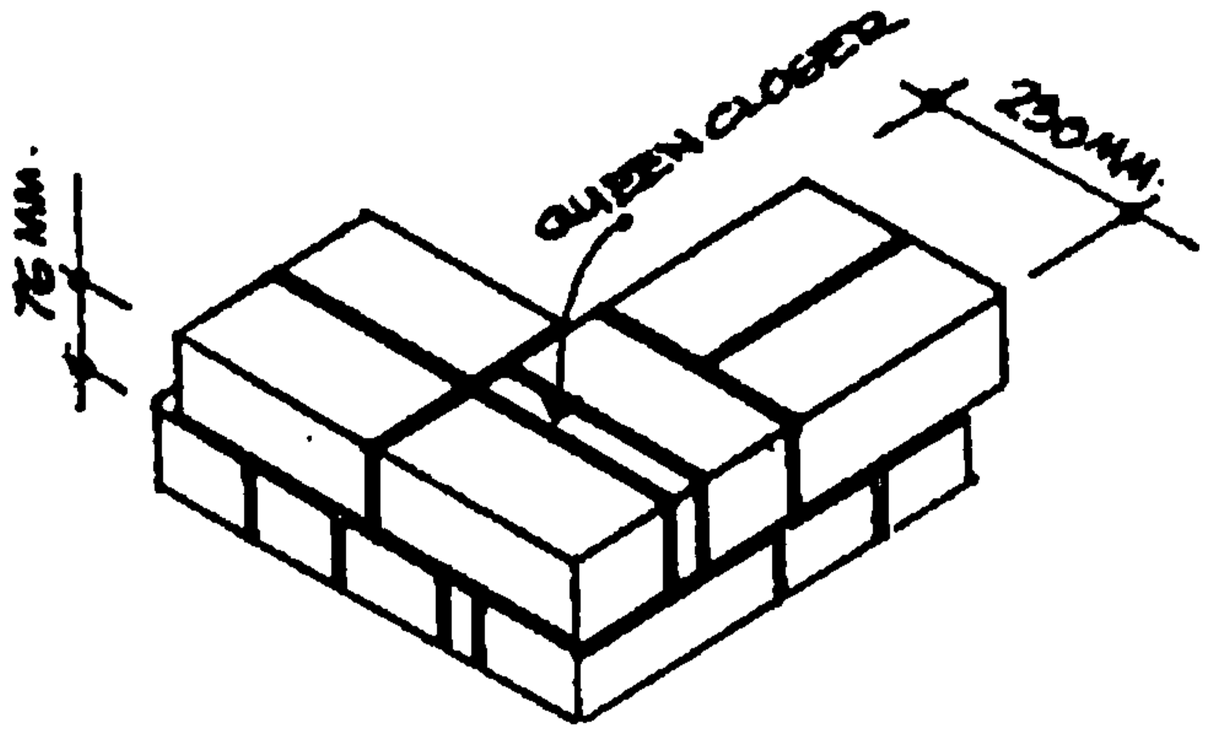


Figure III-6 Corner detail of cement stabilised mud block wall

Table III.5 Data for 1000 Cement Stabilised Mud Block masonry in 1:4:8 cement-soil mortar 230 thick wall

							Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
Soil	3.50	cum	150 00	/cum	525.00	362.96	70.66	0.00	0.00	7.67
Cement	212.00	Kg	2.28	/Kg	483.36	72.50	892.56	0.00	0.06	216.13
Maintenance of machine etc. 1%					10.08	10.08				
B. LABOUR										
Unskilled	9.00	MD	37.80	/day	340.20					

Table III.6 Data for 1.00 cubic meter of Cement Stabilised Mud Block masonry in 1:4:8 cement-soil mortar

							Block size 230mm x 108mm x 76mm			
						Embodied energy				Emission
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
CSMB material cost	425.00	No	1.02	/pc	432.84	189.36	409.37	0.00	0 03	95.11
Soil	0.24	Cum	150.00	/Cum	36.00	24.89	4 85	0.00	0.00	0.53
Sand	0.08	Cum	264.70	/Cum	21.18	3.18	11.01	0.00	0.00	1.19
Cement	37.50	Kg	2.28	/Kg	85.50	12.83	157.88	0.00	0 01	38.23
Scaffolding 1 cum	1.00	cum	23.32		23.32	9 08	0.14	69.62	0 00	0.02
Transportation from building centre to the site										
CSMB	425.00	No	0.05	/no	21.66	20 65	2.86	0	0.00	0.31
Less off site labour					-14.18					
B. LABOUR										
Helper for transportation from building centre					9 25					
On site										
Skilled	1.05	MD	71.50	/day	75.08					
Unskilled	2.20	MD	37.80	/day	83.16					
for CSMB Unskilled	425.00	No	0.34	/pc	144.59					
Unskilled for scaffold					14.18					

Table III.7 The summary of socio- economic and environmental impacts of Cement Stabilised Mud Block masonry wall for new construction

Unit cost	214.49	Rs. /square metre
Retained	55.05	Rs./ square metre
Skilled mason	17.27	Rs./ square metre
Semi-skilled	0.00	Rs./ square metre
unskilled	57.77	Rs./ square metre
Non-renewable	134.15	Mega Joules/ square metre
Renewable	16.01	Mega Joules/ square metre
Waste	0.01	Mega Joules/ square metre
Emission of CO_2	31.07	Kilogram /square metre

III.4 INTERLOCKING CEMENT STABILISED MUD BLOCK

An interlocking cement stabilised mud block is a cement stabilised mud block (10% cement) with the following properties:

Dimensions 300 millimetres x 150 millimetres x 100 millimetres (thick)

Dry weight 7.5 kilograms

Wet strength 35.0 kilograms/ per square centimetre

Dry strength 70.0 kilograms/ per square centimetre

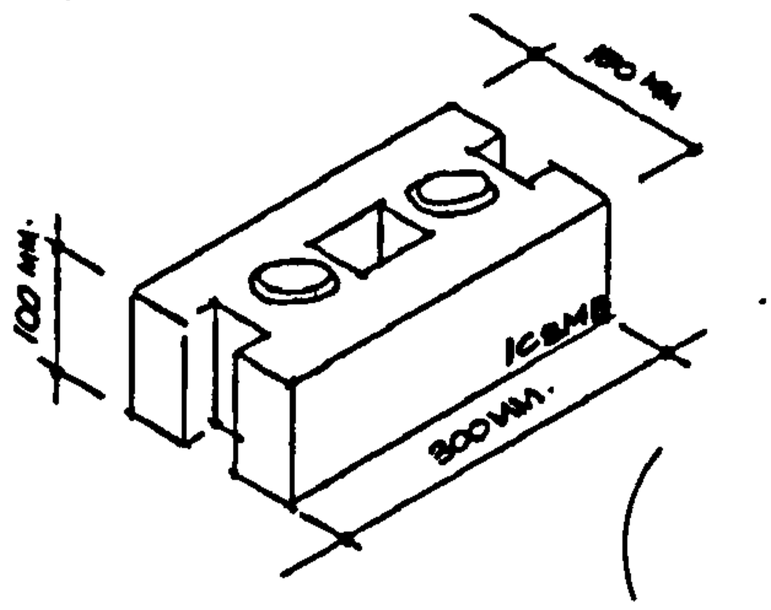


Figure III-7 Dimensions of interlocking cement stabilised mud block

Shape of interlocking cement stabilised mud blocks are such that once a wall is built with them, individual blocks cannot be displaced without disturbing the wall. Solid blocks of same stabilisation are also used, but the latter is more expensive than interlocking cement stabilised mud blocks.

Interlocking cement stabilised mud blocks are arranged with 1:3 cement mortar, to act as a load-bearing wall.

Interlocking cement stabilised mud block may be used if the quality of all other locally available walling materials is poor and/ or if the soil has the following characteristics:

Gravel	0 – 10%	20mm – 2mm
Sand	40 – 70%	2mm – 0.02 mm
Silt	15 – 25%	0.02mm – 0.002mm
Clay	8 – 25%	0.002mm – 0.00mm

Method of Interlocking cement stabilised mud block production

The specifications of soil and method of mixing of cement etc. are same as cement stabilised mud block. But for interlocking cement stabilised mud blocks, the percentage of cement added to the mix is 10. Rest of the procedure, e.g. curing etc. are exactly the same as that adopted for cement stabilised mud block production.

Method of Interlocking cement stabilised mud block masonry construction

The construction of interlocking cement stabilised mud block masonry is similar to 115 millimetres thick brick wall, but without any bed mortar. Only the rectangular holes are to be plugged with 1:3 cement mortar, as shown below.

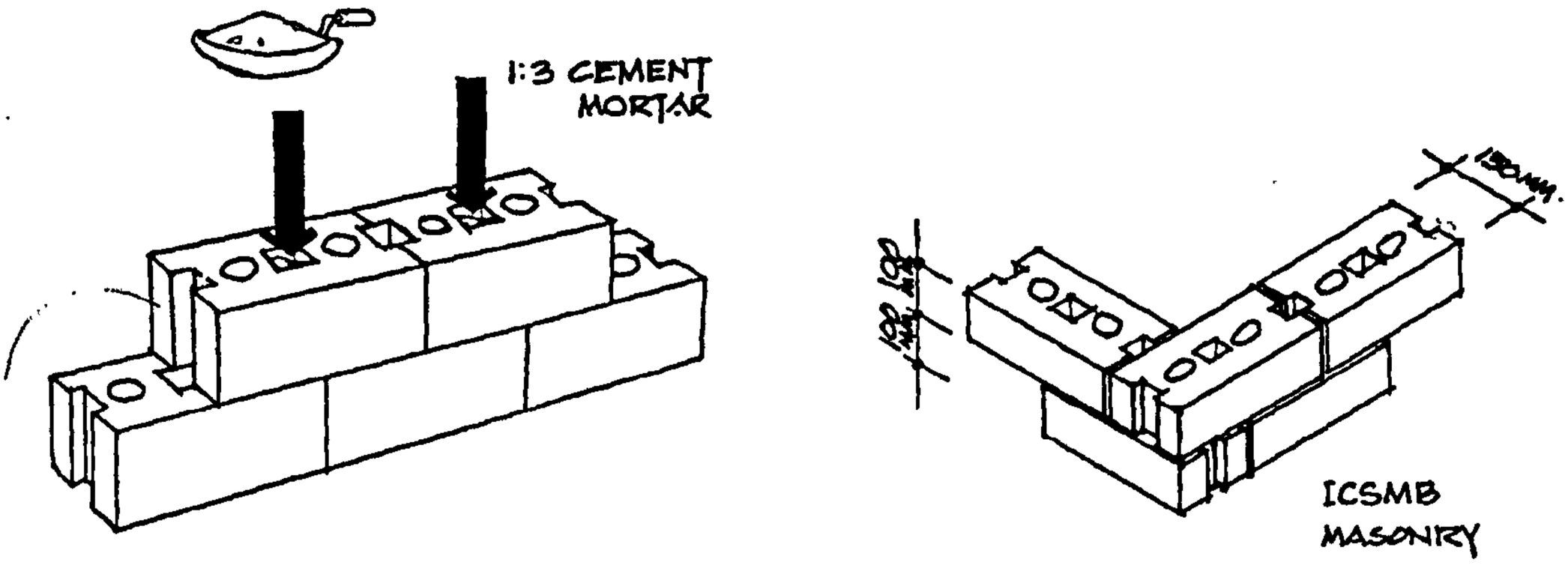


Figure III-8 Construction detail of interlocking cement stabilised mud block wall

Table III.8 Data for 1000 Interlocking Cement Stabilised Mud Block

Data for 1000 ICSMB										
							Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
Soil	7.10	cum	150.00	/cum	1065.00	736.30	143.34	0.00	0.00	15.55
Cement	860.00	Kg	2.28	/Kg	1960.80	294.12	3620.76	0.00	0.25	876.76
Maint etc 1%					30.26	30.26				
B. LABOUR										
Unskilled	18.26	MD	37.80	/day	690.23					

Table III.9 Data for 1.00 cubic meter of Interlocking Cement Stabilised Mud Block masonry in 1:3 cement-sand mortar

							Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
CSMB material cost	222.00	No	3 06	/pc	678.44	235.47	835.63	0.00	0.05	198.09
Sand	0.13	Cum	264.70	/Cum	34.41	5.16	17.89	0.00	0.00	1.94
Cement	62.40	Kg	2.28	/Kg	142.27	21.34	262.72	0.00	0.02	63 62
Scaffolding 1 cum	1.00	cum	23.32		23.32	9.08	0.00	69 62	0.00	0 00
Transportation from building centre to the site										
iCSMB	222.00	No	0.11	/no	23.57	22.48	3.11	0	0.00	0.34
Less off site labour					**-14.18**					
B. LABOUR										
Helper for scaffold					14.18					
Skilled	0.29	MD	71.50	/day	21.02					
Semi-skilled	0.69	MD	55.00	/day	37.73					
Unskilled	2.09	MD	37.80	/day	79.00					
Unskilled for ICSMB	222.00	NOS	0.69	/day	153.23					

Table III.10 The summary of socio- economic and environmental impacts of Interlocking Cement Stabilised Mud Block masonry wall for new construction

Unit cost	178.95	Rs. /square metre
Retained	40.66	Rs./ square metre
Skilled mason	3.15	Rs./ square metre
Semi-skilled	5.66	Rs./ square metre
Unskilled	36.96	Rs./ square metre
Non-renewable	167.43	Mega Joules/ square metre
Renewable	10.44	Mega Joules/ square metre
Waste	0.01	Mega Joules/ square metre
Emission of CO_2	39.55	Kilogram /square metre

III.5 STONE CONCRETE BLOCK MASONRY

Stone concrete blocks are made up of lean concrete mix of the following specifications:

Mix			Strength
Cement	Sand	Aggregate	Kilograms/ square centimetre
1	3	6	100-125
1	4	7	85-110
1	5	8	70-90

Block dimensions	290 millimetres x 190 millimetres x 140 millimetres (thick)
	190 millimetres x 90 millimetres x 140 millimetres (thick)
Weight of one block	18.8 and 6.0 kilograms respectively
Density of masonry	2300 kilograms / cubic metre

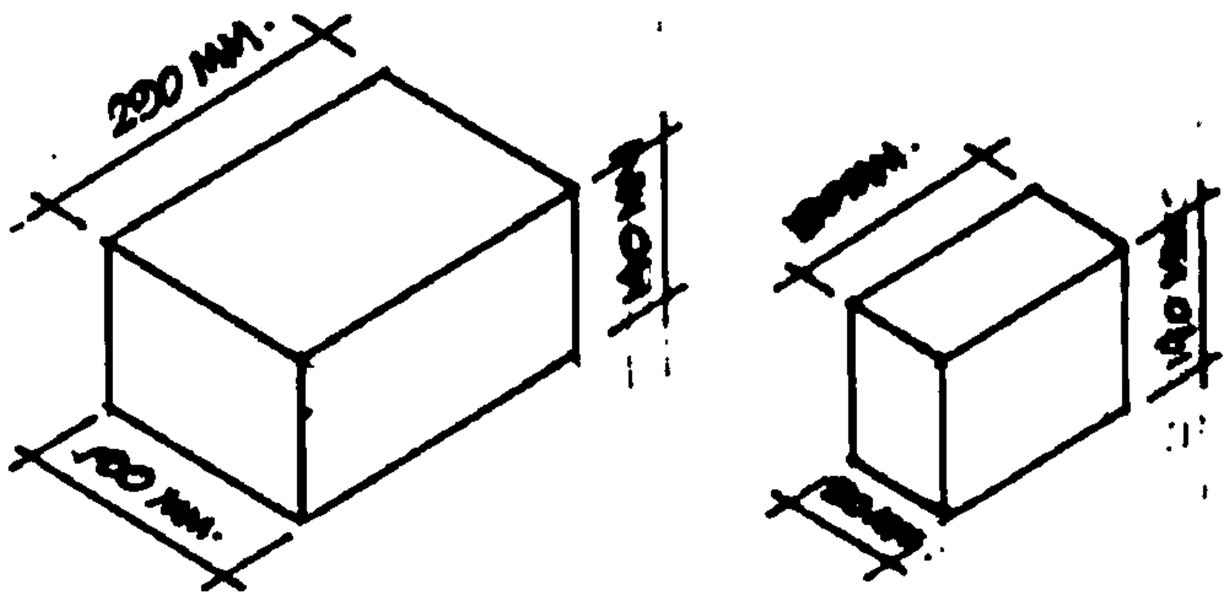


Figure III-9 Dimensions of stone concrete blocks

Stone concrete block masonry is built with stone concrete blocks in 1:6 cement mortar, and the bonding is similar to that of solid brick work.

Stone concrete block is used in places where stone is in abundance and stone concrete block masonry cost is lower than the other types of walls such as solid brick work etc.

Method of stone concrete block production

1. Steel moulds are fabricated first. They may be individual, gang or split type moulds.
2. A smooth, levelled and hard surface is constructed. It consists of 30 millimetres thick 1:3:6 plain cement concrete, finished smooth with neat cement, laid over a base of either brick soling (75 millimetres) or lean concrete 1:8:16. Such a casting platform of about 80 square metres is required for 500 blocks per day.

3. Blocks are made of lean concrete with a stone inserted in the middle. It should be ensured that the concrete cover of these stones is at least 50 millimetres thick. The stone pieces should be 50 millimetres down. Concrete should be of 1:2:4 proportion with 10 millimetres and 6 millimetres chips, medium coarse sand and 43 grade cement. A dry mix is prepared first; water is added to it and then remixed to make it homogeneous.
4. Inner surface of the mould is coated with waste oil. Large spalls are arranged at the bottom of the mould in such a manner that there is a minimum gap of 15 millimetres between the stones and the mould surface. Generally two stone spalls of 100-200 millimetres are used. Next, concreting is done.
5. The gap between the stone pieces is filled with lean concrete and compacted with a vibrator until proper consolidation is achieved.
6. Blocks are air dried before placing them in the curing tank.
7. After 14 days, the blocks are taken out of the curing tank and stacked for air drying.

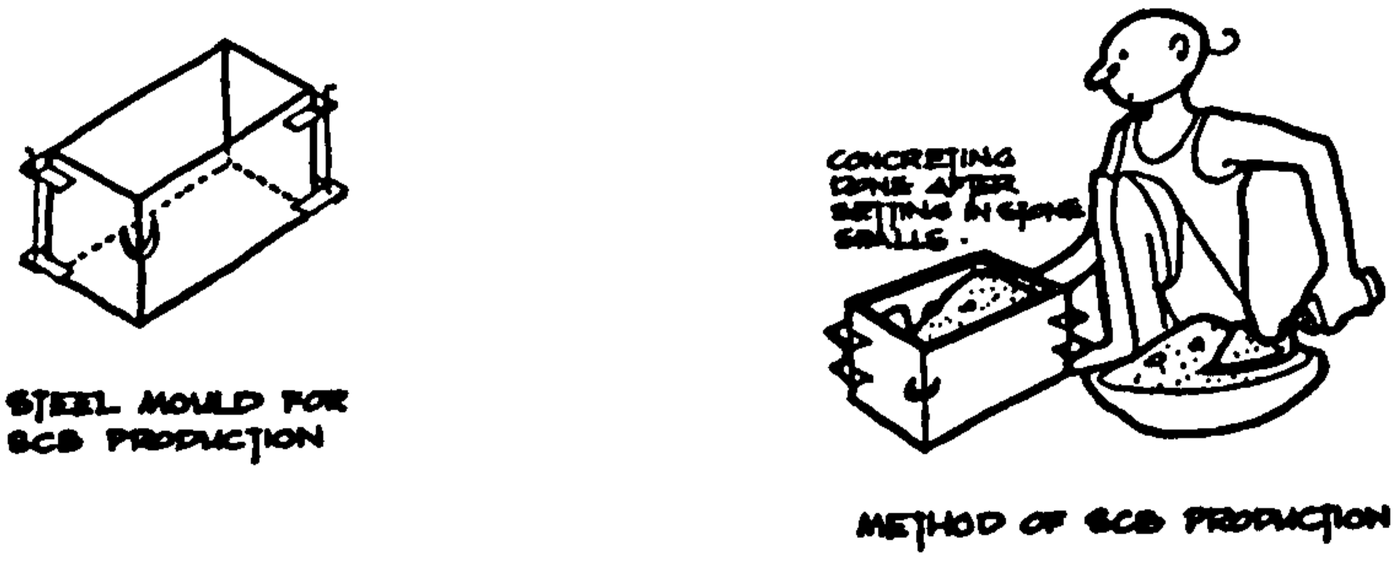


Figure III-10 Mould detail and the process of block making

Method of stone concrete block masonry construction

1. On the damp proof course, the first course of blocks is placed as in the sketch. This is repeated in course numbers 3, 5, 7, 9 etc.
2. The second course is placed as in the sketch. This is repeated in course numbers 4, 6, 8, 10 etc.

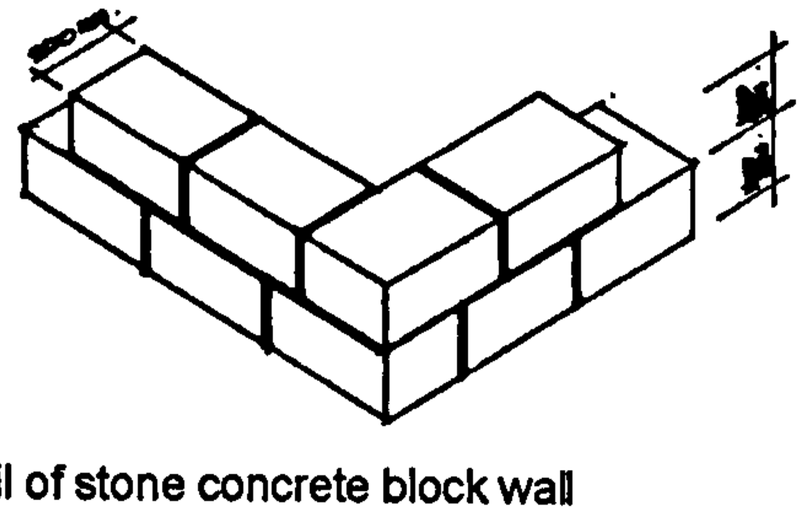


Figure III-11 Corner detail of stone concrete block wall

Table III.11 Data for 1000 Stone Concrete Block (290 x 190 x 140)

Data for 1000 SCB						volume of 1000 blocks		7.714	cum	
						diesel consumption		9.257	litres/ 1000 blocks	
							Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
Cement (1:6CM)	890.00	Kg	2.28	/Kg	2029.20	304.38	3747.07	0.00	0.26	907.35
Sand	2.10	Cum	264.70	/Cum	555.87	83.38	288.92	0.00	0.00	31.35
Stone dust	0.70	Cum	132.35	/Cum	92.65	64.24	14.45	0.00	0.00	1.57
10mm chips	1.50	Cum	411.50	/Cum	617.25	368.26	821.58	0.00	0.36	99.95
6mm chips	4.50	Cum	246.90	/Cum	1111.05	445 56	2464.74	0.00	1.09	299 84
stone spalls	2.50	Cum	281.75	/Cum	704.38	508.74	44.86	0.00	0.00	4.87
steel mould cost 2%	5.11	Kg	20.00	/Kg	102.21	15.33	185.60	0.00	0 00	21.48
10% increase for fabrication - energy and emission							4.49	0.00	0.00	0.49
Diesel - mixer and vibrator	9.257	litre	15.00	/litre	138.85	13.89	412.42	0.00	0 00	25 95
Mixing machine and vibrator charges Rs. 250/10 cum					192.85	96.43				
Less off site labour					**-366.21**					
B. LABOUR										
Off site										
Skilled worker for aggregate					69.13					
Unskilled worker for aggregate					120.98					
Skilled worker for stone spalls					0.00					
Unskilled worker for stone spalls					176.09					
On site										
Labour	50.00	MD	37.80	/day	1890.00					

Table III.12 Data for 1.00 cubic meter of Stone Concrete Block masonry in 1:6 cement-sand mortar

							Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
Blocks	105.00	No	5.18	/no	543.70	199.52	838.33	0.00	0.18	146.25
Cement (1:6CM)	30.00	Kg	2.28	/Kg	68.40	10.26	126.31	0.00	0.01	30.58
Sand (1:6CM)	0.13	Cum	264.70	/Cum	34.41	5.16	17.89	0.00	0.00	1.94
Scaffolding	1	cum	23.32	/Cum	23.32	9.08	0.14	69.62	0.00	0 02
Transportation from building centre to the site										
Stone Concrete Blocks	105.00	No	0.27	/no	27.95	26 65	11.07	0	0 00	1.20
Less off site labour					**-14.18**					
B. LABOUR										
Helper for transportation from building centre (2 helpers extra)					23.88					
Skilled worker for aggregate	105.00		0.07	/no	7.26					
Unskilled worker for aggregate	105.00		0.12	/no	12.70					
Skilled worker for stone spalls	105.00		0 00	/no	0 00					
Unskilled worker for stone spalls	105.00		0.18	/no	18.49					
SCB Labour	105.00		1.89	/no	198.45					
On site										
Skilled mason	0.90	WD	71.50	/day	64.35					
Unskilled	2 30	WD	37.80	/day	86.94					
Unskilled for scaffolding					14.18					

Table III.13 The summary of socio- economic and environmental impacts of Stone Concrete Block Mud Block masonry wall for new construction

Unit cost	**210.87**	Rs. /square metre
Retained	**47.63**	Rs./ square metre
Skilled mason	**13.61**	Rs./ square metre
Semi-skilled	**0.00**	Rs./ square metre
Unskilled	**67.38**	Rs./ square metre
Non-renewable	**188.81**	Mega Joules/ square metre
Renewable	**13.23**	Mega Joules/ square metre
Waste	**0.04**	Mega Joules/ square metre
Emission of CO_2	**34.20**	Kilogram /square metre

III.6 COURSED RUBBLE STONE MASONRY

Since it is the conventional system, the description has not been included in this section.

Table III.14 Data for 1.00 cubic meter of 380 thick Coursed Rubble Stone masonry in 1:6 cement-sand mortar

							Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
CR stone	1.10	Cum	281.75	/Cum	309.93	223.84	19.74	0.00	0 00	2.14
Sand (1.6CM)	0.40	Cum	264.70	/Cum	105.88	15.88	55 03	0.00	0.00	5.97
Cement (1.6CM)	76.80	Kg	2.28	/Kg	175.10	26 27	323.34	0.00	0 02	78.30
Scaffolding	1.00		23.32	/Cum	23.32	9 08	0.14	69.62	0.00	0.02
Less off site labour					**-91.66**					
B. LABOUR										
Off site										
Skilled worker for CRS					0.00					
Unskilled worker for CRS					77.48					
On site										
Skilled mason	0.75	MD	71.50	/day	53.63					
Helper to mason	1.00	MD	37.80	/day	37.80					
Belder	3.36	MD	37.80	/day	126.89					
Unskilled for scaffolding					14.18					

Table III.15 The summary of socio- economic and environmental impacts of Course Rubble Stone Block masonry wall for new construction

Unit cost	**316.37**	Rs. /square metre
Retained	**104.53**	Rs./ square metre
Skilled mason	**20.38**	Rs./ square metre
Semi-skilled	**0.00**	Rs./ square metre
Unskilled	**97.41**	Rs./ square metre
Non-renewable	**151.34**	Mega Joules/ square metre
Renewable	**26.45**	Mega Joules/ square metre
Waste	**0.008**	Mega Joules/ square metre
Emission of CO_2	**32.84**	Kilogram /square metre

APPENDIX IV

ROOFING SYSTEMS

IV.1 Reinforced cement concrete insitu

IV.2 Reinforced cement concrete plank and joist

IV.3 Reinforced cement concrete channel

IV.4 Ferrocement channel

IV.5 Micro concrete tile roofing

IV.6 Hybrid

IV.7 Reinforced cement concrete filler

IV.8 Stone on joist

IV.9 Jack-arch on joists

IV.10 Brick corbel arch

IV.11 Brick pyramid

IV.1 REINFORCED CEMENT CONCRETE INSITU ROOF

Since it is the conventional system, the description has not been included in this section.

Table IV.1 Analysis of rates for 1.00 cubic meter of Reinforced Cement Concrete Slab

Description	Quantity	Unit	Rate	Unit	Total	Retained	Non-renewable	Renewable	Waste	CO_2
A. MATERIALS										
cost of 20mm metal	0.92	cum	411.50		378.58	225.87	503.90	0.00	0.22	61.30
cost of cement (1:2 CM)	331.2	cum	2.28	nos.	755.14	113.27	1394.41	0.00	0.10	337.66
cost of sand (1:2 CM)	0.46	cum	264.70	/Kg	121.76	18.26	63.29	0.00	0.00	6.87
cost of steel	73.356	kg	17.20		1261.73	189.26	2227.25	0.00	0.00	262.03
Shuttering	10	sqm	73.75		737.51	542.07	40.79	1083.26	18 55	9.25
Diesel - mixer and vibrator	1.200	litre	15.00	/litre	18 00	1.80	53.46	0.00	0.00	3.36
Mixing machine and vibrator charges Rs. 250/10 cum					25.00	12 50				
B. LABOUR										
Off site										
Skilled workers for aggregate					15.14					
Unskilled workers for aggregate					26.50					
On site										
Skilled mason for shutter					93.88					
Un-skilled mason for shutter					70.57					
Skilled mason for shutter	0.12	MD	71.50	/Cum	8.58					
Sem-skilled mason	0.28	MD	55 00		15.40					
Helper	5.60	MD	37.80	/day	211.68					

Table IV.2The summary of socio- economic and environmental impacts of Reinforced Cement Concrete Slab for new construction per square meter of plan area

Unit cost	**411.38**	Rs. /square metre
retained	**121.35**	Rs./ square metre
Skilled mason	**12.94**	Rs./ square metre
Semiskilled	**1.69**	Rs./ square metre
unskilled	**33.97**	Rs./ square metre
Non-renewable	**471.19**	Mega Joules/ square metre
Renewable	**119.17**	Mega Joules/ square metre
Waste	**2.08**	Mega Joules/ square metre
Emission of CO_2	**74.86**	Kilogram /square metre

xxx

IV.2 PRE-CAST REINFORCED CEMENT CONCRETE PLANKS AND JOISTS

Pre-cast reinforced cement concrete joists are beams (with small sections) and the planks are small reinforced cement concrete slabs. The joists are supported on beams or walls, then the planks are placed between the joists and the gaps are filled with concrete to form a roof or intermediate floor.

Pre-cast reinforced cement concrete planks and joists are used –

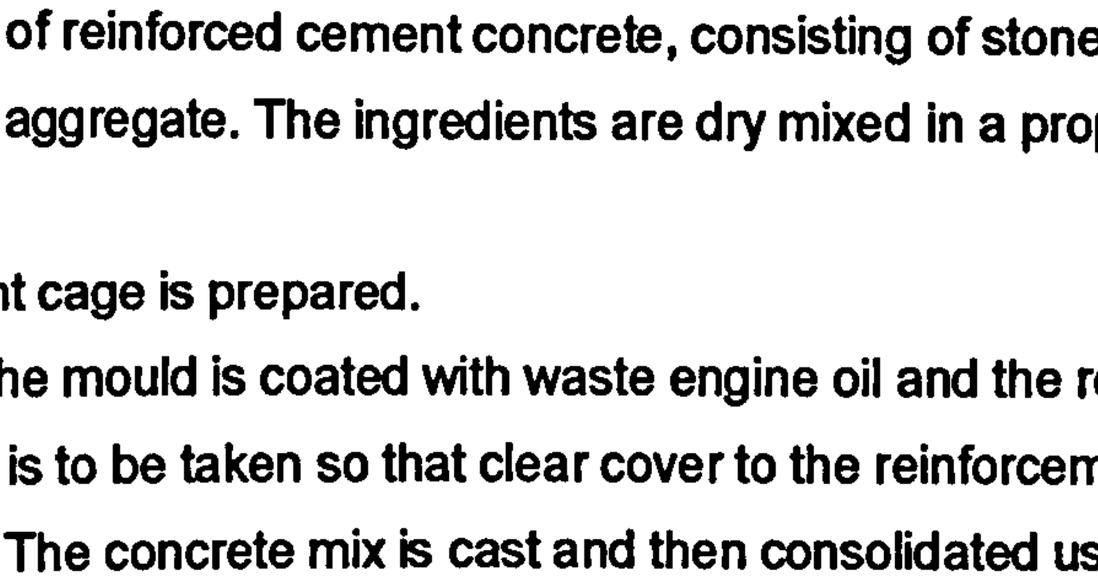
a. if joists are available from the market. Or else, at least a few buildings are to be constructed on identical design, so that the cost of a casting yard, curing tank and mould is justified.
b. if the span is between 2.4 and 3.65 metres, because joists are economic in this span range. However, the width of a classroom is generally more than 3.65 metres. Hence a beam or arch is constructed at the centre of the room so that the span is within 3.65 metres.
c. if there is a need for adding floors to an existing building.

Method of reinforced cement concrete plank production

1. Steel moulds are fabricated first, as shown in the sketch below.
2. A smooth, levelled and hard surface is constructed. The platform shall consist of 30 millimetres thick 1:3:6 cement concrete, finished smooth with neat cement, laid over a base of either brick soling (75 millimetres) or lean concrete 1:8:16.
3. Planks are made of reinforced cement concrete, consisting of stone dust, sand and 10 millimetres down aggregate. The ingredients are dry mixed in a proportion of 1:2:4 and then water is added.
4. The reinforcement cage is prepared.
5. Inner surface of the mould is coated with waste engine oil and the reinforcement cage is placed in it. Care is to be taken so that clear cover to the reinforcement cage from the mould is 15 millimetres. The concrete mix is cast and then consolidated using a plate vibrator.
6. After one day, the plank is de-moulded and kept in a curing tank for 7-10 days.
7. After the plank is removed from the curing tank, it is kept in shade for 14 days for air drying.

The planks are then ready for use.

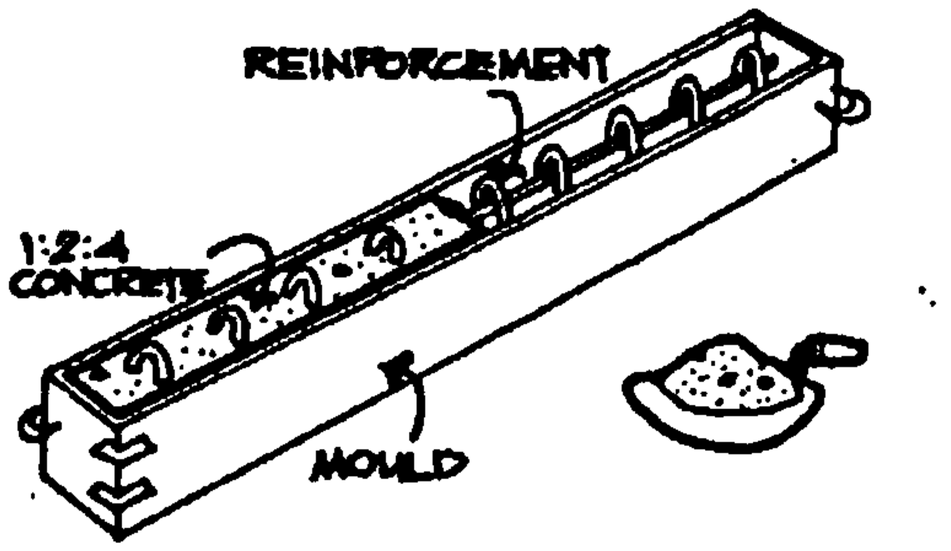
Figure IV-1 Detail of pre-cast reinforced cement concrete plank



Method of pre-cast reinforced cement concrete joist production

It is exactly similar to the production of planks; but with a different mould and reinforcement, which is as shown in the sketch below.

Figure IV-2 Detail of pre-cast reinforced cement concrete joist



Method of pre-cast reinforced cement concrete planks and joists roofing

1. The joists are placed with a spacing of 1570 millimetres centre to centre over supporting beams or walls. 300 millimetres x 230 millimetres x 75 millimetres (thick) bed blocks in 1:3:6 are placed under each supporting end of the joists. After levelling etc., each joist is propped at the centre.
2. The planks are placed side by side on the joists.
3. Two 6 millimetres steel rods are placed parallel to the joists. Two rods of the same diameter are placed over each plank, across the joists. These rods are then tied with the projected reinforcements of the joists.
4. 1:2:4 cement concrete is cast in the gaps. The concrete is consolidated and then water cured for 7-10 days.

Figure IV-3 Plank and joist roofing system

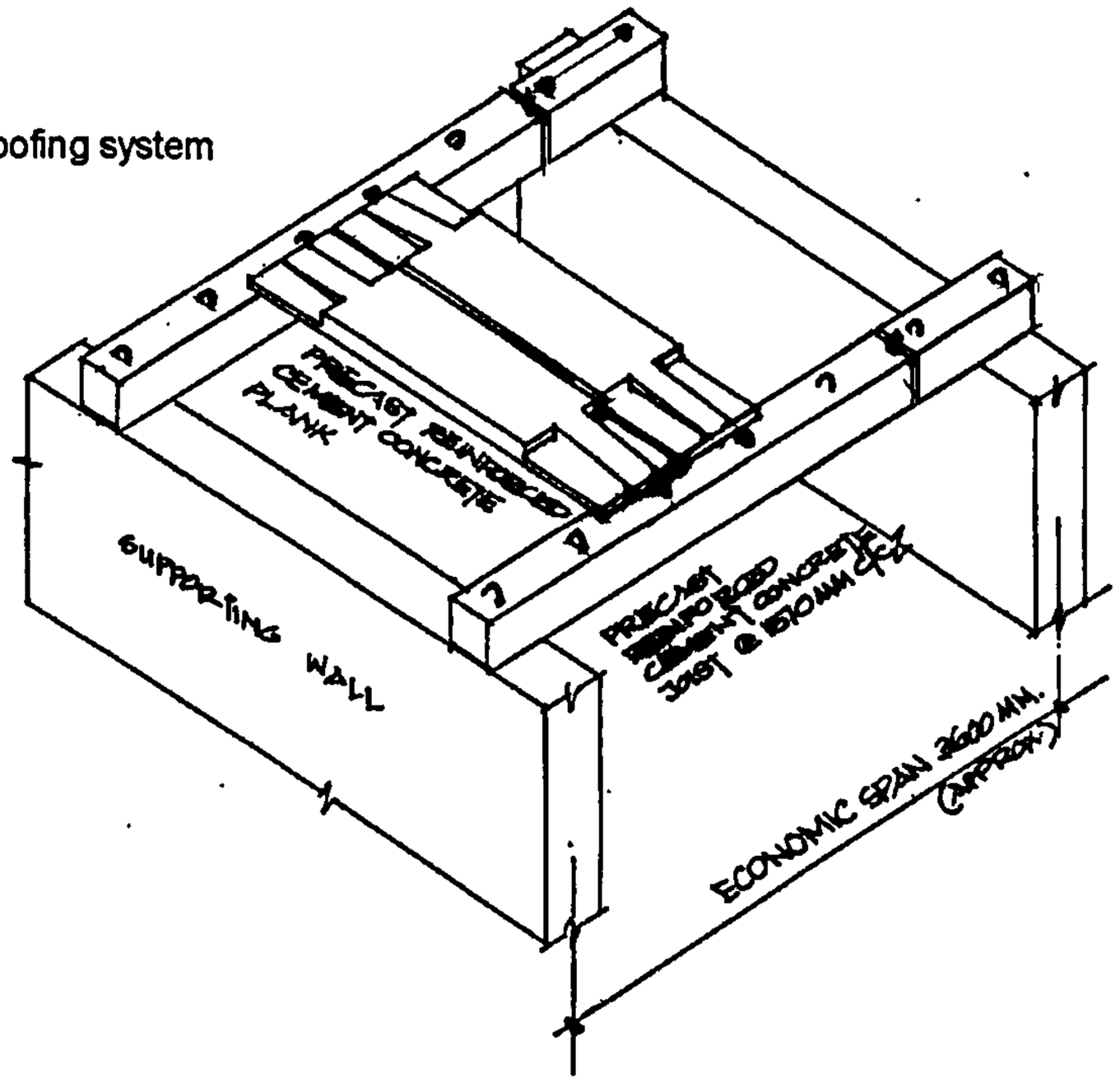


Table IV.3 Analysis of rates for one Pre-cast Reinforced Cement Concrete Plank (1500x300x60)

** mould labour cost @40% of material cost has been considered					volume of one plank		0.022	cum	machine	250	
Data for one plank 1500 x 300 x 60		54.35	kg/no		diesel consumption		0.026	litres/ plank			
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Total**	**Retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**	
A. MATERIALS (including transport)											
Cement	6.95	Kg	2.28	/Kg	15.85	2.38	29.26	0.00	0.00	7.09	
Sand	0.009	Cum	264.70	/Cum	2.38	0.36	1.24	0.00	0.00	0.13	
12mm aggregate	0.005	Cum	411.50	/Cum	2.06	1.23	2.74	0.00	0.00	0.33	
6mm aggregate	0.015	Cum	246.90	/Cum	3.70	1.49	8.22	0.00	0.00	1.00	
binding wire	0.012	kg	25.00	/Kg	0.30	0.05	0.36	0.00	0.00	0.04	
steel 6mm dia	1.4	kg	17.20	/Kg	24.08	3.61	42.51	0.00	0.00	5.00	
steel mould 2% of the total cost	0.05	kg	20.00	/Kg	0.97	0.15	1.76	0.00	0.00	0.20	
10% increase for fabrication - energy and emission							0.18	0.00	0.00	0.02	
Diesel - mixer and vibrator	0.026	litre	15.00	/tre	0.39	0.04	1.16	0.00	0.00	0.0731	
Mixing machine and vibrator charges Rs. 250/10 cum					0.54	0.27					
Less off site labour charges					**-0.63**						
B. LABOUR											
Off site											
Skilled worker for 12mm + 6mm					0.23						
Unskilled worker for 12mm + 6mm					0.40						
skilled labour for mould 40% of material cost	0.0054	MD	71.50	/day	0.39						
On site											
Skilled mason	0.067	MD	71.50	/day	4.79						
barbender	0.04	MD	55.00	/day	2.20						
Labour	0.199	MD	37.80	/day	7.52						
				total	65.17	9.56	87.42	0.00	0.01	13.89	

Table IV.4 Analysis of rates for one Pre-cast Reinforced Cement Concrete Joist of length 2470mm (150x150)

		135.87	kg/no			volume of one joist		0.054	cum	
						diesel consumption		0.065	litres/ joist	
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Total**	**Retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
Cement	19	Kg	2.28	/Kg	43.32	6.50	79.99	0.00	0.01	19.37
Sand	0.025	Cum	264.70	/Cum	6.62	0.99	3.44	0.00	0.00	0.37
12mm aggregate	0.01	Cum	411.50	/Cum	4.12	2.46	5.48	0.00	0.00	0.67
6 mm aggregate	0.04	Cum	246.90	/Cum	9.88	3.96	21.91	0.00	0.01	2.67
binding wire	0.07	kg	25.00	/Kg	1.75	0.26	2.13	0.00	0.00	0.25
steel	8.4	kg	17.20	/Kg	144.48	21.67	255.04	0.00	0.00	30.01
st. mould 2% of the total cost	0.21	kg	20.00	/Kg	4.20	0.63	7.63	0.00	0.00	0.88
10% increase for fabrication - energy and emission							0.76	0.00	0.00	0.09
Diesel - mixer and vibrator	0.065	litre	15.00	/ltre	0.98	0.10	2.91	0.00	0.00	0.18
Mixing machine and vibrator charges Rs. 250/10 cum					1.36	0.68				
Less off site labour charges					-1.54					
B. LABOUR										
Off site Skilled worker for aggregate					0.56					
Unskilled worker for aggregate					0.98					
skilled labour for mould 40% of material cost	0.024	MD	71.50	/day	1.68					
On site										
Skilled mason	0.125	MD	71.50	/day	8.94					
barbender	0.2	MD	55.00	/day	11.00					
Labour	0.515	MD	37.80	/day	19.47					
				total	257.78	37.25	379.29	0.00	0.02	54.49

Table IV.5 Analysis of rates for 10 square meter of Pre-cast Reinforced Cement Concrete Plank and Joist roofing - there is a beam of section 600x200 i.e 0.64 cum

Description	Quantity	Unit	Rate	Unit	Total	Retained	Non renewable	Renewable	Waste	CO_2
A. MATERIALS										
Precast planks mat	21.72	No.	49.64		1078.13	207.64	1898.75	0.00	0.15	301.76
Precast joist mat	21	No.	215.16		451.84	78.22	796.50	0 00	0.04	114.42
Cement	53.3	Kg	2.28	/Kg	121.52	18.23	224.40	0.00	0 02	54.34
Sand	0.072	Cum	264.70	/Cum	19.06	2.86	9.91	0.00	0.00	1.07
12mm aggregate	0.144	Cum	411.50	/Cum	59 26	35.35	78.87	0.00	0.03	9.59
6mm ms bars	9.4	Kg	17.20	/Kg	161.68	24.25	285.40	0.00	0 00	33.58
Primary RCC beam 0.69cum										
12mm aggregate	0.164	Cum	411.50		67.45	40.24	89.78	0.00	0.04	10.92
Cement	59.011	Kg	2.28		134.55	20.18	248.45	0.00	0.02	60.16
Sand	0.082	Cum	264.70		21.69	3.25	11.28	0.00	0.00	1.22
steel	29.248	kg	17.20		503.07	75.46	888.04	0 00	0.00	104.48
Shuttering to cenral beam	1.906	sqm	73.75	/sqm	140.56	103.31	7.78	206.46	3.54	1.76
Transportation from building centre to the site										
Planks	21.720	No.	0.77		16.71	15.93	2.21	0	0.00	0.24
joists	2.100	No.	1.92		4 04	3.85	0.53	0	0.00	0.06
Off site labour for insitu work					-45.28					
B. LABOUR										
Off site										
Skilled worker for Plank + Joist					6.18					
Unskilled worker for Plank + Joist					10.82					
Skilled worker for aggregate					5.07					
Unskilled worker for aggregate					8.87					
Transportation of planks 2 helpers extra					14.28					
Transportation of joists 6 helpers extra					6.90					
On site										
Primary RCC beam 0 69cum										
Skilled	0.021		71.5		1.53					
semi skilled	0.050		55		2.74					
unskilled	0.998		37.8		37.72					
Skilled for shuttering					17.89					
Helper for shuttering					13.449					
Precast planks skilled lab	1.455	No.	71.50		104 05					
Skilled for mould	0.118		71.50		8.40					
Barbender	0.869	No.	55.00		47.78					
un skilled lab	4.322	No.	37.80		163.38					

Precast joist skilled lab	0.263	No.	71.50		18.77					
Skilled for mould	0.049	No.	71.50		3.53					
Bar bender	0.42	No.	55.00		23.10					
unskilled lab	1.082	No.	37.80		40.88					
Skilled masons for hoisting	0.8	MD	71.50	/day	57.20					
Beldar for hoisting	2.4	MD	37.80	/day	90.72					
Skilled masons for laying roof	0.22	MD	71.50	/day	15.73					
Beldar for laying roof	0.66	MD	37.80	/day	24.95					
Barbender	0.3	MD	55.00	/day	16.50					
Helper to barbender	0.3	MD	37.80	/day	11.34					
Unit cost in Rs./sqm	**348.61**									
Money **retained** Rs/sqm	**62.88**			total	**3486.07**	**628.80**	**4541.89**	**206.46**	**3.83**	**693.61**

Table IV.6 The summary of socio- economic and environmental impacts of one square meter of Pre-cast Reinforced Cement Concrete Plank and Joist roofing for new construction

Unit cost	348.61	Rs. /square metre
retained	62.88	Rs./ square metre
Skilled mason	23.84	Rs./ square metre
Semiskilled	9.01	Rs./ square metre
unskilled	42.33	Rs./ square metre
Non-renewable	454.19	Mega Joules/ square metre
Renewable	20.65	Mega Joules/ square metre
Waste	0.38	Mega Joules/ square metre
Emission of CO_2	69.36	Kilogram /square metre

IV.3 PRECAST REINFORCED CEMENT CONCRETE CHANNELS

Pre-cast reinforced cement concrete channel is a trough section cast in reinforced cement concrete and formed on a ground mould. After adequate curing, it is lifted and placed between the walls or beams to make a roof or intermediate slab.

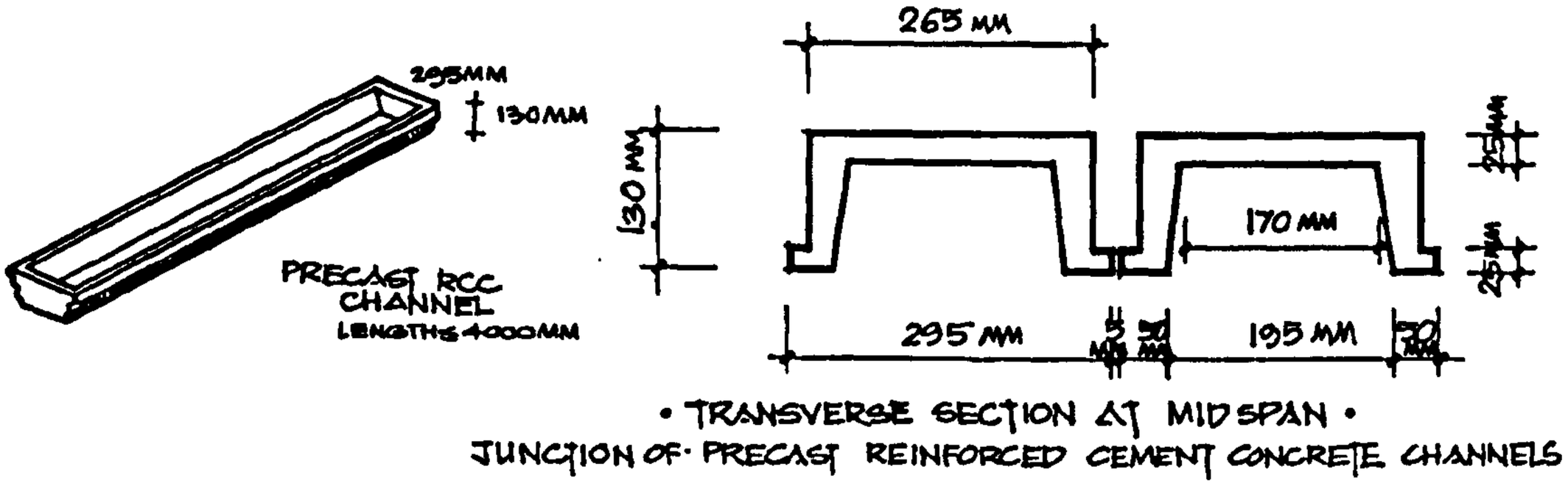


Figure IV-4 Detail of pre-cast reinforced cement concrete channel

Pre-cast reinforced cement concrete channels are used –

a. if channels are available from the market. Or else, at least a few buildings are to be constructed on identical design, so that the cost of a casting yard, curing tank and mould is justified.
b. if the span is between 2.4 and 3.65 metres, because channels are economic in this span range. However, the width of a classroom is generally more than 3.65 metres. Hence a beam or arch is constructed at the centre of the room so that the span is within 3.65 metres.
c. if there is a need for adding floors to an existing building.

Method of pre-cast reinforced cement concrete channel production

1. Steel moulds are fabricated first. They may be individual, gang or split mould.
2. A smooth, levelled and hard surface is constructed. The platform shall consist of 30mm thick 1:3:6 cement concrete, finished smooth with neat cement, laid over a base of either brick soling (75 millimetres) or lean concrete 1:8:16.
3. Channels are made of reinforced cement concrete, consisting of stone dust, sand and 10 millimetres down aggregate. The ingredients are dry mixed in a proportion of 1:2:4 and then water is added.
4. The reinforcement cage is prepared.

5. Inner surface of the mould is coated with waste engine oil and the reinforcement cage is placed in it. Care is to be taken so that clear cover to the reinforcement cage from the mould is 15 millimetres. The concrete mix is cast and then consolidated using a plate vibrator.
6. After one day, the channel is de-moulded and kept in a curing tank for 7-10 days.
7. After the channel is removed from the curing tank, it is kept in shade for 14 days for air drying. The channels are then ready for use.

Method of pre-cast reinforced cement concrete channel roofing

1. The channels are placed on beams or walls
2. One 8 millimetres steel rod is placed between two channels and 1:2:4 cement concrete is cast to fill the gap.
3. The concrete is consolidated and then, water cured for 7-10 days.

Figure IV-5 Channels supported on walls

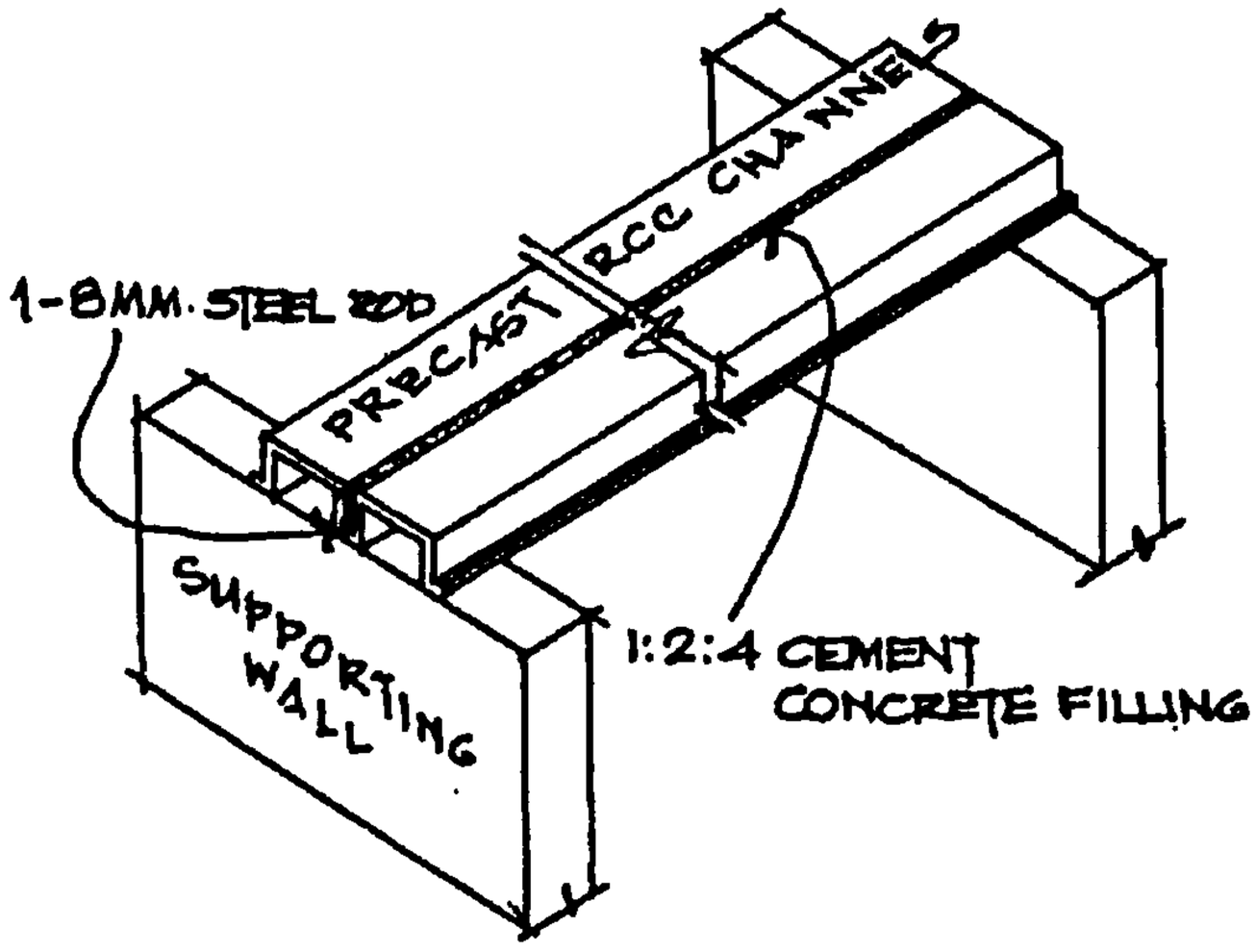


Table IV.7 Analysis of rates for 40 Pre-Cast Reinforced Cement Concrete Channel 3600mm long

						volume of 40 channels			2.283	cum
	one channel = 142.663		kg/no			diesel consumption			2.739	litres/ joist
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Total**	**Retained**	**Non renewable**	**Renewable**	Waste	**CO_2**
A. MATERIALS										
Cement	750	Kg	2.28	/Kg	1710.00	256.50	3157.64	0.00	0.22	764.619
Sand	1.053	Cum	264.70	/Cum	278.73	41.81	144.87	0 00	0.00	15.720
12mm aggregate	0.53	Cum	411.50	/Cum	218.10	130.12	290.29	0.00	0.13	35.315
6mm aggregate	1.57	Cum	246.90	/Cum	387.63	155.45	859.92	0.00	0.38	104.611
binding wire	18.5	kg	25.00	/Kg	462.50	69.38	561.70	0.00	0 00	66.083
steel	202.5	kg	17.20	/Kg	3483.00	522.45	6148.31	0.00	0.00	723.343
mould 2% of the total cost	6.54	kg	20.00	/Kg	130.80	19 62	237.52	0.00	0 00	27.493
10% increase for fabrication - energy and emission							23 75	0.00	0.00	2.749
Diesel - mixer and vibrator	2.739	litre	15.00	/litre	41.09	4.11	122.04	0.00	0.00	7.68
Mixing machine and vibrator charges Rs. 250/10 cum					57.07	28.53				
Less off site labour					**-66.63**					
B. LABOUR										
off site										
Skilled worker for aggregate					24.23					
Unskilled worker for aggregate					42.40					
Skilled lab mould 40% of mat cost	0.73	MD	71.50	/day	52.32					
On site										
Skilled masons	7.5	MD	71.50	/day	536.25					
barbender	5.5	MD	55.00	/day	302.50					
Labour	22	MD	37.80	/day	831.60					
Helper to barbender	11.5	MD	37.80	/day	434.70					

Table IV.8 Analysis of rates for 10 square meters of Pre-Cast Reinforced Cement Concrete Channel roofing

Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Total**	**Retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
Channel mat	9.26	nos	167.56		1551.58	284.27	2672.91	0.00	0.17	404.57
Cement	49 6	Kg	2.28	/Kg	113.09	16 96	208.83	0.00	0.01	50.57
Sand	0.07	Cum	264.70	/Cum	18.53	2.78	9 63	0.00	0.00	1.05
12mm aggregate	0.14	Cum	411.50	/Cum	57.61	34.37	76.68	0.00	0.03	9.33
steel	6.54	kg	17.20	/Kg	112.49	16.87	198.57	0.00	0.00	23.36
Primary RCC beam 0 69cum										
Agg. 12mm	0.187	Cum	411.50		77.00	45 94	102.49	0.00	0.05	12.47
Cement	67.363	Kg	2.28		153.59	23.04	283.61	0.00	0.02	68 68
Sand	0.094	Cum	264.70		24.77	3.71	12.87	0.00	0.00	1.40
steel	31.892	kg	17.20		548.54	82.28	968.30	0.00	0.00	113 92

Shuttering for central beam	1.906	sqm	73.75		140.56	103.31	7.78	206.46	3.54	1.76
Transportation of channels from the building centre										
Channels	9.260	nos	2.02		18 70	17.83	2.47	0	0.00	0.27
Less off site labour					**-46.15**					
B. LABOUR										
off site										
Skilled worker for aggregate/channel					5.61					
Unskilled worker for aggregate/channel					9.82					
Skilled worker for aggregate					5.38					
Unskilled worker for aggregate					9 42					
Helper for transportation from building centre (6 helpers extra)					31.96					
Skilled mason for mould	9.2600		1.31	/channel	12.11					
On site										
Primary RCC beam 0 69cum										
Skilled	0.023		71.5		1.65					
semi skilled	0.054		55		2.97					
unskilled	1.078		37.8		40.76					
Skilled for shuttering					17.89					
Helper for shuttering					13.45					
Skilled mason for ch	9.26	nos	13.41	/ch	124.14					
semi-skilled	9.26	nos	7.56	/ch	70.03					
Helper for ch	9.26	nos	31.66	/ch	293.15					
Skilled masons	0.05	MD	71.50	/day	3.58					
barbender	0.05	MD	55 00	/day	2.75					
Labour	0 9	MD	37.80	/day	34.02					
helper	0.1	MD	37.80	/day	3.78					
Lab for hoisting	4	MD	37.80	/day	151.20					

Table IV.9 The summary of socio- economic and environmental impacts of Pre-Cast Reinforced Cement Concrete Channel roofing for new construction per square meter of plan area

Unit cost	360.40	Rs. /square metre
retained	63.14	Rs./ square metre
Skilled mason	17.04	Rs./ square metre
Semiskilled	7.57	Rs./ square metre
unskilled	58.76	Rs./ square metre
Non-renewable	454.41	Mega Joules/ square metre
Renewable	20.65	Mega Joules/ square metre
Waste	0.38	Mega Joules/ square metre
Emission of CO_2	68.74	Kilogram /square metre

IV.4 PRECAST FERROCEMENT CHANNELS

A pre-cast ferrocement channel is a light weight roofing element, which is made of 1:2 cement and sand mortar and mild steel reinforcement with geometry as shown in the sketch. The casting of ferrocement channel is done on a ground mould, then it is cured and lifted in position to make a roof.

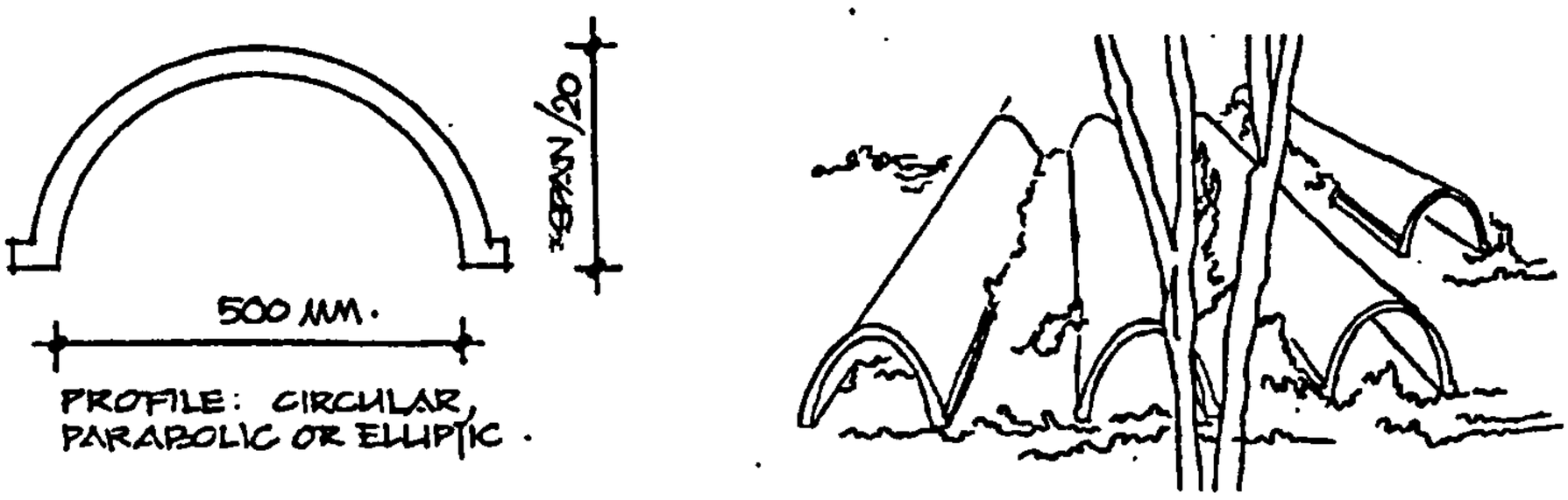


Figure IV-6 Dimensions and view of ferrocement channel

Ferrocement channel is used –

a. if ferrocement channels are available from the market. Or else, at least a few buildings are to be constructed on identical design, so that the cost of a casting yard, curing tank and mould is justified.
b. if the span is around 5-6 metres. Hence it is suitable for a classroom of similar width.
c. if it is an earthquake prone area.

Method of ferrocement channel production

1. A brick masonry mould is prepared on the ground. After proper curing, the surface is cleaned. Waste engine oil is applied until the surface does not absorb any more. Next, another coat of waste engine oil is applied for easy de-moulding.
2. Steel and galvanised iron wire mesh is prepared.
3. Mortar mix of 1: 2 sand-cement is prepared with 22.5 litres of water per bag of cement.
4. Apply a 5 millimetre thick cement mortar on the surface of the mould.
5. Prepared steel cage with mesh is placed on the first layer of cement mortar.
6. The second and final layer of mortar is applied on the steel cage and the surface is tapped to consolidate the mortar. Finally, templates are used to obtain an even thickness all along the channel.
7. The channel is allowed to set on the mould for twenty four hours in shade.

8. After 24 hours, the channel is slightly lifted on one end and then fully lifted and carried manually by holding both ends to the curing tank.
9. Curing time is 7-10 days, depending upon the weather conditions.

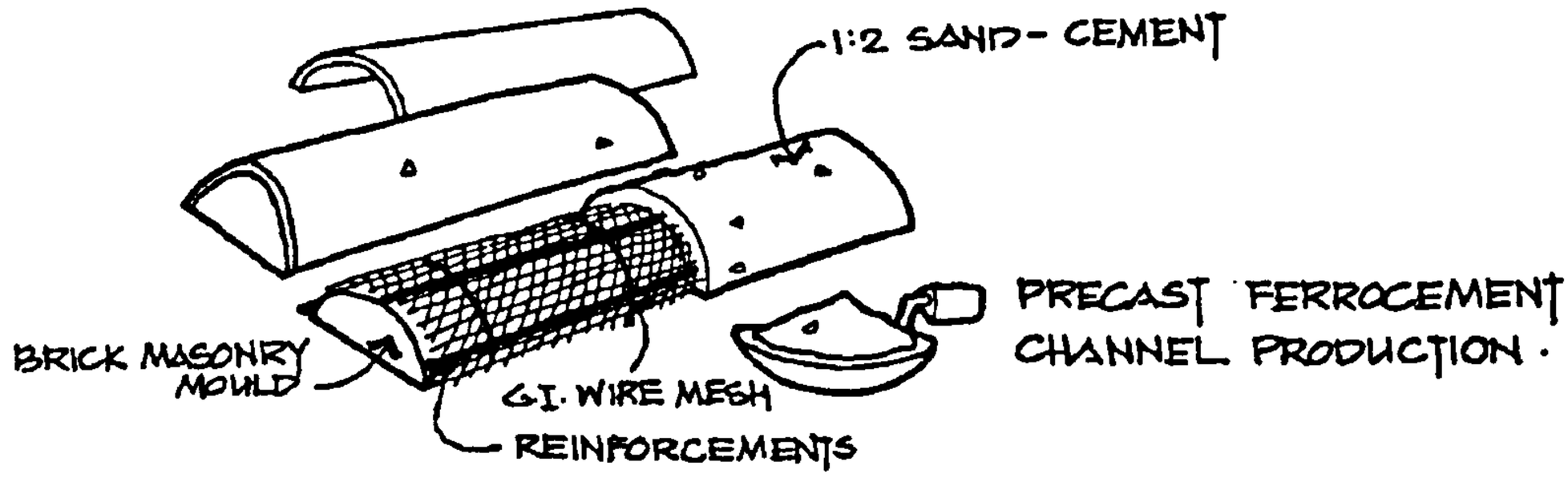


Figure IV-7 Detail of ferrocement channel

Method of pre-cast ferrocement channel roof construction

1. The channels are placed side by side over supporting beams or walls. 75 millimetres thick band lintel is used, on which the channels should rest.
2. One 10 millimetres diameter steel rod is placed parallel to the channels and a strip of galvanised iron wire mesh is tied along the entire length of the channels.
3. 1:2 cement mortar is cast in the gap between the two channels. The mortar is consolidated and water cured for 7-10 days.

Table IV.10 Analysis of rates for one Pre-Cast Ferrocement Channel in 1:2 cement sand mortar 6500 millimeters long

Weight of one channel (kg)	424.03									
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Total**	**Retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
Cement	108	Kg	2.28	/Kg	246.24	36.94	454.70	0.00	0.03	110.11
Sand	0.15	Cum	264.70	/Cum	39.71	5 96	20.64	0.00	0.00	2.24
Steel @3.86kg/sqm +40%	21.08	kg	17.20	/kg	362.50	54.38	639.90	0.00	0.00	75.28
chk wire mesh-150% xtra	4.28	kg	25.80	/kg	110.42	16.56	129.95	0.00	0.00	15 29
W mesh 25x25 -25%xtra	10.3	kg	21.50	/kg	221.45	33.22	312.73	0.00	0.00	36.79
W mesh100x100 -25% xtra	4.37	kg	21.50	/kg	93.96	14.09	132 68	0.00	0.00	15.61
Steel Mould cost 2%	1.07	kg	20.00	/kg	21.49	3.22	39.02	0.00	0.00	4.52
10% increase for fabrication - energy and emission							3.90	0.00	0.00	0.45
B. LABOUR										
Skilled mason	0.25	MD	71.50	/day	17.88					
mould skilled 40% of material cost	0.120	MD	71.50	/day	8.59					

barnender	0.65	MD	55.00	/day	35.75					
Semi skilled	0.25	MD	55.00	/day	13.75					
unskilled	1	MD	37.80	/day	37.80					
demould - unskilled	1.5	MD	37.80	/day	56.70					

Table IV.11 Analysis of rates for 10 square meter Pre-Cast Ferrocement Channel roofing in 1:2 cement sand mortar 6500 millimeters long

Description	Quantity	Unit	Rate	Unit	Total	Retained	Non renewable	Renewable	Waste	CO_2
A. MATERIALS										
FC channel mat	2.28	nos	1095.76		2498.33	374.75	3952.41	0.00	0 07	593.45
Cement	2.88	Kg	2.28	/Kg	6.57	0.98	12.13	0.00	0.00	2.94
Sand	0.004	Cum	264.70	/Cum	1.06	0.16	0.55	0.00	0.00	0.06
Steel	4.03	kg	17.20	/kg	69.32	10.40	122.36	0.00	0.00	14.40
Transportation of ferrocement channels from the building centre										
Channels	2.28	nos	6.00		13.69	13.05	1.81	0	0.00	0.20
B. LABOUR										
Transportation helper (10 extra)					35.08					
Skilled mason for ch	2.28	nos	26 47		60.35					
semiskilled for ch	2.28	nos	49.50		112.86					
labour for ch	2.28	nos	94.50		215.46					
Skilled mason	1	MD	71.50	/day	71.50					
barnender	0.044	MD	55.00	/day	2.42					
labour for ch	2	MD	37.80	/day	75.60					
Helper for hoist	8	MD	37.80	/day	302.40					
curing labour 5% of total cost	1.16		37.80	/day	43.78					

Table IV.12 The summary of socio- economic and environmental impacts of Pre-Cast Ferrocement Channel roofing for new construction per square meter of plan area

Unit cost	**350.84**	Rs. /square metre
retained	**39.93**	Rs./ square metre
Skilled mason	**13.18**	Rs./ square metre
Semiskilled	**11.53**	Rs./ square metre
unskilled	**67.23**	Rs./ square metre
Non-renewable	**408.93**	Mega Joules/ square metre
Renewable	**0.00**	Mega Joules/ square metre
Waste	**0.007**	Mega Joules/ square metre
Emission of CO_2	**61.10**	Kilogram /square metre

IV.5 MICRO-CONCRETE TILES ON STEEL UNDERSTRUCTURE

Micro-concrete tiles are made of plain cement concrete using small stone chips (maximum size not more than 5 millimetres). Hence it is called micro-concrete.

Roofing with micro-concrete tiles is similar to conventional Mangalore tile roof. Therefore, it needs an under-structure of primary members like rafter and purlins to support the tiles. The under-structure may be wooden, ferrocement, or steel. In Andhra Pradesh Primary Education Programme, steel rafters and wooden purlins were used.

Micro-concrete tiles roofing is recommended wherever it is possible to make arrangements for a vibrating table, a number of moulds, cement, stone chips, sand, water and electricity. A micro-concrete tile is an alternative to the conventional Mangalore tile and asbestos cement sheeting. Production of Mangalore tiles require huge amount of fuel input and asbestos has health hazards. The infrastructure required for micro-concrete tiles is relatively inexpensive and entrepreneurs may be trained to set up production units and a local market can be created. Therefore, it may be said that micro-concrete tiles is suitable in all situations where Mangalore tiles or asbestos roof is used at present.

Method of making micro-concrete tiles

1. A water tank of 12000 millimetres (length) x 1500 millimetres (width) x 600 millimetres (depth) should be constructed to hold 1500 tiles for initial curing period.
2. A dry mix is prepared with cement to aggregate ratio 1:3 by weight, i.e. to every bag of cement is added 150 kilograms of combined aggregate. Only enough raw materials are mixed that can be comfortably used in 30 minutes.
3. For every bag of cement present in the dry mix, 25 litres of water is added.
4. A mix with one bag of cement will produce roughly 87 pan tiles.
5. The prepared mix is placed on a piece of plastic sheet attached to the frame. The frame, attached to the vibrating table, defines the thickness and boundaries of the tile. The vibrating table is switched on until the mix is consolidated and a tile is formed.
6. The two diagonally opposite corners of the plastic sheet are picked up and placed gently on the mould.
7. A nail is inserted carefully into the nib of the tile. The surface is lightly brushed to close any mild cracks formed during removing the tile from the vibrating table and at the time of placing it on the mould.
8. The moulds are stacked.

9. The mould is taken to the water tank and the tile de-moulded. The de-moulding time depends upon the weather conditions, which in any case should not be done before 24 hours.
10. The nail is carefully removed with a pair of pliers.
11. The plastic sheet is removed and a knife is used to clean the excess flashing from the tile. The tile is placed in the curing tank and left for 10-14 days. After curing, the tiles are taken out and stacked for air drying. The tiles are ready for use after another 14-21 days.

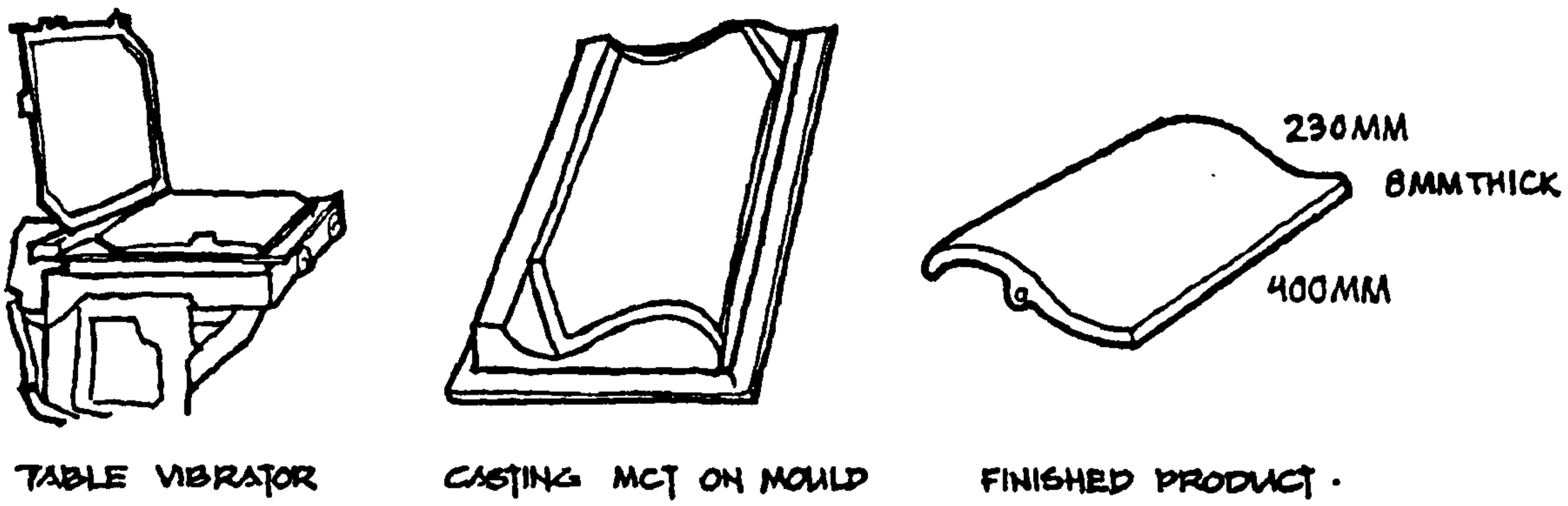


Figure IV-8 The table vibrator, mould and finished micro-concrete tile

Method of micro-concrete tiles roofing with steel under-structure

The roof is made after the tiles are ready for use. The finished tiles are placed and tied on the wooden battens. The wooden battens are supported on structural steel tubes as shown in the sketch below.

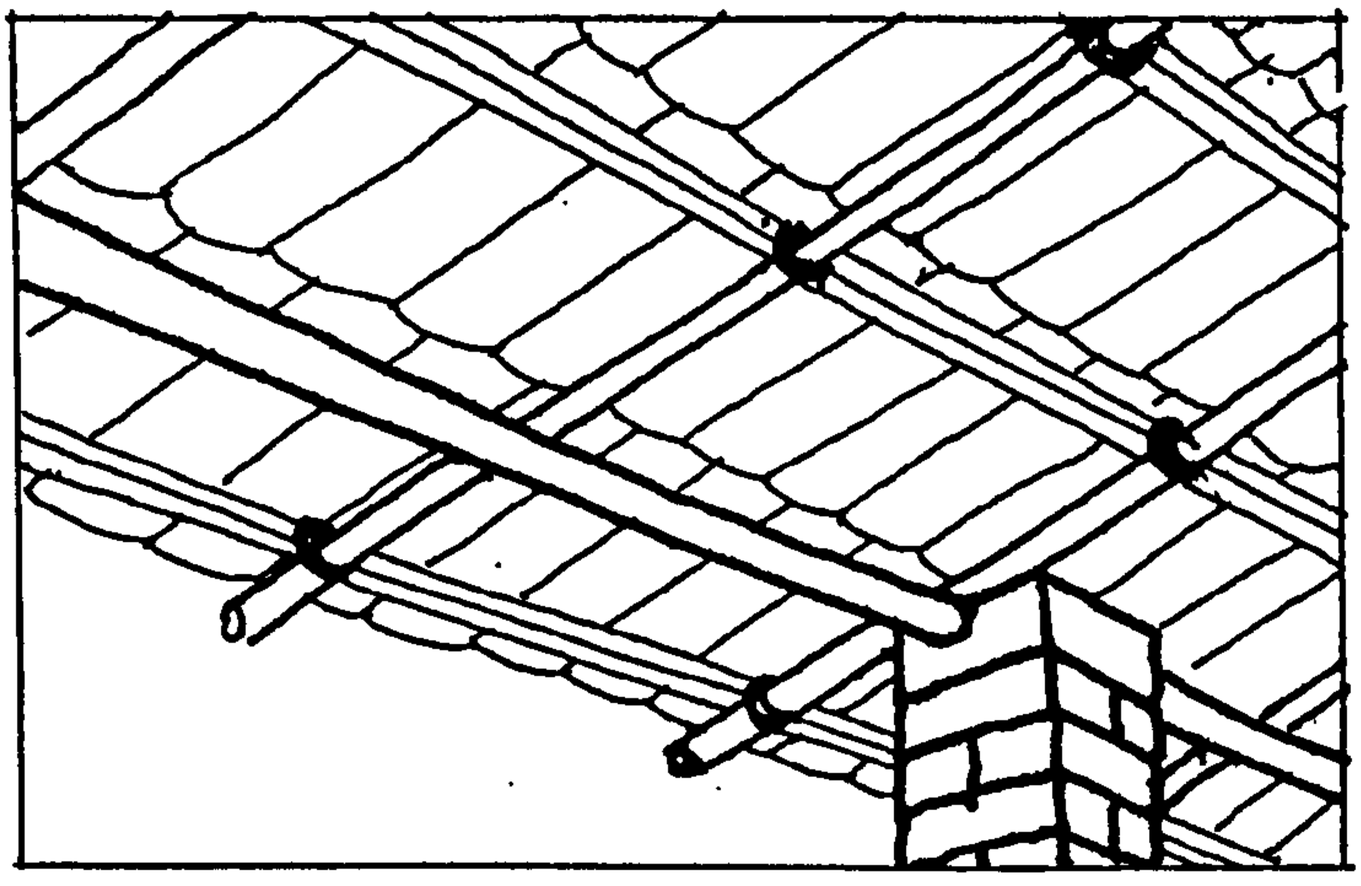


Figure IV-9 Micro-concrete tile roofing

Table IV.13 Analysis of rates for 150 Micro concrete tiles

Source Ranjit Singh Rawat, Development Alternatives, New Delhi

The vibrating table operates on a 0.25 Horse Power motor and it takes about 1 minute and 15 second to consolidate and finish the tile.

0.25 Horse Power = 0.746 Kilo watts For 1 tile production electrical energy required = 0.746 x 1.25/60 = 0.0039 kWh

Energy for the machine, its transportation etc have not been considered

Description	Quantity	Unit	Rate	Unit	Total	Retained	Non renewable	Renewable	Waste	CO_2
cement	90.00	Kg	2.28	/Kg	205.20	30.78	378.917	0	0.0259	91.7543
sand	0.112	Cum	264.70	/Cum	29.65	4 447	15.409	0.000	0 000	1.672
6mm agg	0.04	Cum	246.90	/Cum	9.88	3.961	21.909	0.000	0 010	2.665
consumables 10% of tile cost					24.47	24.47				
electricity 1%					2.69	0 00	2.1030	0.0000	0.0000	0.1711
Add 1% for mould - embodied energy and emission							4.1834	0.0000	0.0004	0.9626
B. LABOUR										
Off site										
Skilled worker for aggregate					0.40					
Unskilled worker for aggregate					0.69					
On site										
Skilled mason	1	MD	71.50	/day	71.50					
labour for tile	3	nos	37.80		113.40					
curing labour	0.25	MD	37.80	/day	9.45					

Table IV.14 Analysis of rates for 36.446 square meter of roofing Micro concrete tile roofing

12m long pipes were necessary for open type verandah as end support, which is not needed for wall support

Data on shuttering has been adopted for embodied energy of timber purlins

Description	Quantity	Unit	Rate	Unit	Total	Retained	Non renewable	Renewable	Waste	CO_2
A. MATERIALS										
MCT material	**524.00**	nos	1.81	pc	949.8	222.38	1476.01	0.00	0.13	339 64
MS pipes kg	**173.28**	kg	20	/kg	3465.6	519.84	6293.29	0.00	0.00	728 43
Timber purlin cum (energy as/flush door)	**0.23**	cum	10000.0	/cum	2300.0	1875	44.64	356.05	22.45	10.68
nail+GI+8mm tor cleats kg	**5.09**	kg	25.00	/kg	127.3	19.09	154.54	0.00	0.00	18.18
cement	**73.86**	kg	2.28	/kg	168.4	25.26	310.96	0.00	0.02	75.30
sand	**0.10**	cum	264.70	/cum	26.5	3.97	13.76	0.00	0.00	1.49
20mm agg	**0.21**	cum	411.50	/cum	86.4	51.56	115.02	0.00	0.05	13.99
Transportation of MCT from building centre to the site										
Micro concrete tiles	**524.00**		0.03		17.1	16.27	6.76			0.73

Less off site labour					**-400.5**					
B. LABOUR										
Off dite										
Skilled worker for aggregate/MCT					1.4					
Unskilled worker for aggregate/MCT					2.4					
Skilled worker for 20mm aggregate					3.5					
Unskilled worker for 20mm aggregate					6.0					
Skilled worker for timber					276.0					
Unskilled worker for timber					115.0					
Micro concrete tiles transportation from building centre to the site					43 7					
On site										
MCT skilled	524 00	Man Day	0.48	/day	249.8					
MCT unskilled	524.00		0.76	/day	396.1					
MCT cunng	524 00		0 06	/day	33.0					
carpenter	4	MD	71.50	/day	286 00					
welder	8.39	MD	71.50	/day	599 89					
Skilled mason	0.03	MD	71.50	/day	2.15					
semi skilled	0.06	MD	55.00	/day	3.30					
helper to carpenter	8	MD	37.80	/day	302.40					
Labour	1.27	MD	37.80	/day	48.01					

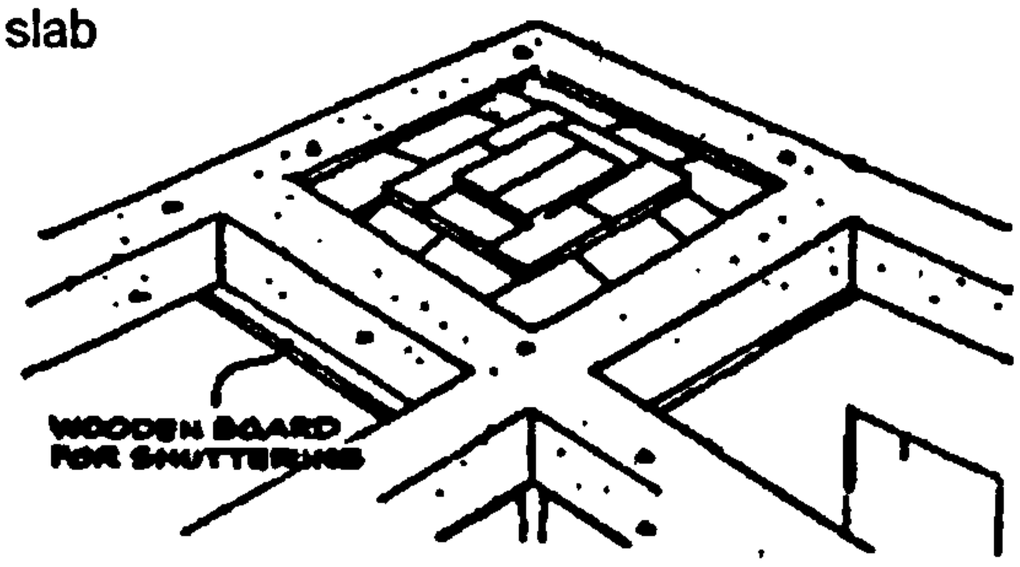
Table IV.15 The summary of socio- economic and environmental impacts of Micro concrete tile roofing for new construction per square meter of plan area

Unit cost	**249.94**	Rs. /square metre
retained	**75.01**	Rs./ square metre
Skilled mason	**38.92**	Rs./ square metre
Semiskilled	**0.09**	Rs./ square metre
unskilled	**25.98**	Rs./ square metre
Non-renewable	**230.889**	Mega Joules/ square metre
Renewable	**9.769**	Mega Joules/ square metre
Waste	**0.622**	Mega Joules/ square metre
Emission of CO_2	**32.609**	Kilogram /square metre

IV.6 REINFORCED CEMENT CONCRETE HYBRID SLAB

This is a combination of reinforced cement concrete ribs and brick panels. Bricks are strong in compression and are used structurally.

Figure IV-10 Hybrid slab



Reinforced cement concrete ribbed brick slab is used in a hot-dry or hot-humid place, where bricks of strength 50 kilograms per square centimetre are available. The room should not be more than 3.65 metres, otherwise a beam or an arch should be constructed to reduce the span to 3.65 metres.

Method of construction

1. Wooden or steel shuttering is prepared as per the room dimensions.
2. The reinforcements are prepared and laid.
3. Bricks are laid in 1:6 cement mortar and cured for 2 days.
4. A dry mix is prepared of 1:2:4 cement, coarse sand and aggregate and after thorough mixing, water is added to it at the rate of 25 litres per bag of cement.
5. This concrete in the gaps between the brick panels and consolidated.
6. The slab is water cured for another 7-10 days.

Figure IV-11 Construction detail of hybrid slab

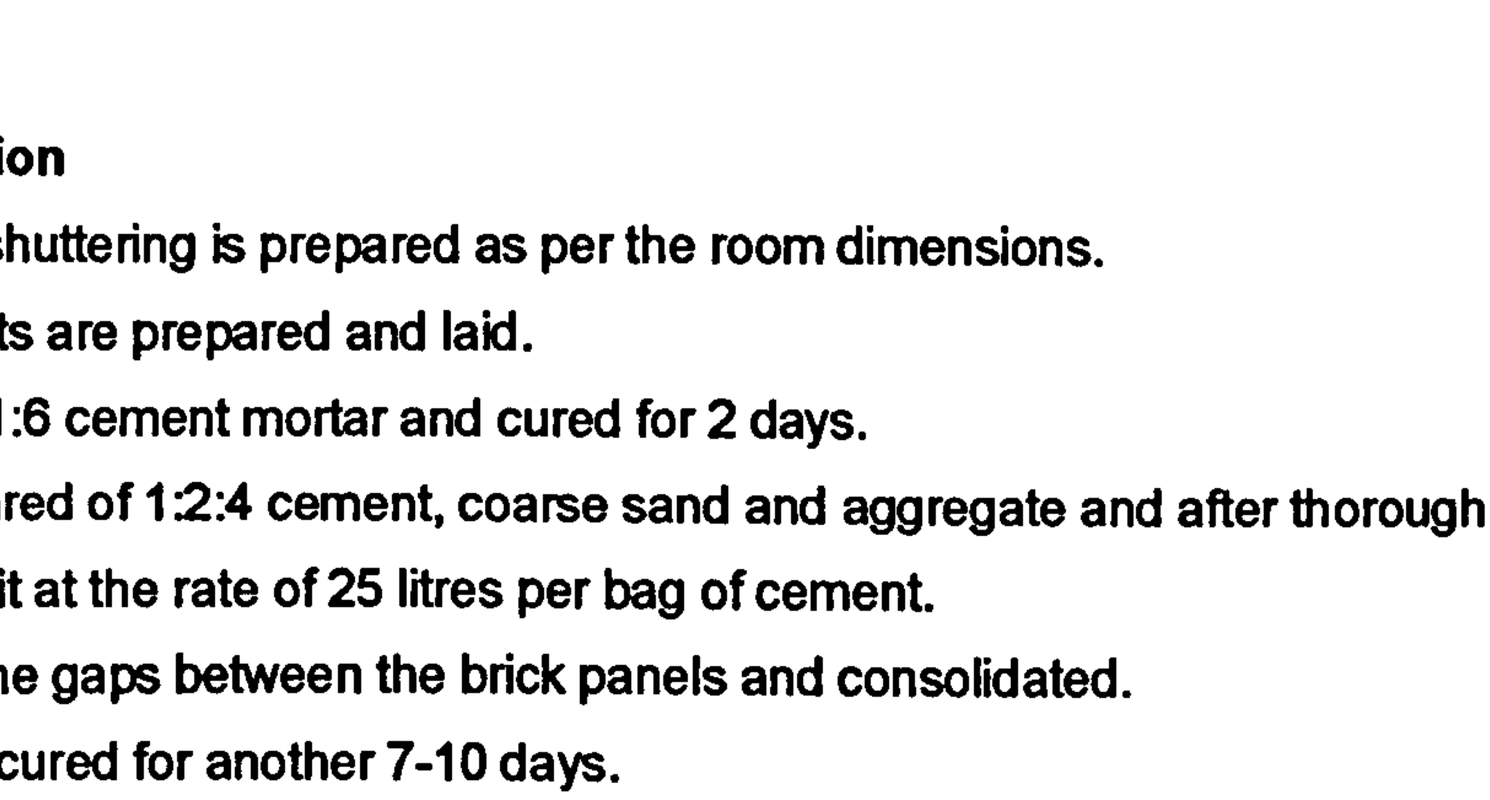


Table IV.16 Analysis of rates for 8.7 square meter of Two way reinforced concrete ribbed brick slab called as hybrid roofing (assuming hand mixing)

Beam section 200x400 due to T beam action. Reduce steel by 20% due to T beam action

Skilled worker for brick making 0 050 /no

Unskilled worker for brick making 0.106 /no

Description	Quantity	Unit	Rate	Unit	Total	Retained	Non renewable	Renewable	Waste	CO_2
Brick cost and labour brought from WALL										
A. MATERIALS										
Bricks	306	No.	1.30	/No.	397.80	345.31	8.47	0.00	1533.29	167.53
Sand	0.38	Cum	264.70	/Cum	100.59	15.09	52.28	0.00	0 00	5.67
Cement	162.28	Kg	2.28	/Kg	370.00	55.50	683.23	0.00	0 05	165.44
20mm aggregate	0.371	Cum	411.50	/Cum	152.67	91.08	203 20	0.00	0.09	24.72
Shuttering	8.7	Sqm	73.75	/Sqm	641.63	471.60	35.49	942.44	16.14	8.05
Steel	35.89	Kg	17.20	/Kg	617.31	92.60	1089.69	0.00	0.00	128 20
Central beam										
20mm Agg	0.119	cum	411.50		48.82	29.13	64 99	0.00	0.03	7.91
cement	92.85	kg	2.28		211.71	31.76	390.93	0.00	0.03	94.66
sand	0.059	cum	264.70		15.70	2.36	8.16	0.00	0.00	0.89
Steel same % as RC channel roofing	22.20	kg	17.20		381.78	57.27	673.94	0.00	0.00	79 29
Shutter to central beam	1.3614	sqm	73 75		100.40	73 79	5.55	147.47	2.53	1.26
Less off site labour					**-235.32**					
B. LABOUR										
Off site										
Skilled worker for aggregate					8 06					
Unskilled worker for aggregate					14.10					
Skilled for brickmaking					15.32					
Un-skilled for brickmaking					32.39					
On site										
Primary RCC beam 0.69cum										
Skilled	0.011	working days	71.5	/day	0.80					
semi skilled	0.026	working days	55	/day	1.44					
un-skilled	0.525	working days	37.8	/day	19.85					
Skilled for shuttering					94.46					
un-skilled for shuttering					71.00					
unskilled	0.525	working days	37.8	/day	19.85					
Skilled mason	0.501	working days	71.5	/day	35.82					
Barbender	1.100	working days	55	/day	60.50					
Semi skilled	1.160	working days	55	/day	63.80					
Beldar	3.930	working days	37.8	/day	148.55					

Table IV.17 The summary of socio- economic and environmental impacts of Hybrid Slab roofing for new construction per square meter of plan area

Unit cost	**412.24**	Rs. /square metre
retained	**147.67**	Rs./ square metre
Skilled mason	**20.01**	Rs./ square metre
Semiskilled	**18.50**	Rs./ square metre
unskilled	**42.63**	Rs./ square metre
Non-renewable	**381.41**	Mega Joules/ square metre
Renewable	**133.28**	Mega Joules/ square metre
Waste	**178.41**	Mega Joules/ square metre
Emission of CO_2	**81.28**	Kilogram /square metre

IV.7 FOLDED FILLER SLAB WITH MANGALORE (CLAY) TILES

Reinforced cement concrete slabs cast in shapes as shown in sketches below are called folded slabs. When a reinforced cement concrete folded slab is cast with a pair of Clay tiles at its bottom surface as filler material, it is called a folded filler slab with Mangalore tiles.

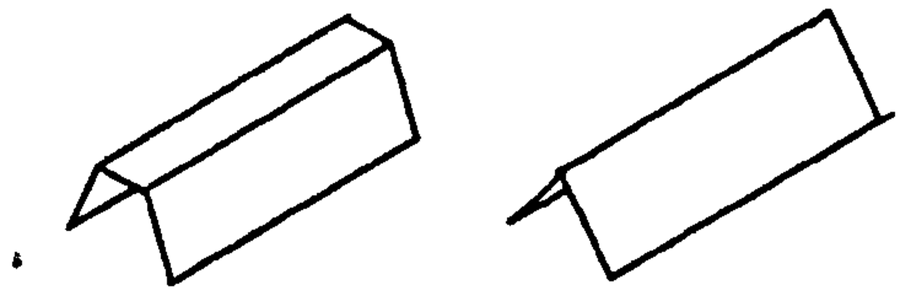
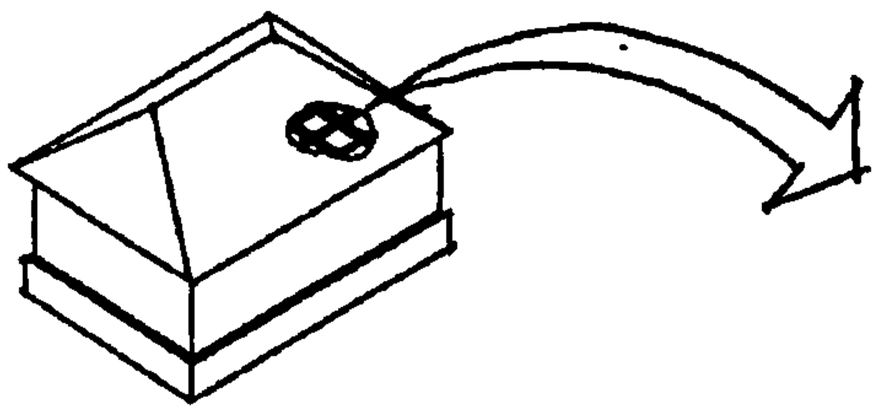


Figure IV-12 Types of folded plates

Folded filler slab with Mangalore tiles may be used up to a span of 6.0 metres, beyond which the room height will become too high.

Method of construction

1. Wooden or steel shuttering is prepared, and waste engine oil is applied for easy de-shuttering.
2. The reinforcements are placed with a clear cover of 15 millimetres from the surface of the shuttering.
3. A dry mix is prepared of 1:2:4 cement, coarse sand and 20 millimetres down stone chips. Water is added at the rate of 25 litres per bag of cement. The mixing is done thoroughly, so that it is homogenous and ready for use.
4. Pairs of Mangalore tiles are placed and concrete poured in the horizontal space between the tiles as well as on the top. Overall thickness of the slab should be 100 millimetres. Hand or machine compacting method is used.
5. The slanting surfaces are water cured by placing jute bags which will hold the water for some time. Water curing should be done at least five times a day for 10-14 days, depending upon span.



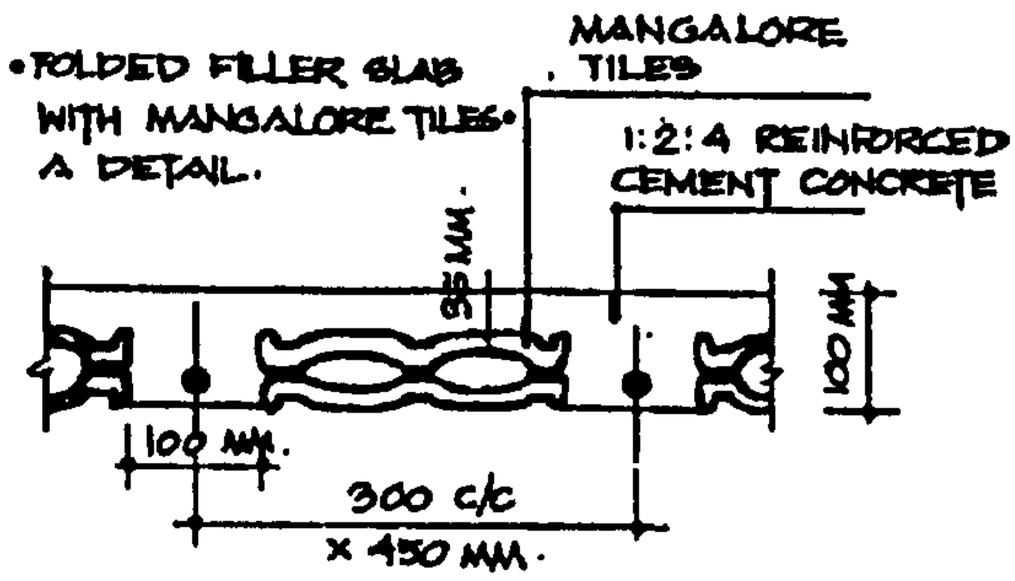


Figure IV-13 Construction detail of filler slab

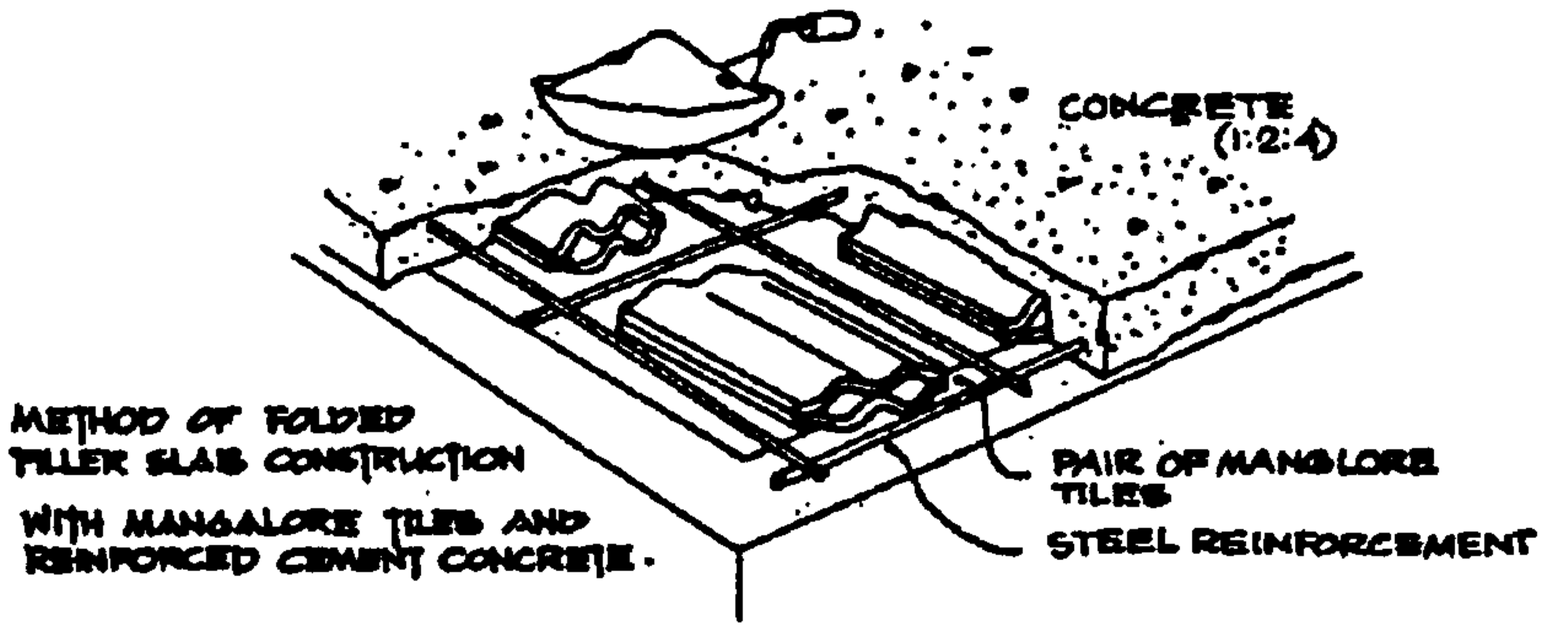


Figure IV-14 Reinforcement and tile placement detail

Table IV.18 Analysis of rates for 10 square meter of Folded Filler Slab

Increment factor as in Ponnal 1.48 , 25% increase for solid portion										
						volume of 10 sqm		0.081	cum	
						diesel consumption		0.098	litres	
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Total**	**Retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
cement	269.1	Kg	2.28	/Kg	613.55	92.03	1132.96	0.000	0.08	274.35
sand	0.037	Cum	264.70	/Cum	9.89	1.48	5.14	0.00	0.00	0.56
20mm aggregate	0.075	Cum	411.50	/Cum	30.76	18.35	40.94	0.00	0.02	4.98
mangalore tiles	108	nos	4.00	/no	432.00	277.18	31.31	422.60	392.31	94.30
shutter 48% extra for slope	14.83	Sqm	73.75	/Sqm	1094 07	804.14	60.52	1606.98	27.52	13.72
Reinforcing steel	33.33	kg	17.20	/Kg	573.28	124 99	1011.97	0.00	0.00	119.06
b'wire+steel	0.5	kg	25.00	/Kg	12 50	1.88	15.18	0.00	0.00	1.79
Diesel - mixer and vibrator	0.098	litre	15.00	/litre	1.46	0.15	4.34	0.00	0.00	0.27
Mixing machine and vibrator charges Rs. 250/10 cum					2.03	1.02				
Less off site labour					**- 378.625**					
B. LABOUR										
Off site										
Skilled worker for aggregate					1.23					
Unskilled worker for aggregate					2.15					
Skilled worker for Mangalore tiles					17.28					
Unskilled worker for Mangalore tiles					69.12					
On site										
Skilled mason -shuttering increase labour by 48% for the slope					206.12					
Un-skilled mason -shuttering increase labour by 48% for the slope					154 93					
Skilled mason	1.67	MD	71.5	/day	119 41					
Barbender	0 82	MD	55	/day	45.10					
Labour	3.72	MD	37.8	/day	140.62					
Curing labour	1.22	MD	37.8	/day	46.12					

Table IV.19 The summary of socio- economic and environmental impacts of Folded Filler Slab roofing for new construction per square meter of plan area

Unit cost	**364.69**	Rs. /square metre
retained	**136.55**	Rs./ square metre
Skilled mason	**38.91**	Rs./ square metre
Semiskilled	**12.60**	Rs./ square metre
unskilled	**56.27**	Rs./ square metre
Non-renewable	**253.75**	Mega Joules/ square metre
Renewable	**218.97**	Mega Joules/ square metre
Waste	**41.99**	Mega Joules/ square metre
Emission of CO_2	**56.32**	Kilogram /square metre

IV.8 STONE ROOFING ON PRE-CAST REINFORCED CEMENT CONCRETE JOISTS

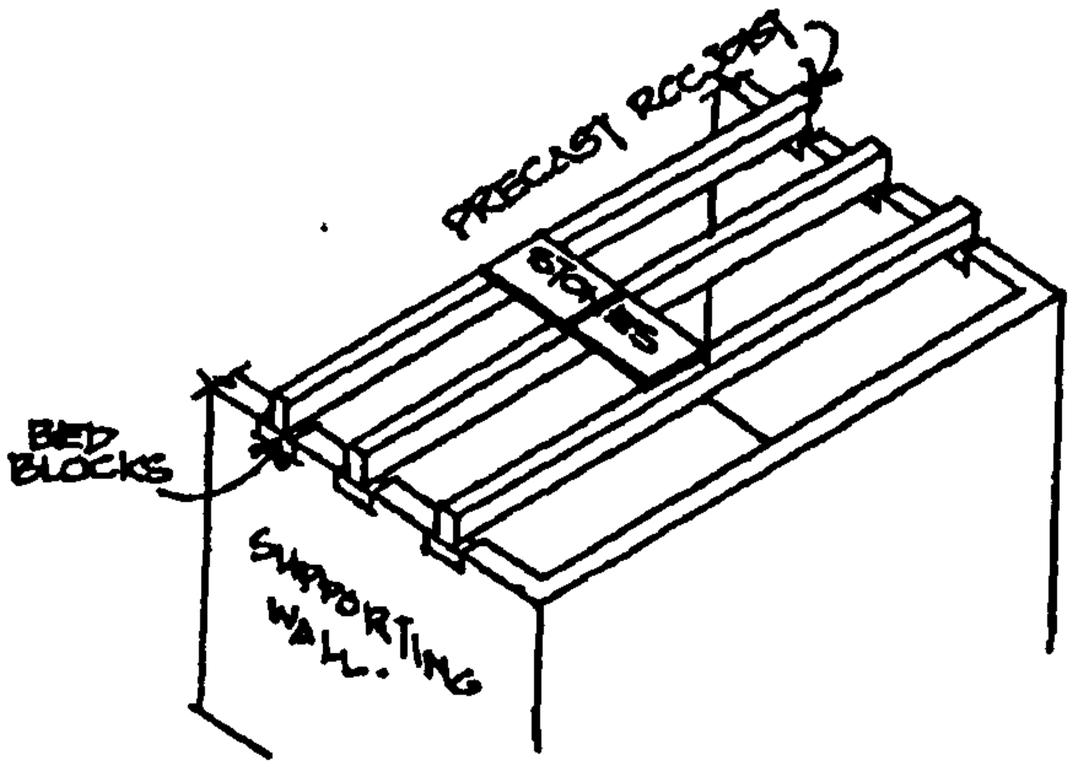
Sand stone roofing on pre-cast reinforced cement concrete joists is made up of sand stone panels supported by pr-cast reinforced cement concrete joists which are supported on walls or beams.

This type of roofing system is used –

a. if joists are available from the market. Or else, at least a few buildings are to be constructed on identical design, so that the cost of a casting yard, curing tank and mould is justified.
b. if the span is between 2.4 and 3.65 metres, because joists are economic in this span range. However, the width of a classroom is generally more than 3.65 metres. Hence a beam or arch is constructed at the centre of the room so that the span is within 3.65 metres.
c. if stone slabs of sizes 600 millimetres x 900 millimetres or 450 millimetres x 900 millimetres or 300 millimetres x 900 millimetres are available.

Method of construction

Method of construction is same as for the jack arch, but with stone slabs in place of brick arches.



SANDSTONE ROOFING ON PRECAST RCC JOISTS.

Figure IV-15 Construction detail of stone roofing

Table IV.20 Analysis of rates for 10 square meter of Stone roof on Pre-cast Reinforced Cement Concrete Joists

Data on primary beam is from Gandipet- covered area = 71.16 sqm vol of concrete 2.558 cum steel 399 25kg										
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Total**	**Retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
A. Materials										
Stone slab	10	Sqm	45.00	/Sqm	450.00	90.00	116.6441	0	0	12.657
Sand (1.6CM)	0.014	Cum	264.70	/Cum	3.71	0.56	1.9261	0	0	0.209
Cement (1.6CM)	2.79	Kg	2.28	/Kg	6.36	0.95	11.7464	0.000	0.001	2.844
Precast joist mat	**4.5**	**No.**	**215.16**	/no	968.22	167.62	1706.792	0.000	0.079	245.183
Transportation of joists from the building centre to the site										
Joists	**4.5**	**No.**	**1.92**	/no	8.66	8.25	1.143	0	0.000	0.124
Primary RCC beam 2 558cum										
12mm aggregate	0.331	Cum	411.50		136.09	81.19	181.14	0.00	0.08	22.04
Cement	119 057	Kg	2.28		271.45	40.72	501.25	0 00	0.03	121.38
Sand	0.165	Cum	264.70		43.77	6.57	22.75	0.00	0 00	2.47
steel	56.106	kg	17.20		965.02	144.75	1703.49	0 00	0.00	200.41
Shuttering material	1.280	sqm	73.75		94.39	69 37	5.2208	138 63	2.37	1.18
Less offsite labour					**-36.02**					
B. LABOUR										
Off site										
Skilled worker for aggregate/ central beam					5 44					
Unskilled worker for aggregate/central beam					9.53					
Skilled worker for aggregate/joists	4.5		0.56		2.52					
Unskilled worker for aggregate/joists	4.5		0.98		4.41					
Helper for Joist transport (6 extra)					14.79					
On site										
Primary RCC beam										
Skilled	0.087		71.5		6.20					
semi skilled	0.202		55		11.12					
unskilled	4.044		37.8		152.87					
Skilled for shuttering					12.01					
un-skilled for shuttering					9.03					
Skilled masons for joist	4.5	No.	10.62	/no	47.78					
Barnender	4.5	No.	11.00	/no	49.50					
Unskilled	4.5	No.	19.47	/no	87.60					
Skilled for hoisting	1.8	MD	71.5	/day	128.70					
skilled for laying	0 81	MD	71.5	/day	57.92					
Labour for joist										
unskilled for hoisting	5.4	MD	37.8	/day	204.12					
Labour for laying roof	1.8	MD	37.8	/day	68.04					

Table IV.21 The summary of socio- economic and environmental impacts of Stone roof on Pre-cast Reinforced Cement Concrete Joists for new construction per square meter of plan area

Unit cost	378.32	Rs. /square metre
retained	61.00	Rs./ square metre
Skilled mason	26.06	Rs./ square metre
Semiskilled	6.06	Rs./ square metre
unskilled	55.04	Rs./ square metre
Non-renewable	425.21	Mega Joules/ square metre
Renewable	13.86	Mega Joules/ square metre
Waste	0.26	Mega Joules/ square metre
Emission of CO_2	60.85	Kilogram /square metre

IV.9 JACK ARCH WITH BRICKS AND PRE-CAST REINFORCED CEMENT CONCRETE JOISTS

A jack arch is a continuous brick arch (i.e., a vault) constructed on two pre-cast reinforced cement concrete joists, which are supported on walls or beams. If the system is repeated sidewise, it forms a jack arch roof.

Jack arch with bricks and pre-cast reinforced cement concrete joists are used –

b. if pre-cast reinforced cement concrete joists are available from the market. Or else, at least a few buildings are to be constructed on identical design, so that the cost of a casting yard, curing tank and mould is justified.
c. if burnt bricks are available (minimum strength 35 kilograms per square centimetre).
d. if the span is between 2.4 and 3.65 metres, because joists are economic in this span range. However, the width of a classroom is generally more than 3.65 metres. Hence a beam or arch is constructed at the centre of the room so that the span is within 3.65 metres.

Method of construction

1. For the production of reinforced cement concrete joists, refer to the section on reinforced cement concrete planks and joists.
2. Joists are placed between walls or beams and steel ties are to be provided to arrest lateral movements of the joists.
3. A sliding type of mould is placed between two joists
4. Arch with wire cut bricks in 1:6 cement mortar is constructed. Immediate de-moulding of the newly constructed arch is done by sliding the mould to the position where the next arch is to be constructed. The process is continued until the whole length of the supporting joist is covered.
5. Similar operation is repeated between every two joists to complete the roof.
6. The outer surface is plastered in 1:4 cement mortar with a neat cement finish.
7. Water curing should be continued up to another seven days after the construction work is over.

Figure IV-16 Jack arch roofing system

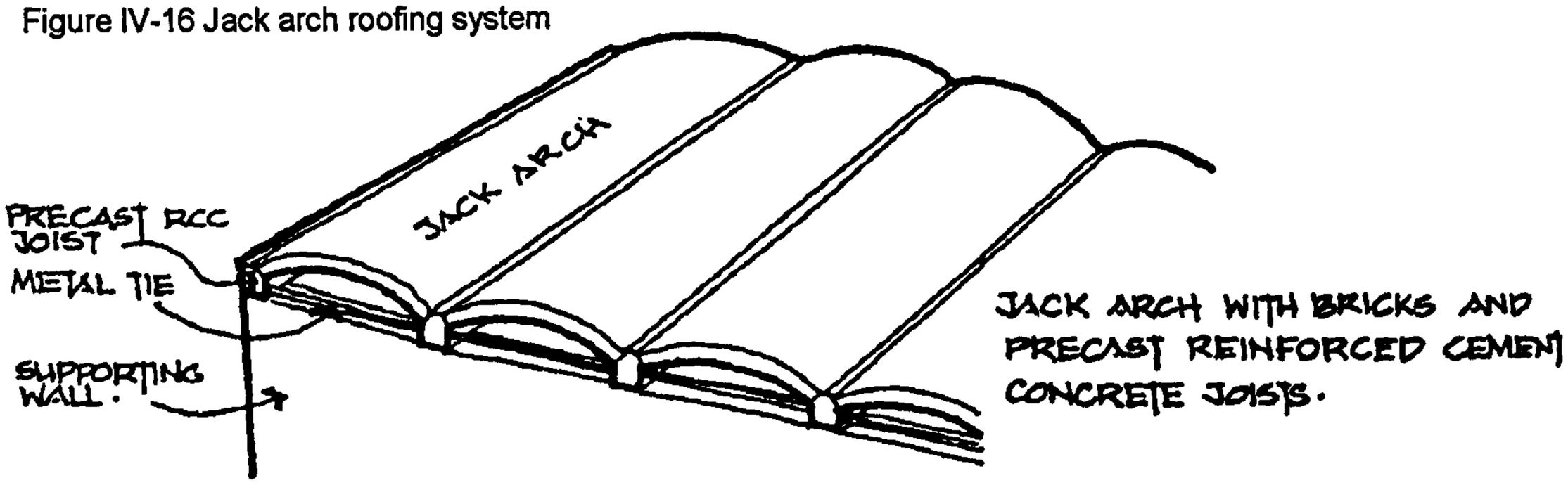


Table IV.22 analysis of rates for 10 square meter of Jack arch on Pre-cast Reinforced Cement Concrete Joists

					Skilled worker for brick making			0.050	/no	
is 115.618 kg- cov area = 6.8mx5.27m i.e. 35.836sqm (Kokapet)					Unskilled worker for brick making			0.106	/no	
10 sqm of roof										
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Total**	**Retained**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
A. MATERIALS										
Bricks	645	nos.	1.30	nos.	838.50	727.86	17.85	0.00	3231.94	353.13
Cement (1:6CM)	72.4	Kg	2.28	/Kg	165.07	24.76	304.82	0.00	0.02	73.81
Sand (1:6CM)	0.25	Cum	264.70	/Cum	66.18	9.93	34.40	0.00	0.00	3.73
Precast joist	**3.37**	**No.**	**216.70**	**/No**	730.27	**125.53**	**1278.20**	**0.00**	**0.06**	**183.61**
Tie rods	2.26	Kg	17.20	/Kg	38.87	5.83	68.62	0.00	0.00	8.07
Transportation of joists from the building centre to the site										
Joists	3.37	No.	1.92	/No	6.48	6.18	0.86			0.09
Primary RCC beam 0.69cum										
Agg. 12.5mm	0.177	Cum	411.50		72.89	43.49	97.02	0.00	0.04	11.80
Cement	63.771	Kg	2.28		145.40	21.81	268.49	0.00	0.02	65.01
Sand	0.089	Cum	264.70		23.44	3.52	12.19	0.00	0.00	1.32
Reinforcing steel	32.263	kg	17.20		554.93	83.24	979.57	0.00	0.00	115.25
Shuttering for beam	1.906	sqm	73.75		140.56	103.31	7.78	206.46	3.54	1.76
steel mould 8% of total cost	7.36		20.00		147.11	22.07	267.14	0.00	0.00	30.92
10% increase for fabrication - energy and emission							26.71	0.00	0.00	3.09
Less for off site labour					-139.91					
B. LABOUR										
Off site										
Skilled for brickmaking					32.28					
Unskilled for brickmaking					68.27					
Skilled worker for aggregate					2.92					
Unskilled worker for					5.10					

aggregate										
Transportation of joists from the building centre (6 helpers extra)					11.08					
skilled mason for aggregate/joist	3.37	nos.	0.560		1.89					
Un-skilled mason for aggergate/joist	3.37	nos.	0.979		3.30					
On site										
Primary RCC beam 0.69cum										
Skilled	0.023		71.5		1.65					
semi skilled	0.054		55		2.97					
unskilled	1.078		37.8		40.76					
skilled mason for shuttering					17.89					
Un-skilled mason for shuttering					13.45					
Skilled masons for joist mould	3.37	No.	1.68	/no	5.67					
Skilled masons for joist	3.37	No.	8.94	/no	30.12					
semi-skilled for joist	3.37	No.	11.00	/no	37.07					
un-skilled for joist	3.37	No.	19.47	/no	65.60					
For arch work										
Skilled mason	0.53	MD	71.5	/day	37.90					
Semiskilled mason	1.232	MD	55	/day	67.76					
Skilled mason for hoisting	1.35	MD	71.5	/day	96.53					
Labour	3.52	MD	37.8	/day	133.06					
Labour for joist										
Labour for hoisting	4.04	MD	37.8	/day	152.71					

Table IV.23 The summary of socio- economic and environmental impacts of Jack arch on Pre-cast Reinforced Cement Concrete Joists for new construction per square meter of plan area

Unit cost	361.78	Rs. /square metre
retained	117.75	Rs./ square metre
Skilled mason	21.93	Rs./ square metre
Semiskilled	10.78	Rs./ square metre
unskilled	49.00	Rs./ square metre
Non-renewable	336.36	Mega Joules/ square metre
Renewable	20.65	Mega Joules/ square metre
Waste	323.56	Mega Joules/ square metre
Emission of CO_2	85.16	Kilogram /square metre

IV.10 CORBELLED BRICK ARCH ROOF

When a brick arch is constructed by corbelling from an existing arch, then one gets a corbelled brick arch. If a series of such corbelled brick arches are constructed from the two opposite corners of a room so that they meet at the diagonal of the room, then it is called a corbelled brick-arch roof.

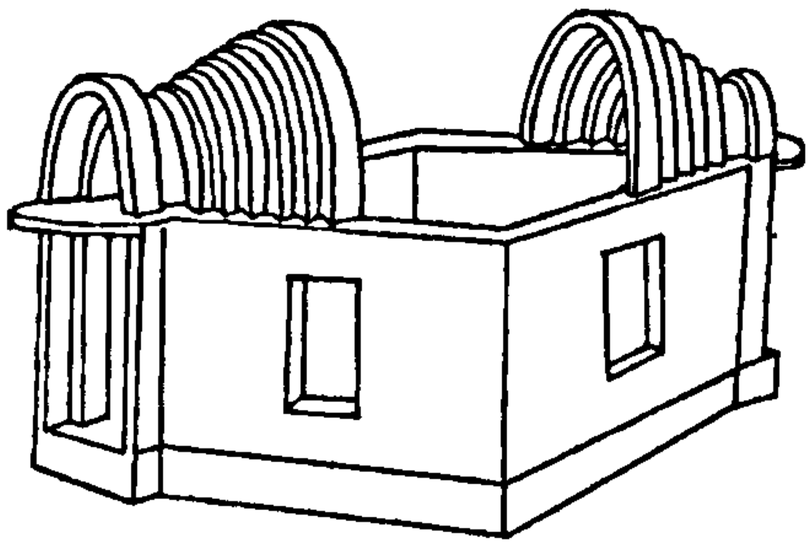


Figure IV-17 Corbelled brick arch roof

A corbelled brick-arch roof is used –

a. if bricks with a compressive strength of at least 50 kilograms per square centimetre are available.
b. for a room width between 2.4 metres to 6.0 metres. Ratio of the sides should preferably be within 1:2. Therefore, a corbelled brick-arch roof is suitable for both residential and school buildings.
c. if the climate is hot-dry or hot-humid or the region is a cyclone prone area.

Method of construction

1. A band lintel-chujja is cast as a base to the corbelled roof.
2. Two semi-circular brick arches are constructed at the two opposite corners of the room – these are the base arches.
3. The first course of bricks is laid with a projection of 75 millimetres from the base arch to complete the first corbelled brick arch. The next arch can be constructed right after finishing the first arch with exactly the same projection.
4. Only two arches can be constructed in a day.
5. As the two diagonally opposite corbelled arches come together, a closing arch has to be constructed to complete the roof.
6. After the closing arch has been laid, water curing should be continued for another seven days to ensure proper strength to the roof.

Table IV.24 Analysis of rates for one cubic meter of Corbelled brick arch roof in wire-cut brick and 1:6 cement mortar

area at Anatharam	75.68	sqm	volume of corbel	17.538	cum	
less centre+strips	9 0984	sqm	1 cum can generate	3.796	sq.m. of covered area	
net plan area	**66.58**	**sqm**				

Description	Quantity	Unit	Rate	Unit	Total	Retained	Non renewable	Renewable	Waste	CO_2
A. MATERIALS										
Bricks	480.00	nos.	1.30	nos.	624.00	541.664	13.286	0.000	2405.162771	262.791
Cement (1.6CM)	40.39	Kg	2.28	/Kg	92.09	13 814	170 058	0.000	0.012	41.179
Sand (1:6CM)	0.19	Cum	264.70	/Cum	50 29	7.544	26.140	0	0	2.836
Less for labour - brick					**-74.83**					
B. LABOUR										
Off site										
Skilled for brickmaking					24.024					
Unskilled for brickmaking					50.8032					
On site										
Skilled mason	3.00	MD	71.50	/day	214 50					
Semiskilled mason	4.40	MD	55.00	/day	242.00					
Helper	9.21	MD	37.80	/day	348.14					

Table IV.25 The summary of socio- economic and environmental impacts Corbelled brick arch roof in wire-cut brick for new construction per square meter of plan area

Unit cost	413.82	Rs. /square metre
retained	148.30	Rs./ square metre
Skilled mason	62.83	Rs./ square metre
Semiskilled	63.74	Rs./ square metre
unskilled	105.08	Rs./ square metre
Non-renewable	55.18	Mega Joules/ square metre
Renewable	0.00	Mega Joules/ square metre
Waste	633.54	Mega Joules/ square metre
Emission of CO_2	80.81	Kilogram /square metre

IV.11 CORBELLED BRICK PYRAMID

A corbel means a projection. A brick placed on another one with a projection which does not topple, is called a corbelled brick. Pyramid is a form whose base is a polygon and other faces are triangular with a common vertex. A corbelled pyramid is developed by corbelling courses of bricks.

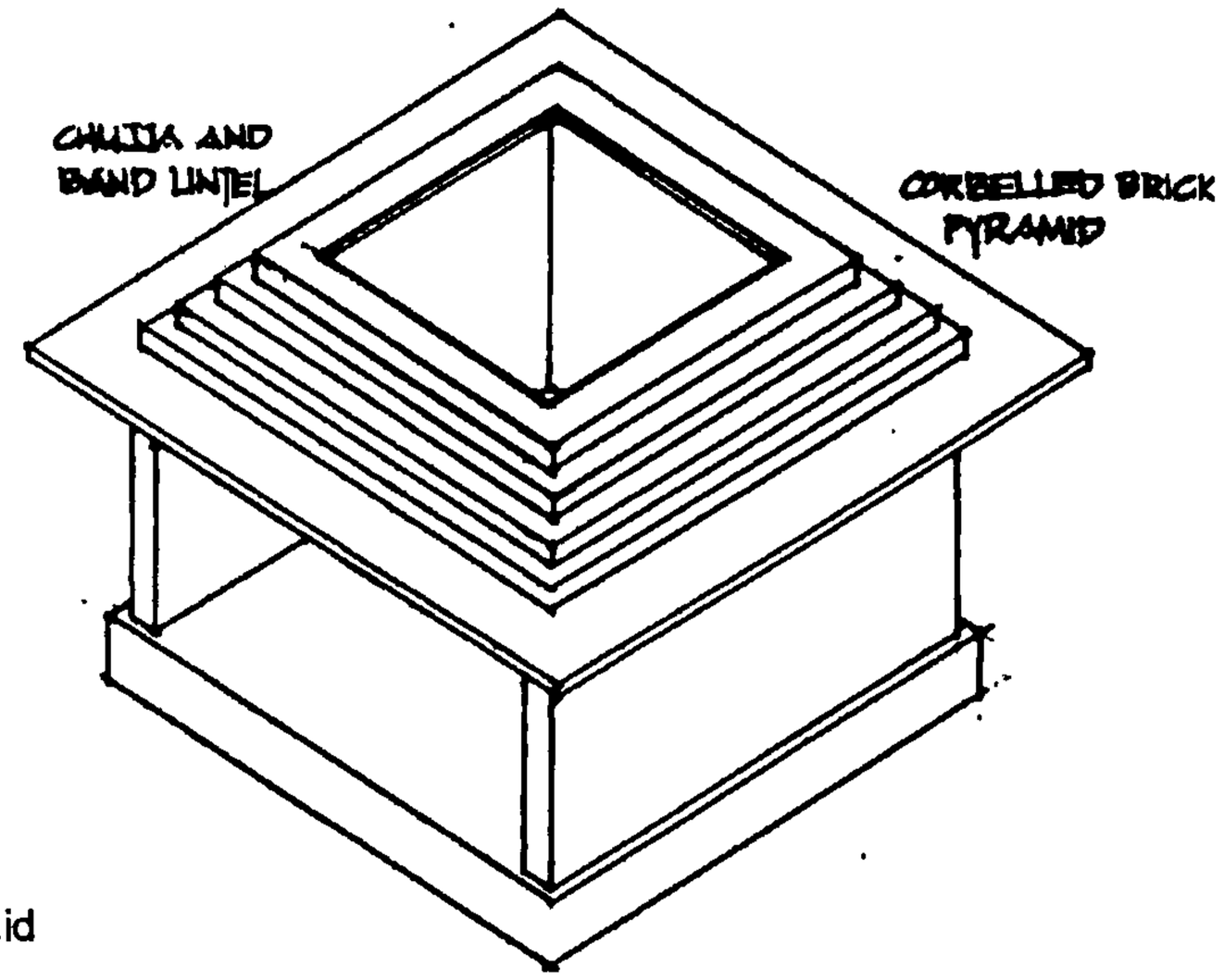


Figure IV-18 Corbelled brick pyramid

Corbelled brick pyramid is used –

a. if bricks with a compressive strength of at least 50 kilograms per square centimetre are available.
b. for a room width between 2.4 metres to 6.0 metres. Ratio of the sides should preferably be within 1:2. Therefore, a brick pyramid is suitable for both residential and school buildings.
c. if the climate is hot-dry or hot-humid or the region is a cyclone prone area.

Method of construction

1. A band lintel-chujja is cast as a base to the pyramid.
2. The first course of bricks is laid in 1:6 cement mortar without any projections.
3. The second course is laid with a projection of 62.5 millimetres. Similarly, the third, fourth, fifth and sixth courses are laid, each with a projection of 62.5 millimetres from its previous layer.
4. The projection is increased to 75 millimetres from the seventh course. The eighth, ninth, tenth, eleventh, twelfth, thirteenth and fourteenth courses are laid in a similar way.
5. The fifteenth course is laid with a projection of 87.5 millimetres and the same is continued till the twenty seventh course.

6. Only two layers may be constructed in a day. On the next day, the masons can stand on these day-old layers and work.
7. Water curing should be done 5-6 times a day. After the last course has been laid, the pyramid is water cured for another 7 days.

Figure IV-19 Construction detail of corbelling

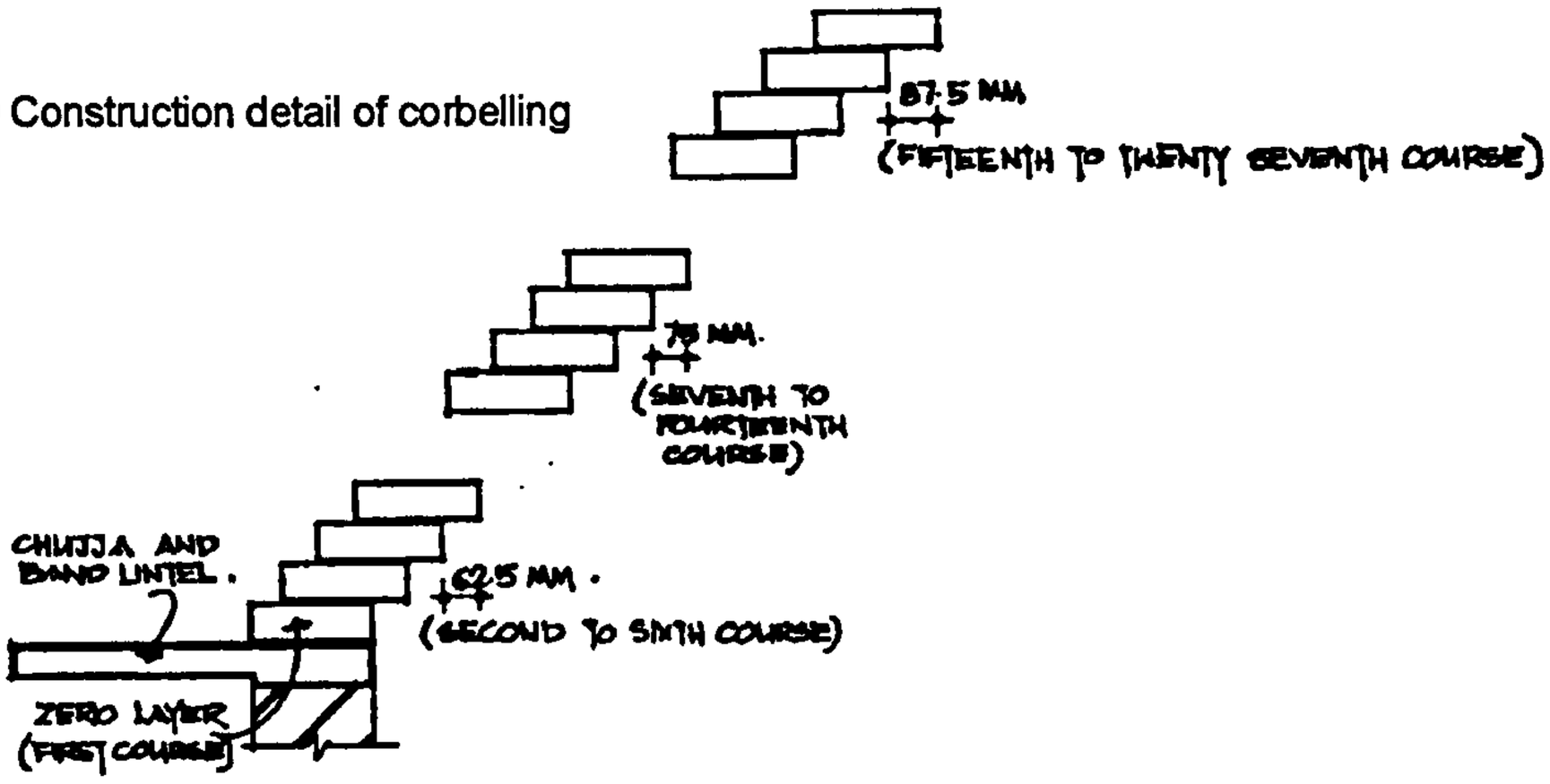


Table IV.26 Analysis of rates for one cubic meter of Corbelled brick pyramid roof in wire-cut brick and 1:6 cement mortar

Majeedpur 6m x 6m room number of course @75mm 41 1 cum of brickwork will cover 3.95 sqm of plan area

	base length	height
	6 23	3.69
volume of pyramid	10.575	cum

Description	Quantity	Unit	Rate	Unit	Total	Retained	Non renewable	Renewable	Waste	CO_2
A. MATERIALS										
Bricks	480.00	nos.	1.30	nos.	624.00	541.66	13.29	0	2405.162771	262.791
Cement (1.6CM)	52.51	Kg	2.28	/Kg	119.72	17.96	221.08	0.00	0.02	53.53
Sand (1:6CM)	0.25	Cum	264.70	/Cum	65.38	9.81	33 98	0.00	0.00	3.69
Less off site labour					**-74.83**					
B. LABOUR										
Off site										
Skilled for brickmaking					24.02					
Unskilled for brickmaking					50.80					
On site										
Skilled mason	2.43	MD	71.50	/day	173.75					
Semiskilled mason	1.50	MD	55.00	/day	82.50					
Helper	9.45	MD	37.80	/day	357.21					

Table IV.27 The summary of socio- economic and environmental impacts of Corbelled brick pyramid roofing for new construction per square meter of plan area

Unit cost	360.48	Rs. /square metre
retained	144.29	Rs./ square metre
Skilled mason	50.11	Rs./ square metre
Semiskilled	20.91	Rs./ square metre
unskilled	103.39	Rs./ square metre
Non-renewable	68.00	Mega Joules/ square metre
Renewable	0.00	Mega Joules/ square metre
Waste	609.47	Mega Joules/ square metre
Emission of CO_2	81.09	Kilogram /square metre

APPENDIX V

SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS OF THE WALLING AND ROOFING SYSTEMS- NEW CONSTRUCTION

WALLING SYSTEMS: NEW CONSTRUCTION

All values shown in the tables are in terms of quantities per square metre of the elevation area of the walls

Table V.1 Socio-economic and environmental impacts of the walling systems for new construction : Data on basic structure (without finishing)

	Socio-economic impact					Environmental impact			
Walling systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs /sq m	Rs / sq m.	Rs / sq m	Rs / sq m	Rs / sq m.	MJ/ sq m.	MJ/ sq m.	MJ/ sq m.	Kg / sq m.
Solid brick wall	228 70	134 23	11.77	12.40	40 23	74.38	16.01	553 19	76 57
Rat-trap	206.79	110.11	13 86	12 65	44.90	42.19	16 01	460 99	59.33
CSMB 5%	214 49	55 05	17 27	0 00	57.77	134 15	16 01	0 01	31 07
ICSMB 10%	178 95	40 66	3.15	5 66	36 96	167 43	10.44	0 01	39 55
SCB	210 87	47.63	13 61	0 00	67.38	188 81	13 23	0 04	34 20
CRS	316 37	104 53	20.38	0 00	97.41	151.34	26.45	0 01	32 84
The Highest	**316.37**	**134.23**	**20.38**	**12.65**	**97.41**	**188.81**	**26.45**	**553.19**	**76.57**

Table V.2 Socio-economic and environmental impacts of the walling systems for new construction : Data on finishing items on the walls External wall plastering/pointing costs

			Mason/workers						
	Unit cost	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs /sq m.	Rs / sq m.	Rs./ sq m.	Rs / sq m.	Rs / sq m.	MJ/ sq m.	MJ/ sq m.	MJ/ sq m.	Kg / sq m.
Cement-sand plaster	45 39	4.42	4 50	8 09	14 98	23 52	16 01	0 00	5 41
Cement-sand pointing	29 22	3 31	3 43	6 16	9 31	12 98	16 01	0.00	3 03
Stabilised Mud plaster	33.31	3.89	4.50	8 09	12 42	7.83	16 01	0.00	1.77
latex-cement paint	50 07	4.76	3 29	0 00	3 71	25 41	0 00	0 00	0 43
Cement-sand pointing	29 22	3 31	3 43	6 16	9.31	12 98	16 01	0 00	3 03
Cement-sand pointing	29 22	3.31	3 43	6.16	9 31	12 98	16 01	0 00	3 03

Table V.3 Socio-economic and environmental impacts of the Internal wall plastering

			Mason/workers						
	Unit cost	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs /sq m.	Rs / sq m.	Rs / sq.m.	Rs / sq m.	Rs / sq m	MJ/ sq.m.	MJ/ sq m.	MJ/ sq m.	Kg / sq m.
Cement-sand plaster	45.39	4.42	4.50	8 09	14 98	23 52	16 01	0.00	5.41
Cement-sand plaster	45 39	4 42	4 50	8 09	14 98	23 52	16 01	0.00	5 41
Stabilised Mud plaster	33 31	3 89	4 50	8 09	12 42	7 83	16 01	0.00	1.77
No plastering	0 00	0.00	0 00	0.00	0 00	0 00	0 00	0.00	0 00
Cement-sand plaster	45.39	4 42	4 50	8 09	14 98	23 52	16 01	0 00	5 41
Cement-sand plaster	45.39	4.42	4.50	8 09	14 98	23 52	16 01	0 00	5 41

Table V.4 Socio-economic and environmental impacts of the Internal wall painting

			Mason/workers						
	Unit cost	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs /sq m.	Rs./ sq m.	Rs / sq m	Rs / sq m.	Rs / sq m.	MJ/ sq m.	MJ/ sq m	MJ/ sq.m.	Kg./ sq m.
White wash for solid wall only	12.13	2 28	1.29	2.31	5 68	1.33	16 01	0 00	0 34
Rat-trap	12.13	2.28	1.29	2.31	5.68	1.33	16 01	0.00	0.34
CSMB 5%	12.13	2 28	1 29	2.31	5 68	1.33	16 01	0 00	0 34
ICSMB 10%	12.13	2.28	1.29	2.31	5 68	1 33	16 01	0 00	0 34
SCB	12.13	2.28	1.29	2.31	5 68	1 33	16 01	0 00	0.34
CRS	12.13	2 28	1 29	2.31	5 68	1.33	16.01	0 00	0.34

Table V.5 Socio-economic and environmental impacts of the external wall painting

			Mason/workers						
	Unit cost	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs./sq m.	Rs./ sq m.	Rs / sq m.	Rs / sq m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq m.	Kg / sq m.
White wash for solid wall only	12.13	2 28	1.29	2.31	5 68	1.33	16 01	0.00	0 34
Rat-trap	0.00	0 00	0.00	0 00	0 00	0 00	0.00	0 00	0 00
CSMB 5%	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0.00	0 00
ICSMB 10%	0 00	0.00	0 00	0.00	0 00	0 00	0 00	0 00	0 00
SCB	0 00	0 00	0 00	0 00	0.00	0 00	0 00	0 00	0 00
CRS	0 00	0 00	0 00	0 00	0 00	0 00	0.00	0 00	0 00

Table V.6 total socio-economic and environmental impacts of new Construction of the different walling systems on socio-economic and environmental aspects, Basic structure + external + internal wall rendering etc all complete

	Socio-economic impact					**Environmental impact**			
Walling systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs./sq m.	Rs / sq m.	Rs./ sq m.	Rs./ sq.m.	Rs./ sq.m	MJ/ sq m.	MJ/ sq.m.	MJ/ sq.m.	Kg / sq.m.
Solid brick	343 74	147 64	23.35	33 19	81.55	124.08	80 06	553 19	88 08
Rat-trap	293 52	120.12	23 09	29.21	74 87	80 02	64 05	460 99	68.11
CSMB 5%	293.24	65.10	27.56	18 48	88.30	151.14	64.05	0 01	34.96
ICSMB 10%	241 15	47 69	7.73	7 97	46 35	194.18	26 45	0 01	40 31
SCB	297.61	57.64	22.83	16 56	97.35	226 64	61 26	0 04	42 98
CRS	403 11	114 54	29 60	16 56	127 38	189 17	74 49	0 01	41 63
The Highest	**403.11**	**147.64**	**29.60**	**33.19**	**127.38**	**226.64**	**80.06**	**553.19**	**88.08**

ROOFING SYSTEMS : NEW CONSTRUCTION

Table V.7 Socio-economic and environmental impacts of the roofing systems for new construction : Data on basic structure (without finishing)

	Socio-economic impact					Environmental impact			
Roofing systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Labourer**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs /sq m	Rs / sq m.	Rs / sq m.	Rs./ sq m	Rs / sq m	MJ/ sq m.	MJ/ sq m.	MJ/ sq.m.	Kg / sq m
RCC instu	411.38	121.35	12.94	1.69	33 97	471 19	119.17	2.08	74 86
RC plank and joist	348 61	62.88	23 84	9 01	42.33	454 19	20 65	0 38	69 36
RC channel	360 40	63.14	17 04	7.57	58.76	454 41	20 65	0 38	68.74
Ferrocement channel	350 84	39 93	13 18	11 53	67 23	408 93	0 00	0 01	61 10
MCT roofing	249 94	75 01	38 92	0 09	25 98	230 89	9.77	0 62	32 61
Hybrid	412.24	147 67	20 01	18.50	42 63	381 41	133.28	178 41	81 28
RCC Filler	364 69	136 55	38 91	12.60	56 27	253 75	218 97	41.99	56.32
Stone on joist	378 32	61 00	26 06	6 06	55 04	425 21	13 86	0 26	60 85
Jackarch on joists	361.78	117.75	21 93	10.78	49 00	336 36	20 65	323 56	85.16
Brick corbel arch	413 82	148 30	62 83	63 74	105 08	55 18	0 00	633 54	80 81
Brick pyramid	360 48	144 29	50 11	20 91	103.39	68 00	0.00	609 47	81 09
The Highest	**413.82**	**148.30**	**62.83**	**63.74**	**105.08**	**471.19**	**218.97**	**633.54**	**85.16**

Table V.8 Socio-economic and environmental impacts of the waterproofing on the roofing systems for new construction : Data on basic structure (without finishing)

	Socio-economic impact					Environmental impact			
Roofing systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs./sq m.	Rs./ sq m	Rs./ sq m	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.	Kg./ sq.m.
Impervious coat on RCC	61.17	4.81	4.72	8 47	13.99	59.53	0.0000	0.00	12.13
Impervious coat on P&J	61.17	4.81	4.72	8 47	13.99	59.53	0 0000	0.00	12.13
Impervious coat on RC CHNL	61.17	4.81	4.72	8.47	13.99	59.53	0.0000	0.00	12.13
Polymer-cement on FC CHNL	57.58	5.47	3.78	0 00	4.27	29.22	0 0000	0.00	0.49
Replacement of 5% MCT	5.24	0.31	2.31	0 00	1.63	2.02	0.0000	0.00	0.47
Impervious coat on HYB	61.17	4.81	4.72	8 47	13.99	59.53	0.0000	0.00	12.13
Impervious coat on filler (48% extra)	90.54	7.11	6.98	12.54	20.70	88.10	0.00	0.00	17.95
Brickbat coba on stone roofing	220.02	64.19	9.83	0.00	22.47	255.85	0.0000	192.29	71.03
Plaster on jackarch roofing	67.29	5.29	5.19	9.32	15.38	65.48	0.0000	0.00	13.34
Plaster on corbelled archroof	108.76	7.38	9.71	17.43	28.78	91.51	0.0000	0.00	20.6
Plaster on pyramid	125.40	8.51	11.19	20.09	33.18	105.50	0.0000	0.00	17.89

Table V.9 Socio-economic and environmental impacts of the ceiling painting (Preventive) for new construction : Data on basic structure (without finishing). This component will be repeated after every 4 years

unit data

Lime washing - three coats including cost and conveyence of all materials and labour charges, segnorage charges etc complete. pointing 10% area

	Unit cost	Retained	Skilled	Semi	Unskilled	Non ren	Ren	Waste	CO_2
RCC slab	12.13	2.28	1.29	2.31	5.68	1.33	16.01	0.00	0.34
RC plank and joist	12.13	2.28	1.29	2.31	5.68	1.33	16.01	0.00	0.34
RC channel	12.13	2.28	1.29	2.31	5.68	1.33	16.01	0.00	0.34
Ferrocement channel	13.34	2.50	1.42	2.54	6.25	1.46	17.61	0.00	0.37
MCT under structure paining	11.02	0.64	1.65	0.00	2.96	6.96	0.00	0.00	0.76
Hybrid slab ribs painting	4.73	0.89	0.50	0.90	2.21	0.52	6.24	0.00	0.13
Filler slab (48% extra)	17.95	3.37	1.90	3.42	8.41	1.97	23.70	0.00	0.50
Stone roofing	6.06	1.14	0.64	1.16	2.84	0.67	8.01	0.00	0.17
Jackarch roofing	4.61	0.87	0.49	0.88	2.16	0.51	6.24	0.00	0.13
Brick corbel arch	2.73	0.31	0.32	0.58	0.87	1.21	1.50	0.00	0.28
Brick pyramid	3.15	0.36	0.37	0.66	1.00	1.40	1.73	0.00	0.33

Table V.10 Socio-economic and environmental impacts of the basic structure + roof treatment + ceiling painting

	Socio-economic impact					Environmental impact			
Roofing systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m	Rs./ sq.m	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.	Kg./ sq.m.
Reinforced cement concrete insitu	484.686	128.428	18.944	12.474	53.631	532.050	135.183	2.078	87.331
Reinforced cement concrete plank and joist	421.910	69.962	29.841	19.793	61.996	515.050	36.658	0.386	81.832
Reinforced cement concrete channel	433.700	70.221	23.043	18.354	78.421	515.274	36.658	0.384	81.208
Ferrocement channel	421.763	47.910	18.383	14.069	77.749	439.611	17.613	0.008	61.969
Micro concrete tile roofing	266.194	75.953	42.880	0.091	30.567	239.876	9.769	0.622	33.830
Hybrid	478.145	153.364	25.227	27.867	58.834	441.456	139.528	178.411	93.548
Reinforced cement concrete filler	473.179	147.028	47.797	28.549	85.377	343.828	242.668	41.999	74.775
Stone on joist	604.411	126.322	36.536	7.217	80.350	681.723	21.870	192.543	132.050
Jackarch on joists	433.676	123.904	27.608	20.974	66.545	402.352	26.891	323.565	98.635
Brick corbel arch	525.314	155.991	72.859	81.748	134.732	147.900	1.498	633.542	101.719
Brick pyramid	489.024	153.157	61.679	41.663	137.573	174.898	1.727	609.477	99.304
The Highest	**604.411**	**155.991**	**72.859**	**81.748**	**137.573**	**681.723**	**242.668**	**633.542**	**132.050**

APPENDIX VI

LIFE CYCLE SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS OF THE WALLING AND ROOFING SYSTEMS.

WALLING SYSTEMS : LIFE CYCLE IMPACTS

For all repair works 100% extra labour charge has been added for de-plastering, scraping cleaning etc. for all repair works 50% extra material charge has been added for wastage and higher transportation charges

Table VI.1 Socio-economic and environmental impacts of the major external repair of walling systems
This part is to be repeated after every ten years, i.e., 11th ,21st ,31st and 41st years

	Socio-economic impact					Environmental impact			
Walling systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs./sq m.	Rs / sq m.	Rs / sq m.	Rs / sq m	Rs / sq m.	MJ/ sq m.	MJ/ sq.m	MJ/ sq m	Kg / sq m.
20% replastering	16.37	1.33	1.80	3.23	5.99	4.70	3.20	0.0003	1.083
30% repointing	15.98	1.49	2.06	3.70	5.58	3.89	4.80	0.0002	0.909
30 % mud plaster	18.740	1.75	2.70	4.85	7.45	2.35	4.80	0.0001	0.532
30 % Latex-cement	23.58	2.14	1.97	0.00	2.23	7.62	0.00	0.0001	0.128
30% repointing	15.98	1.49	2.06	3.70	5.58	3.89	4.80	0.0002	0.909
30% repointing	15.98	1.49	2.06	3.70	5.58	3.89	4.80	0.0002	0.909

Table VI.2 Lifecycle impacts of the external repairs with a frequency of 10 years, based on the data in Table VI.1

	Socio-economic impact					Environmental impact			
Walling systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs./sq.m.	Rs./ sq.m.	Rs./ sq m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq m.	Kg./ sq.m.
Solid brick wall	22.87	1.85	2.52	4.52	8.37	18.81	12.81	0.00	4.33
Rat-trap	22.32	2.08	2.88	5.16	7.80	15.58	19.21	0.00	3.63
CSMB 5%	26.17	2.44	3.77	6.78	10.41	9.40	19.21	0.00	2.13
ICSMB 10%	32.94	2.99	2.76	0.00	3.11	30.49	0.00	0.00	0.51
SCB	22.32	2.08	2.88	5.16	7.80	15.58	19.21	0.00	3.63
CRS	22.32	2.08	2.88	5.16	7.80	15.58	19.21	0.00	3.63

Table VI.3 Socio-economic and environmental impacts of Internal and external painting - routine maintenance after every 4 years

	Socio-economic impact					Environmental impact			
Walling systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs /sq m.	Rs / sq m.	Rs / sq m.	Rs / sq m.	Rs / sq m.	MJ/ sq.m.	MJ/ sq m.	MJ/ sq.m	Kg / sq m.
Solid brick wall	24.26	4.55	2.57	4.62	11.36	2.66	32.02	0.00	0.68
Rat-trap	12.13	2.28	1.29	2.31	5.68	1.33	16.01	0.00	0.34
CSMB 5%	12.13	2.28	1.29	2.31	5.68	1.33	16.01	0.00	0.34
ICSMB 10%	12.13	2.28	1.29	2.31	5.68	1.33	16.01	0.00	0.34
SCB	12.13	2.28	1.29	2.31	5.68	1.33	16.01	0.00	0.34
CRS	12.13	2.28	1.29	2.31	5.68	1.33	16.01	0.00	0.34

Table VI.4 Lifecycle impacts of the internal and external painting with a frequency of 4 years (5,9,13,17,21,25,29,33, 37, 41,45 years) based on data in Table VI.3

	Socio-economic impact					Environmental impact			
Walling systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs./ sq m.	Rs./ sq m.	Rs./ sq m.	Rs./ sq.m.	Rs / sq.m.	MJ/ sq m.	MJ/ sq m.	MJ/ sq m.	Kg./ sq.m.
Solid brick wall	100.89	18.94	10.70	19.21	47.24	29.30	352.27	0.00	7.50
Rat-trap	50.44	9.47	5.35	9.61	23.62	14.65	176.13	0.00	3.75
CSMB 5%	50.44	9.47	5.35	9.61	23.62	14.65	176.13	0.00	3.75
ICSMB 10%	50.44	9.47	5.35	9 61	23.62	14.65	176.13	0.00	3.75
SCB	50.44	9.47	5.35	9.61	23.62	14.65	176.13	0 00	3.75
CRS	50.44	9.47	5.35	9.61	23.62	14.65	176.13	0.00	3.75

Table VI.5 Total Lifecycle impacts of basic structure + external + internal wall rendering etc all complete

	Socio-economic						Environmental			
	Unit cost Rs./sq.m.	**Total retention Rs/sq,m,**	Retained Rs./ q.m.	Skilled Rs./ q.m.	Semi skilled Rs./ q m.	Un skilled Rs./ sq.m.	Non renewable MJ/ sq m.	Re newable MJ/ sq m.	Waste MJ/ sq.m.	CO_2 Kg / sq m.
Solid brick wall	467.49	**399.07**	168.43	36 57	56 92	137.15	172.19	445.14	553.20	99 91
Rat-trap	366 29	**313.25**	131.67	31.31	43 97	106 29	110 24	259 40	461.00	75 50
CSMB 5%	369 85	**270.89**	77.01	36 69	34.86	122 33	175.19	259 40	0 01	40 83
ICSMB 10%	324 53	**166.65**	60.15	15 84	17.58	73 08	239 31	202.59	0 01	44 58
SCB	370.37	**260.34**	69.19	31.06	31.32	128 77	256 87	256 61	0 04	50.37
CRS	475 87	**354.04**	126 09	37 83	31.32	158 80	219 39	269 84	0 01	49 01
The Highest	**475.87**	**399.07**	**168.43**	**37.83**	**56.92**	**158.80**	**256.87**	**445.14**	**553.20**	**99.91**

ROOFING SYSTEMS : LIFE CYCLE IMPACTS

Table VI.6 Socio-economic and environmental impacts of waterproofing on rooftop This component will be repeated after every 10 years, i.e., 11th, 21st, 31st, 41st years

	Socio-economic impact					Environmental impact			
Roofing systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs./sq.m.	Rs./ sq m.	Rs./ sq m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq m	Kg / sq.m.
Impervious coat on RCC	61.17	4.81	4.72	8 47	13.99	59.53	0.0000	0.00	12.13
Impervious coat on P&J	61.17	4.81	4.72	8.47	13.99	59.53	0.0000	0.00	12.13
Impervious coat on RC CHNL	61.17	4.81	4.72	8.47	13.99	59 53	0.0000	0 00	12.13
Polymer-cement on FC CHNL	57.58	5.47	3.78	0.00	4.27	29.22	0.0000	0.00	0.49
Replacement of 5% MCT	5.24	0.31	2.31	0.00	1.63	2.02	0.0000	0.00	0.47
Impervious coat on HYB	61.17	4.81	4.72	8.47	13.99	59.53	0 0000	0.00	12.13
Impervious coat on filler (48% extra)	90.54	7.11	6.98	12.54	20.70	88.10	0.00	0.00	17.95
Brickbat coba on stone roofing	220.02	64.19	9.83	0.00	22.47	255.85	0.0000	192.29	71.03
Plaster on jackarch roofing	67.29	5.29	5.19	9.32	15.38	65.48	0 0000	0.00	13.34
Plaster on corbelled archroof	108.76	7.38	9.71	17.43	28.78	91.51	0.0000	0.00	20 6
Plaster on pyramid	125.40	8.51	11.19	20.09	33.18	105.50	0.0000	0.00	17.89

Table VI.7 Life cycle socio-economic and environmental impacts of waterproofing on rooftop

	Socio-economic impact					Environmental impact			
Roofing systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs./sq.m.	Rs./ sq m.	Rs./ sq m.	Rs / sq m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq m.	Kg / sq m.
Reinforced cement concrete insitu	146.61	11.52	11.31	20.30	33.52	297.65	0.00	0.01	60.65
Reinforced cement concrete plank and joist	146 61	11.52	11.31	20.30	33.52	297.65	0.00	0.01	60.65
Reinforced cement concrete channel	146.61	11.52	11.31	20.30	33.52	297.65	0.00	0.01	60.65
Ferrocement channel	138.00	13.11	9.07	0.00	10.23	146.10	0.00	0 00	2.45
Micro concrete tile roofing	12.56	0.73	5.53	0.00	3 90	10.12	0.00	0 00	2.33
Hybrid	146.61	11.52	11.31	20.30	33.52	297.65	0.00	0.01	60.65
Reinforced cement concrete filler	216 99	17.05	16.74	30.04	49.61	440.52	0.00	0.02	89.77
Stone on joist	527.33	153.83	23.57	0 00	53 86	1279.23	0.00	961.43	355.15
Jackarch on joists	161.28	12.67	12.44	22.33	36.87	327.41	0.00	0.02	66.72
Brick corbel arch	260 67	17.68	23.27	41.77	68.97	457.53	0.00	0.02	103.11
Brick pyramid	300.54	20.39	26.83	48.16	79 52	527.50	0.00	0.02	89.43

Table VI.8 Socio-economic and environmental impacts of ceiling painting (preventive). This component will be repeated after every 4 years, i.e., 5,9,13,17,21,25,29,33, 37, 41,45 years

	Unit cost	Retained	Skilled	Semi	Unskilled	Non ren	Ren	Waste	CO_2
RCC slab	12.13	2.28	1.29	2.31	5 68	1.33	16.01	0.00	0.34
RC plank and joist	12.13	2.28	1.29	2.31	5 68	1.33	16.01	0.00	0.34
RC channel	12.13	2.28	1.29	2.31	5.68	1.33	16.01	0.00	0.34
Ferrocement channel	13.34	2.50	1.42	2.54	6.25	1.46	17.61	0.00	0.37
MCT under structure painting	11.02	0.64	1.65	0.00	2.96	6.96	0.00	0.00	0.76
Hybrid slab ribs painting	4.73	0.89	0.50	0.90	2.21	0.52	6.24	0 00	0.13
Filler slab (48% extra)	17.95	3.37	1.90	3.42	8.41	1.97	23.70	0.00	0.50
Stone roofing	6.06	1.14	0.64	1.16	2.84	0.67	8.01	0.00	0.17
Jackarch roofing	4.61	0.87	0.49	0.88	2.16	0.51	6.24	0.00	0.13
Brick corbel arch	2.73	0.31	0.32	0.58	0.87	1.21	1.50	0.00	0.28
Brick pyramid	3.15	0.36	0.37	0.66	1.00	1.40	1.73	0.00	0.33

Table VI.9 Life cycle socio-economic and environmental impacts of ceiling painting

	Socio-economic impact					Environmental impact			
Roofing systems	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**	**CO_2**
	Rs./sq.m.	Rs./ sq m.	Rs./ sq m.	Rs./ sq m	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq m	Kg./ sq.m.
Reinforced cement concrete insitu	62.57	11.74	6.64	11.92	29.30	15.98	192.15	0.00	4.09
Reinforced cement concrete plank and joist	62.57	11.74	6.64	11.92	29.30	15.98	192.15	0 00	4.09
Reinforced cement concrete channel	62.57	11.74	6.64	11.92	29.30	15.98	192.15	0.00	4.09
Ferrocement channel	68 83	12.92	7.30	13.11	32.23	17.58	211.36	0.00	4.50
Micro concrete tile roofing	56 84	3.31	8.51	0 00	15.27	83.54	0 00	0.00	9.07
Hybrid	24 40	4.58	2.59	4.65	11.43	6.23	74.94	0.00	1.59
Reinforced cement concrete filler	92.61	17.38	9.83	17.64	43.36	23.65	284.38	0.00	6.05
Stone on joist	31.29	5.87	3.32	5.96	14.65	7.99	96.07	0.00	2.04
Jackarch on joists	23.78	4.46	2.52	4.53	11.13	6.07	74.94	0 00	1.55
Brick corbel arch	14.10	1.60	1.66	2.97	4.49	14.57	17.97	0.00	3.40
Brick pyramid	16.25	1.84	1.91	3.43	5.18	16.80	20.72	0.00	3 92

Table VI.10 Total Lifecycle impacts of basic structure + waterproofing + ceiling painting

	Socio-economic						Environmental			
	Unit cost Rs./sq.m.	**Total retention Rs/sq,m,**	Retained Rs./ q.m.	Skilled Rs./ q m.	Semi skilled Rs./ q.m.	Un skilled Rs./ sq.m.	Non renewable MJ/ sq m.	Re newable MJ/ sq m.	Waste MJ/ sq.m.	CO_2 Kg./ sq.m.
Reinforced cement concrete insitu	620.57	**306.19**	144.61	30.89	33.91	96.78	784.82	311.32	2.09	139.60
Reinforced cement concrete plank and joist	557.79	**274.31**	86.14	41.78	41.23	105.15	767.82	212.79	0.40	134.10
Reinforced cement concrete channel	569.58	**282.75**	86.40	34.99	39.79	121.57	768.04	212.79	0.40	133.48
Ferrocement channel	557.67	**229.85**	65.97	29.55	24.64	109.69	572.61	211.36	0.01	68.05
Micro concrete tile roofing	319.34	**177.25**	79.04	52.96	0.09	45.16	324.56	9.77	0.62	44.00
Hybrid	583.26	**328.70**	163.77	33.91	43.44	87.58	685.29	208.22	178.42	143.53
Reinforced cement concrete filler	674.29	**445.97**	170.98	65.47	60.28	149.24	717.92	503.35	42.02	152.14
Stone on joist	936.94	**409.22**	220.70	52.95	12.02	123.54	1712.43	109.94	961.69	418.04
Jackarch on joists	546.83	**306.42**	134.89	36.89	37.64	97.01	669.85	95.58	323.58	153.44
Brick corbel arch	688.59	**542.37**	167.58	87.76	108.49	178.55	527.28	17.97	633.56	187.32
Brick pyramid	677.27	**505.95**	166.52	78.85	72.49	188.09	612.30	20.72	609.49	174.44
The Highest	**936.94**	**542.37**	**220.70**	**87.76**	**108.49**	**188.09**	**1712.43**	**503.35**	**961.69**	**418.04**

APPENDIX VII

SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS: PRIMARY SCHOOL CONSTRUCTION AT DIFFERENT SITES UNDER ANDHRA PRADESH PRIMARY EDUCATION PROJECT

Unit rates of material and labour: Standard Schedule of Rates, 1995-96, Government of Andhra Pradesh.

Table VII.1 Socio-economic and environmental impacts of the different materials adopted in the school construction at 29 sites in Ranga Reddy district under the Andhra Pradesh Primary Education Project.

	Socio-economic impact					Environmental impact		
	Unit cost	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
	Rs.	Rs.	Rs	Rs.	Rs.	MJ	MJ	MJ
Excavation/cum	24 68	0 00	0.00	0 00	24 68	0 00	0 00	0 00
Back fill/cum	12 34	0 00	0.00	0 00	12 34	0 00	0 00	0 00
1 00 cubic metre CC 1:5.10 /cum	847.21	188 30	14 98	7 70	139 67	1173 87	0 00	0 27
1 00 cubic metre CC 1:3:6	1131.48	282.09	37.07	7.70	150.15	1506.55	207 30	4.74
1 00 cubic metre CC 1:2:4 DPC/cum	1656.14	373 90	23.72	15 40	238 18	2407.94	0 00	0.32
1 00 cubic metre CC 1:2:4 /cum	1531.14	357 40	23 72	15 40	238.18	1961 60	0 00	0.32
Course/ Random Rubble per cum	762.07	216 62	53 63	96.25	121.13	387.11	0 00	0 02
flush pointing CRS/ brick / sqm	29.22	3 31	3 43	6.16	9 31	12 98	16 01	0 00
Impervious coat/sqm	61.17	4 81	4 72	8 47	13 99	59 53	0 00	0.00
Impervious coat pyramids/sq m.	58.15	3 94	5.19	9 32	15 38	48 92	0 00	0.00
Plastering with sponge finish/ sq m.	45.39	4.42	4 50	8 09	14 98	23 52	16 01	0 00
Brickbat coba / sq m	220 02	64 19	9 83	0.00	22.47	255 85	0 00	192 29
Mud plaster / sq m.	33.31	3 89	4 50	8 09	12.42	7.83	16 01	0 00
Cement pointing-Tandur stone / sq m.	10.56	0 41	1 72	3 08	3 02	4 32	0 00	0 00
Tandur stone flooring / sq m.	81.27	9 80	6 86	12.32	12.47	15 98	0 00	0 00
Black board / sq m.	81.44	8.10	3 32	5.97	11.72	83.23	0.00	0 00
Painting on new wood / sq m.	17.19	1.00	2.57	0 00	4 62	10 86	0 00	0 00
Lime washing / sq.m.	12.13	2.28	1.29	2 31	5 68	1 33	16 01	0.00
Brickarch/cum	2350 48	1453 57	229 89	96 25	323 99	389 41	1756 64	2435 26
Skirting / sq.m.	40 21	3 29	7.15	0 00	11.11	35 27	0 00	0 00
Khurra / number	144.52	11 54	18 18	0 20	40 84	357 04	0 00	0 00
PVC per meter	70 37	4 92	8 94	0 00	4 73	383 45	0 00	0 00
Tandur stone roof cover / sq m.	107 92	13 10	14 30	0 00	21 92	48.13	0 00	0 00
sailo-xe-crete	50.07	4 76	3 29	0 00	3 71	25 41	0 00	0 00
Reinforcing rods / kg	17 20	2.58	1 72	0 00	0 86	30 36	0 00	0 00
Structural steel / kg	20 00	3 00	2 00	1.00	1 00	36 32	0 00	0 00
Solid brick wall / sq m.	228 70	134 23	11 77	12.40	40 23	74 38	16 01	553.19
Rat-trap / sq m.	206 79	110 11	13 86	12.65	44 90	42.19	16 01	460 99
CSMB 5% / sq. m	214 49	55 05	17.27	0 00	57.77	134 15	16 01	0.01
ICSMB 10% / sq m.	178 95	40 66	3.15	5 66	36 96	167.43	10 44	0.01
SCB/ sq m.	210 87	47.63	13 61	0 00	67 38	188 81	13 23	0 04
CRS / sq.m.	316 37	104 53	20 38	0 00	97 41	151.34	26 45	0 01
RCC slab / sq m.	411 38	121.35	12.94	1 69	33 97	471.19	119.17	2.08
RC plank and joist / sq m.	348 61	62 88	23 84	9 01	42 33	454 19	20 65	0 38
RC channel / sq m	360 40	63.14	17 04	7.57	58.76	454 41	20 65	0 38
Ferrocement channel / sq m.	350 84	39 93	13 18	11 53	67.23	408 93	0 00	0 01
MCT roofing / sq m.	249 94	75 01	38 92	0 09	25 98	230 89	9 77	0 62
Hybrid / sq m.	412 24	147 67	20 01	18 50	42 63	381 41	133 28	178 41
Filler slab / sq m.	364 69	136 55	38 91	12 60	56 27	253 75	218 97	41 99
Stone roofing/ sq m.	378 32	61 00	26.06	6 06	55.04	425.21	13 86	0.26
Jackarch roofing / sq m	361.78	117 75	21 93	10 78	49 00	336 36	20 65	323 56

Brick corbel arch / sq m.	413 82	148 30	62.83	63 74	105 08	55.18	0 00	633 54
Brick pyramid / sq.m.	360 48	144.29	50 11	20 91	103 39	68 00	0 00	609 47
Second class brick / cu m	885.53	422.85	55 66	53 90	156.06	2288 83	670 57	0 02
Timber door / sq m.	1000 00	731.49	150 00	0.00	80.00	289 57	260.37	9 27
Structural timber / cum	10000 00	8153 67	1200 00	0.00	500 00	194 07	1548 03	97.63
Shuttering / sq m.	73 75	54 21	9 39	0.00	7.06	4 08	108.33	1 85
pyramid as solid brick 1 cum	1422 56	569 43	197.77	11 99	408 01	268.34	0 00	2405.18
finishing soffit of pyramid	221 78	16 39	35 75	0 00	127.58	69 02	69 62	0 00
Corbelled arch as solid brick 1 cum	1571 02	563 02	238 52	242 00	398 94	209 48	0 00	2405 17

CONVENTIONAL DESIGN AND TECHNOLOGIES

Design - same planform as Majeedpur (Annexure- VIII.1) and with same carpet area However, the covered area is different since wall thickness is 345mm

Covered area - 60.803 sq.m .

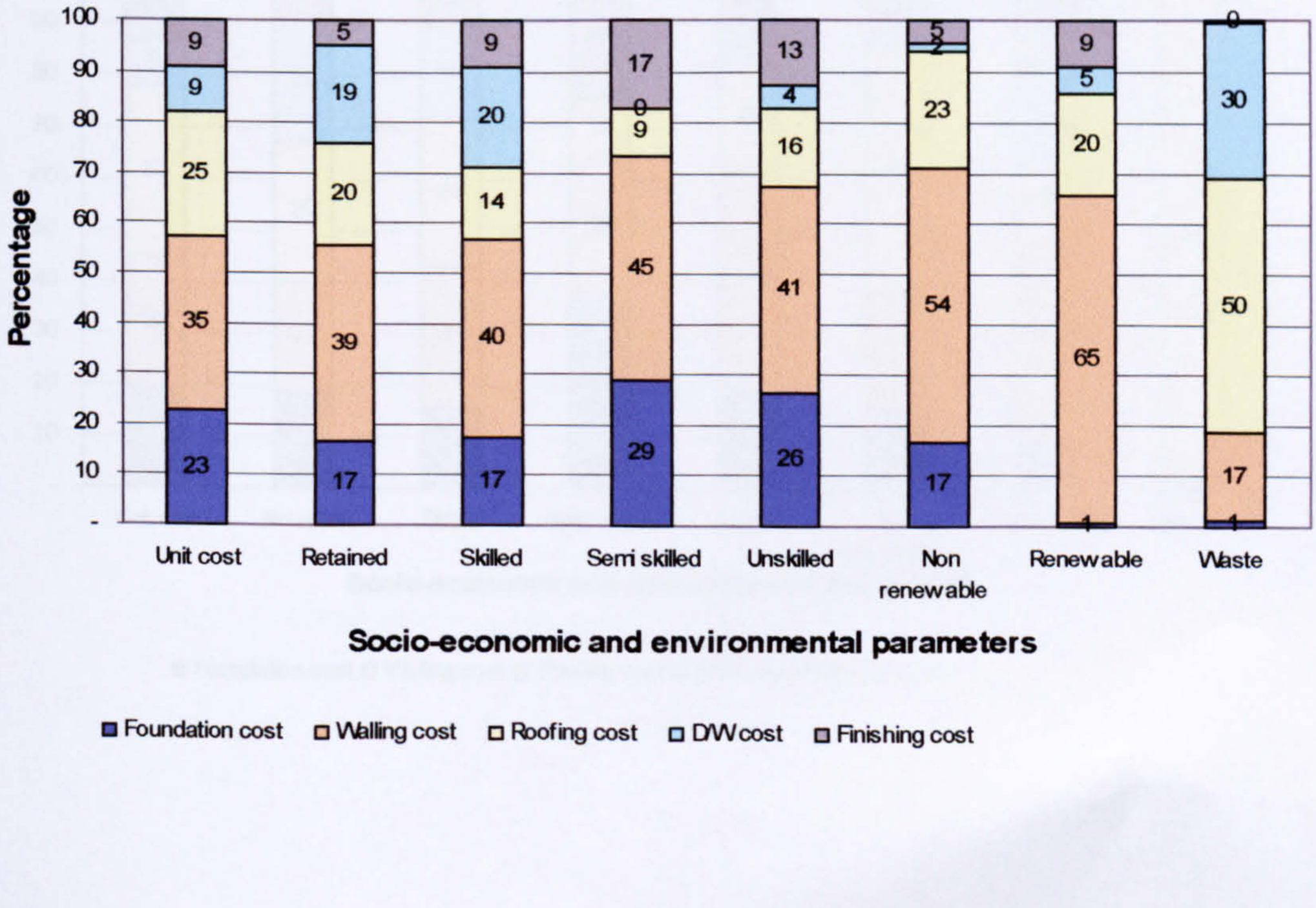
Construction technologies

Foundation	450 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (230 x 115 x 75 brick)	345 mm thick masonry wall in 1:6 cement mortar with clamp bond bricks
Roof	110mm thick reinforced cement concrete in-situ slab
Door and window	wooden frame and shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and exterior of Wall

Table VII.2 Socio-economic impacts of the primary school construction adopting conventional design

		Socio-economic impact					Environmental impact		
130,470.94		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
2,145.80	/sqm	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		486.5	117.9	23.7	35.2	91.0	431.2	5.1	0.1
Walling cost		745.2	272.9	54.0	54.5	143.0	1,415.5	436.7	0.8
Roofing cost		529.6	141.4	19.8	11.4	53.7	594.8	133.6	2.3
D/W cost		193.1	135.7	26.9	-	14.6	40.7	36.1	1.4
Finishing cost		191.4	33.0	12.3	20.5	44.0	118.0	59.3	0.0
Total (A+B+C+D+E)		2,145.80	700.88	136.62	121.63	346.33	2,600.1	670.74	4.62

Figure VII.1 The walling system in the convention system had very high impacts



SURANGAL, RANGA REDDY WEST

Design reference- Annexure- VIII.28

Covered area - 67.81 sq.m .

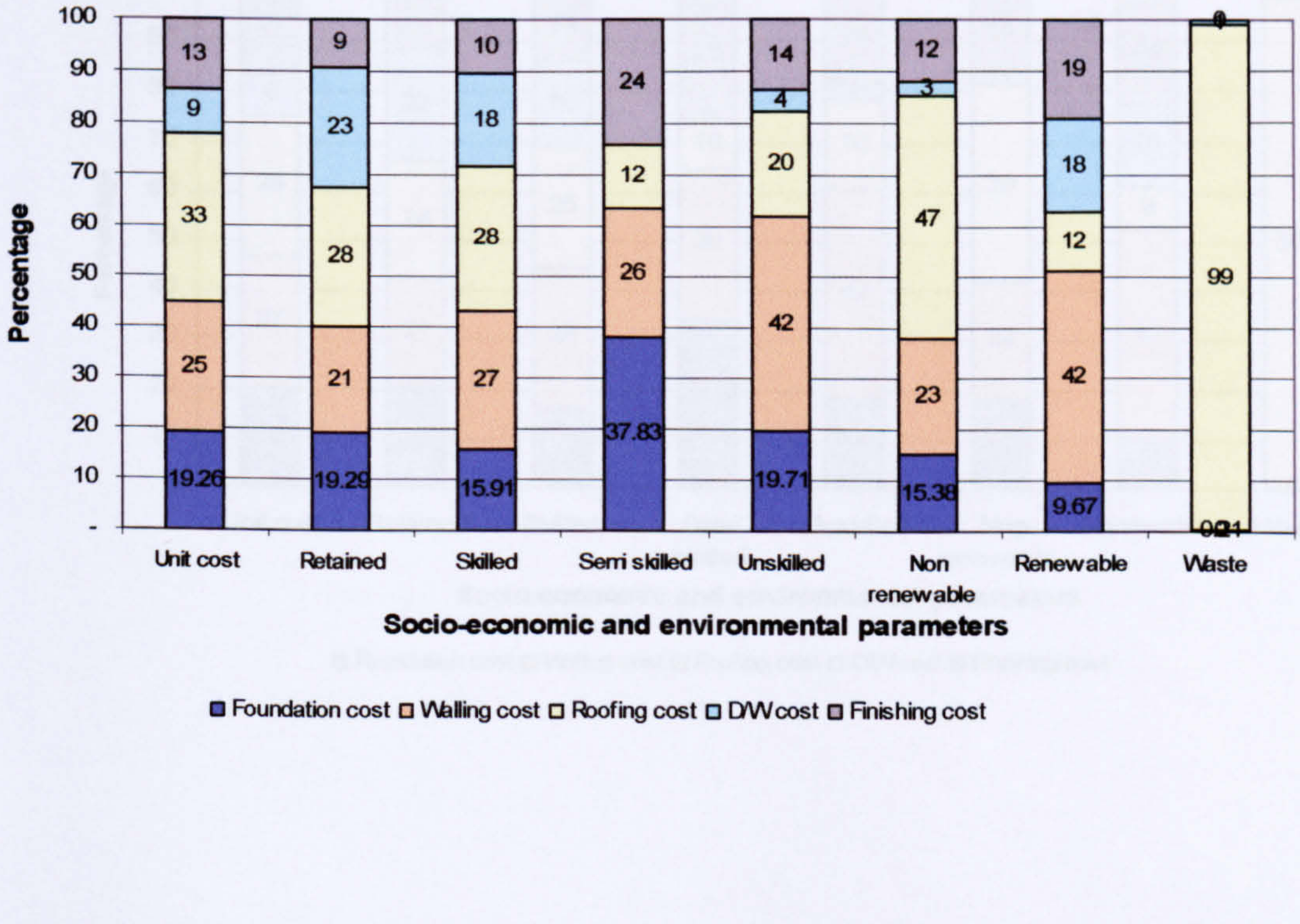
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (190x290x150 block)	190 mm thick stone concrete block masonry wall in 1:6 cement mortar
Roof	100mm thick precast reinforced cement concrete plank & joists
Door and window	frameless wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior

Table VII.3 Socio-economic impacts of the primary school construction at **Surangal**

		Socio-economic impact					**Environmental impact**		
122,722.91		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,809.81	/sq.m.	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		345.77	89.61	20.07	31.43	65.99	244.17	19.69	0.37
Walling cost		472.09	97.88	35.72	21.38	142.71	386.33	84.98	0.34
Roofing cost		594.20	129.20	35.95	10.25	68.34	746.47	23.48	173.24
D/W cost		155.61	106.87	22.82	-	12.91	43.36	36.63	1.34
Finishing cost		242.14	43.14	13.05	20.03	45.65	193.33	38.88	0.14
Total (A+B+C+D+E)		1,809.81	466.70	127.61	83.10	335.60	1,613.7	203.66	175.43

Figure VII.2 The walling and roofing systems combined at had very high impacts Surangal



CHILKOOR, RANGA REDDY WEST

Design reference- Annexure- VIII.25
Covered area - 137.72 sqm

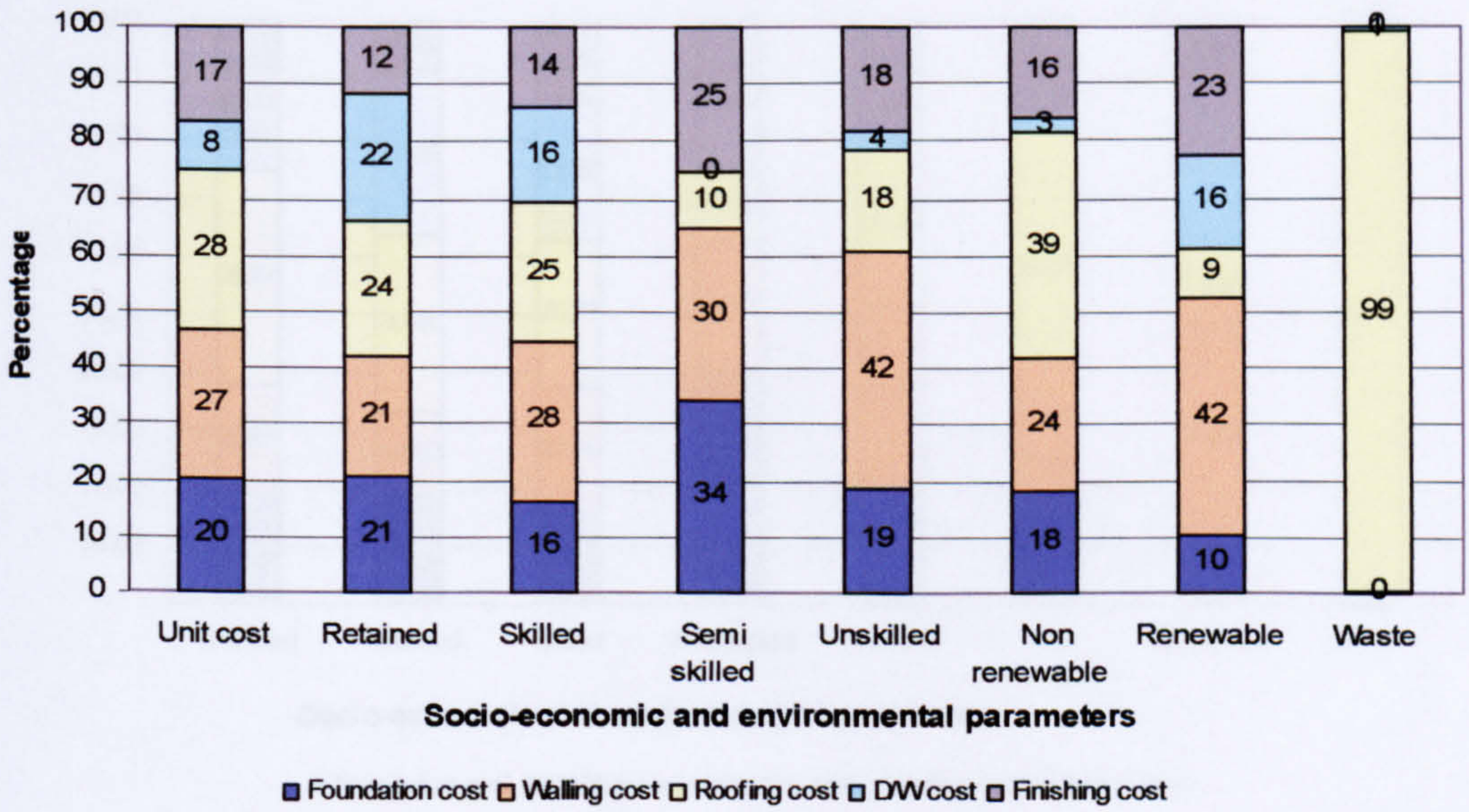
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (190x290x150 block)	190 mm thick stone concrete block masonry wall in 1:6 cement mortar
Roof	100mm thick precast reinforced cement concrete plank & joists
Door and window	frameless wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and exterior of Wall

Table VII.4 Socio-economic impacts of the primary school construction at Chilkoor

	Unit cost	Retained	Skilled	Semi skilled	Unskilled	Non renewable	Renewable	Waste
	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost	411.46	105.74	24.08	31.71	73.73	333.16	25.57	0.47
Walling cost	546.28	110.31	41.85	28.13	164.89	441.19	102.01	0.40
Roofing cost	582.54	124.68	36.86	9.38	69.98	730.49	21.45	169.90
D/W cost	164.22	114.08	24.23	-	13.87	46.76	39.34	1.43
Finishing cost	340.84	60.12	20.99	23.22	71.23	300.66	55.51	0.06
Total (A+B+C+D+E)	2,045.3	514.93	148.01	92.45	393.70	1852.26	243.88	172.26

Figure VII.3 The impacts of the foundation, walling and roofing systems combined had high impacts at Chilkoor



MEDIPALLY, RANGA REDDY WEST

Design reference- Annexure- VIII.27
Covered area - 64.81 sq.m .

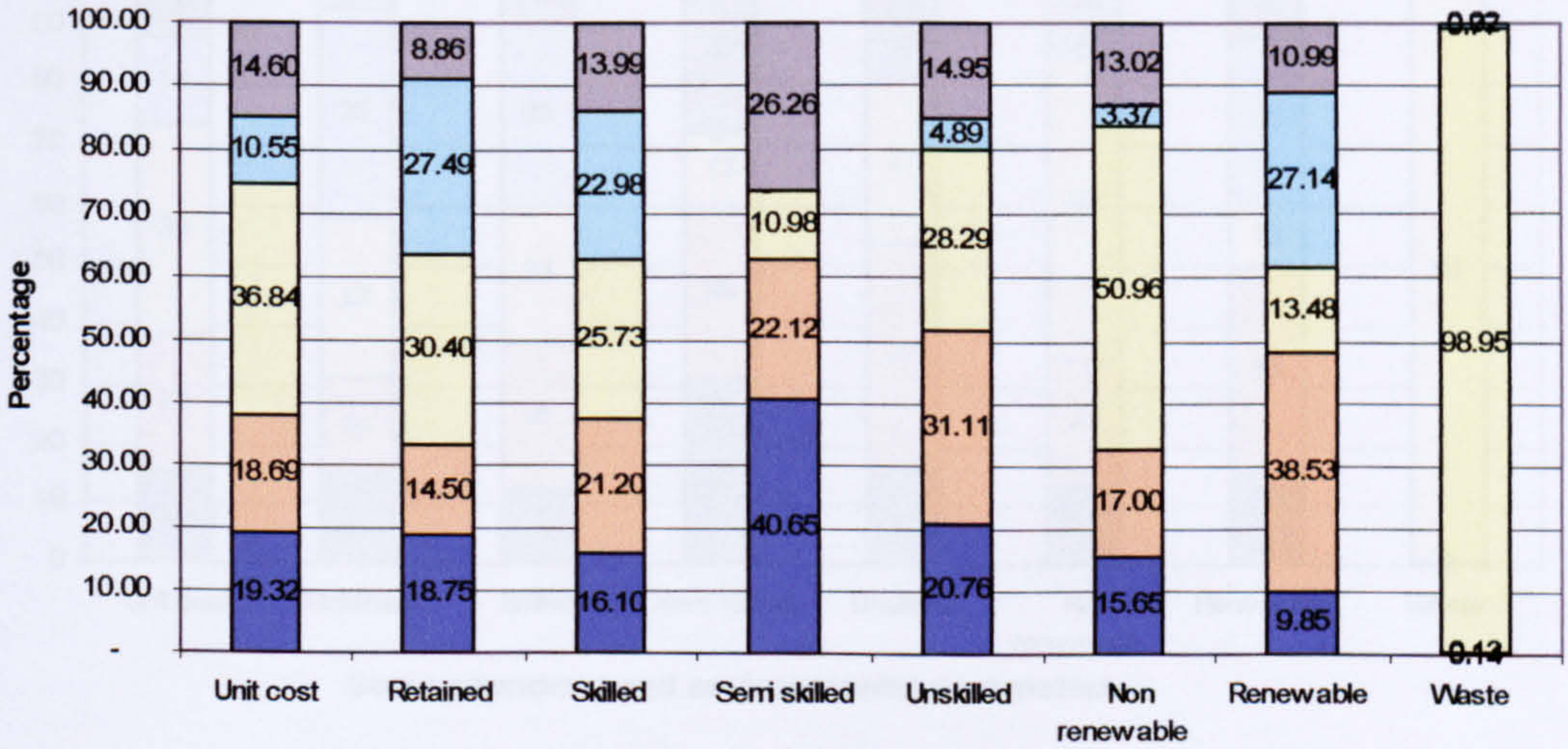
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (190x290x150 block)	190 mm thick stone concrete block masonry wall in 1:6 cement mortar
Roof	100mm thick precast reinforced cement concrete channel
Door and window	frameless wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and exterior of Wall

Table VII.5 Socio-economic impacts of the primary school construction at Medipally

111,951.70		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,727.38		Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		333.72	85.44	18.81	29.79	64.88	240.58	15.74	0.29
Walling cost		322.81	66.08	24.77	16.21	97.20	261.26	61.55	0.25
Roofing cost		636.37	138.51	30.06	8.04	88.39	783.24	21.54	201.02
D/W cost		182.28	125.28	26.85	-	15.29	51.82	43.36	1.57
Finishing cost		252.21	40.37	16.34	19.24	46.73	200.18	17.56	0.03
Total (A+B+C+D+E)		1,727.38	455.69	116.85	73.28	312.49	1,537.09	159.74	203.16

Figure VII.4 The impacts of the foundation, walling and roofing systems combined was high at **Medipally**



CHINNAMANGALARAM, RANGA REDDY WEST

Design reference- Annexure- VIII.26
Covered area - 68.44 sq.m .

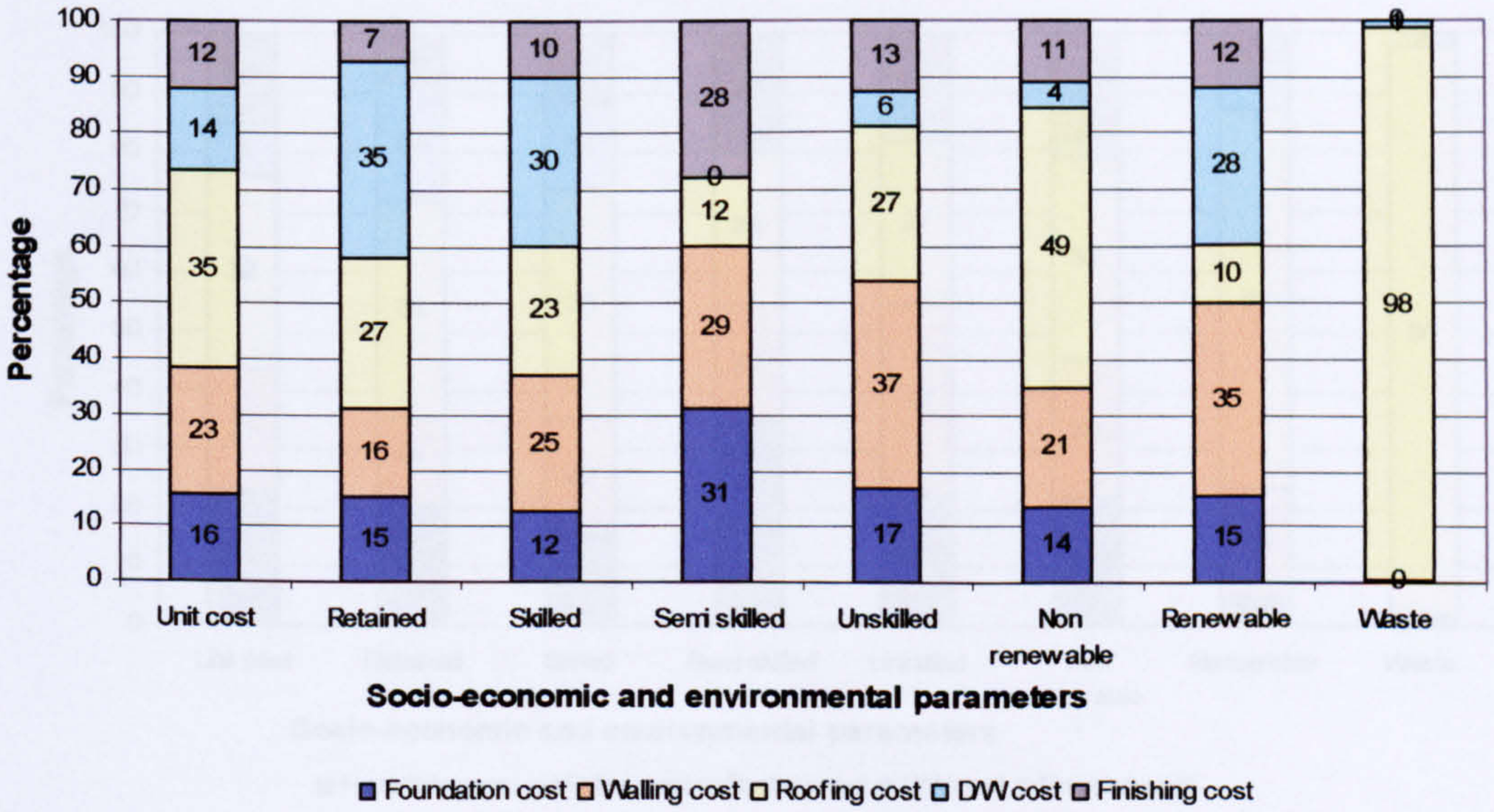
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (190x290x150 block)	190 mm thick stone concrete block masonry wall in 1:6 cement mortar
Roof	100mm thick precast reinforced cement concrete channel
Door and window	frameless wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and exterior of Wall

Table VII.6 Socio-economic impacts of the primary school construction at **Chinnamangalaram**

132,916.72		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,942.09	/SQM	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		306.51	83.37	17.00	23.06	59.86	229.91	36.40	0.64
Walling cost		439.80	90.13	33.62	21.59	131.56	359.07	82.24	0.35
Roofing cost		679.83	148.83	31.74	8.83	95.33	829.52	24.07	224.65
D/W cost		274.66	192.70	40.25	-	22.10	74.64	65.67	2.42
Finishing cost		241.28	40.39	13.60	20.65	44.79	186.61	27.49	0.03
Total (A+B+C+D+E)		1,942.09	555.41	136.20	74.13	353.64	1,679.75	235.86	228.09

Figure VII.5 The impacts of the foundation, walling and roofing systems combined was high at Chinnamangalaram



SHRIRAMNAGAR, RANGA REDDY WEST

Design reference- Annexure- VIII.29
Covered area 67.81 sq.m .

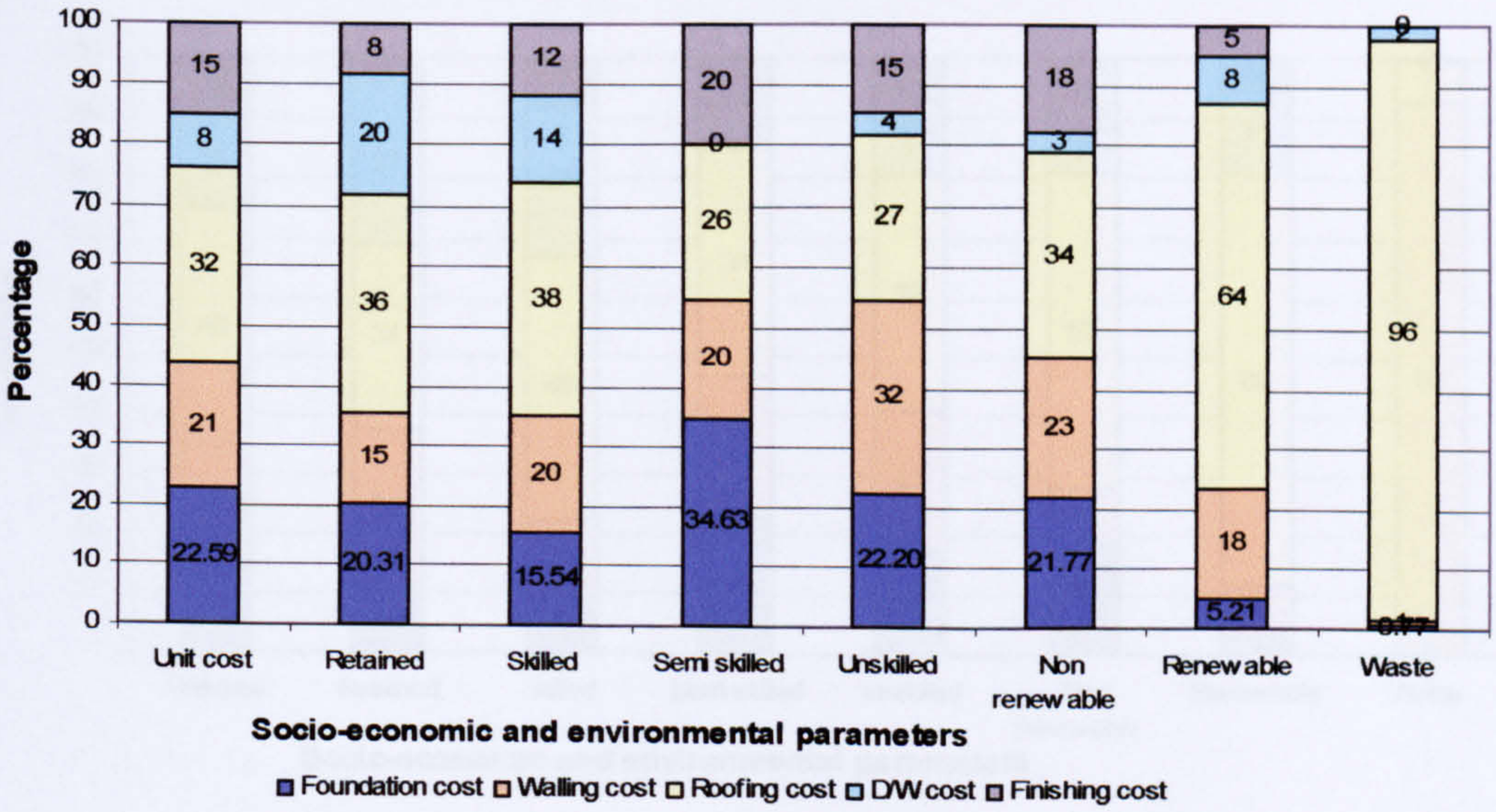
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (190x290x150 block)	190 mm thick stone concrete block masonry wall in 1:6 cement mortar
Roof	100mm thick reinforced cement concrete filler slab with Mangalore tiles
Door and window	frameless wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and exterior of Wall

Table VII.7 Socio-economic impacts of the primary school construction at **Shriramnagar**

103,785.61		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,530.54	/SQM	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		345.77	89.61	20.07	31.43	65.99	244.17	19.69	0.37
Walling cost		326.58	67.06	25.57	18.03	96.15	263.19	69.04	0.32
Roofing cost		494.24	160.29	49.65	23.30	80.43	379.41	240.90	46.20
D/W cost		127.88	87.04	18.10	-	10.46	34.92	29.72	1.09
Finishing cost		236.06	37.13	15.78	18.00	44.24	199.92	18.95	0.03
Total (A+B+C+D+E)		1,530.54	441.1	**129.17**	90.76	297.28	1121.61	378.30	48.02

Figure VII.6 The impacts of the foundation, walling and roofing systems combined was high at Shriramnagar



LUXMAPUR, RANGA REDDY EAST

Design reference- Annexure- VIII.7
Covered area 143.21 sq.m .

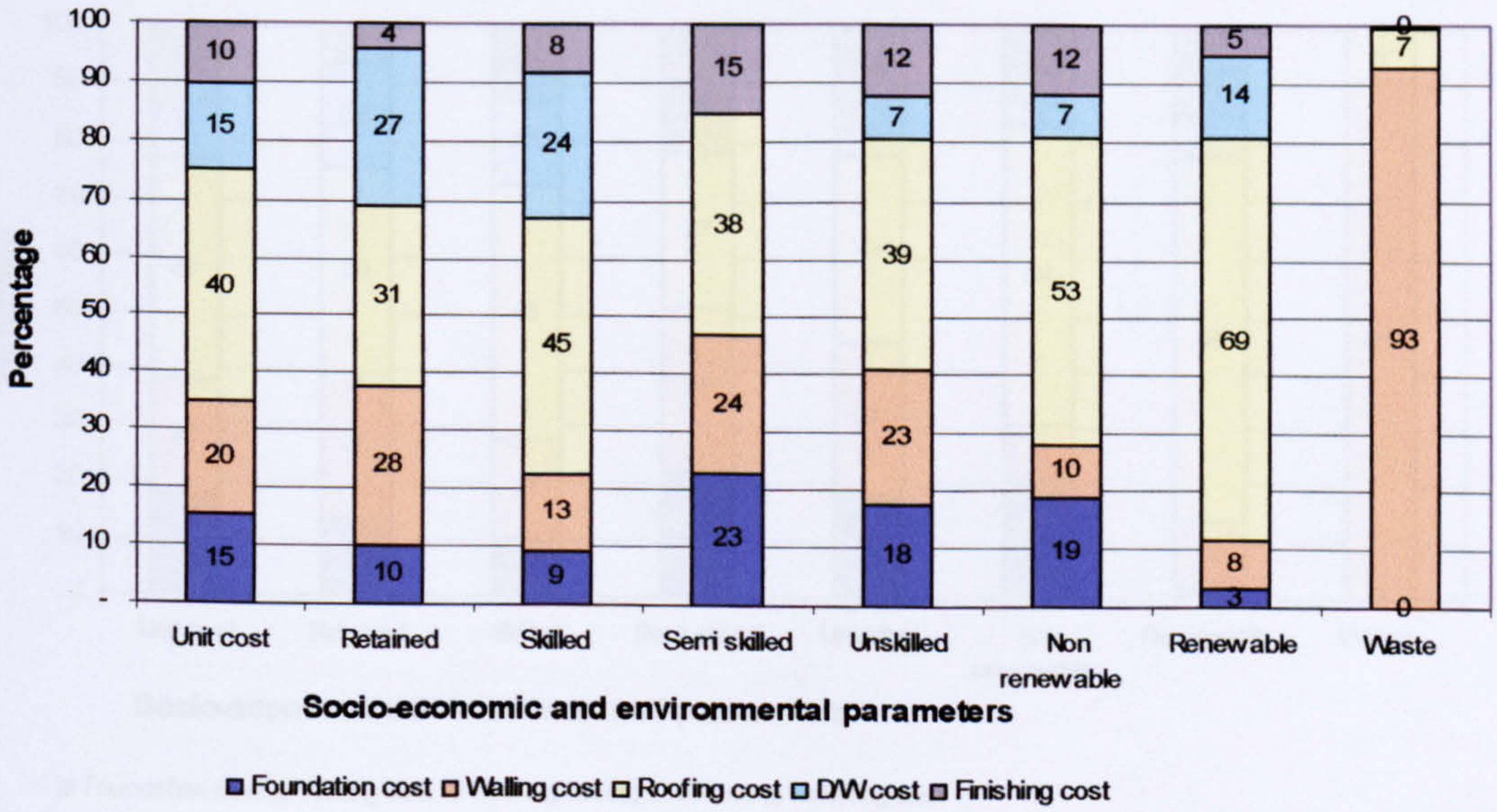
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (230x115x75 brick)	230 mm thick rat-trap bonded brick masonry in 1:6 cement-sand mortar
Roof	100mm thick reinforced cement concrete filler slab with Mangalore tiles
Door and window	frameless wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and flush pointing

Table VII.8 Socio-economic impacts of the primary school construction at **Luxmapur**

271,946.71		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,898.94	/sqm	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		292.14	73.84	15.85	24.60	57.11	221.76	14.83	0.26
Walling cost		372.98	199.02	22.73	25.75	73.98	113.45	41.67	808.97
Roofing cost		757.33	224.90	76.22	40.56	125.71	624.40	340.61	59.66
D/W cost		280.44	193.25	41.63	-	23.98	82.39	67.91	2.43
Finishing cost		196.05	31.15	14.25	16.15	39.53	144.47	25.77	0.024
Total (A+B+C+D+E)		1,898.94	722.16	170.69	107.06	320.31	1,186.46	490.79	871.35

Figure VII.7 The impacts of the foundation, walling and roofing systems combined was high at Luxmapur



PONNAL, RANGA REDDY EAST

Design reference- Annexure- VIII.10
Covered area - 126.73 sq.m.

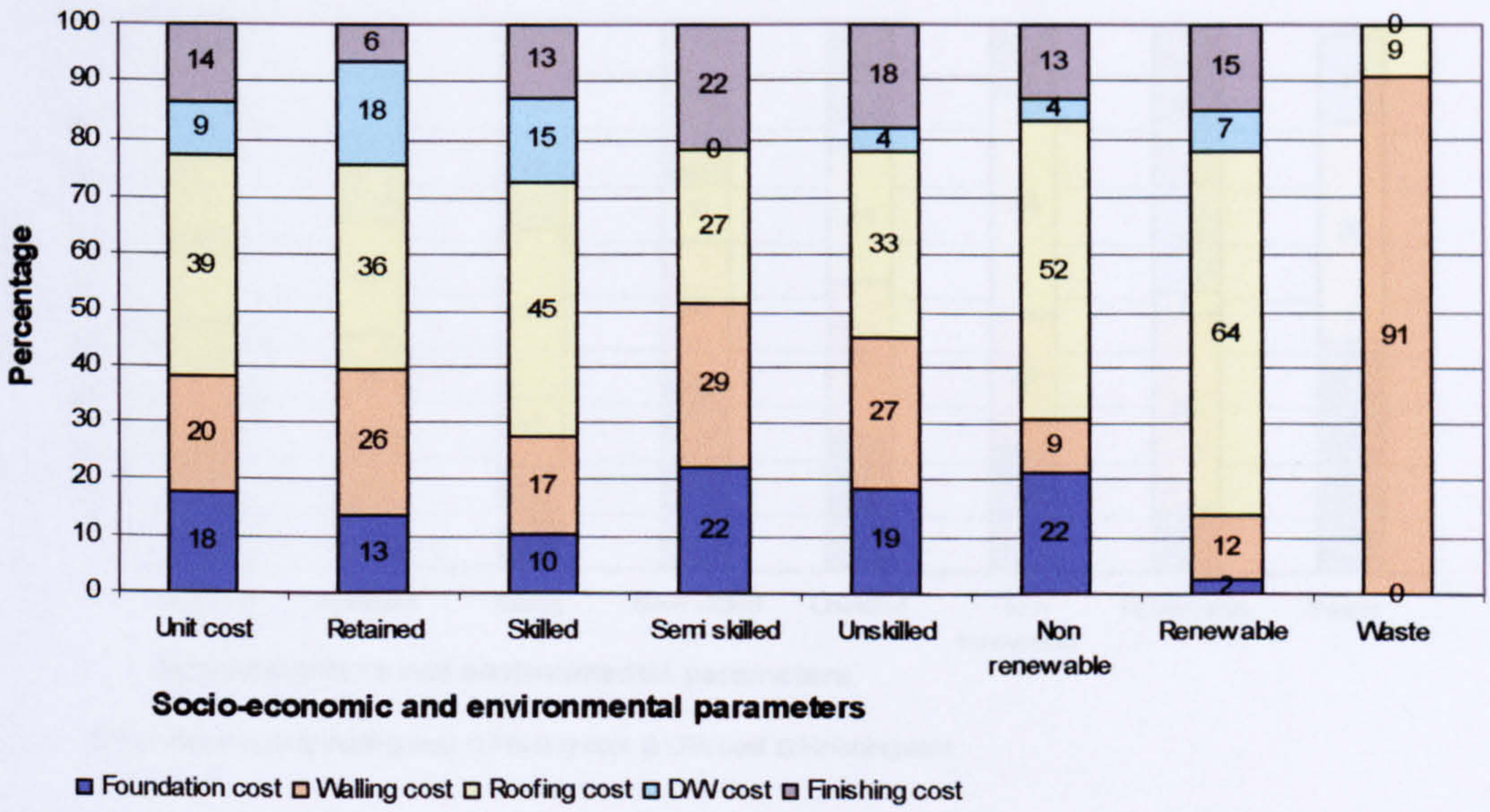
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (230x115x75 brick)	230 mm thick rat-trap bonded brick masonry in 1:6 cement-sand mortar
Roof	100mm thick reinforced cement concrete filler slab with Mangalore tiles
Door and window	frameless wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and flush pointing with 1:3 cement-sand mortar on exterior wall

Table VII.9 Socio-economic impacts of the primary school construction at **Ponnal**

234,792.82		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,852.70	/sqm	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		329.79	84.22	17.07	26.10	63.26	258.12	12.39	0.30
Walling cost		377.05	162.63	28.05	34.82	90.08	111.33	60.83	637.85
Roofing cost		729.05	227.20	73.91	31.45	110.32	624.90	330.75	62.64
D/W cost		162.08	112.15	23.75	-	13.68	44.90	37.01	1.34
Finishing cost		254.73	40.37	20.59	25.87	61.71	156.42	78.80	0.024
Total (A+B+C+D+E)		1,852.70	626.58	163.36	118.24	339.05	1,195.67	519.78	702.16

Figure VII.8 The impacts of the foundation, walling and roofing systems combined was high at Ponnal



HIMAYATSAGAR, RANGA REDDY WEST

Design reference- Annexure- VIII.14)
Covered area 67.3 sq.m .

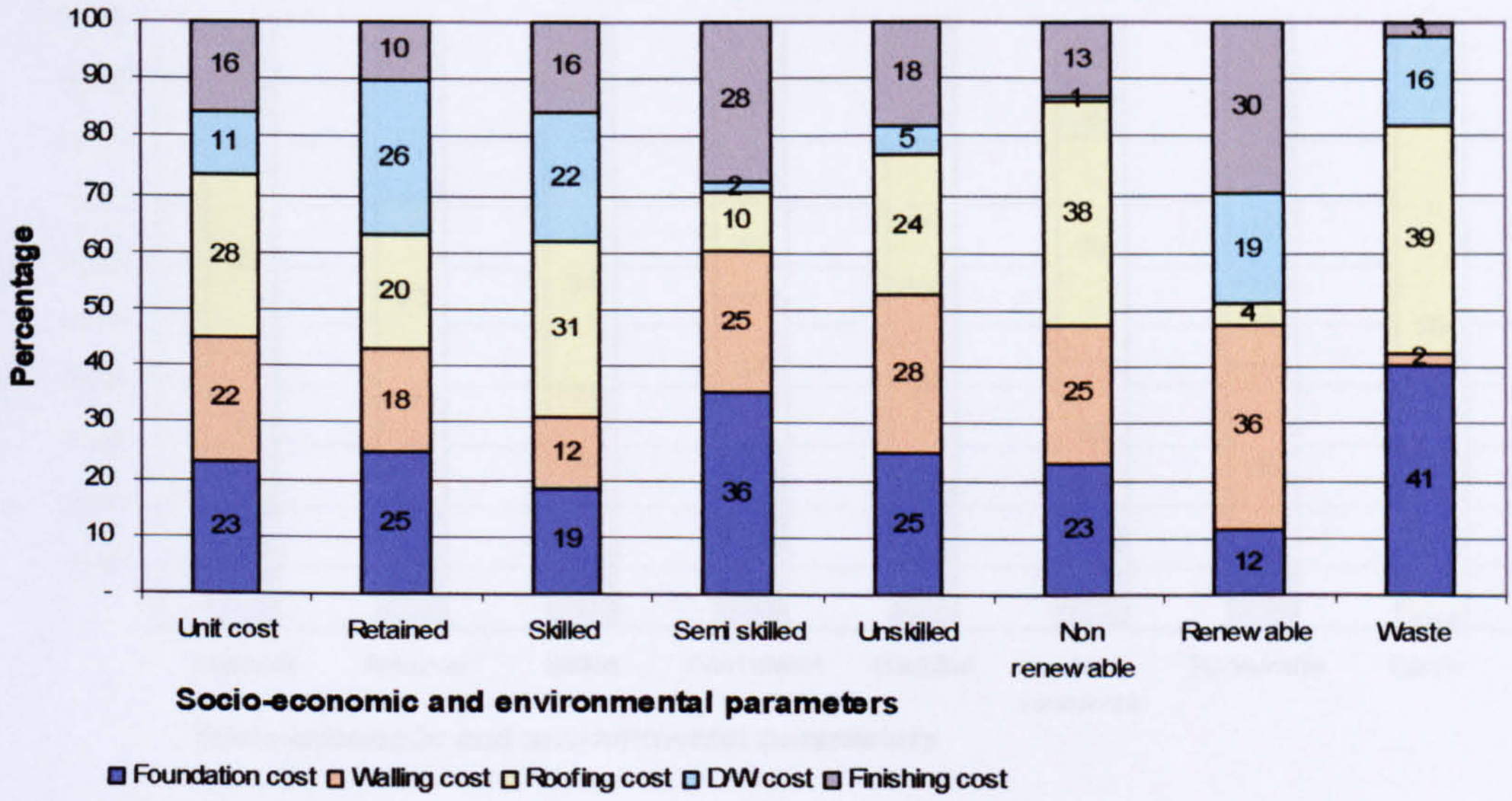
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (290x140x100 block)	140 mm thick interlocking cement stabilised mud block (10%) masonry in 1:6 cement-sand mortar
Roof	25mm thick precast ferrocement channel
Door and window	Mild steel angle door and window frames and wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and exposed exterior with 1:3 cement-sand mortar on exterior wall

Table VII.10 Socio-economic impacts of the primary school construction at **Himayatsagar**

101,131.45		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,503.14	/SQM	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		350.70	89.46	19.51	30.24	67.03	262.96	19.59	0.35
Walling cost		326.64	65.34	13.04	21.03	77.08	280.00	59.25	0.02
Roofing cost		425.94	73.10	32.68	8.63	65.48	437.39	6.10	0.33
D/W cost		166.67	94.95	23.17	1.46	13.38	9.83	31.81	0.13
Finishing cost		233.19	36.76	16.64	23.45	49.24	151.04	49.68	0.02
Total (A+B+C+D+E)		1,503.14	359.60	105.04	84.81	272.21	1,141.23	166.43	0.86

Figure VII.9 The impacts of the foundation, wall and roof combined was high at Himayatsagar



PUPPALGUDA, RANGA REDDY WEST

Design reference- Annexure- VIII.21
Covered area - 137.3 **s**q.m .

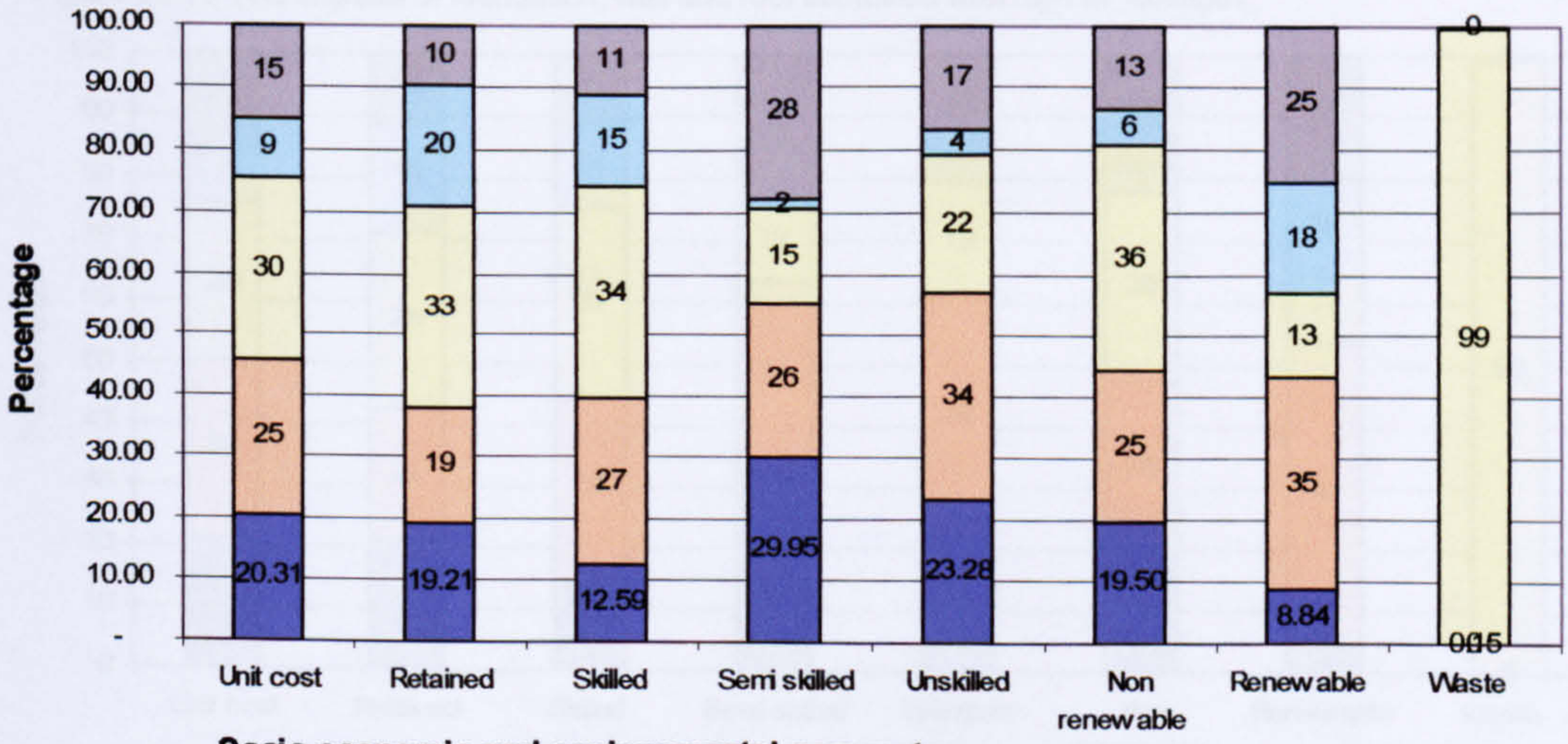
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (230x108x76 block)	230 mm thick cement stabilised mud block (5%) masonry in 1:4:8 cement-sand-mud mortar
Roof	jackarch in brick masonry in 1:6 cement-sand mortar on precast reinforced cement concrete joists micro concrete tile roofing on steel and timber under-structure
Door and window	mild steel angle door and window frames and wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and exterior of wall

Table VII.11 Socio-economic impacts of the primary school construction at **Puppalguda**

187,060.44		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,362.42	/sqm	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		276.74	70.24	14.57	22.23	56.07	207.75	12.00	0.29
Walling cost		345.49	69.76	31.50	19.04	81.09	266.57	47.03	0.06
Roofing cost		407.99	119.23	39.68	11.31	53.46	384.89	18.12	191.95
D/W cost		122.82	71.65	17.11	1.15	9.66	62.69	24.08	0.86
Finishing cost		209.38	34.77	12.84	20.50	40.60	143.55	34.42	0.02
Total (A+B+C+D+E)		1,362.42	365.65	115.70	74.24	240.87	1,065.4	135.64	193.18

Figure VII.10 The impacts of the foundation, wall and roof combined was high at Puppalguda



KOKAPET, RANGA REDDY WEST

Design reference- Annexure- VIII.22)
Covered area - 67.3 sq.m .

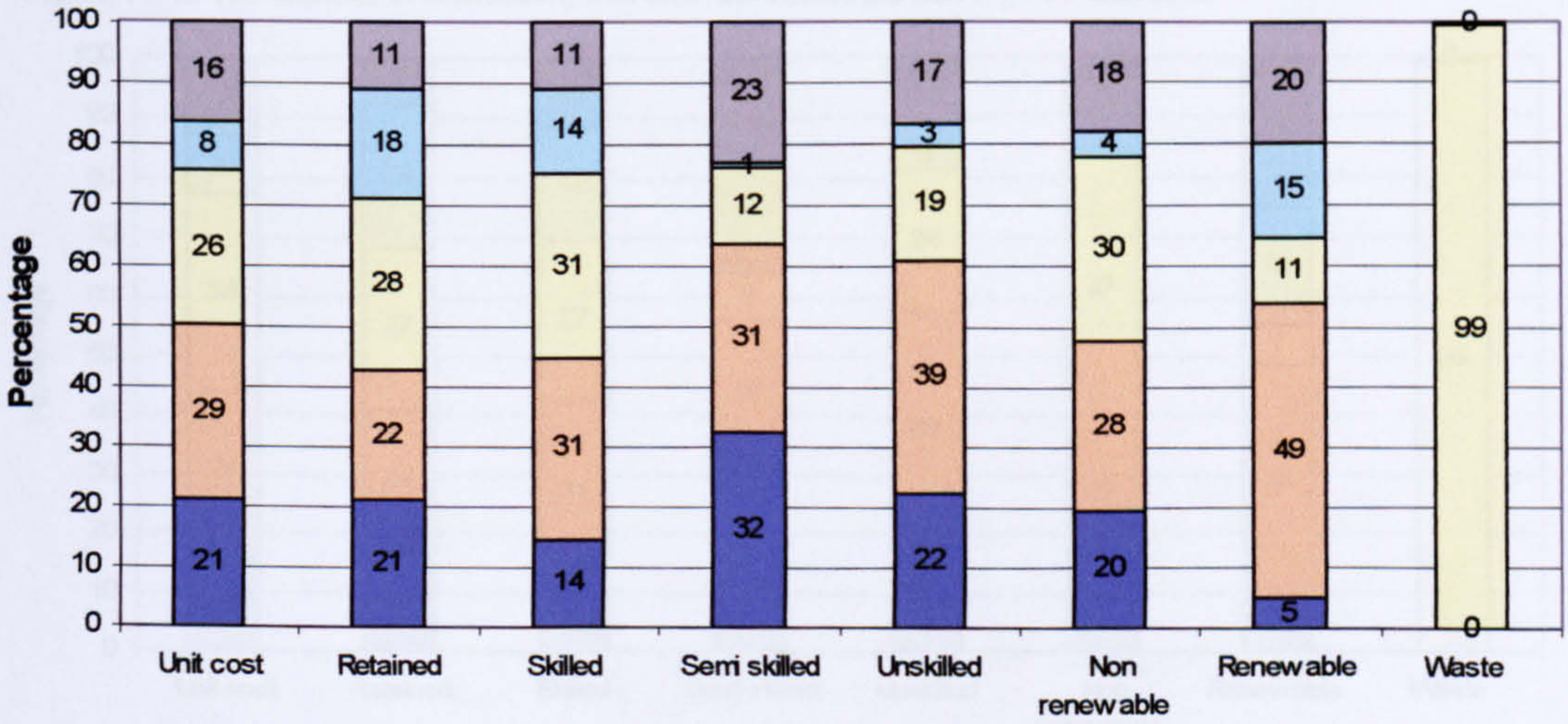
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (230x108x76 block)	230 mm thick cement stabilised mud block (5%) masonry in 1:4:8 cement-sand-mud mortar
Roof	jackarch in brick masonry in 1:6 cement-sand mortar on precast reinforced cement concrete joists micro concrete tile roofing on steel and timber under-structure
Door and window	mild steel angle door and window frames and wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and exterior with groove pointing in 1:3 cement sand mortar

Table VII.12 Socio-economic impacts of the primary school construction at **Kokapet**

104,143.96		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,547.46	/SQM	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		329.61	85.68	18.24	29.42	62.43	236.84	8.44	0.21
Walling cost		447.42	88.90	38.68	28.58	108.41	339.75	79.14	0.16
Roofing cost		395.78	116.23	38.82	11.25	52.20	368.63	17.86	188.60
D/W cost		121.25	72.99	17.11	0.82	9.59	54.09	24.83	0.88
Finishing cost		253.40	44.20	13.76	20.78	46.86	214.00	32.62	0.03
Total (A+B+C+D+E)		1,547.46	407.99	126.61	90.85	279.50	1,213.3	162.90	189.89

Figure VII.11 Tthe impacts of foundation, wall and roof combined was high at Kokapet,



GANDIPET, RANGA REDDY WEST

Design reference- Annexure- VIII.23
Covered area - 71.16 sqm

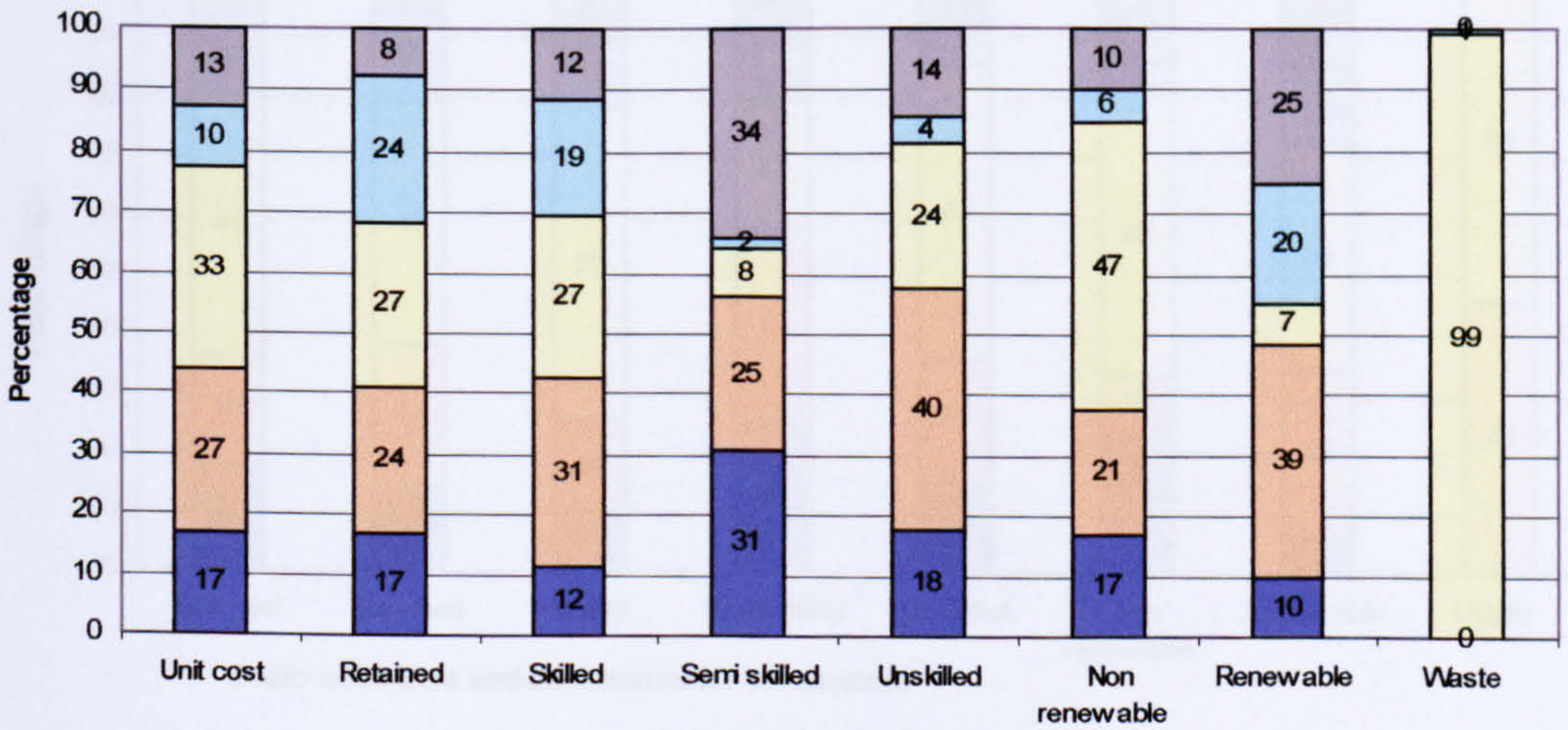
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (230x108x76 block)	230 mm thick cement stabilised mud block (5%) masonry in 1:4:8 cement-sand-mud mortar
Roof	jackarch in brick masonry in 1:6 cement-sand mortar on precast reinforced cement concrete joist micro concrete tile roofing on steel and timber under-structure
Door and window	mild steel angle door and window frames and wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and exterior with groove pointing in 1:3 cement sand mortar

Table VII.13 Socio-economic impacts of the primary school construction at **Gandipet**

136,188.23		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,913.83	/SQM	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		324.69	81.45	16.71	24.65	62.87	264.34	19.48	0.38
Walling cost		518.36	115.99	44.27	20.36	141.12	330.55	77.07	0.02
Roofing cost		637.50	132.39	38.65	6.39	83.90	736.85	14.52	201.60
D/W cost		191.82	115.53	27.07	1.39	15.31	88.31	39.28	1.40
Finishing cost		241.46	37.33	16.63	27.33	50.43	152.14	49.77	0.02
Total (A+B+C+D+E)		1913.83	482.69	143.32	80.11	353.64	1572.19	200.11	203.42

Figure VII.12 The impacts of foundation, wall and roof combined was high at Gandipet



JAGGAMGUDA, RANGA REDDY EAST

Design reference- Annexure- VIII.5

Covered area 52.72 sqm

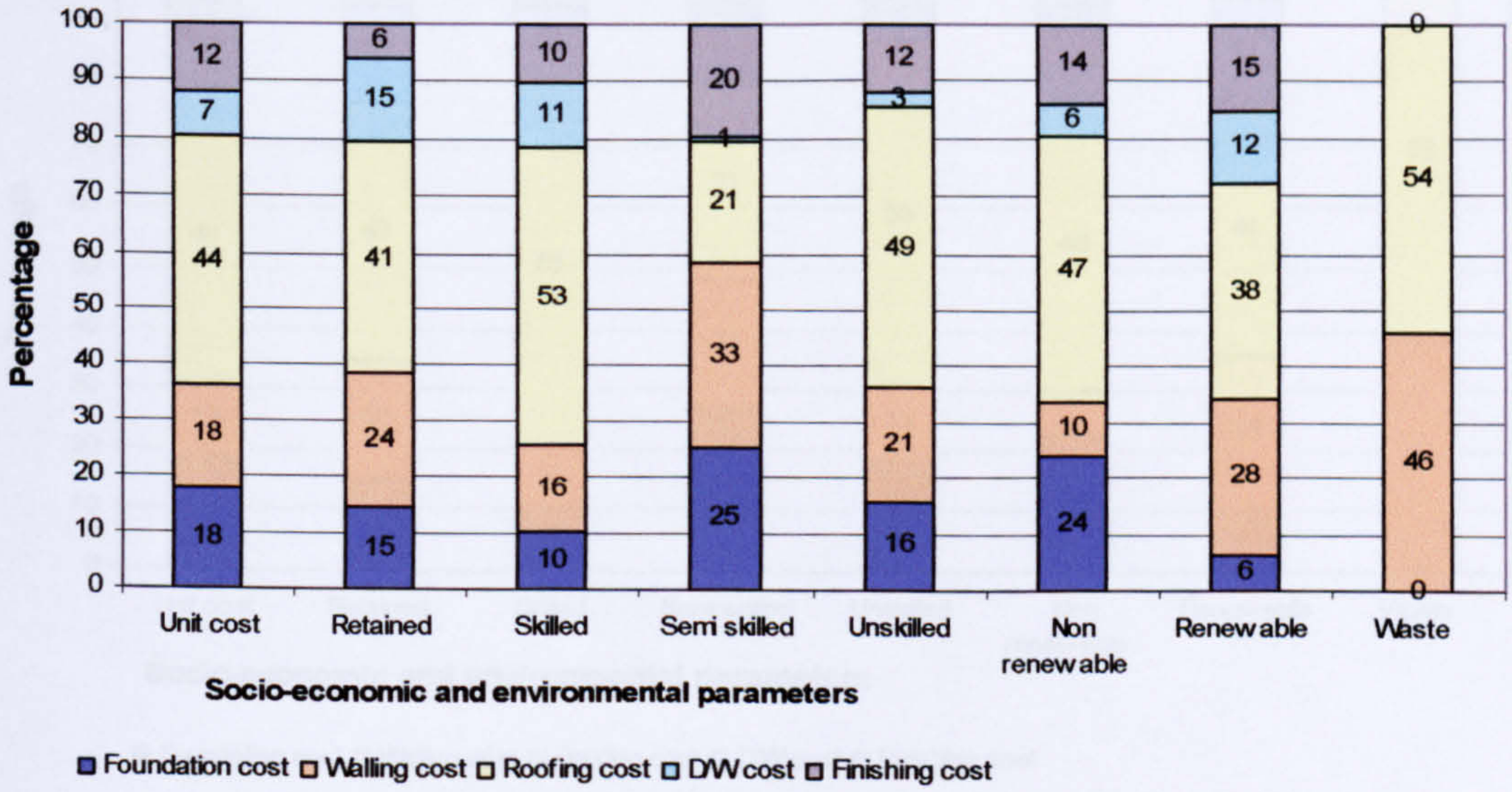
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (230x115x75 brick)	230 mm thick rat-trap bonded brick masonry in 1:6 cement-sand mortar
Roof	Corbelled brick pyramid in 1:6 cement-sand mortar
Door and window	mild steel angle door and window frames and wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and flush pointing with 1:3 cement-sand mortar on exterior wall

Table VII.14 Socio-economic impacts of the primary school construction at **Jaggamguda**

95570.33	Foundation cost	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1812.79	/SQM	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		325.53	83.09	16.78	25.24	62.37	257.54	14.08	0.34
Walling cost		334.53	136.64	25.77	33.27	81.93	102.65	61.24	525.72
Roofing cost		798.76	234.64	86.92	20.72	195.85	497.99	84.42	611.46
D/W cost		135.92	82.87	18.56	0.90	10.70	58.96	27.51	1.00
Finishing cost		218.05	32.98	16.80	19.59	47.21	152.76	33.90	0.02
Total (A+B+C+D+E)		1812.79	570.22	164.83	99.71	398.07	1069.90	221.15	1138.54

Figure VII.13 The impacts of the roof was high at Jaggamguda



TURKAPALLY, RANGA REDDY EAST

Design reference- Annexure- VIII.2)

covered area : 124.76 sqm

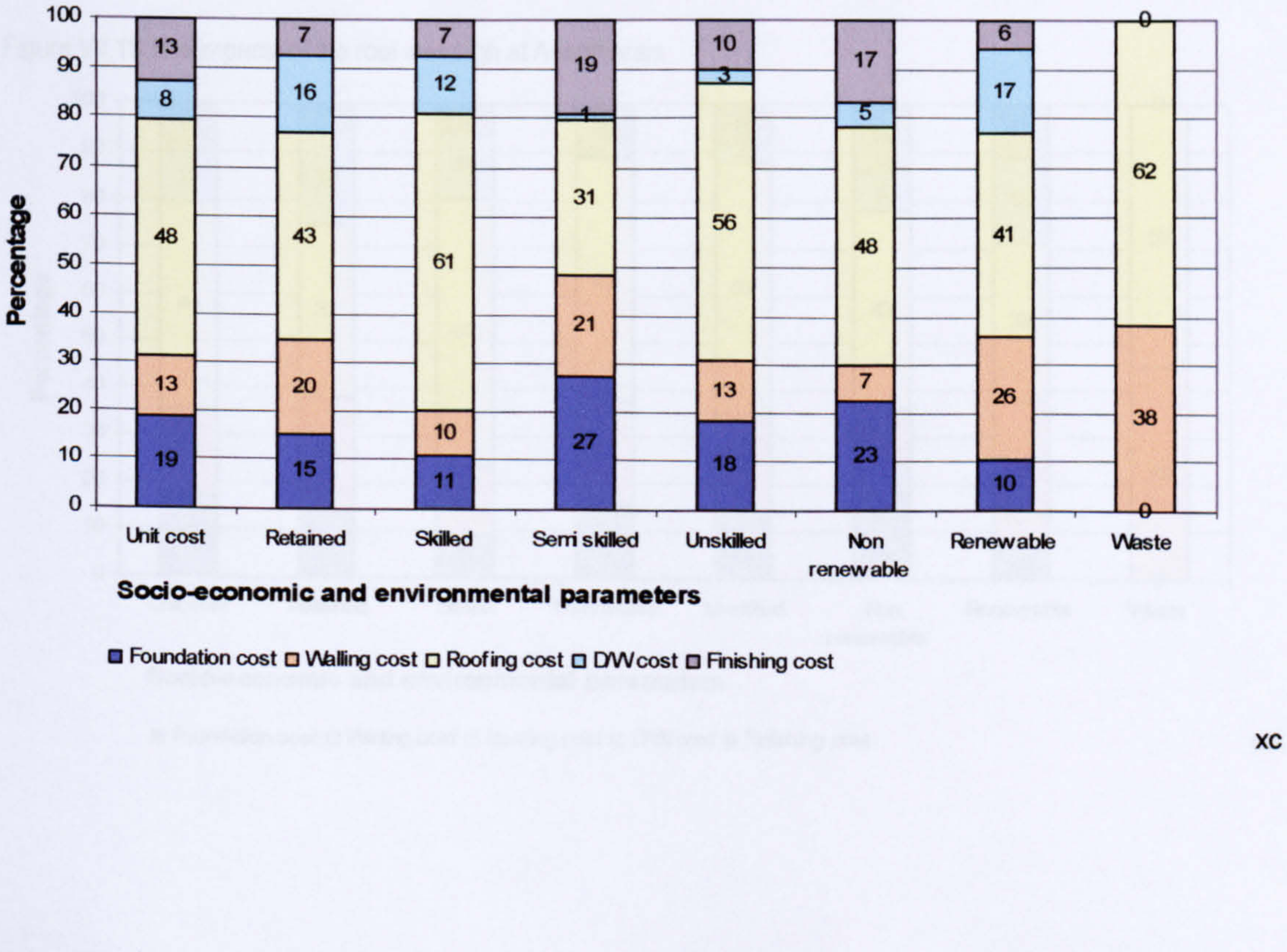
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (230x115x75 brick)	230 mm thick and 115mm thick solidat-trap bonded brick masonry in 1:6 cement-sand mortar
Roof	Corbelled brick pyramid in 1:6 cement-sand mortar
Door and window	mild steel angle door and window frames and wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and cement paint on exterior

Table VII.15 Socio-economic impacts of the primary school construction at **Turkapally.**

175,001.51		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,402.71	/SQM	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		260.49	64.45	13.41	20.28	54.22	202.80	13.53	0.26
Walling cost		178.30	83.33	11.90	15.80	37.42	64.89	33.27	308.12
Roofing cost		671.89	181.37	75.54	23.38	166.48	427.00	53.30	497.93
D/W cost		110.03	66.16	14.67	0.70	8.18	46.67	22.49	0.80
Finishing cost		181.99	31.36	9.21	14.36	30.50	148.40	7.56	0.03
Total (A+B+C+D+E)		1,402.71	426.66	124.72	74.52	296.80	889.76	130.15	807.14

Figure VII.14 The impacts of the roof was high at Turkapally



XC

ANANTHARAM, RANGA REDDY EAST

Design reference- Annexure- VIII.3)

covered area : 77.65 sqm

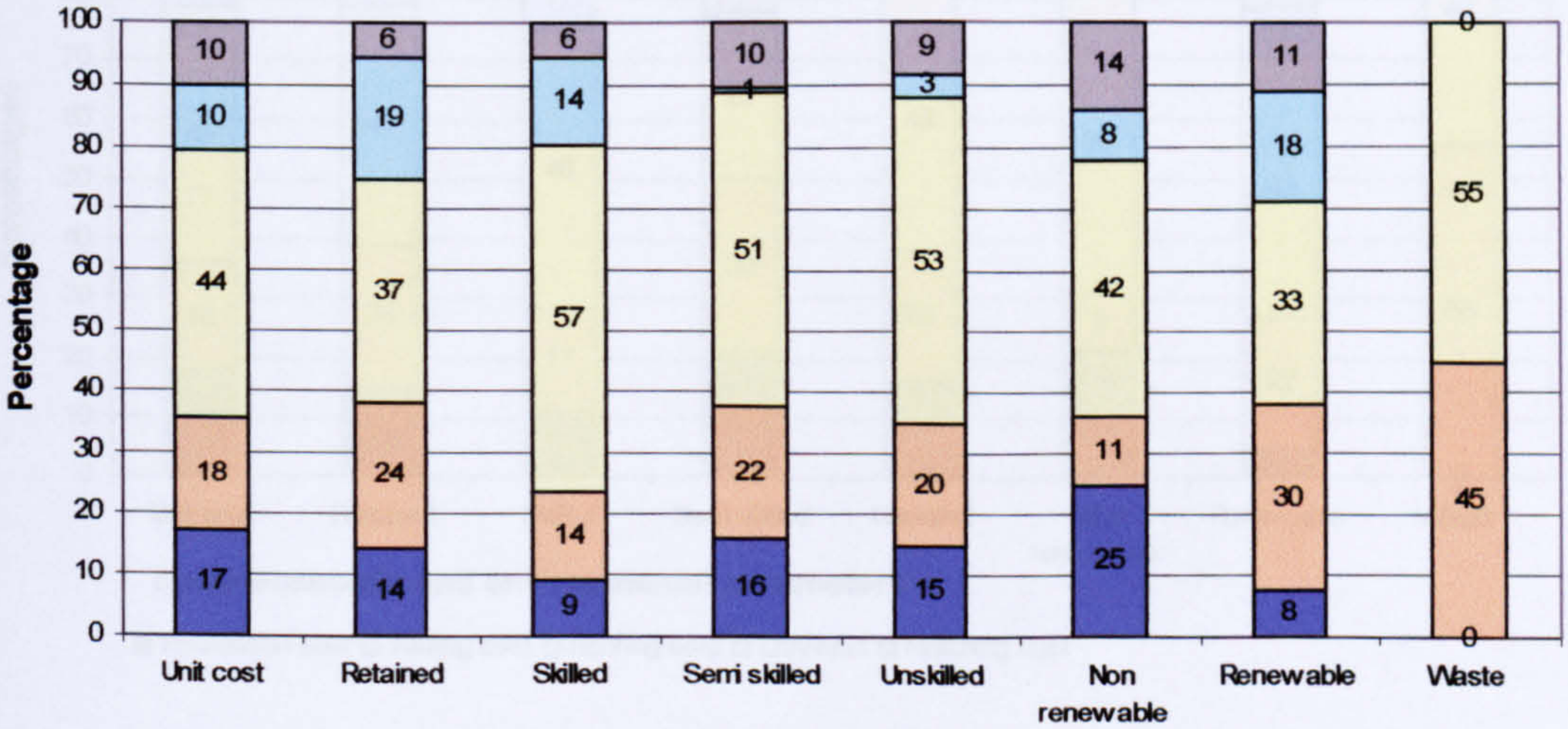
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (230x115x75 brick)	230 mm thick rat-trap bonded brick masonry in 1:6 cement-sand mortar
Roof	Corbelled brick arch in 1:6 cement-sand mortar
Door and window	mild steel angle door and window frames and wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and cement paint on exterior

Table VII.16 Socio-economic impacts of the primary school construction at **Anantharam.**

130,057.07		**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1,674.91	/SQM	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		289.00	72.99	15.29	23.35	55.96	226.16	14.63	0.28
Walling cost		304.56	119.58	23.10	31.39	74.69	104.85	57.63	450.36
Roofing cost		741.20	187.25	93.69	74.15	198.34	380.90	62.40	557.86
D/W cost		170.47	99.02	22.53	1.22	13.02	76.12	33.40	1.19
Finishing cost		169.68	29.05	9.42	15.11	31.91	126.38	21.18	0.02
Total (A+B+C+D+E)		1,674.91	507.90	164.02	145.21	373.91	914.41	189.23	1,009.72

Figure VII.15 The impacts of the roof was high at Anantharam



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LALGADIMALAKPET, RANGA REDDY EAST

Design reference- Annexure- VIII.4)
Covered area 56.36

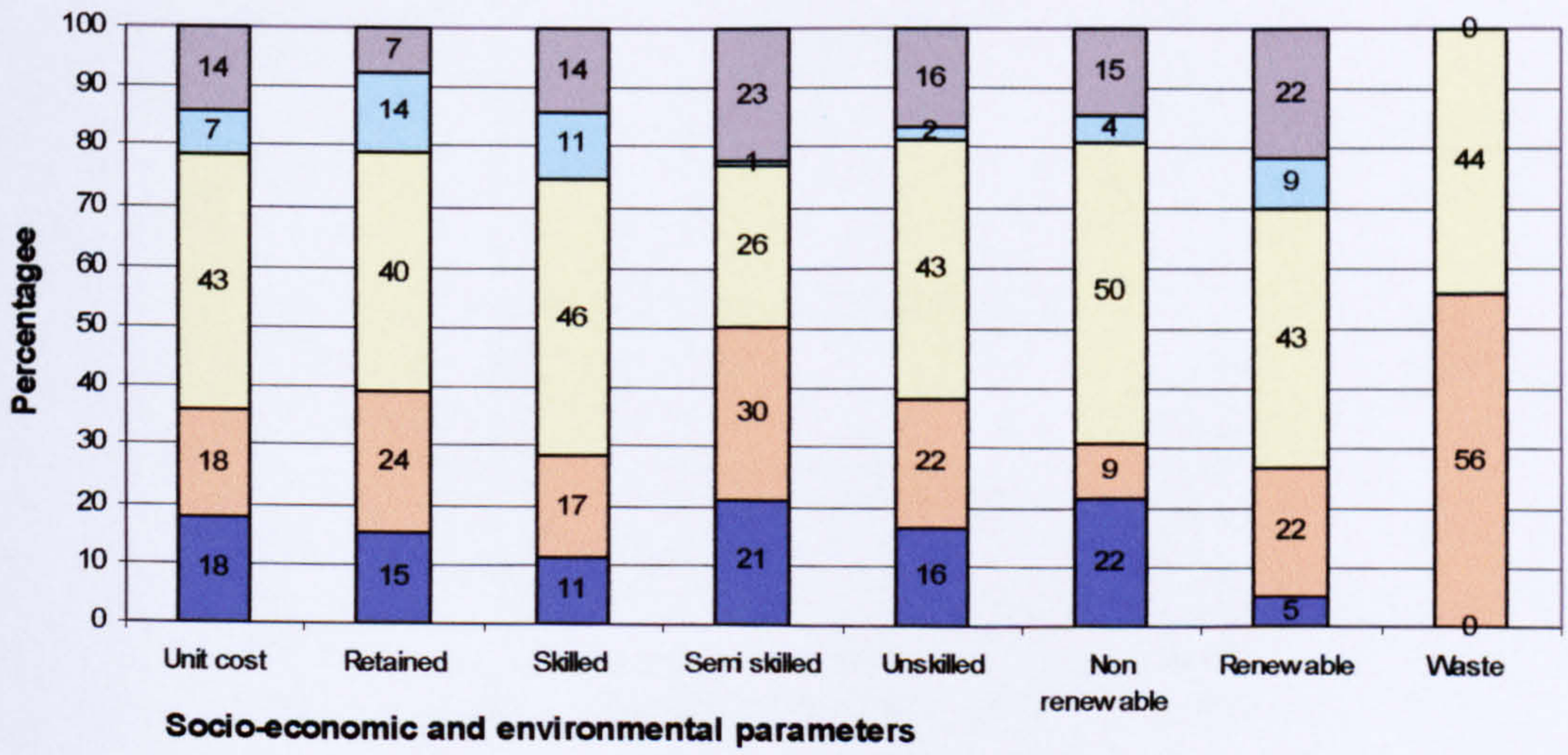
Construction technologies

Foundation	380 thick course and random rubble stone masonry in 1:6 cement mortar
Wall (230x115x75 brick)	230 mm thick rat-trap bonded brick masonry in 1:6 cement-sand mortar
Roof	Corbelled brick pyramid in 1:6 cement-sand mortar
Door and window	mild steel angle door and window frames and wooden shutter
Finishing	rough Tandur stone floor, plastered and lime washed interior and 1:3 cement ppointing on exterior

Table VII.17 Socio-economic impacts of the primary school construction at **Lalgadimalakpet**

96104.46	Foundation cost	**Unit cost**	**Retained**	**Skilled**	**Semi skilled**	**Unskilled**	**Non renewable**	**Renewable**	**Waste**
1705.19	/SQM	Rs./sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	Rs./ sq.m.	MJ/ sq.m.	MJ/ sq.m.	MJ/ sq.m.
Foundation cost		299.55	76.08	15.20	22.66	57.85	240.35	13.27	0.32
Walling cost		311.37	120.94	23.96	31.70	77.78	102.68	56.59	457.65
Roofing cost		730.0	199.4	63.8	28.1	152.4	555.2	112.2	363.3
D/W cost		123.02	68.57	15.02	0.80	8.44	49.17	22.33	0.81
Finishing cost		241.2	36.3	19.5	24.2	57.9	162.1	56.0	0.0
Total (A+B+C+D+E)		1705.19	501.27	137.47	107.44	354.37	1109.47	260.45	822.13

Figure VII.16 The impacts of the wall and roof combined was high at Lalgadimalakpet

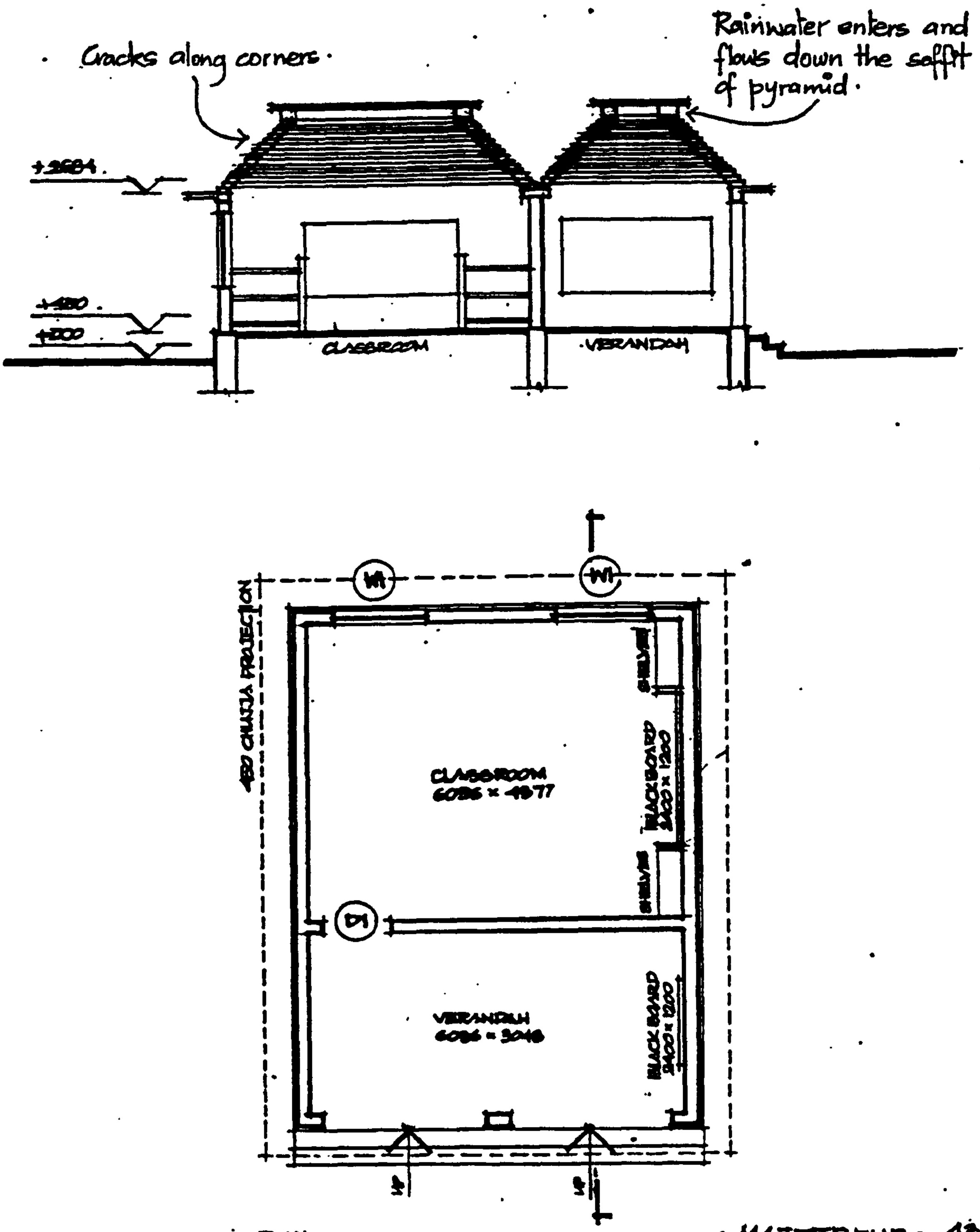


APPENDIX VIII

DEFECT MAPPING: REPAIR AND UPGRADING PROGRAMME OF THE SCHOOLS CONSTRUCTED UNDER ANDHRA PRADESH PRIMARY EDUCATION PROJECT.

Special note: the investigation team from Intermediate Technology Development Group, UK and National Council for Cement and Building Materials carried out the initial defect studies. However, prior to the implementation of the Repair and Upgrading, the government engineers, the communities and DFID consultants carried out a very in-depth exercise and made the following defect mapping.

Figure VIII.1 Majeedpur, Ranga Reddy East, Andhra Pradesh.



PLAN

• MAJEEDPUR • 43

Figure VIII.2 : Turkapally, Ranga Reddy East, Andhra Pradesh.

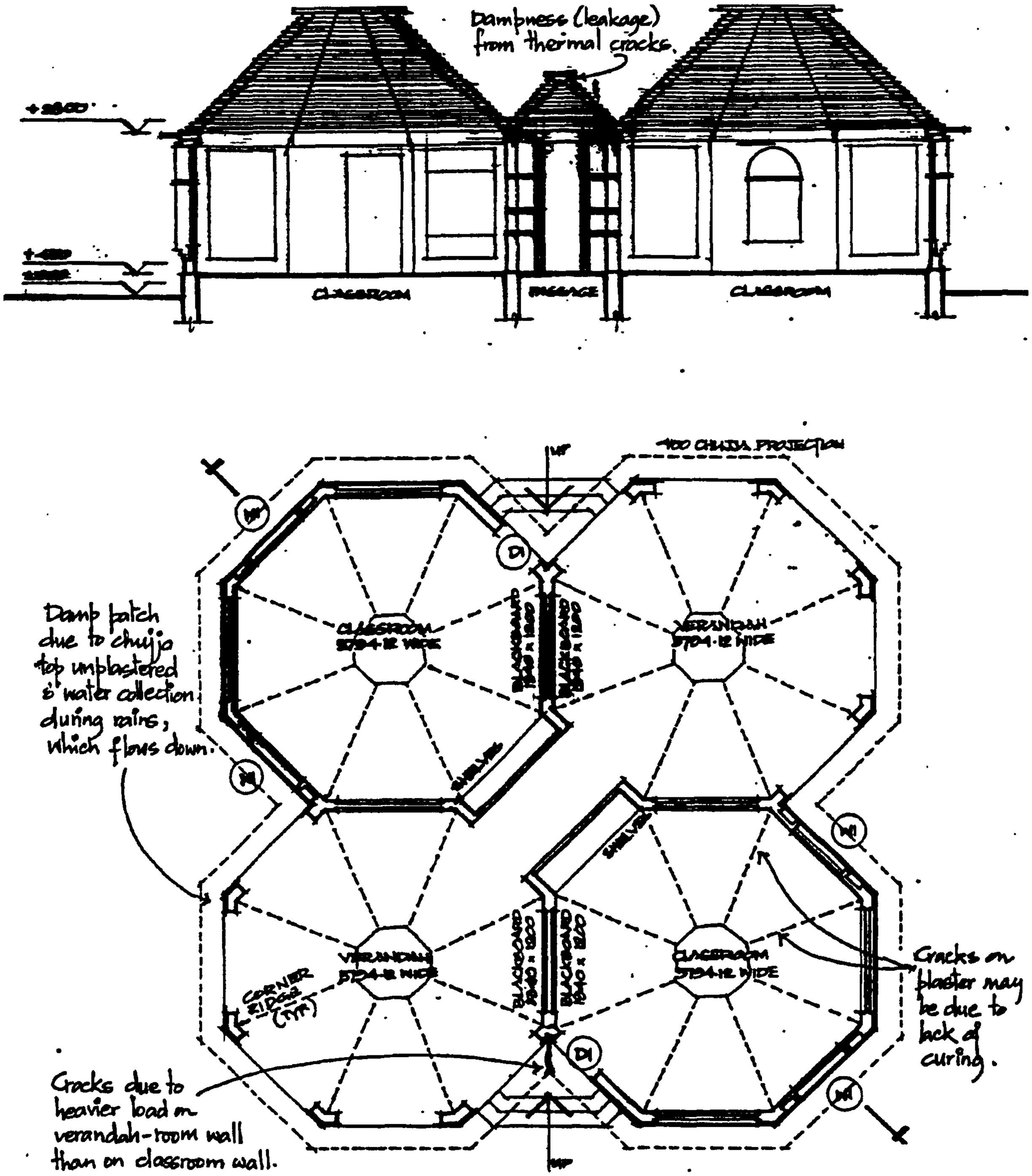
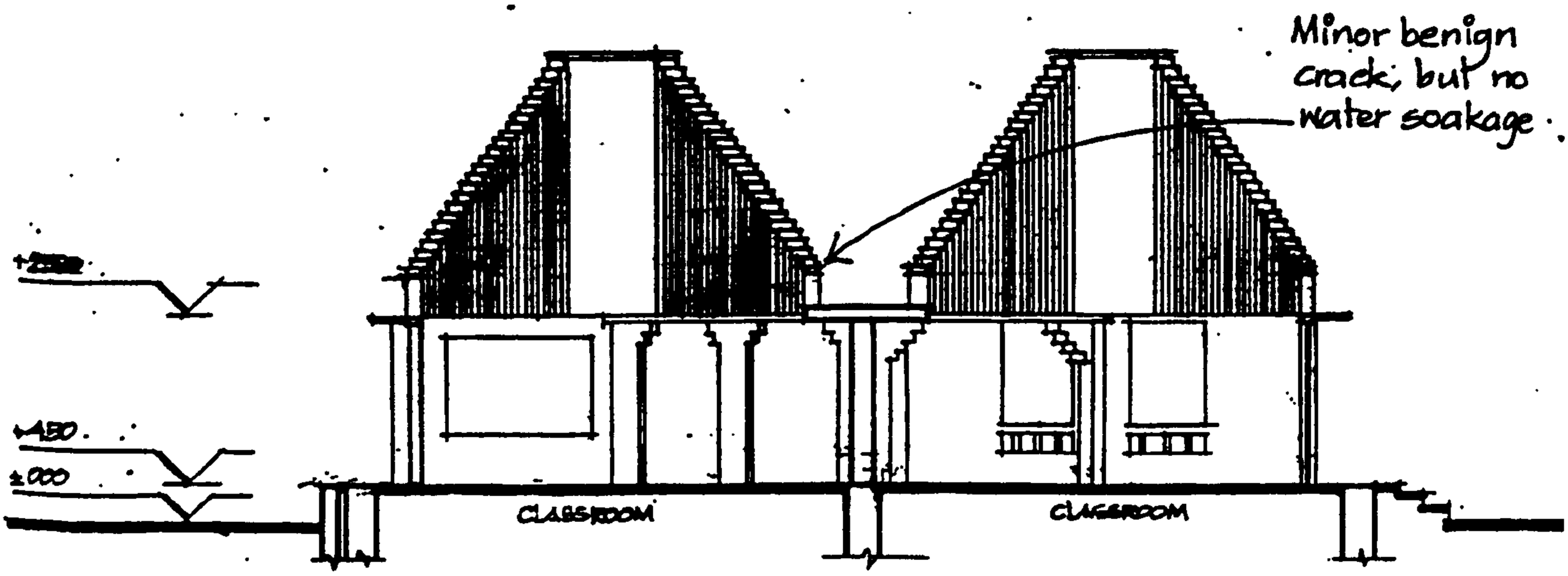
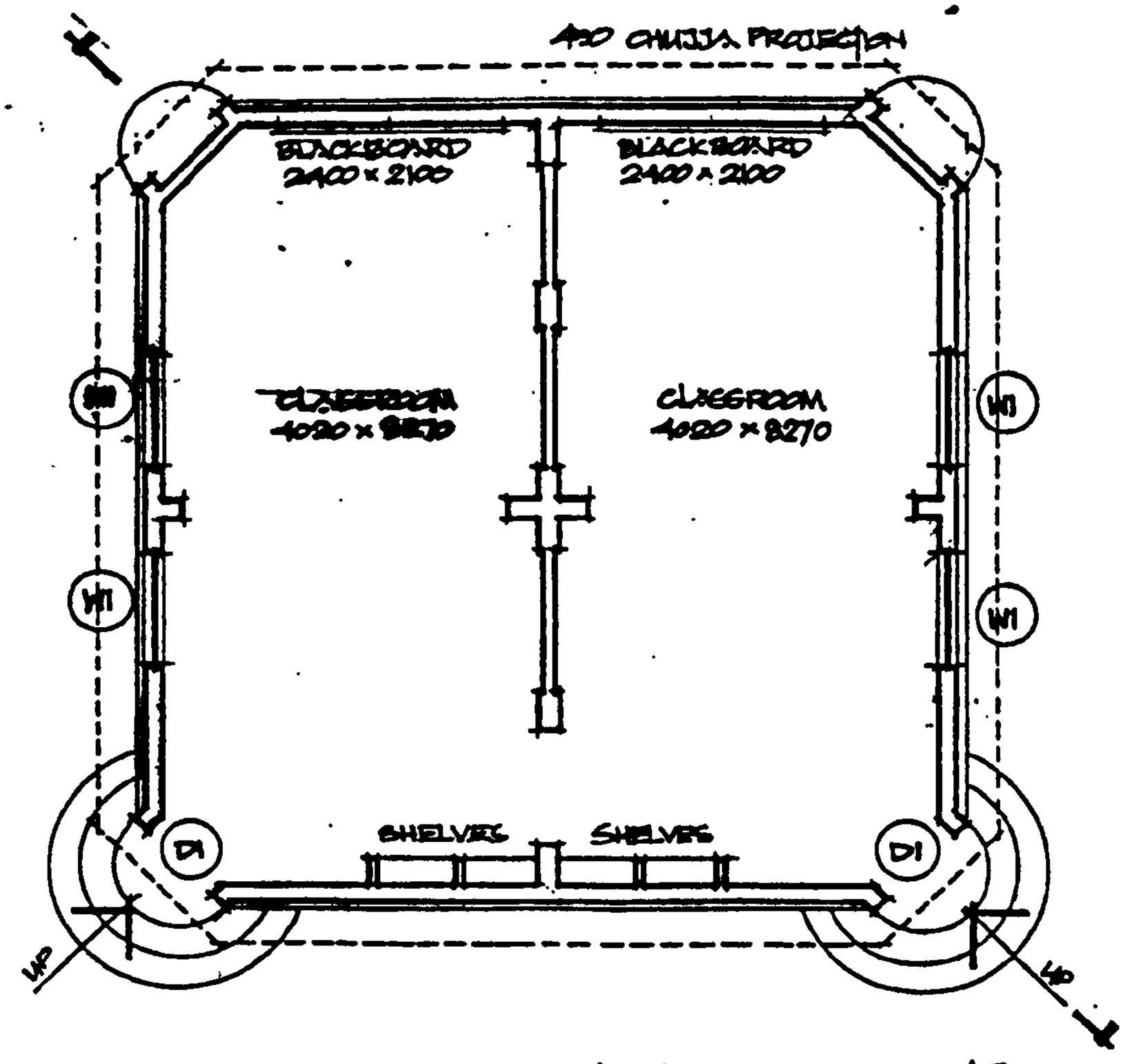


Figure VIII.3: Anantharam, Ranga Reddy East, Andhra Pradesh.





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Figure VIII.4 : Lalgadimalakpet, Ranga Reddy East, Andhra Pradesh.

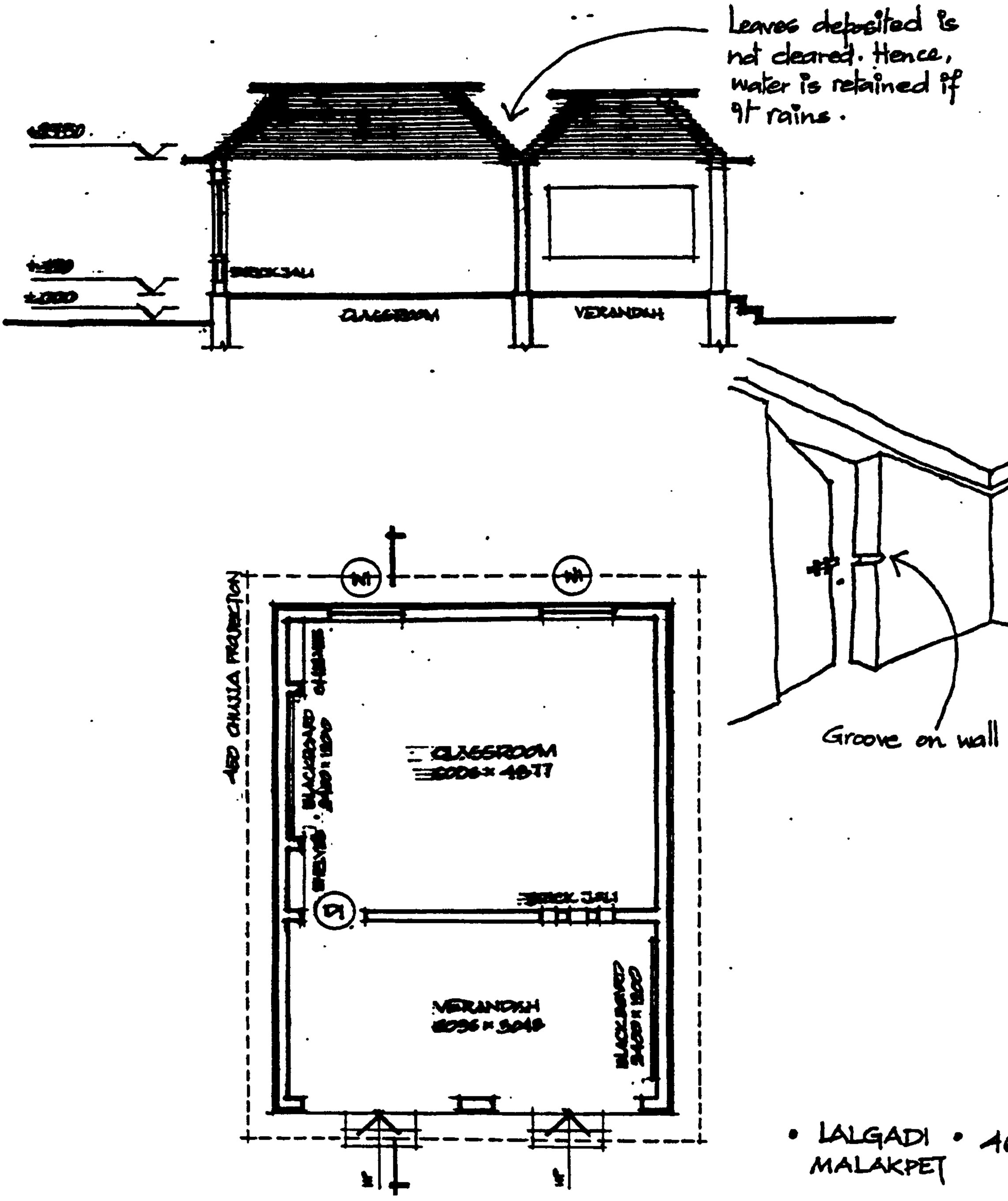


Figure VIII.5: Jaggamguda, Ranga Reddy East, Andhra Pradesh.

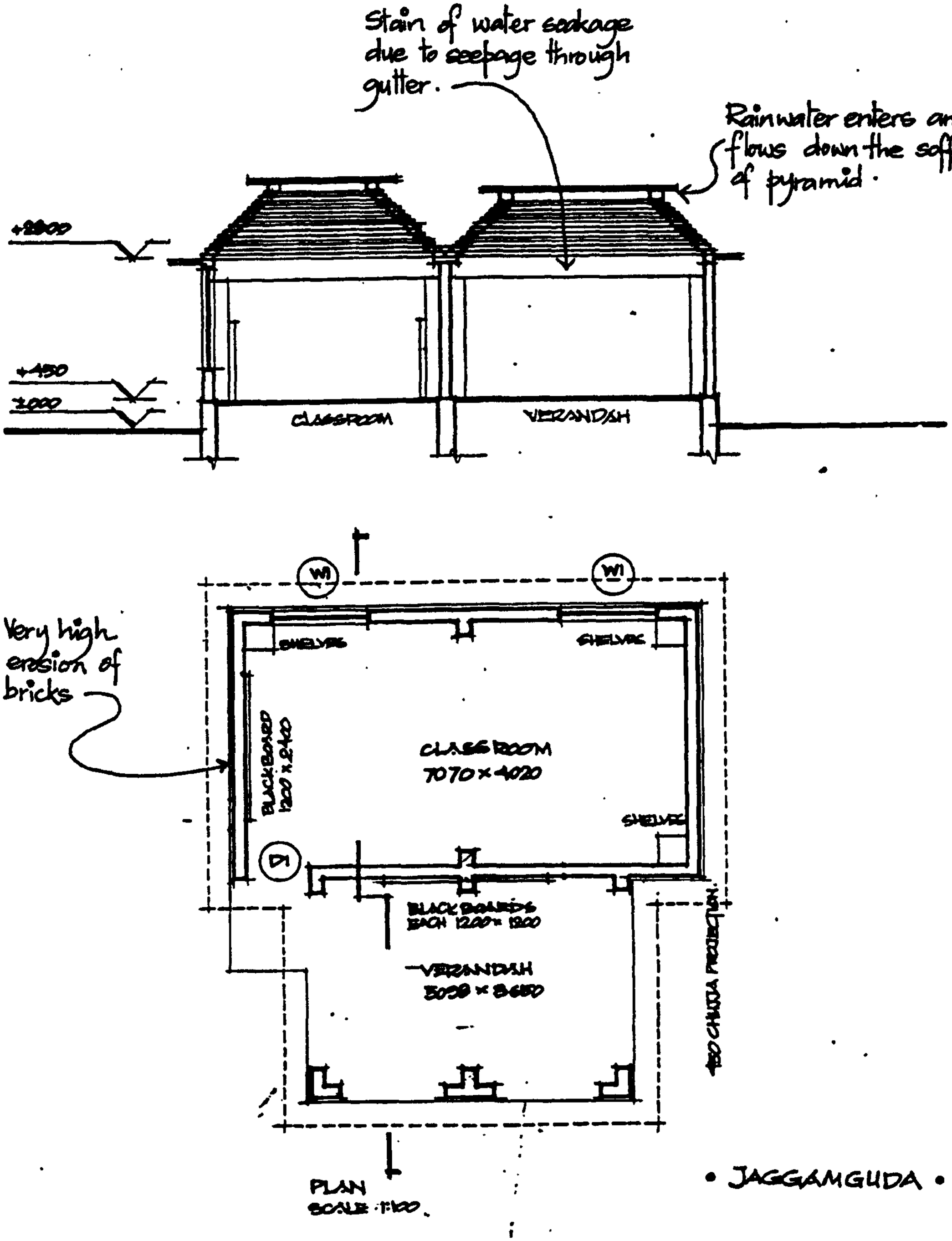
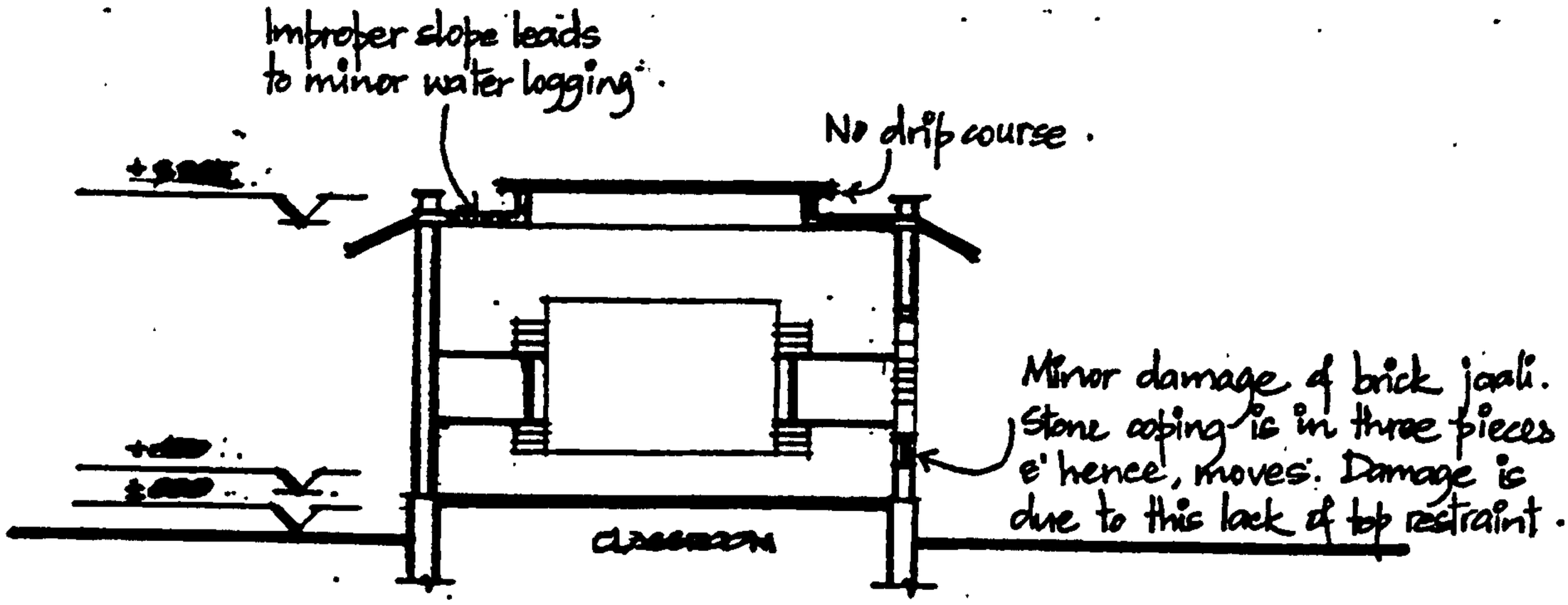
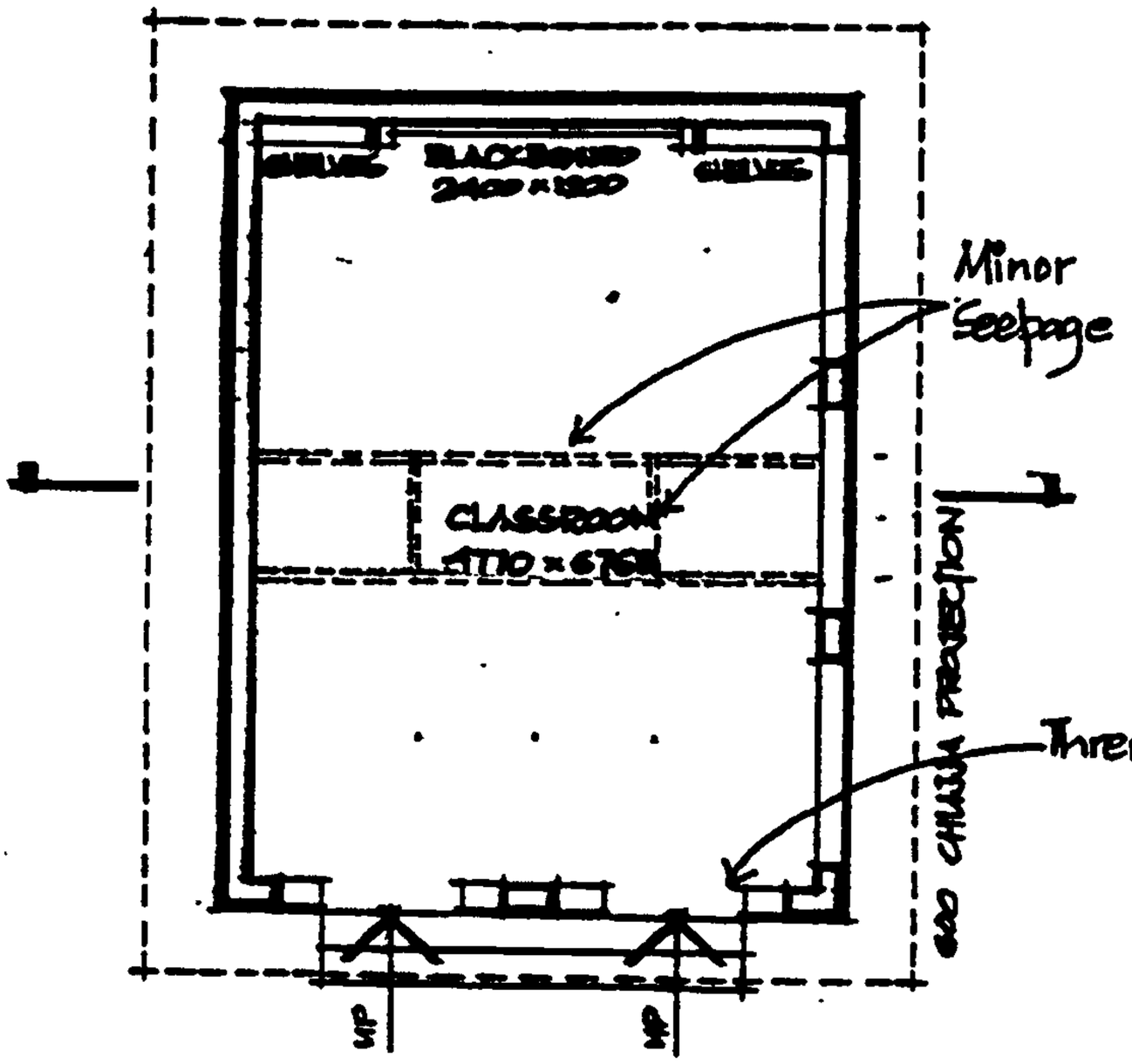


Figure VIII.6 : MC Pally, Ranga Reddy East, Andhra Pradesh.





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Figure VIII.7 Luxmapur, Ranga Reddy East, Andhra Pradesh

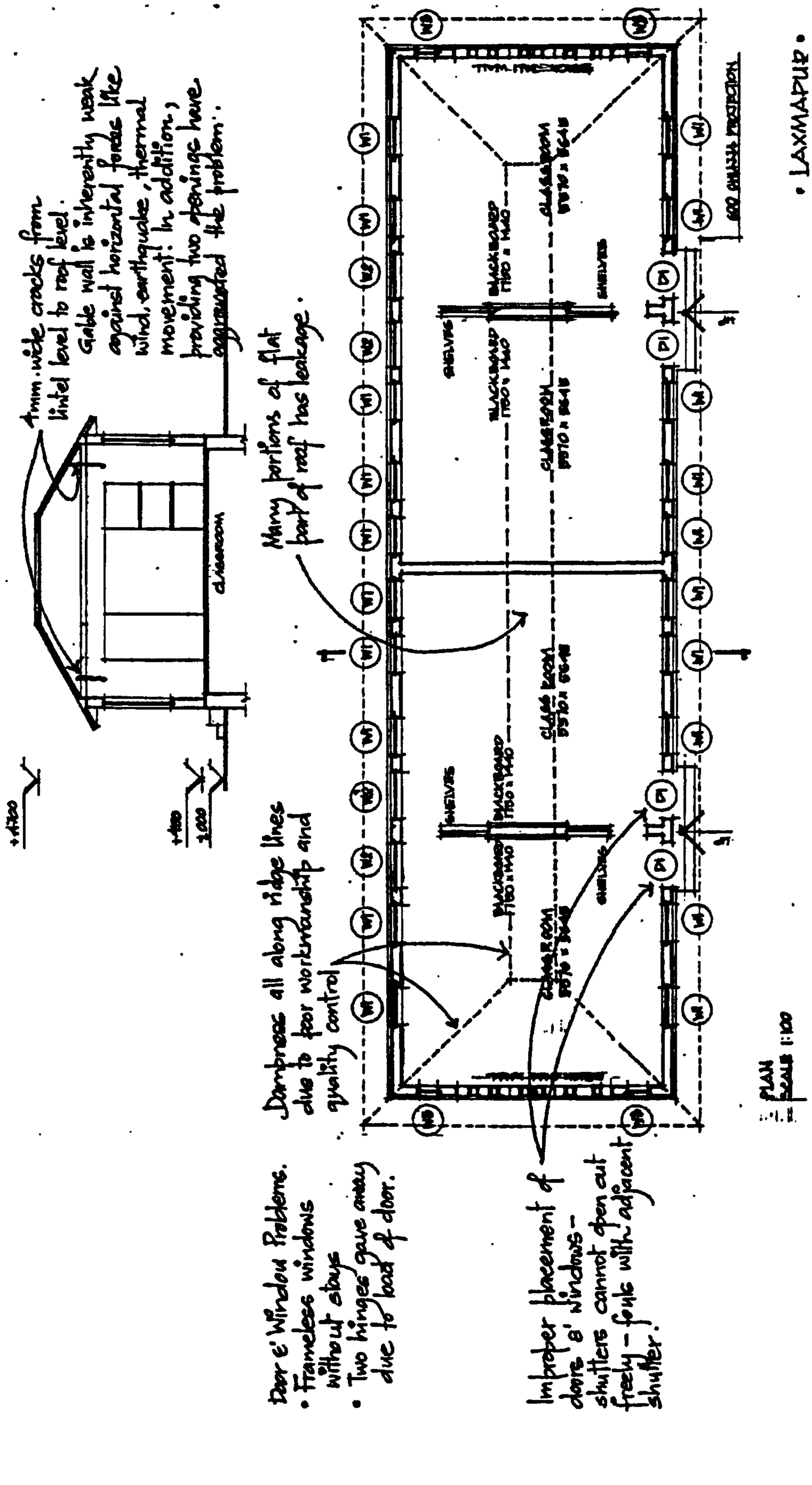


Figure VIII.8 Keshavpur, Ranga Reddy East, Andhra Pradesh

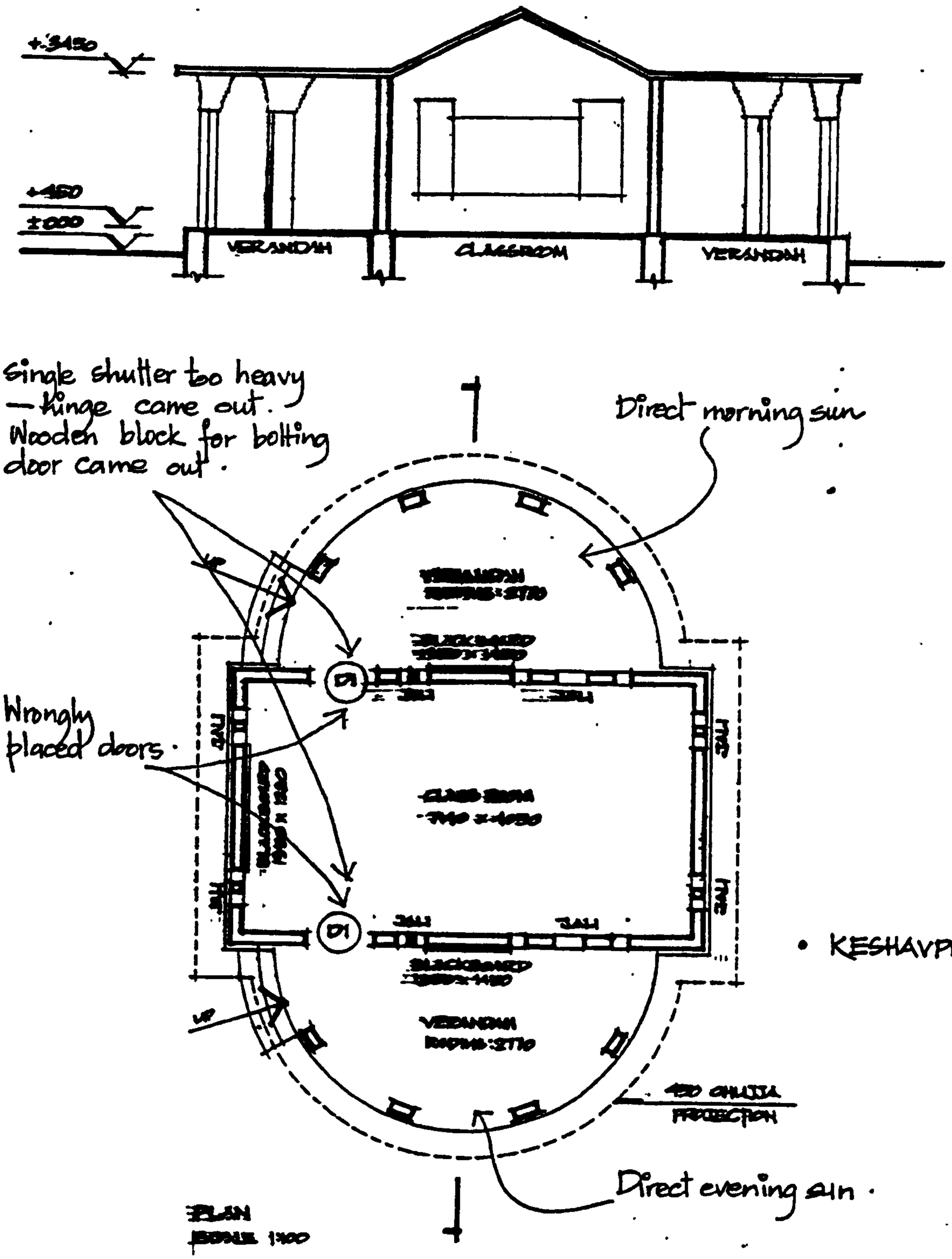


Figure VIII.9 : Adraspally, Ranga Reddy East, Andhra Pradesh

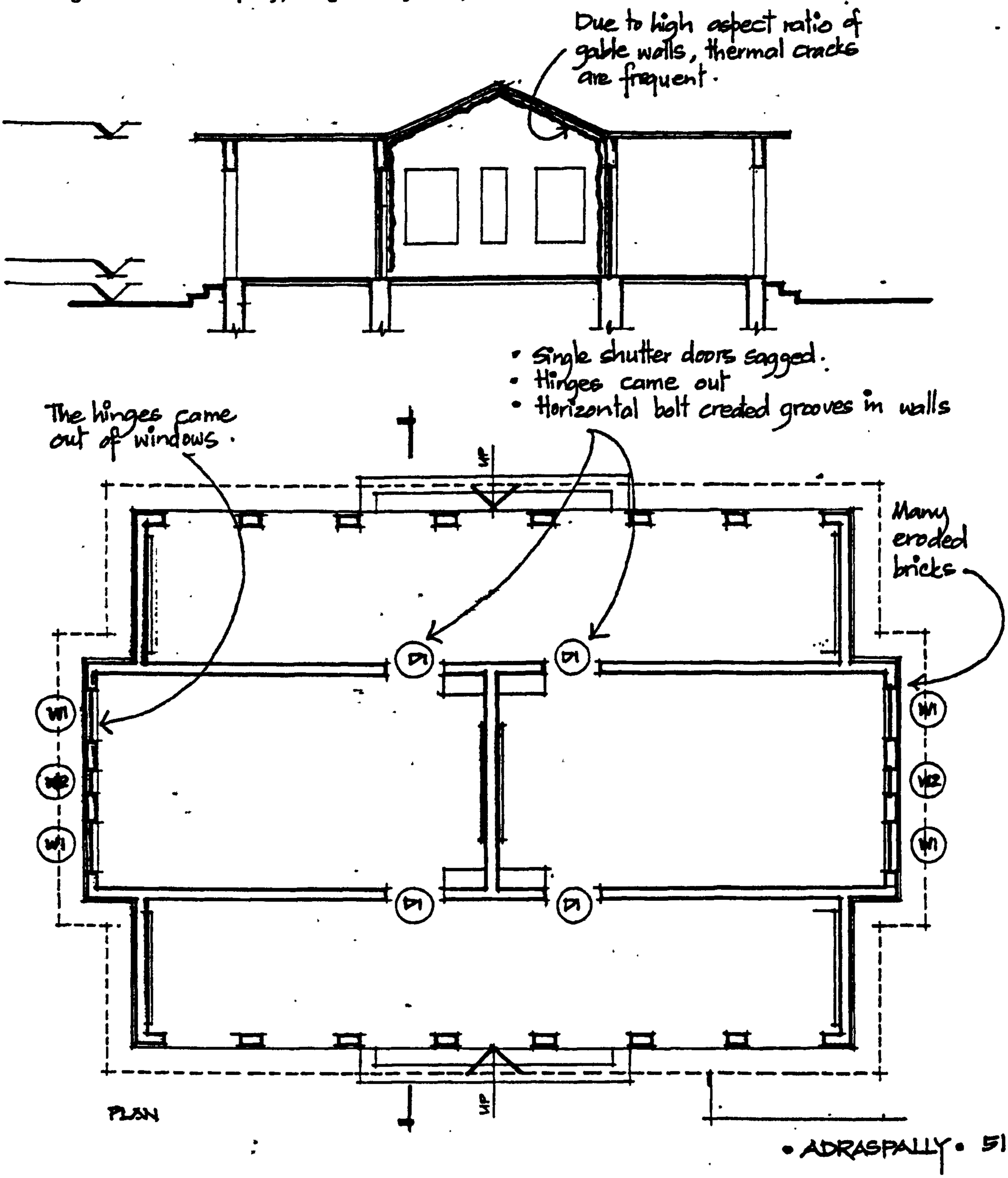


Figure VIII.10 : Ponnal, Ranga Reddy East, Andhra Pradesh

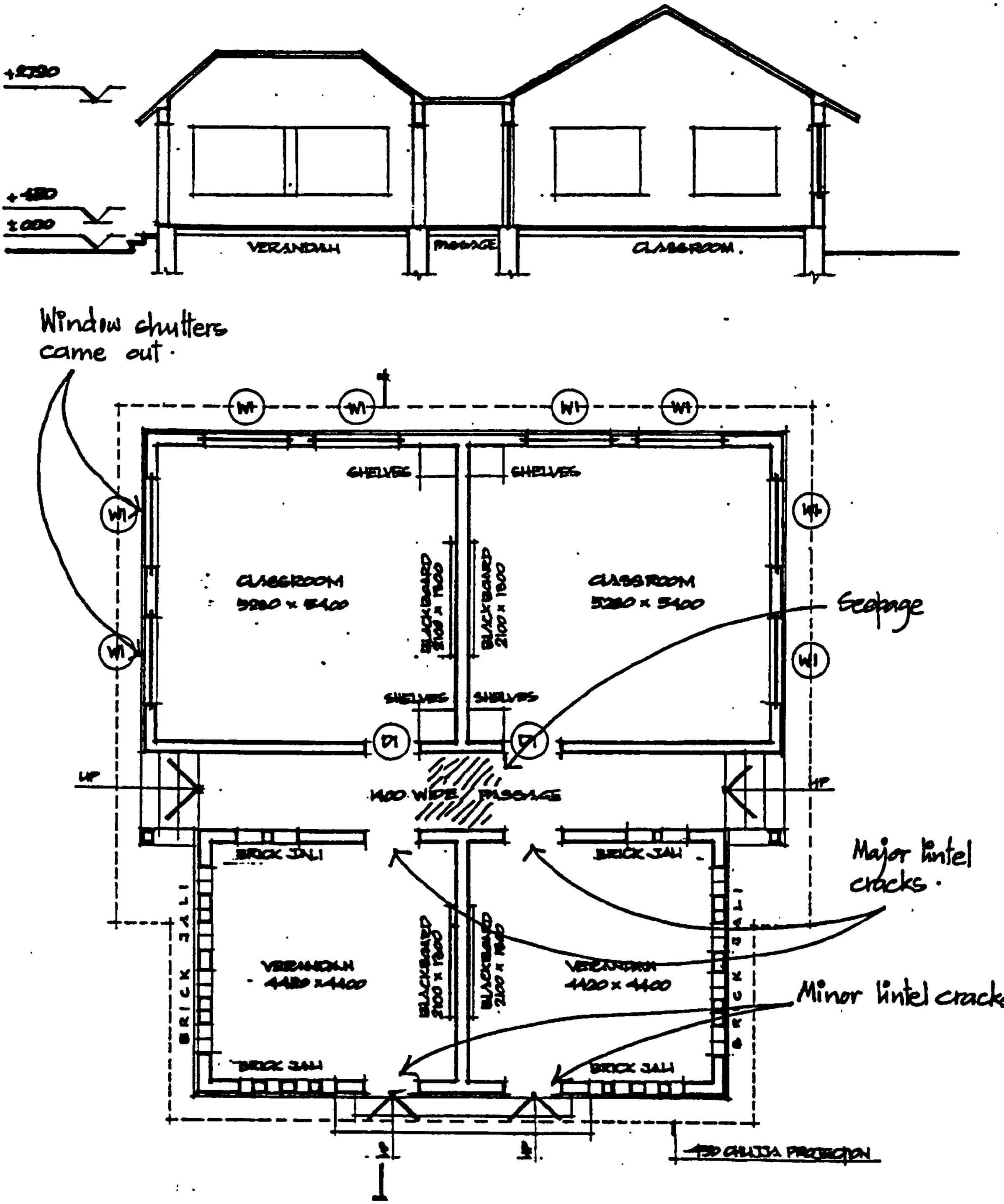


Figure VIII.11 : Bomraspet, Ranga Reddy East, Andhra Pradesh

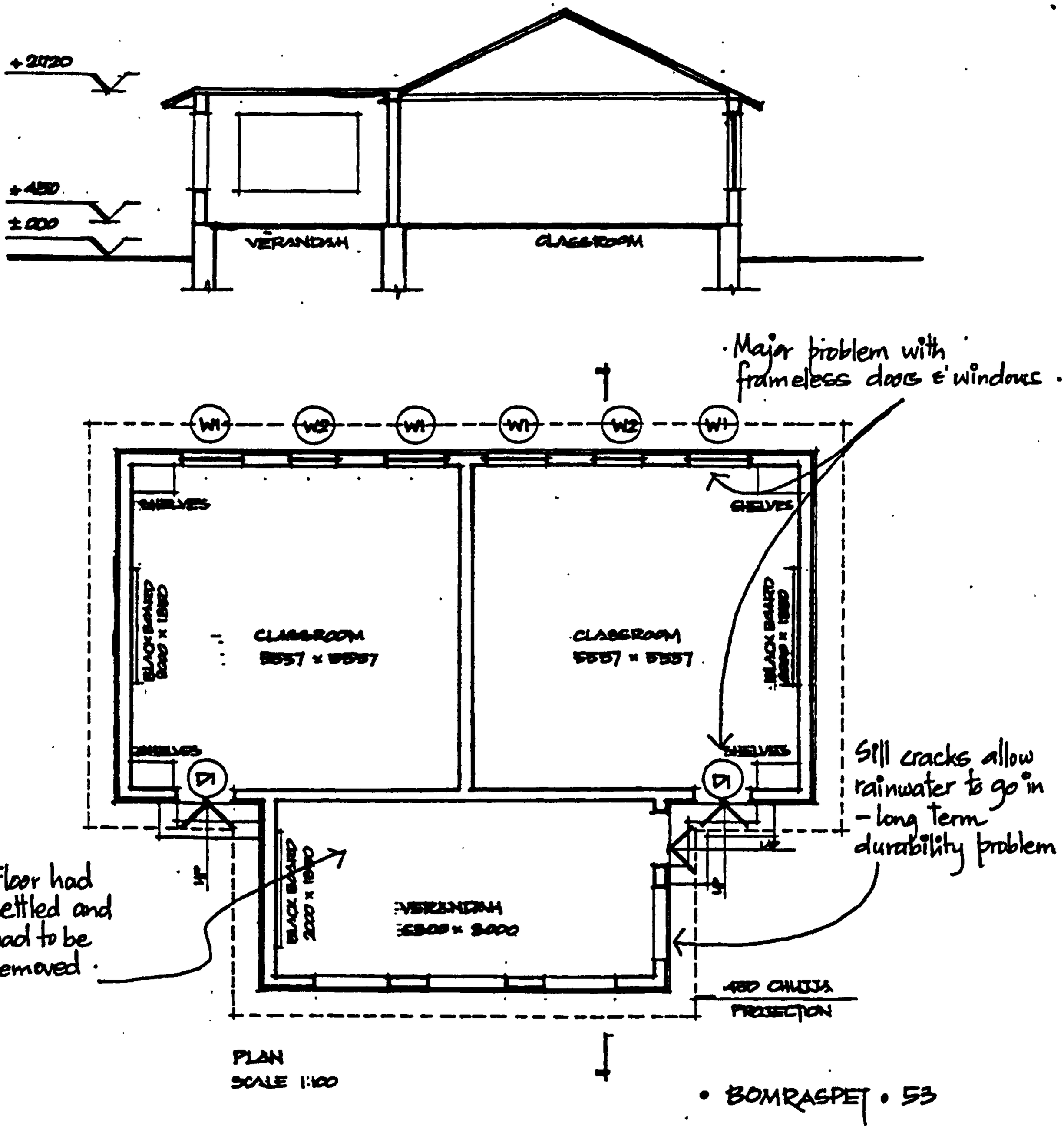
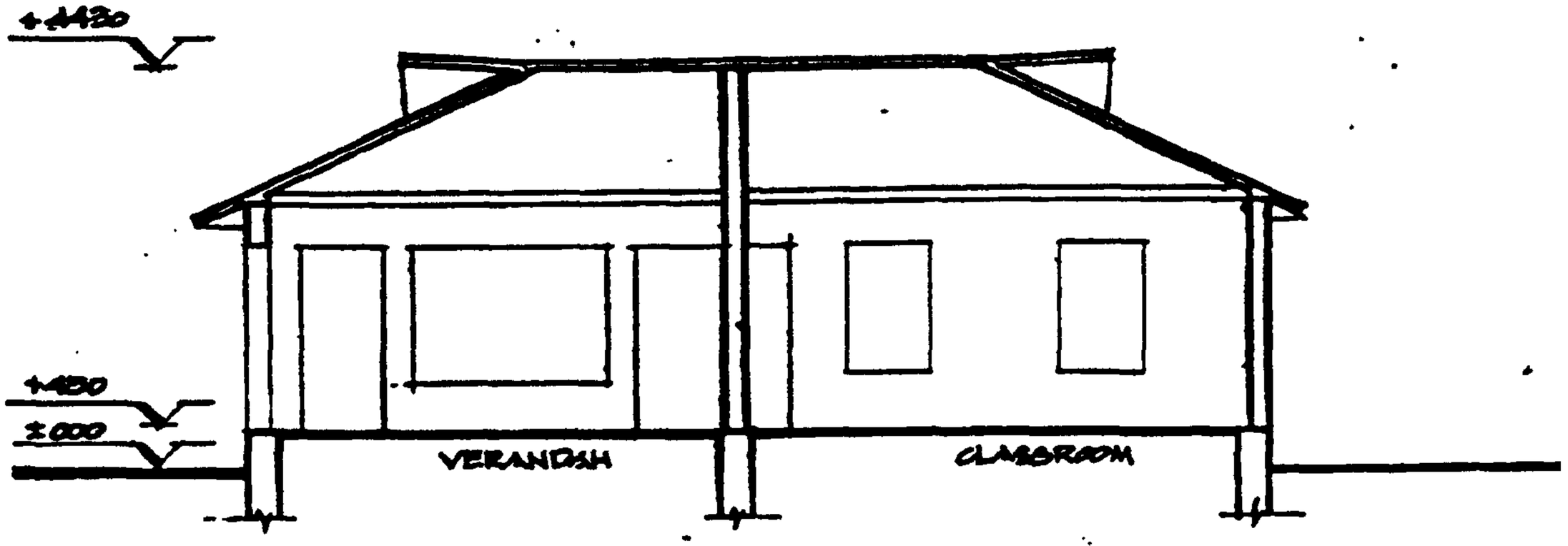
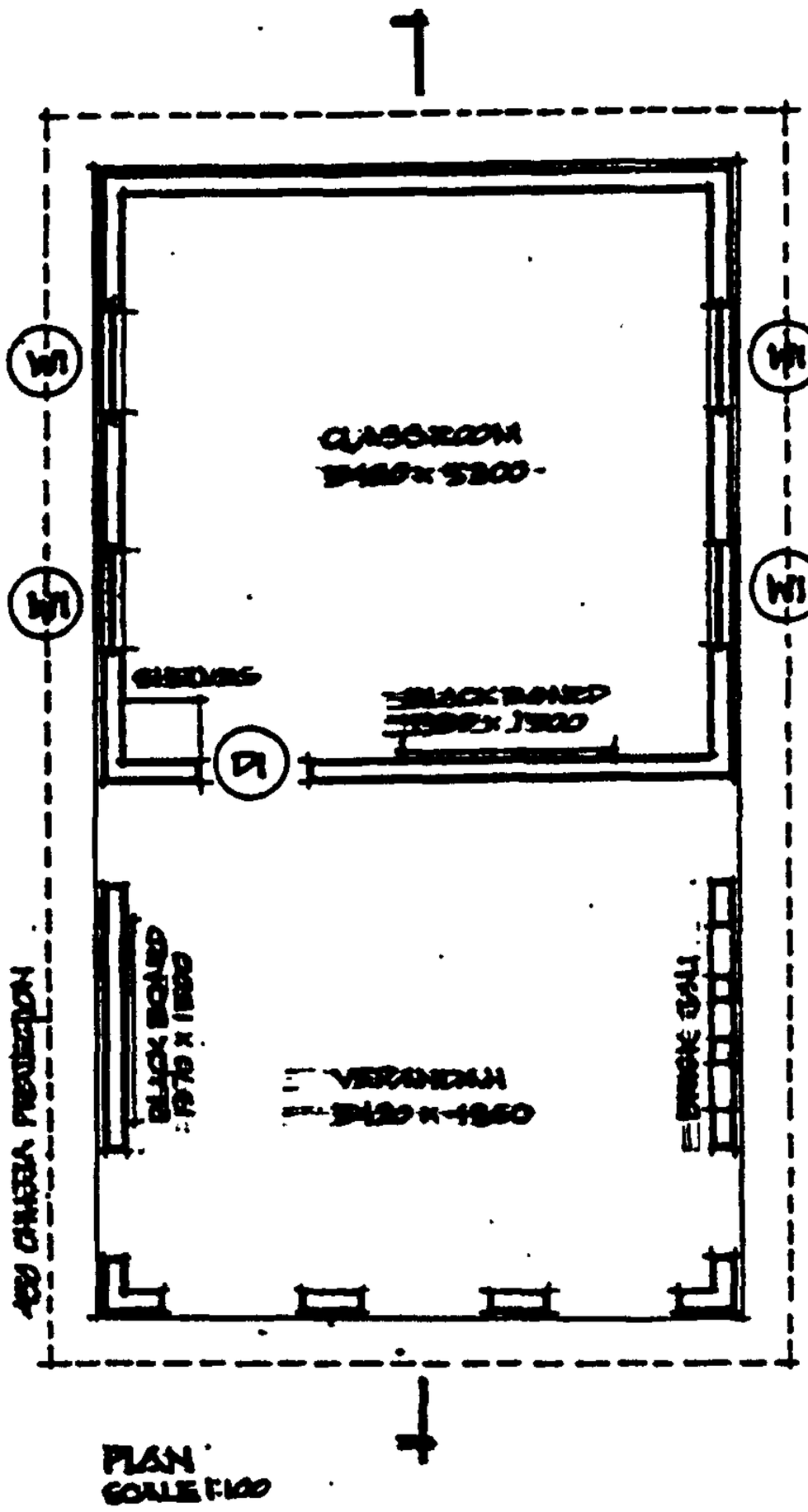


Figure VIII.12 Shameerpet, Ranga Reddy East, Andhra Pradesh





- Doors and windows damaged.
- Many eroded bricks.

- SHAMEERPET -

Figure VIII.13 Kismatpur, Ranga Reddy West, Andhra Pradesh

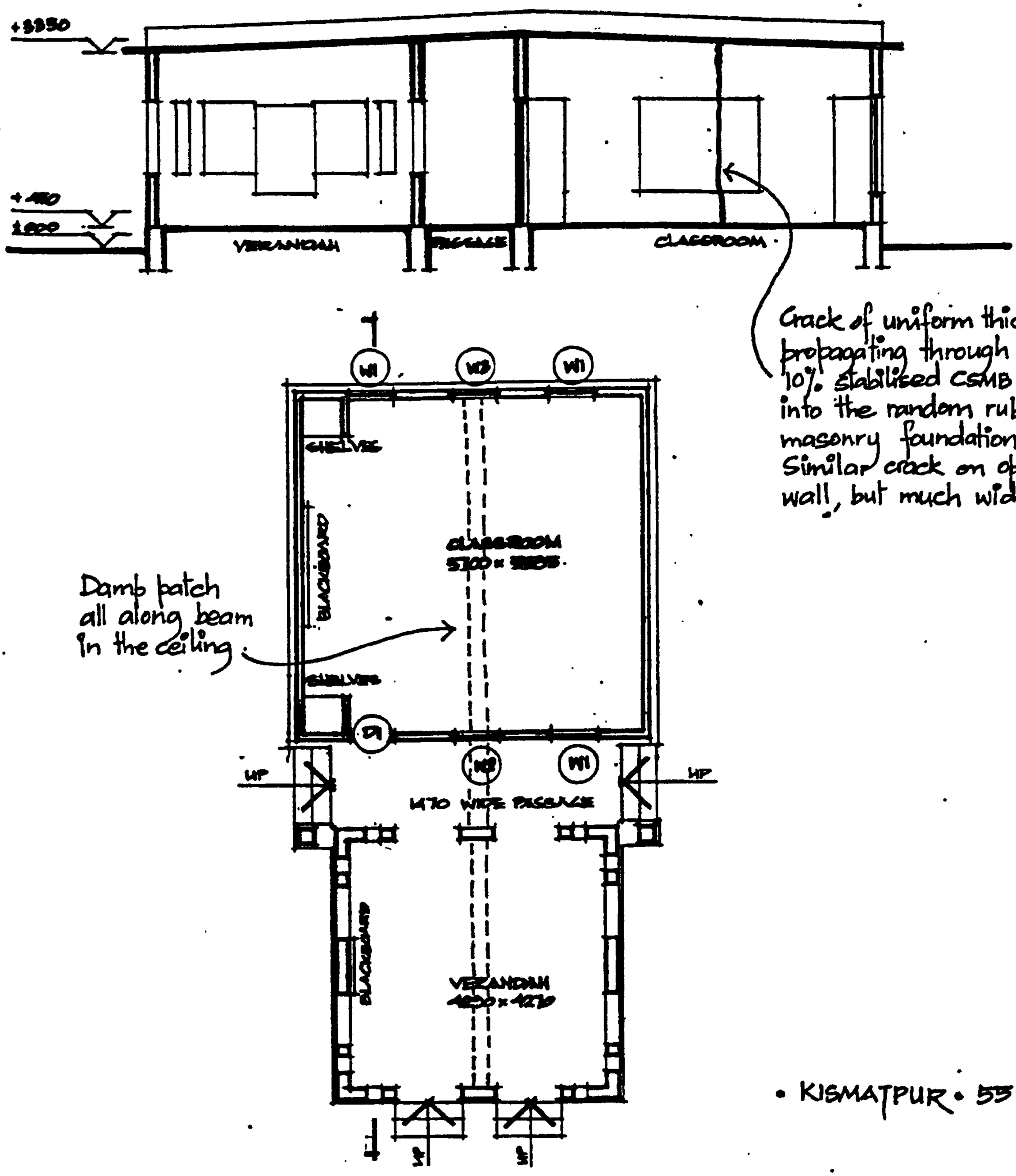


Figure VIII.14 : Himayatsagar, Ranga Reddy West, Andhra Pradesh

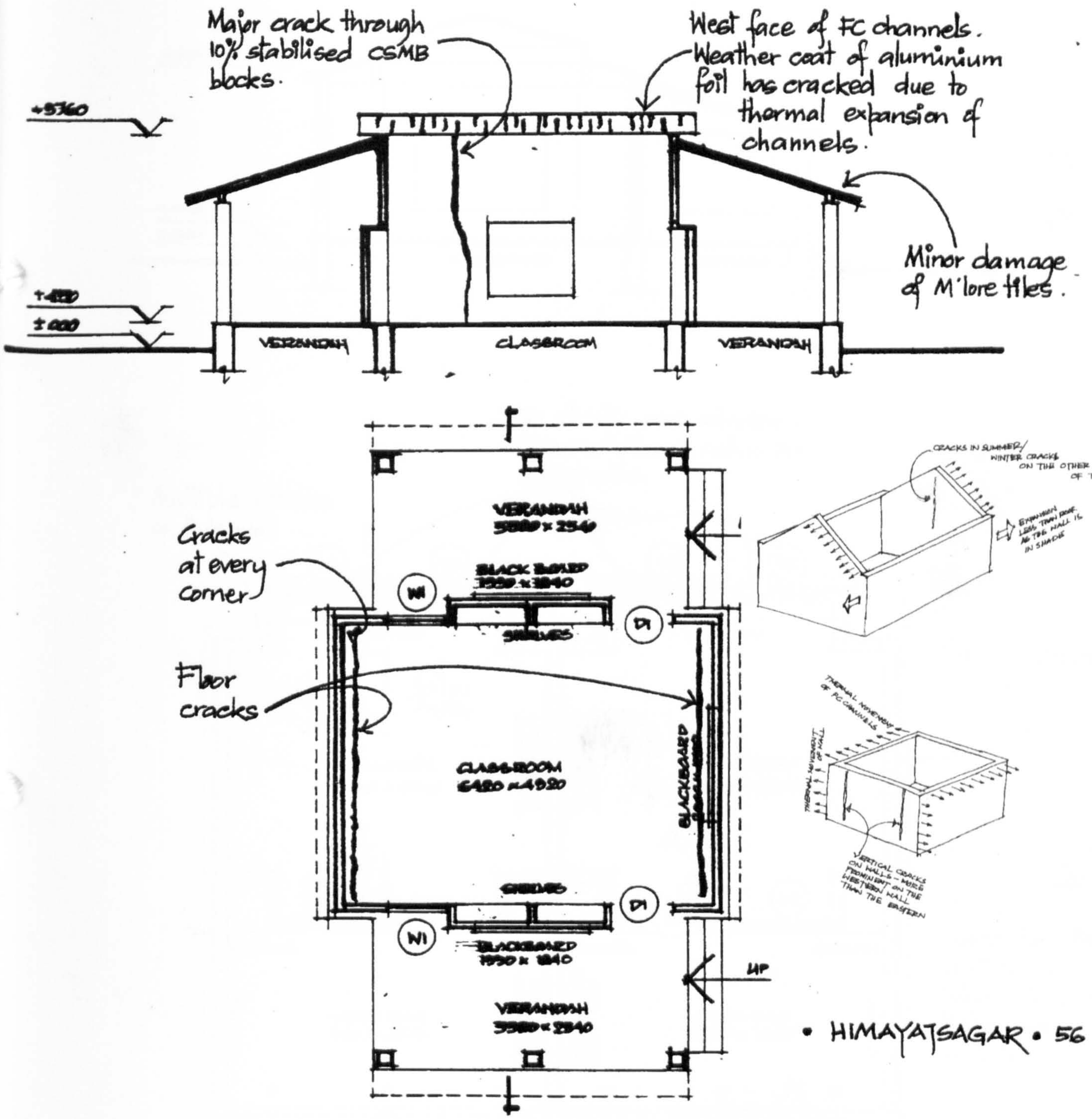
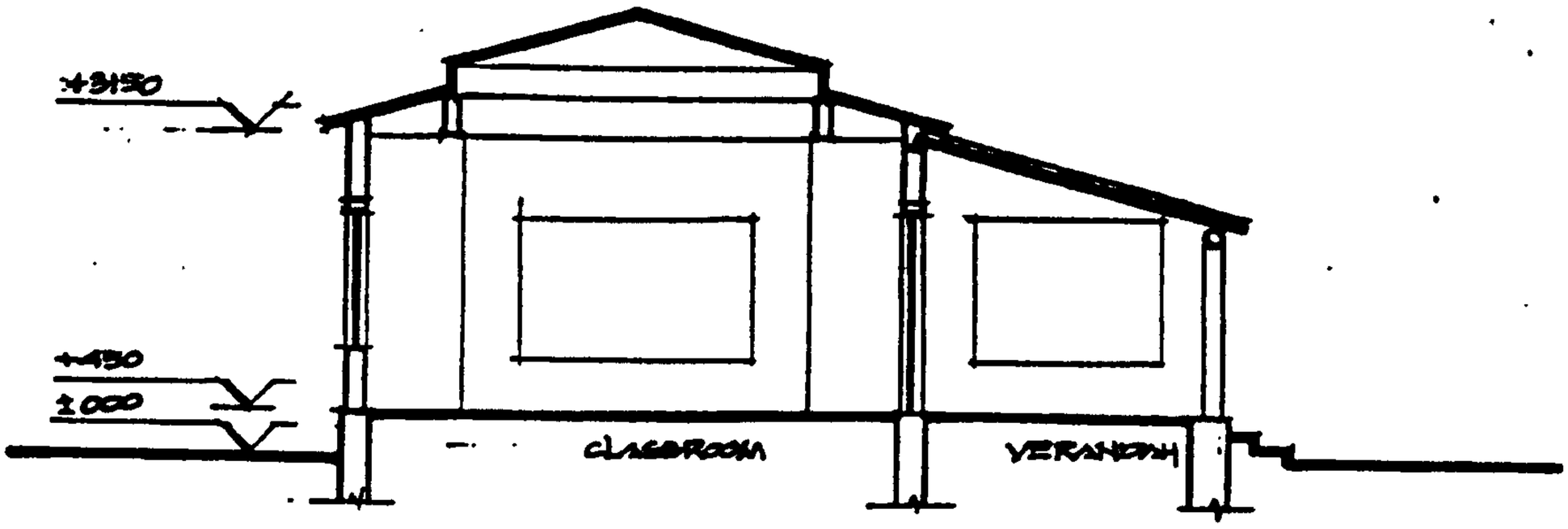
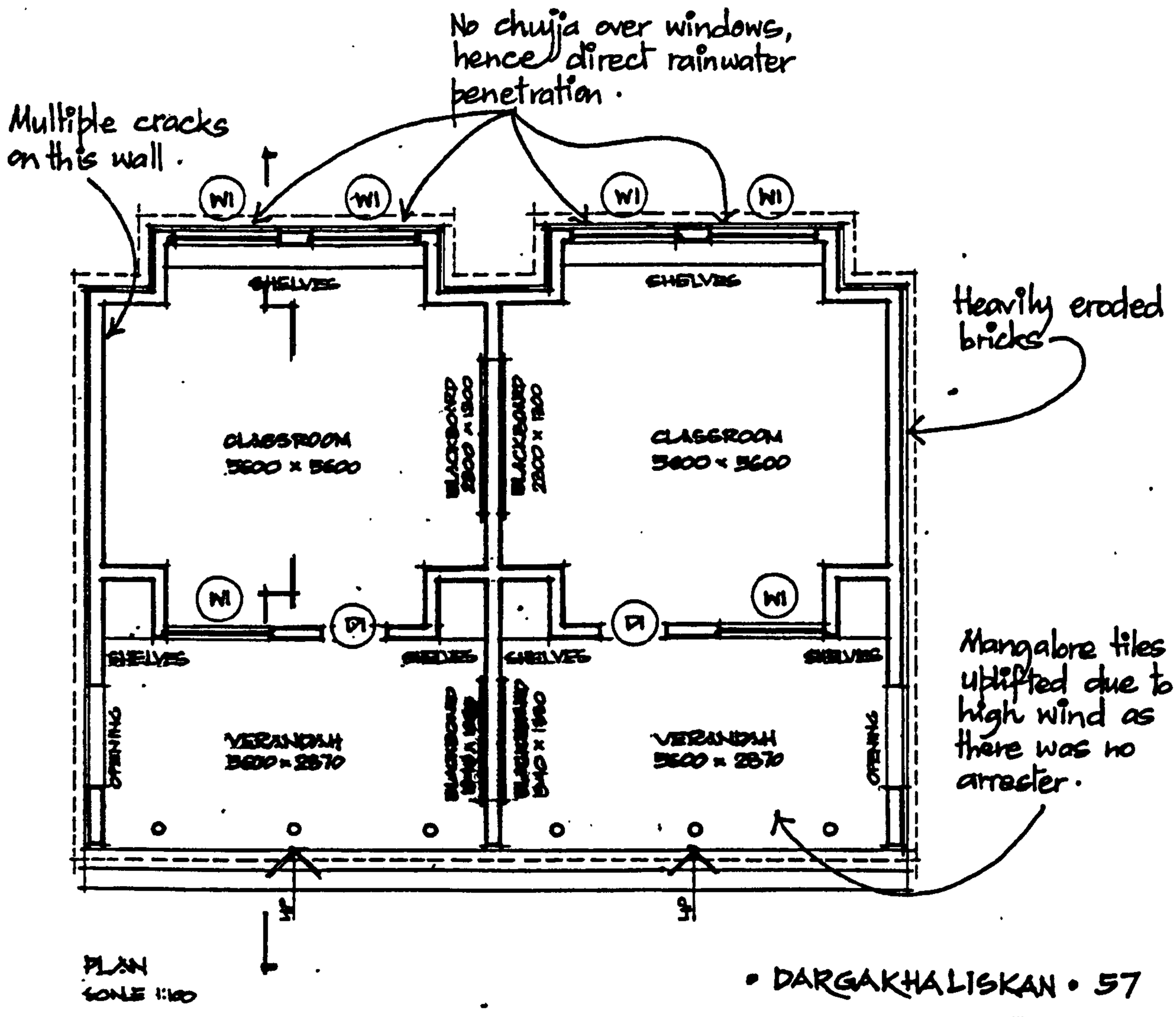


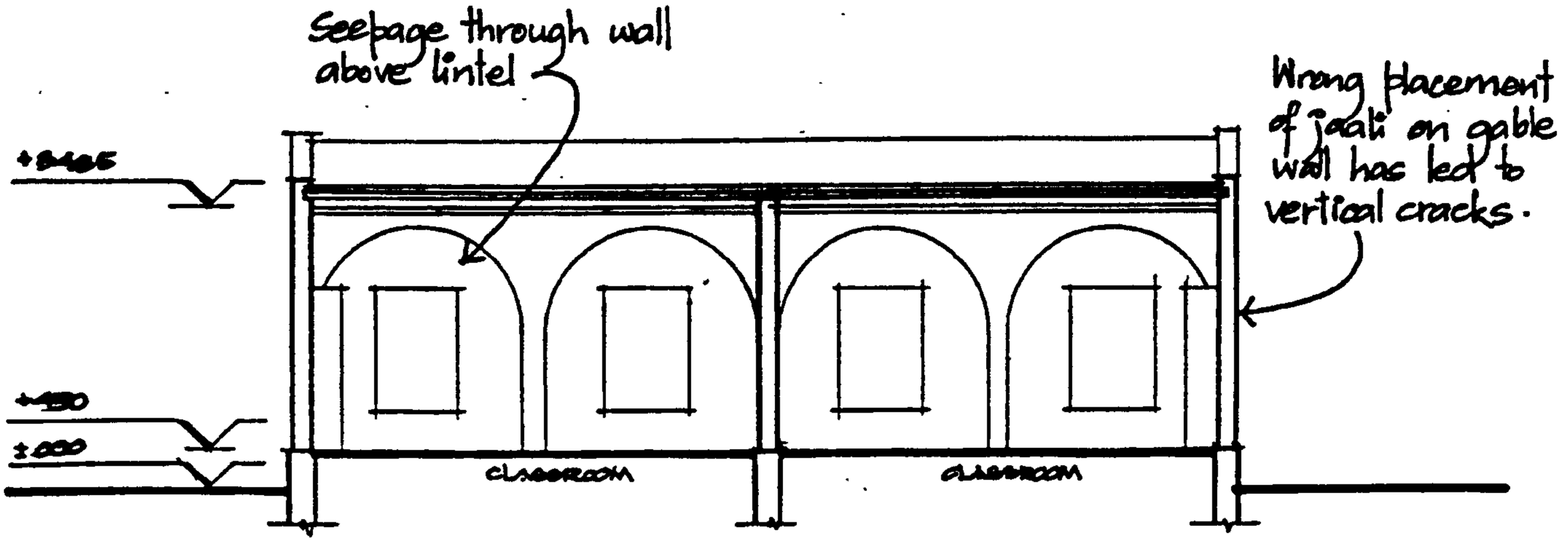
Figure VIII.15 : Dargakhalistan, Ranga Reddy West, Andhra Pradesh

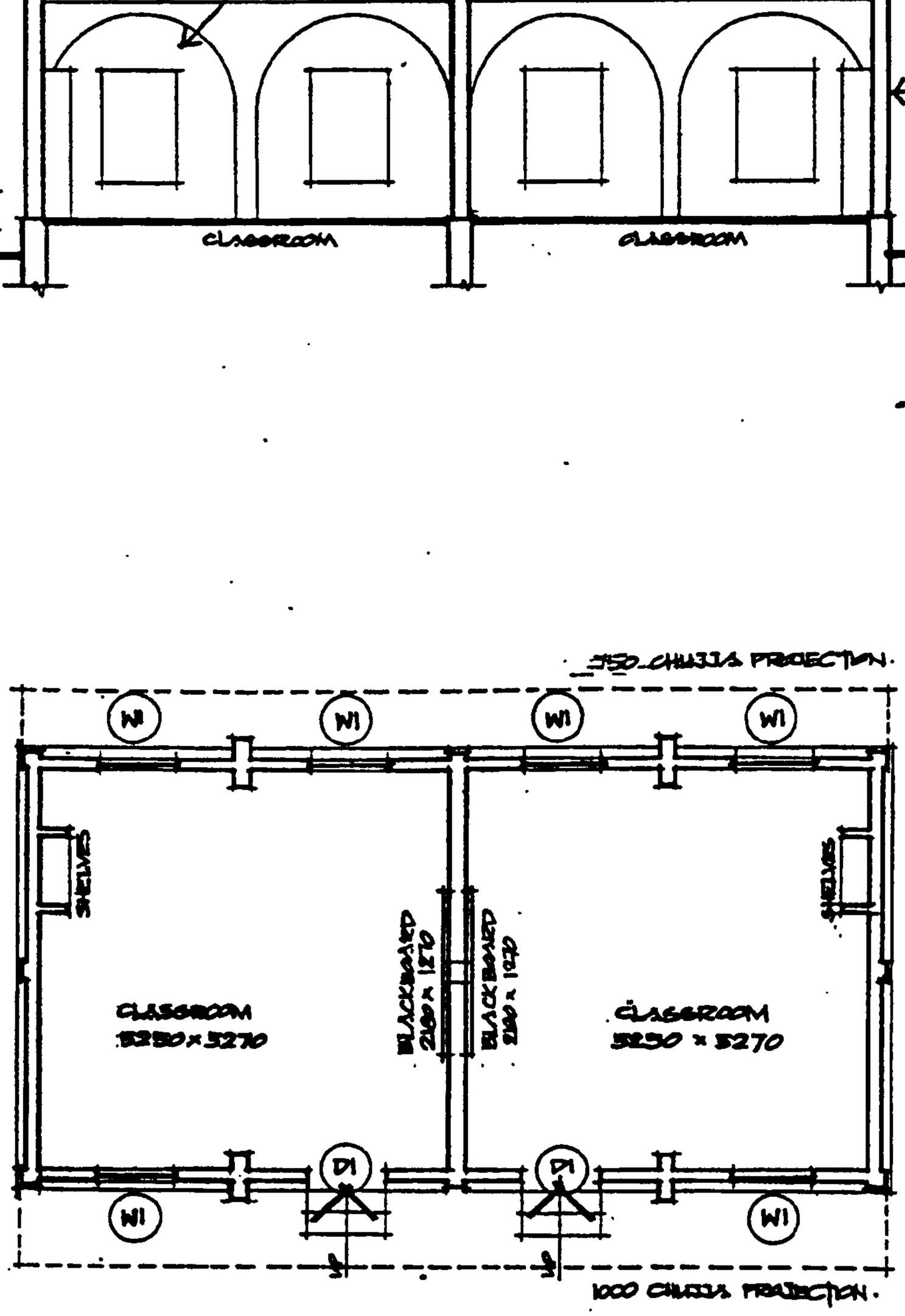




PLAN
SCALE 1:100

Figure VIII.16 : Hydershakote, Ranga Reddy West, Andhra Pradesh

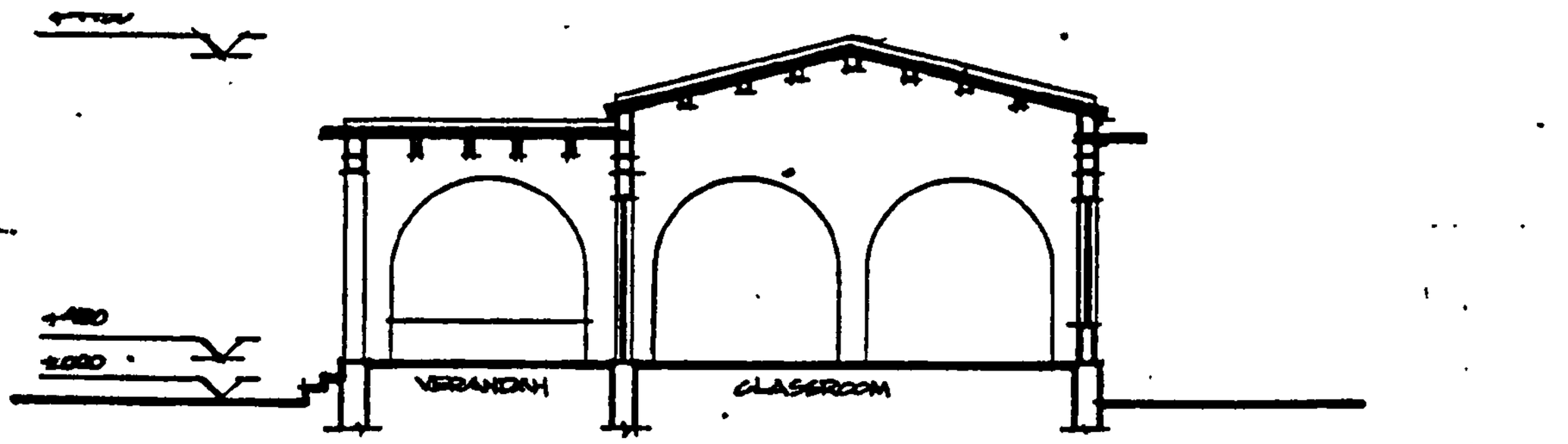




PLAN

• HYDERSHAKOTE
58

Figure VIII.17 : Narsinghi, Ranga Reddy West, Andhra Pradesh



Roof seepage at a few points.

Figure VIII.18 : Himayatnagar, Ranga Reddy West, Andhra Pradesh

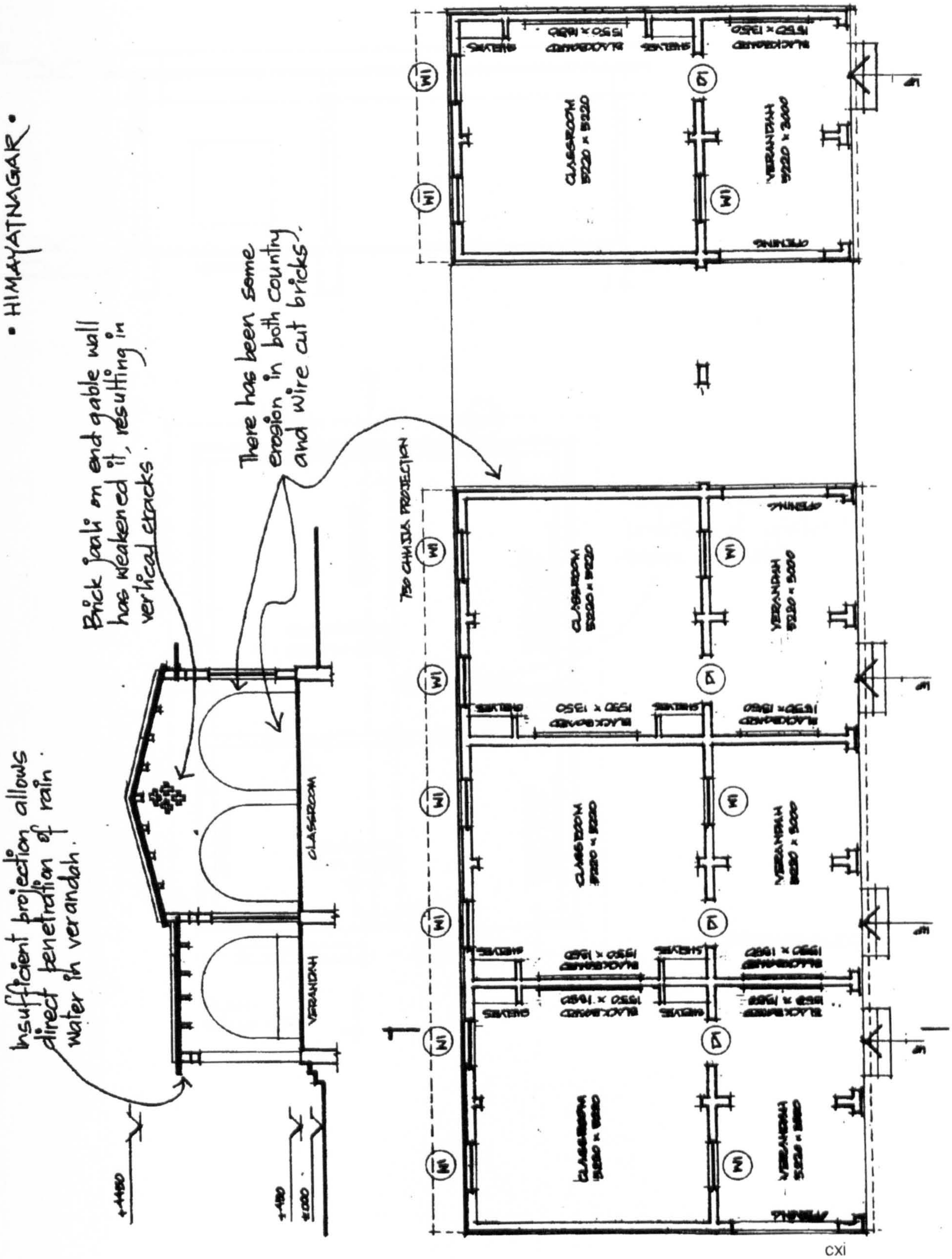


Figure VIII.19 : Appojiguda, Ranga Reddy West, Andhra Pradesh

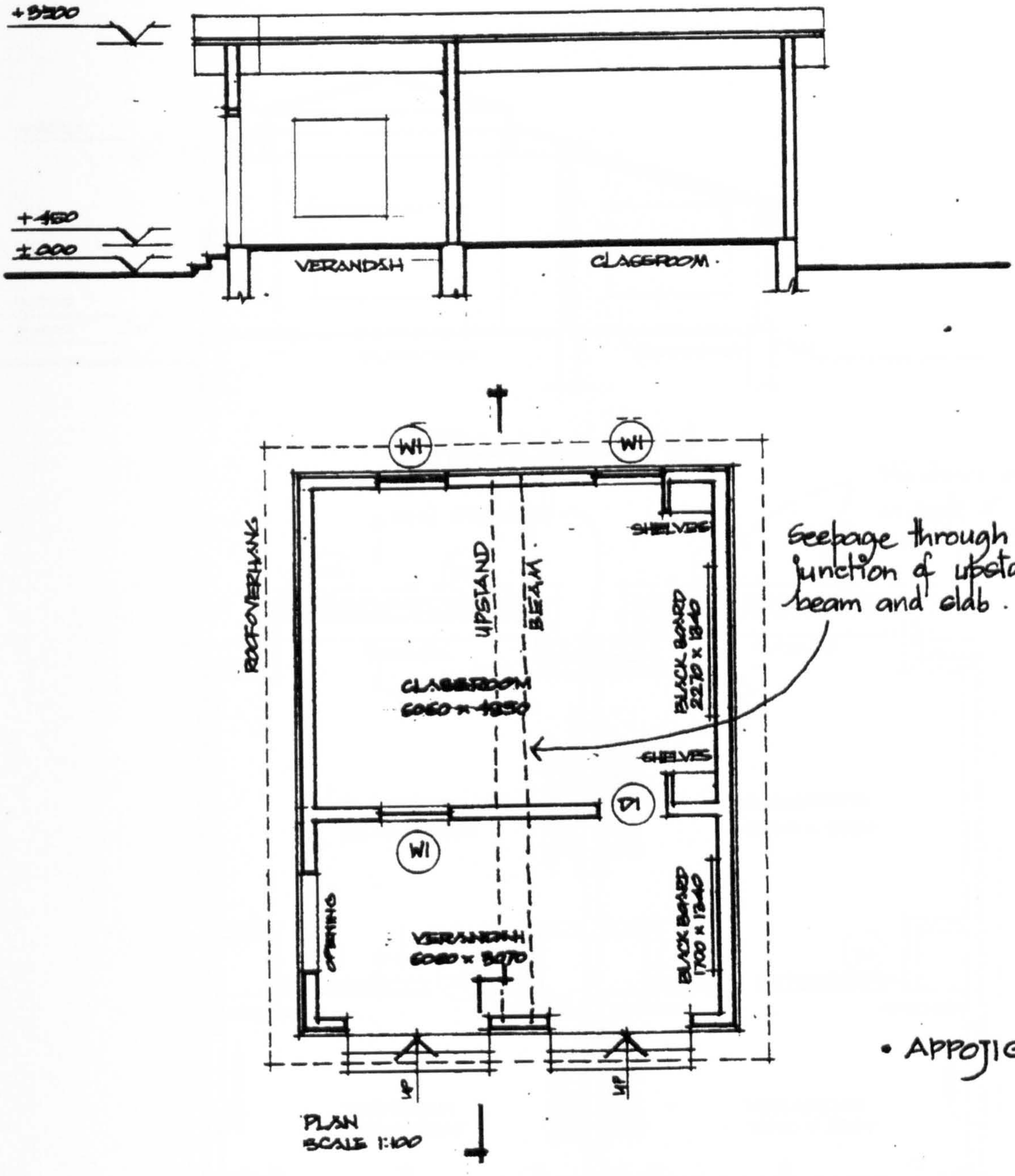


Figure VIII.20 : Chandanagar (By Design Architecture and Allied Technologies) , Ranga Reddy West, Andhra Pradesh

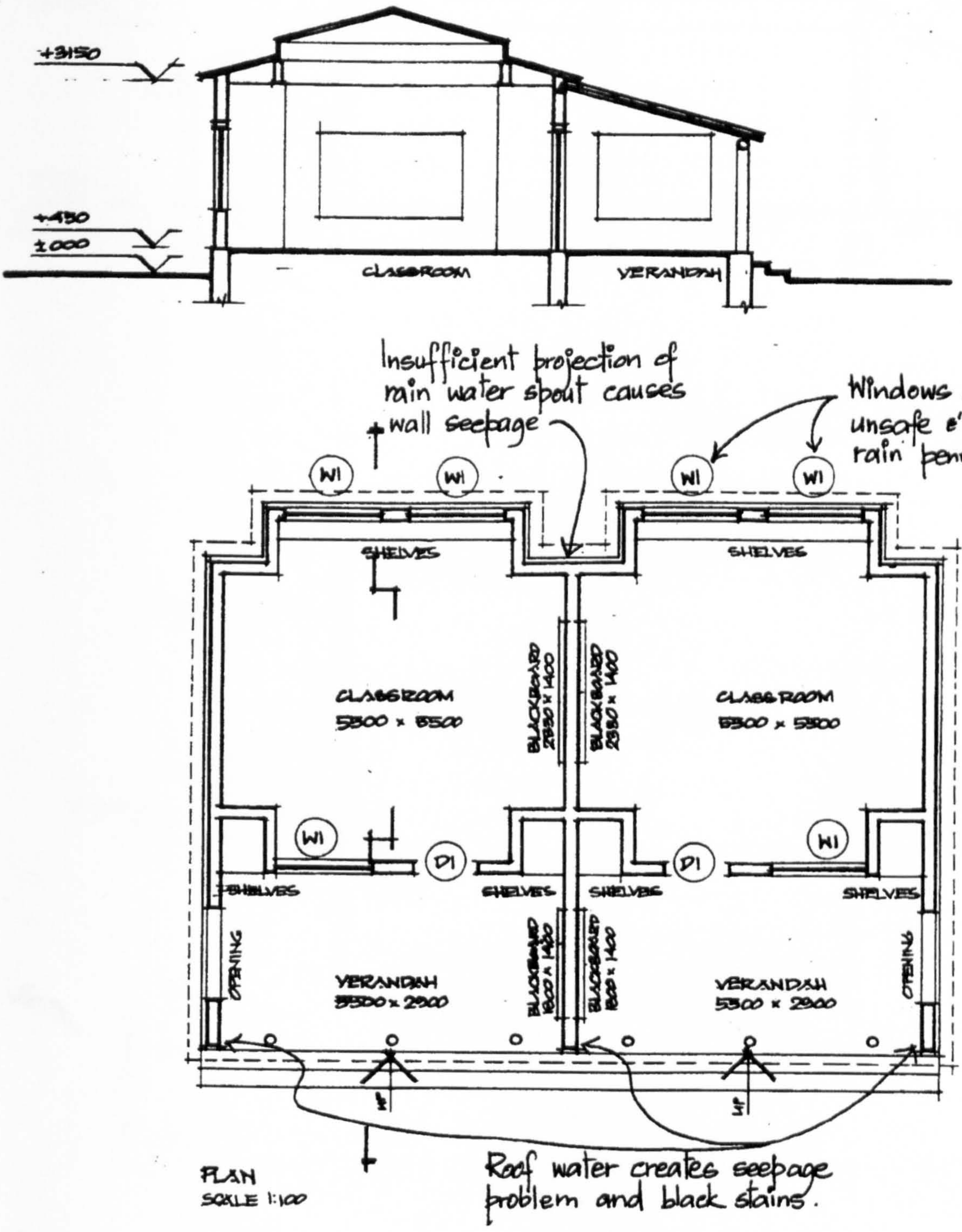


Figure VIII.21 : Puppalguda, Ranga Reddy West, Andhra Pradesh

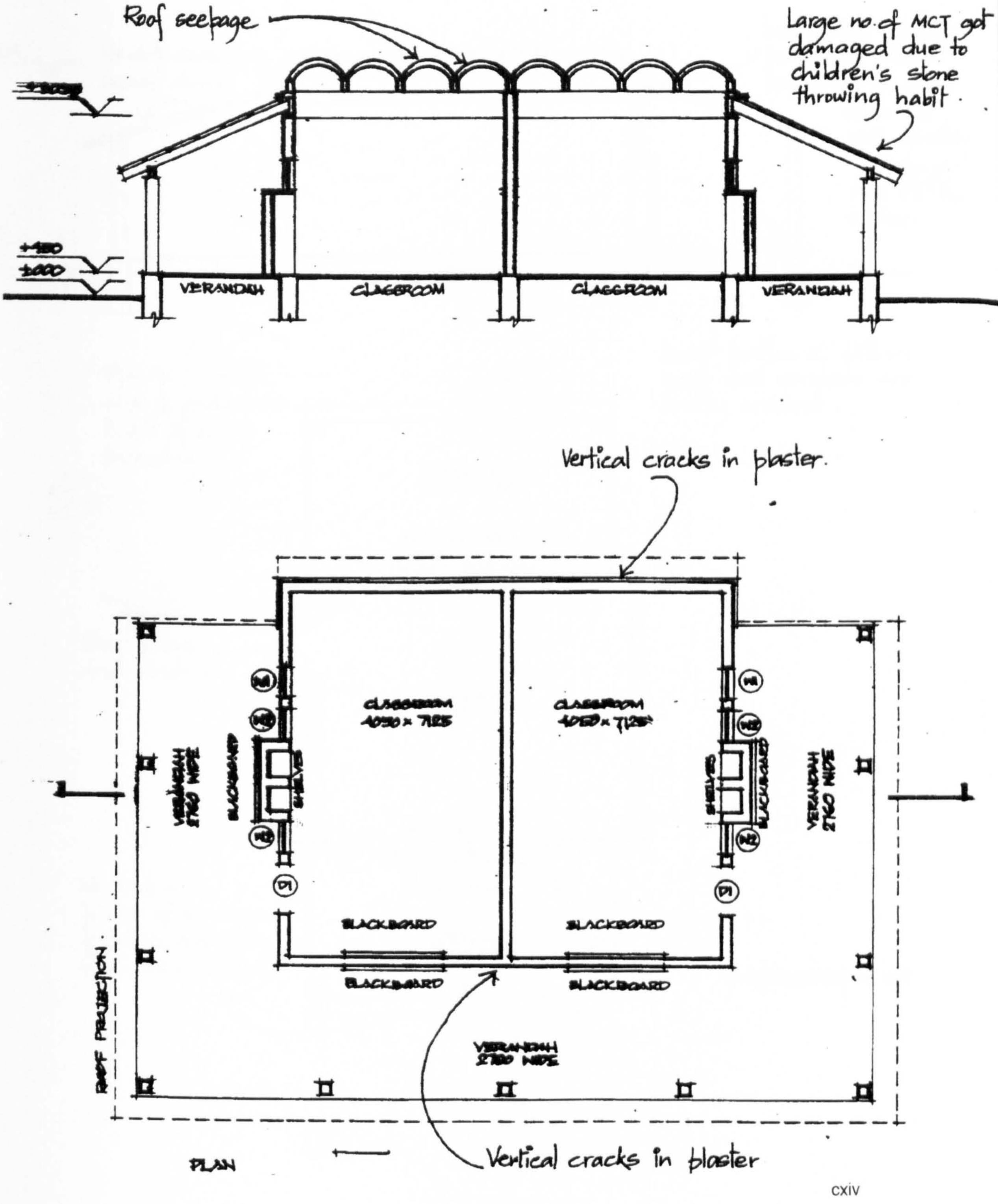
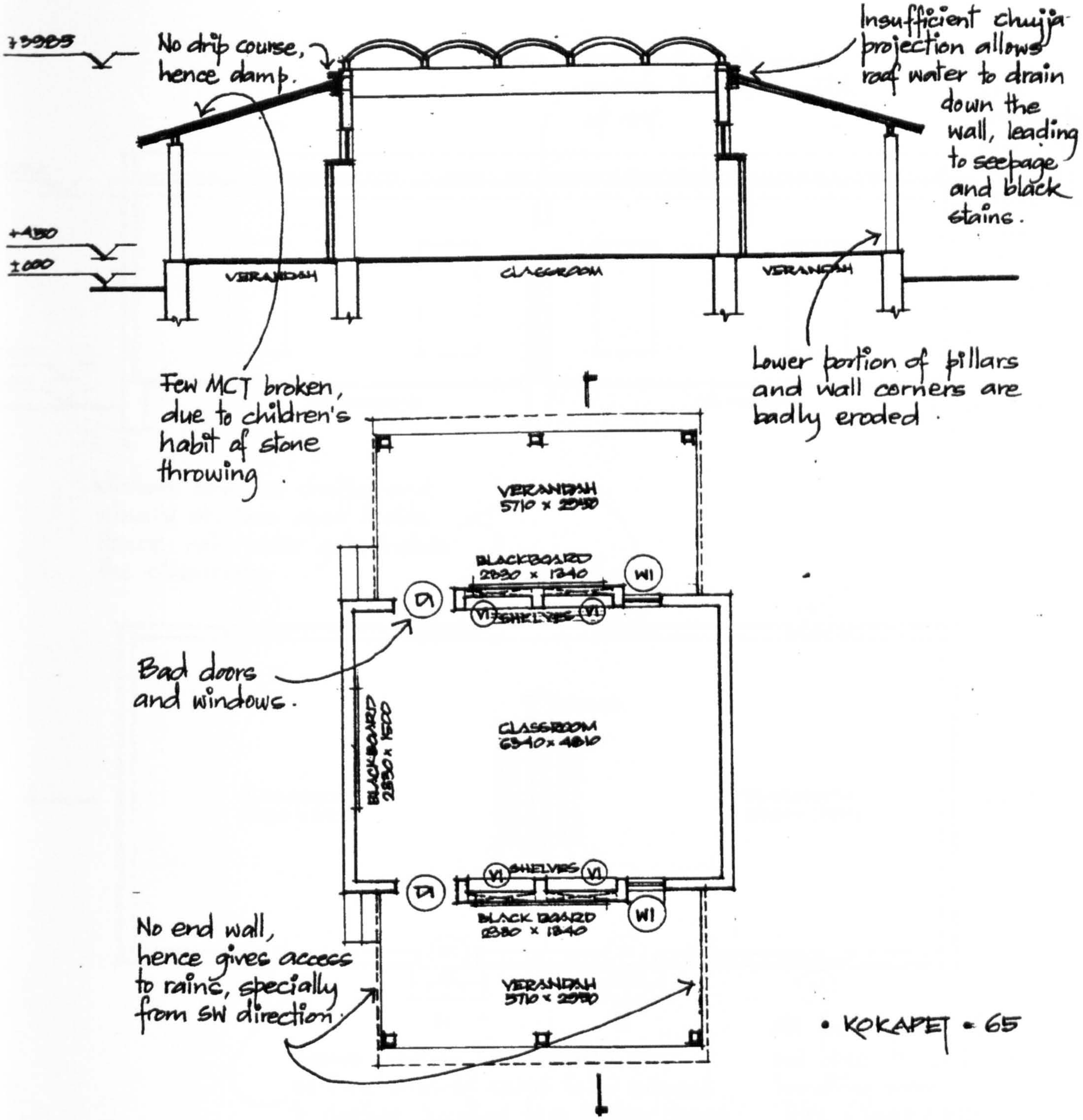


Figure VIII.22 : Kokapet, Ranga Reddy West, Andhra Pradesh



• KOKAPET • 65

Figure VIII.23 : Gandipet, Ranga Reddy West, Andhra Pradesh

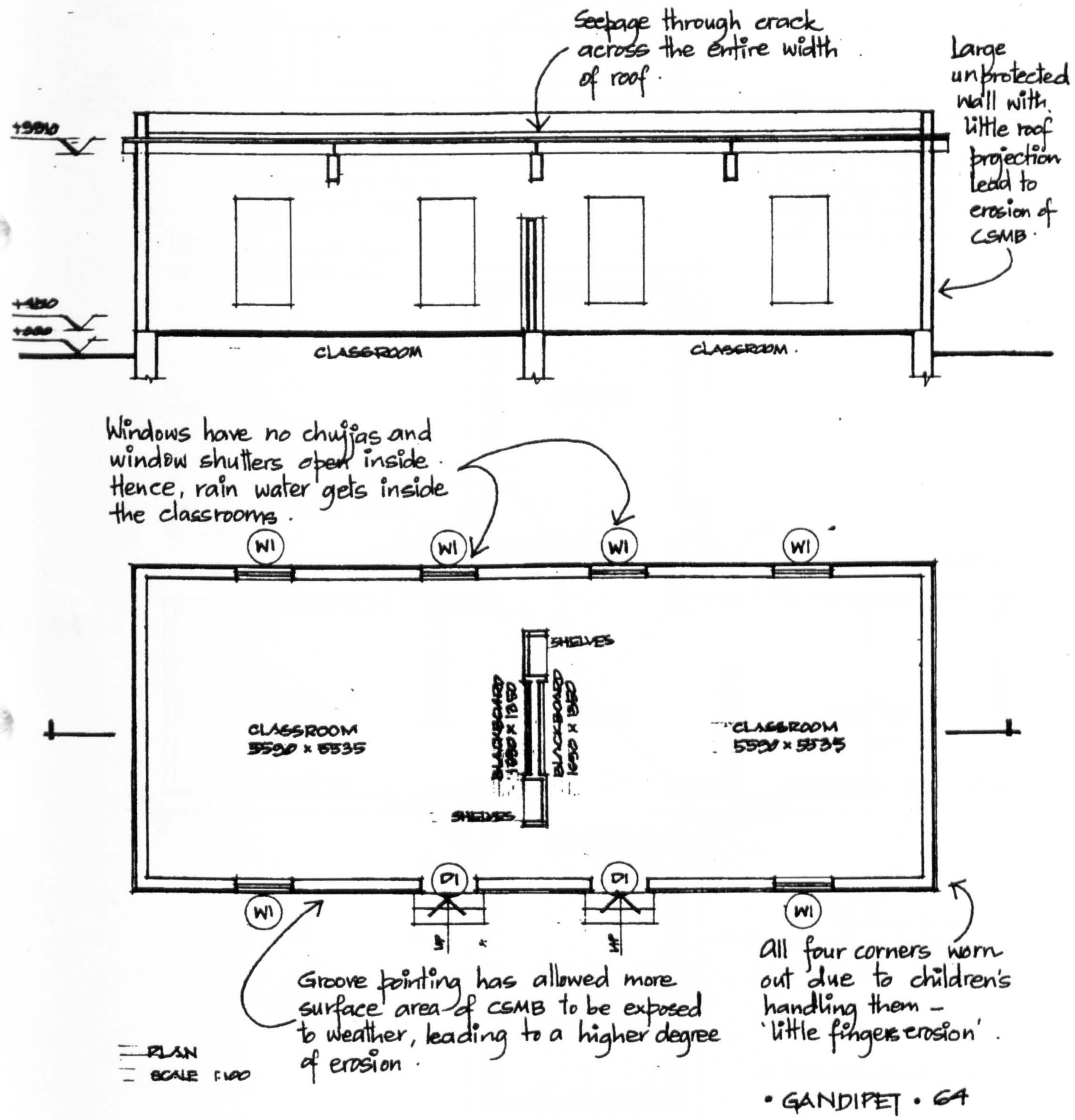
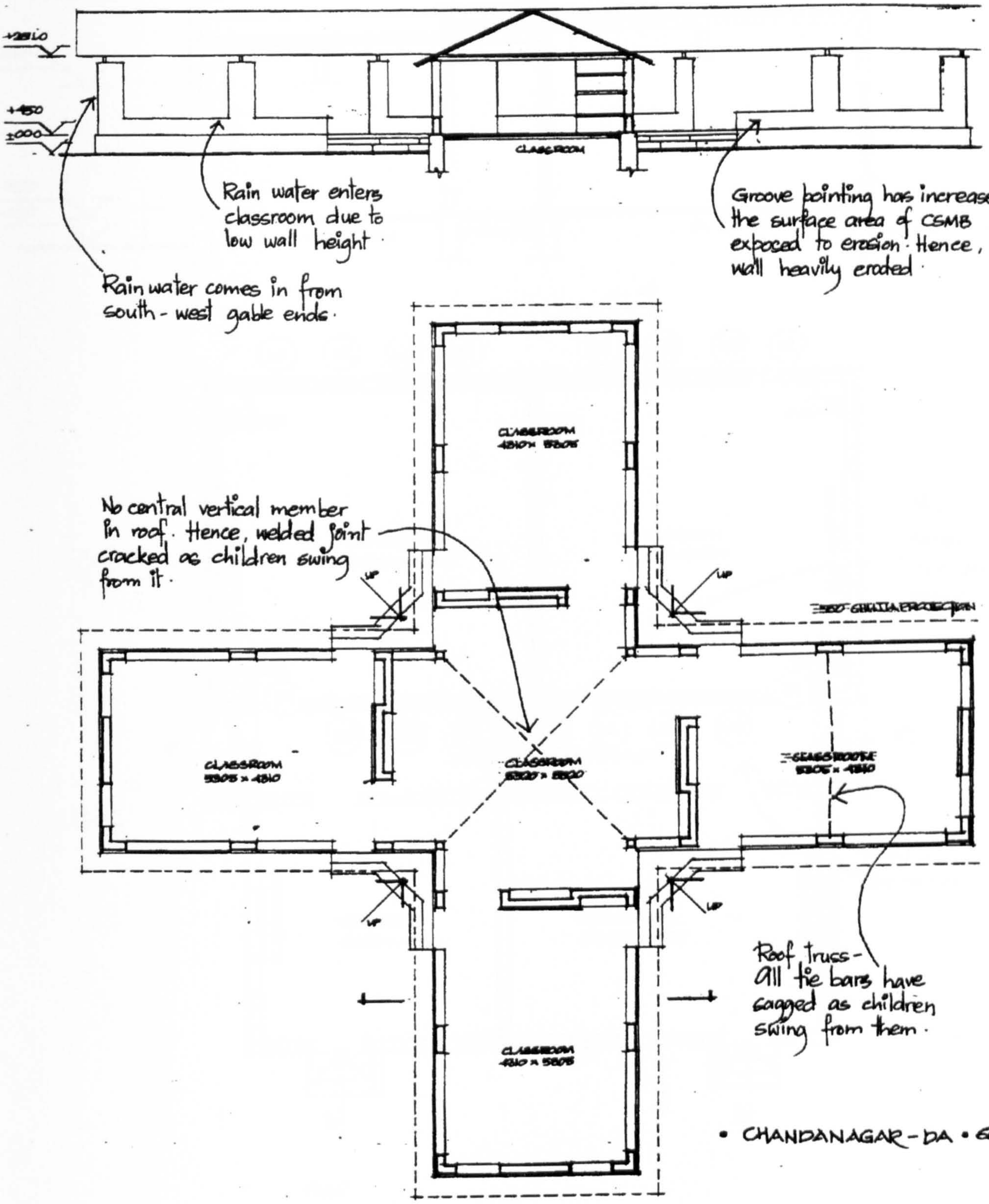
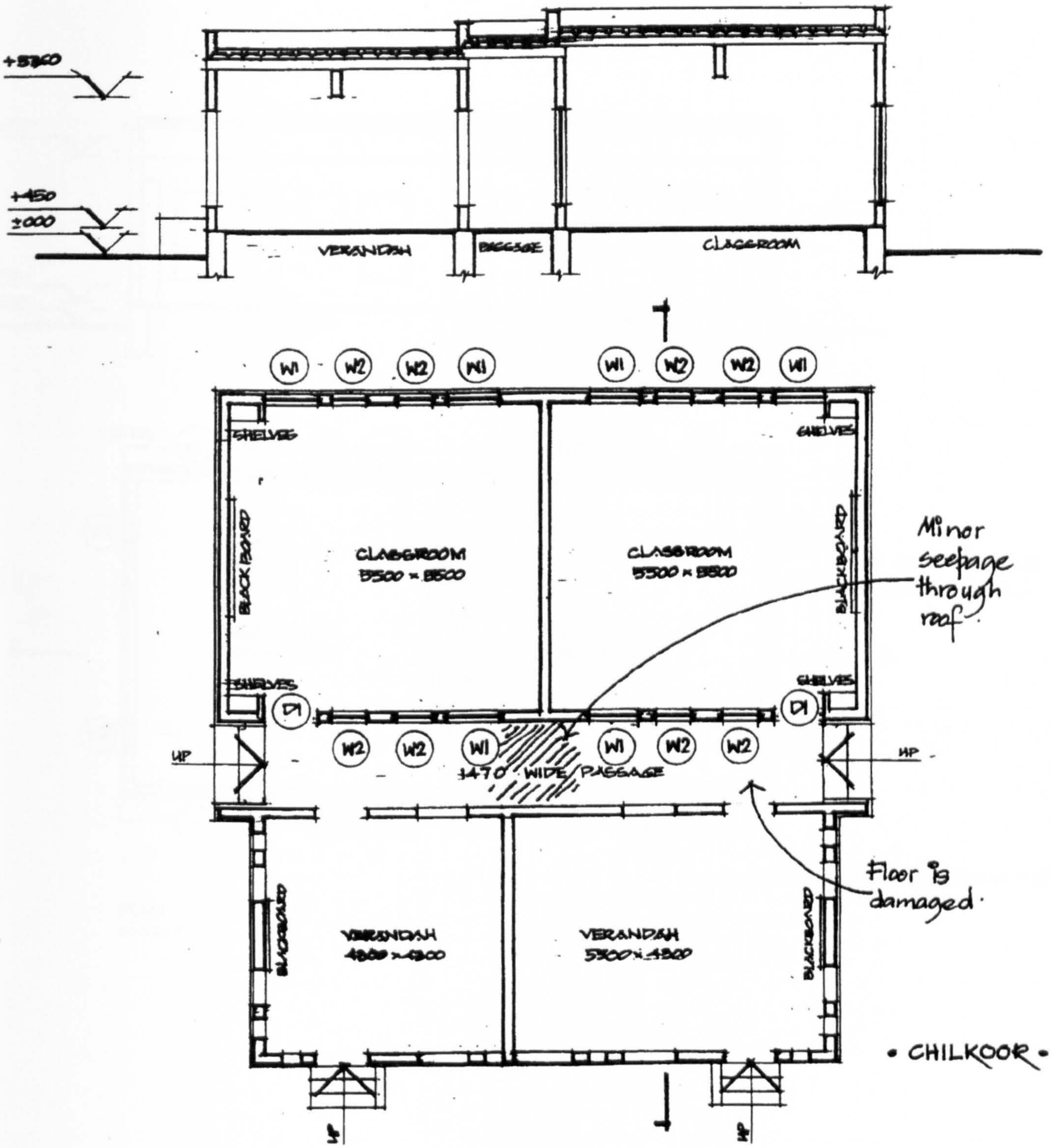


Figure VIII.24 : Chandanagar (By Development Alternatives), Ranga Reddy West, Andhra Pradesh



• CHANDANAGAR - DA • 66

Figure VIII.25 : Chilkoor, Ranga Reddy West, Andhra Pradesh



TEXT CUT OFF IN ORIGINAL

Figure VIII.26 : Chinnamangalaram, Ranga Reddy West, Andhra Pradesh

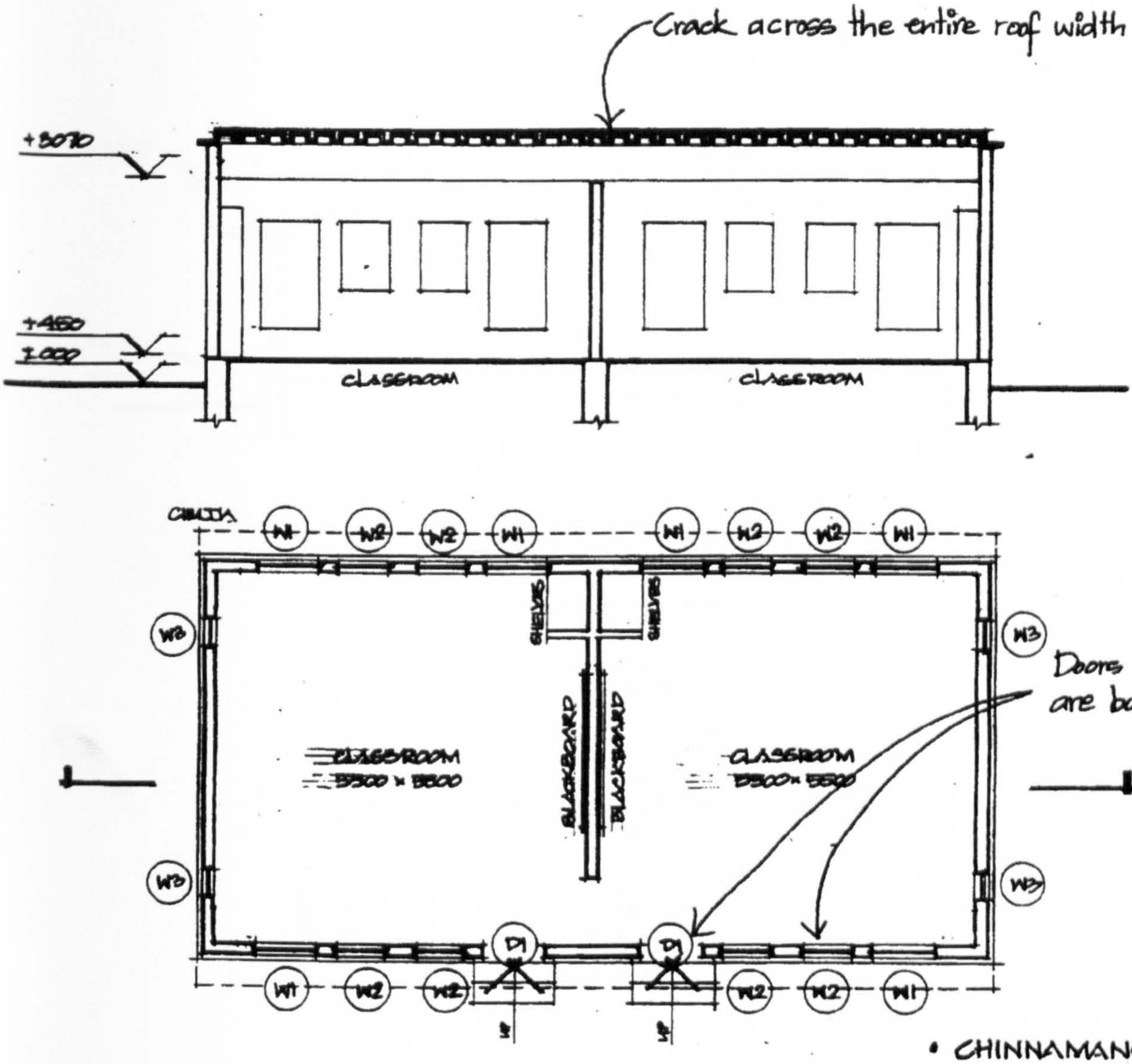
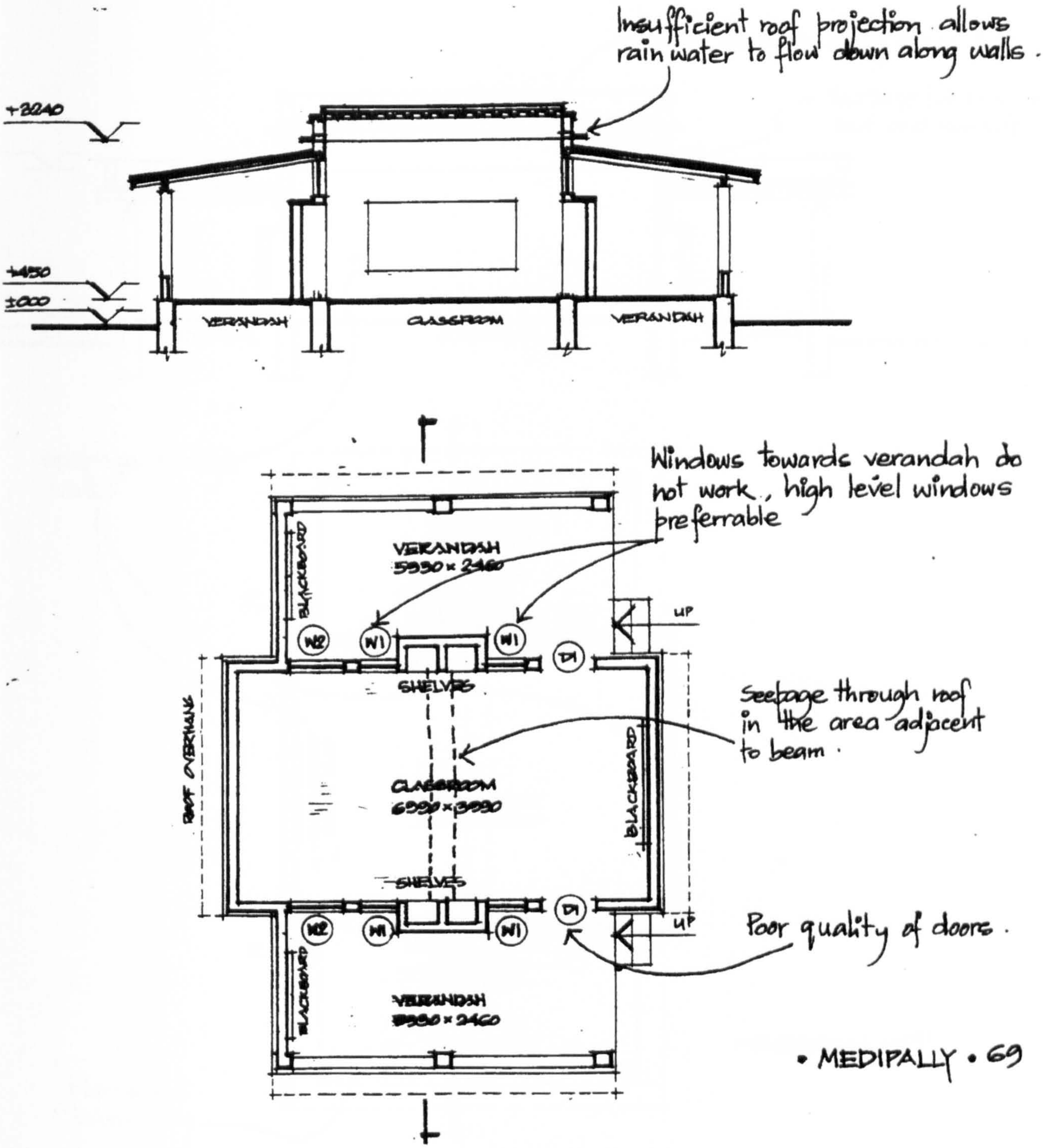


Figure VIII.27 : Medipally, Ranga Reddy West, Andhra Pradesh



TEXT BOUND INTO THE SPINE

TEXT CUT OFF IN ORIGINAL

Figure VIII.28 : Surangal, Ranga Reddy East, Andhra Pradesh

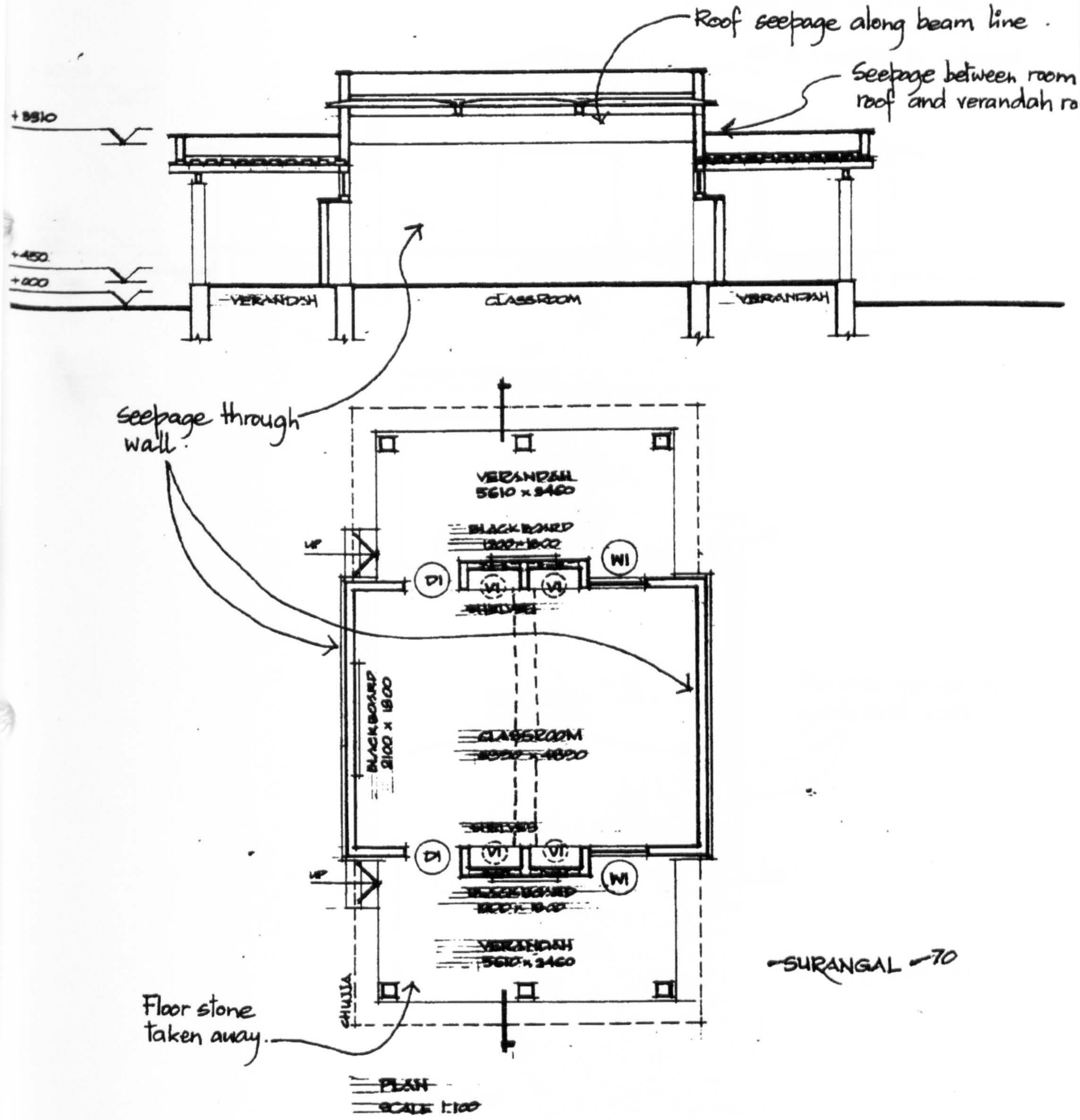
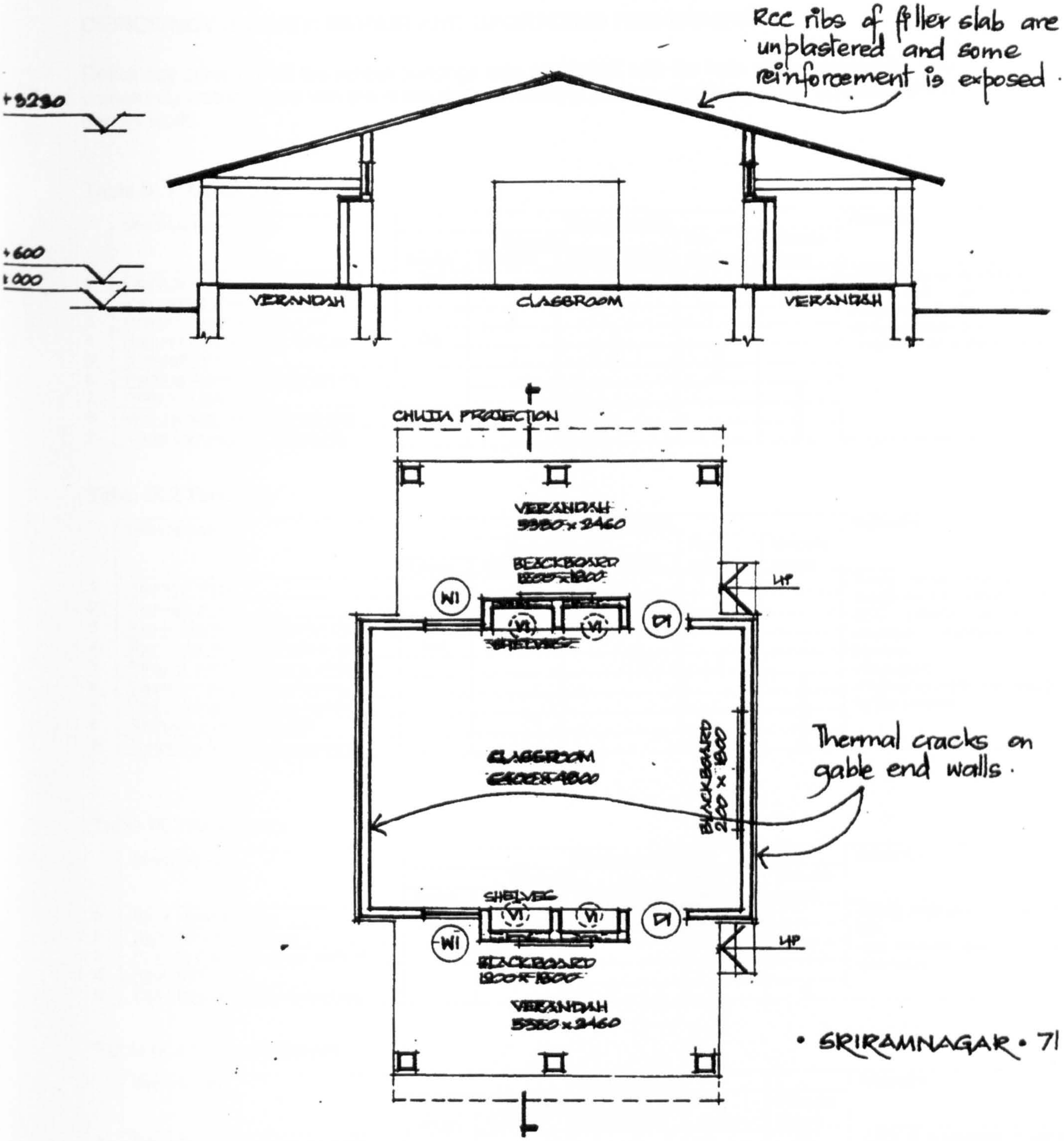


Figure VIII.29 : Sriramnagar, Ranga Reddy East, Andhra Pradesh



APPENDIX IX

DEFICIENCY SURVEY: REPAIR AND UPGRADING PROGRAMME

Deficiency survey of all the school buildings was conducted with the help of the community. The community was involved with the entire decision making process. Following is the summary of the survey work.

Table IX.1: Majeedpur

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Distraction- toe wall at verandas	AD					-Community highly motivated. -HM and the teachers participated in the construction work and saved cost. -Teachers did all the art works
2	Improvising chalk board			X			
3	Repair of eroded bricks -roof		X				
4	Rain water penetration-Roof vent	Det.		X			
5	Soakage in roof			X	X		
6	Painting doors-windows-walls etc				X		
7	Grills and gate					X	
8	Wall painting -Teaching-learning					X	
9	Visual campaign for community					X	

Table IX.2 Turkapally

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Repair of steps				X		Young women teachers were deeply involved with the work. SCC –initially not very co-operative – eventually deeply involved. HM is good -Profession artist was engaged for the art work
2	Soakage of roof			X	X		
3	Repair of grading plaster on chujja				X		
4	Rain water penetration-Roof vent	Det.					
5	Painting doors, windows, walls etc.				X		
6	Visual campaign for community					X	
7	Wall painting -Teaching-learning					X	
8	Reshaping verandah walls					X	
9	Tree-base for open class room					X	

Table IX.3 Anatharam

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Minor repair of steps				X		-Highly motivated SCC and the HM. -HM invested money from his own funds
2	Repair of eroded bricks		X				
3	Painting doors, windows, walls etc.				X		
4	Roof painting				X		
5	Wall painting -Teaching-learning					X	

Table IX.4 Lalgadimalakpet

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Plastering of underside- pyramid					X	-Lack of enthusiasm observed among the school teachers. -SCC took more interest
2	Repair of eroded bricks		X				
3	Roof and gutter treatment				X		
4	Painting doors, windows, walls etc.				X		
5	Minor repair doors and windows		X		X		

Table IX.5 Jaggamguda

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Blocking of roof vent	Det					-HM personally went to the nearest town to buy good quality materials.
2	Repair of eroded bricks		X				
3	Repair of windows		X				
4	Roof and gutter treatment				X		
5	Painting doors, windows, walls etc.				X		
6	Minor repair doors and windows		X				
7	Improvising chalk board			X			

Table IX.6 MC Pally

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Minor repair of floor				X		-HM and the SCC co-operative. -School teachers took part in the repair work and art work
2	Repair of eroded bricks		X				
3	Roof and gutter treatment				X		
4	Painting of existing blgds (old)					X	
5	Wall painting -Teaching-learning					X	

Table IX.7 Luxmapur

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Repair of frameless doors	Det					-There was conflict between the HM and the SCC. Since the HM was temporarily posted in the school, he was not too keen on taking active part in the repair work.
2	Repair of eroded bricks		X				
3	Blocking opening in class rooms	AD					
4	Painting doors, walls etc.				X		
5	Gable wall cracks	AD					
6	Lintel cracks	STR					
7	Roof soakage			X			
8	Additional chalk boards					X	
9	Guard wall for the front garden					X	

Table IX.8 Kesavpur

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Repair of frameless doors	Det					-The HM is dynamic interms of speed, decision making etc. but could not save cost compared to other schools
2	Repair of eroded bricks		X				
3	Sunlight in verandah	Ornt					
4	Painting doors, walls etc.				X		
5	Painting main gate + boundary wall					X	
6	Distraction – toe wall	AD					
7	Roof understructure- stage					X	
8	Board- school' name					X	
9	Wall painting -Teaching-learning					X	
10	Visual campaign for community					X	

Table IX.9 Adraspally.

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscella neous	
		Design	Matenals	Workmanship			
1	Repair of frameless doors-windows	Det					-The HM is dynamic interms of speed, decision making etc. but could not save cost compared to other schools
2	Repair of eroded bricks		X				
3	Distraction-toe wall in verandah	AD					
4	Painting doors, windows, walls etc.				X		
5	Repair of plinth protection			X			
6	Repair of steps			X			
7	Gable wall cracks	AD					
8	Painting main gate + boundary wall					X	
9	Repair of thermal cracks in walls	AD					
10	Repair of verandah floor						

Table IX.10 Ponnal

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscella neous	
		Design	Materials	Workmanship			
1	Repair of doors-windows		X				-The HM is very honest and gentle- he was exploited by the masons.
2	Repair of eroded bricks		X				
3	Repair of cracked lintel	Str		X			
4	Painting doors, windows, walls etc.				X		
5	Minor roof soakage			X			
6	Wall painting -Teaching-learning					X	
7	Painting of other existing bldgs					X	
8	Painting main gate + boundary wall					X	
9	Gable wall cracks	AD					

Table IX.11 Bomraspet:

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscella neous	
		Design	Materials	Workmanship			
1	Repair of frameless doors-windows	Det					-The best HM interms of speed, decision making, negotiation for cost reduction etc.
2	Repair of eroded bricks		X				
3	Repair of verandah floor			X			
4	Painting doors, windows, walls etc.				X		
5	Minor sill cracks	Det					
6	Tree-base					X	
7	Wall painting -Teaching-learning					X	
8	Cupboard in the HM's room					X	
9	Painting of other existing bldgs					X	
10	Painting –in other existing blgd.					X	
11	Painting main gate + boundary wall					X	

Table IX.12 Shameerpet

	Description	Type of repair					Remarks
		Essential			Preventi ve	Miscella neous	
		Design	Materials	Workmanship			
1	Repair of windows	Det.					-HM - very slow and involved more in the teachers' union. -When he was asked to return money for slow progress, he completed work in 4- days
2	Repair of eroded bricks		X				
3	Distraction- toe wall in verandah	AD					
4	Painting of existing blgds (old)					X	
5	Painting doors, windows, walls etc.				X		

Table IX.13 Kismatpur

	Description of defects	Type of repair					Remarks
		Essential			Pre-ventive	Miscella neous	
		Design	Matenals	Workmanship			
1	Repair of windows		X				-Very highly organised school teachers and the HM. -Very peaceful co-existence of the SCC and the teachers -Highly motivated young teacher involved the work.
2	Repair highly eroded ICSMB-10%		X				
3	Cracked blocks (ICSMB 10%)	AD					
4	Painting doors,windows, walls etc.				X		
5	Roof soakage			X			
6	Repair of chalk boards				X		

Table IX.14 Himayatsagar

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscella neous	
		Design	Matenals	Workmanship			
1	Repair of doors and windows		X				-Low level of participation by the teachers. -SCC is a mason and conducted the entire repair single handedly and with high level of finish
2	Roof leakage- gutter of FC channel	Det	X				
3	Cracked blocks (ICSMB 10%)	AD					
4	Painting doors,windows, walls etc.				X		
5	Rainwater – high level opening	AD		X			
6	Repair of cracked floor	AD					
7	Minor repair of Mangalore tiles				X		
8	Repair of corners	Det					
9	Repair of cracked floor	AD					

Table IX.15 Dargakhaliskan

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscella neous	
		Design	Matenals	Workmanship			
1	Repair of doors and windows		X				-Remarkably responsible and honest woman HM. -SCC – a local shop owner is sincere specially under the vigilance of the HM
2	Window shutters inside- unsafe	AD					
3	Cracked walls	STR					
4	Painting doors,windows, walls etc.				X		
5	Wind uplift of Mangalore tiles	STR		X			
6	Repair of eroded bricks		X				
7	Rain penetration- no chujja	AD					
8	Re-locate verandah blackboard	AD					

Table IX.16 Narsinghi

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscella neous	
		Design	Matenals	Workmanship			
1	Repair of doors and windows		X				-Competent HM, prefers to make his own decisions even in technical matters that created some problems- dominating. SCC - more involved with the project. However, the HM was prompt in bill settlement.
2	Window shutters inside- unsafe	AD					
3	Soakage in wall		X				
4	Painting doors,windows, walls etc.				X		
5	Repair of window grills			X			
6	Repair of eroded bricks		X				
7	Rain penetration- no drip course	AD					
8	Soakage through roof			X			

Table IX.17 Himayatnagar

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Repair of doors and windows		X				-Very honest HM and highly motivated teachers. One young teacher(MSc) attended school on a holiday to negotiate with masons to bring down labour charges.
2	Window shutters inside- unsafe	AD					
3	Soakage in gable wall		X				
4	Painting doors,windows, walls etc.				X		
5	Gable wall cracks			X			
6	Repair of eroded bricks		X				
7	Rain penetration- no chujja	AD					
8	Flush pointing on brick walls	Det		X			

Table IX.18 Appojiguda:

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Repair of doors and windows		X				-Unassuming lady teacher. All characters of an ideal teacher may be attributed to her. The SCC had full confidence and respect for the HM. Excellent record keeping of the on site process.
2	Window shutters inside- unsafe	AD					
3	Soakage in ridgeline of roof			X			
4	Painting doors,windows, walls etc.				X		
5	Black board cracks			X			
6	Wall cracks- thermal	AD					
7	One step at class- rm door unsafe	AD					

Table IX.19 Chandanagar-DAAT

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Eroded bricks		X				- Good HM but has very little control over the repair work. The SCC is not co-operative. The villagers damaged the roof tiles and jali even during repair work..
2	Damaged Mangalore tile roof			X			
3	Window shutters inside- unsafe	AD					
4	Repair of door and window shutter		X				
5	Painting doors,windows, walls etc..				X		
6	Wall cracks	Det					
7	Black board repair			X			

Table IX.20 Puppalguda

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Repair of doors and windows		X				-The HM is a famous artist but had hardly any particiaption
2	Replacement of wooden reaper		X				
3	Roof leakage through cracks	AD					
4	Painting doors,windows, walls etc.				X		
5	Cracks on mud plaster			X			
6	Wall cracks- thermal	AD					
7	Hip gutter damaged	Det					
8	Drip course at joist end	Det					

Table IX.21 Kokapet.

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Repair of doors and windows		X				-The HM is a soft spoken gentle man totally dominated by the ex-sapranch.
2	Drip course in roof projection	Det					
3	Wall soakage – no roof projection	Det					
4	Painting doors,windows, walls etc.				X		
5	Cracks on mud plaster			X			
6	Eroded CSMB masonry	AD					
7	Damaged wall corners	Det					
8	Damaged column base.	Det					

Table IX.22 Gandipet

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Repair of doors and windows		X				-The HM is a good and competent. The SCC could never deliver things as promised
2	No chujja	AD					
3	Roof leakage through cracks	AD					
4	Painting doors,windows, walls etc.				X		
5	Cracks on mud plaster			X			
6	Eroded CSMB masonry	AD					
7	Damaged wall corners	Det					
8	Damaged column base.	Det					
9	Wall cracks beam movement - thermal	AD					

Table IX.23 Chandanagar-DA

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Stabilised mud plaster of eroded walls	AD					- Good HM but has very little control over the repair work. The SCC is not co-operative. The villagers damaged the roof tiles and jali even during repair work..
2	Convert groove to flush pointing	Det					
3	Rainwater penetration- gable opening	Orient					
4	Deflected roof truss	AD					
5	Painting, walls understructure etc.				X		
6	Rainwater penetration- low sill height	AD					
7	Distraction- low sill height	AD					
8	Changed orientation of black board	AD					

Table IX.24 Chilkoor

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Replacement of doors and windows		X				- The HM at Chilkoor reported that door and windows were stolen, Very honest HM but needs capacity building for site management- very weak in negotiating material and labour costs. SCC rendered little hel;p to the school repair.
2	No chujja at verandah	AD					
3	Damaged floor- corridor			X			
4	Painting doors,windows, walls etc.				X		
5	Rainwater penetration in verandah	AD					
6	Minor seepage in roof			X			
7	Noise problem due to openness	AD					

Table IX.25 Chinnamangalaram

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Replacement of doors and windows		X				- The HM acted as an observer. The SEC is a hard working and responsible man who did the entire work single handedly.
2	Roof leakage through crack	Det					
3	Wall cracks due to thermal movement	AD		X			
4	Painting doors,windows, walls etc.				X		

Table IX.26 Medipally

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Replacement of doors and windows		X				- The HM is honest and very serious about the repair work. He saved a lot of cost by purchasing materials directly from the nearest market centre.
2	Verandah- misuse- SCB jali	AD					
3	Minor seepage- small roof projection	Det		X			
4	Painting doors,windows, walls etc.				X		
5	Painting of existing old buildings					X	
6	Construction of podium for functions					X	

Table IX.27 Surangal

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Replacement of doors and windows		X				- The HM is good. One lady teacher in the school has lot of ideas and inclination to implement whatever she learnt in the DPEP teachers' training.
2	Minor roof soakage			X			
3	SCB soakage		X				
4	Painting doors,windows, walls etc.				X		
5	Damaged floor			X		X	
6	Art work- teaching learning display					X	
7	Installation of main gate					X	
8	Painting of the existing old building					X	

Table IX.28 Sreeramnagar

	Description	Type of repair					Remarks
		Essential			Pre-ventive	Miscellaneous	
		Design	Materials	Workmanship			
1	Replacement of doors and windows		X				- Inspirational The HM who participated in the repair work by personally painting the walls of the class room. Took pains to explain every financial aspect to the inquisitive community.
2	Minor roof soakage			X			
3	Ceiling treatment	AD					
4	Painting doors,windows, walls etc.				X		
5	Gable wall crack- thermal movement	AD					
6	Art work- teaching learning display					X	
7	Repair of black board					X	
8	Repair of wall cracks- thermal	AD					

Table IX.29 **Summary of distresses**

SCHOOL NAMES	TYPES OF DEFECTS	Direct sunlight in classroom	D/W leaves opening inside-unsafe	Open verandah- distraction	Rainwater penetration- no chujja	Rainwater penetration- roof vent	Rainwater penetration- low sill heig	Cracked CSMB(10%)	Lintel cracks	Roof leakage-CRACKS	Disturbed roof tiles-wind uplift	Eroded CSMB (5%)	Gable wall crack	Damaged frameless door/window	Joint crack- FC channel	Rainwater penetration- no drip cour	Defective door/window	Eroded bricks	Eroded CSMB (10%)	Roof leakage-SOAKING	SCB Wall soakage
		DESIGN															MATERIAL			W'SHIP	
Majeedpur		0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Turkapally		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Anantharam		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lalgadi Malakpet		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Juggumguda		0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
MCPally		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Laxmapur		0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	1	0
Keshavp		1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0
Adraspally		1	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0
Ponnal		0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0
Bomraspet		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Shamirpet		0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Kismatpur		1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0
Himayatsagar		1	0	1	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0
Dargakhaliskan		0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0
Hydershakote		0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
Narsinghi		0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
Himayatnagar		1	1	1	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0
Appojiguda		0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Chandanagar-DAAT		0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0
Puppalguda		0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0
Kokapet		1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0
Gandipet		0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Chandanagar-DA		1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Chilkoor		0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Chinnamangalaram		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Medipally		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Surangal		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Sreeramnagar		0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0

Frequency of occurance in %	D1 28	D2 34	D3 45	D4 14	D5 40	D6 3.4	D7 100	D8 10	D9 3.4	D10 50	D11 75	D12 67	D13 100	D14 100	D15 14	M1 62	M2 67	M3 50	W1 38	W2 20

APPENDIX X

DATA ANALYSIS : REPAIR AND UPGRADING PROGRAMME

PART I – IMPACTS WHEN THE PROGRAMME WAS IMPLEMENTED

Table X.1 The summary of data analysis (costs in rupees.)

1GB£ = Rs.80 (in 2004)

Sl no	Name of the school	Expenditure Essential	Expenditure preventive	Expenditure misc.	Total Expenditure	Project cost in 1996	Essential %	Preventive %	misc %
I	**Shameerpet Mandal**								
1	Majeedpur	5,500.00	6,423.00	7,300.00	19,223.00	96,800.00	5.68	6.64	7.54
2	Turkapally	10,625.00	6,497.00	6,500.00	23,622.00	199,000.00	5.34	3.26	3.27
3	Anantharam	1,200.00	3,630.00	2,100.00	6,930.00	129,800.00	0.92	2.80	1.62
4	Lalgadi Malakpet	2,250.00	4,468.00	2,000.00	8,718.00	84,100.00	2.68	5.31	2.38
5	Jaggamguda	5,700.00	5,252.00	800.00	11,752.00	88,700.00	6.43	5.92	0.90
6	MCPally	646.00	2,789.00	2,000.00	5,435.00	55,000.00	1.17	5.07	3.64
7	Laxmapur	22,518.00	11,257.00	8,000.00	41,775.00	232,000.00	9.71	4.85	3.45
8	Keshav pur	2,000.00	6,308.00	5,000.00	13,308.00	96,000.00	2.08	6.57	5.21
9	Adras pally	5,500.00	7,696.00	8,500.00	21,696.00	206,000.00	2.67	3.74	4.13
10	Ponnal	6,000.00	8,893.00	2,000.00	16,893.00	235,000.00	2.55	3.78	0.85
11	Bommaras pet	3,719.00	5,333.00	5,360.00	14,412.00	158,000.00	2.35	3.38	3.39
12	Shameerpet	900.00	5,399.00	500.00	6,799.00	116,000.00	0.78	4.65	0.43
II	**Rajedra Nagar & Moinabad Mandal**								
1	Kismat pur	11,831.90	6,271.10	4,482.00	22,585.00	110,000.00	10.76	5.70	4.07
2	Himayatsagar	10,271.04	4,730.00	-	15,001.04	130,000.00	7.90	3.64	-
3	Dargakhalishkan	13,300.28	5,038.50	1,380.00	19,718.78	180,000.00	7.39	2.80	0.77
4	Hydershakot	2,700.00	14,997.00	1,100.00	18,797.00	153,000.00	1.76	9.80	0.72
5	Narsinghi	6,926.00	13,725.00	-	20,651.00	393,000.08	1.76	3.49	-
6	Himayatnagar	19,305.00	12,478.00	12,500.00	44,283.00	413,000.00	4.67	3.02	3.03
7	Appoji guda	3,462.00	4,954.00	1,600.00	10,016.00	107,000.00	3.24	4.63	1.50
8	Chanda (DAAT)	2,025.00	3,810.00	-	5,835.00	179,000.00	1.13	2.13	-
9	Ruppal guda	12,109.72	11,582.28	-	23,692.00	215,000.00	5.63	5.39	-
10	Kokapet	22,092.00	6,846.00	-	28,938.00	224,000.00	9.86	3.06	-
11	Gandipet	9,895.71	4,098.00	-	13,993.71	167,000.00	5.93	2.45	-
12	Chanda (DA)	13,875.00	2,058.00	17,350.00	33,283.00	230,000.00	6.03	0.89	7.54
13	Chilkoor	8,225.00	9,773.00	12,860.00	30,858.00	223,734.00	3.68	4.37	5.75
14	Chinamangalaram	12,800.00	4,915.00	6,200.00	23,915.00	105,000.00	12.19	4.68	5.90
15	Medi pally	2,205.00	5,250.00	7,536.00	14,991.00	88,867.00	2.48	5.91	8.48
16	Suran gal	5,089.30	11,059.70	10,500.00	26,649.00	208,582.00	2.44	5.30	5.03
17	Sreeramnagar	3,935.00	13,118.31	11,114.00	28,167.31	184,310.00	2.13	7.12	6.03

Table X.2 The fund release and reimbursement (costs in rupees.)

SLNo -	Name of the Schools .	Estimated cost in RS.	Phase-I release-50%	Phase-II release-35%	Phase-III reimbursement
I	**Shameerpet Mandal**				
1	Majeedpur	22220.15	11110.08	7,777.05	-413.00
2	Turkapally	27219.77	13,609.89	9,526.92	-512.00
3	Anantharam	8864.70	4432.35	3,102.65	605.00
4	Lalgadi Malakpet	9487.15	4743.58	3,320.50	-674.00
5	Jaggamguda	11508.55	5754.28	4,027.99	-1998.00
6	MCPally	6534.95	3267.48	2,287.23	32.00
7	Laxmapur	53413.83	26706.92	18,694.84	-4768.00
8	Keshav pur	10829.29	5414.65	3,790.25	7.00
9	Adras pally	25591.54	12795.77	8,957.04	0.00
10	Ponnal	19985.25	9992.63	6,994.84	0.00
11	Bommaras pet	8480.61	4240.31	2,968.21	-3072.00
12	Shameerpet	8086.61	4043.31	2,830.31	44.00
II	**Rajedranagar & Moinabad Mandal**				
1	Kismat pur	22263.03	1113152	7,792.06	-32100
2	Himayatagar	14495.41	7247.71	5,073.39	0.00
3	Dargakhalishkan	23239.54	11619.77	8,133.84	122
4	Hydershakot	22165.79	11082.90	7,758.03	-14.00
5	Narsinghi	31028.33	15514.17	10,859.92	-1637.00
6	Himayatnagar	45418.23	22709.12	15,896.38	-6213.00
7	Appoji guda	10005.40	5002.70	5,002.70	-10.00
8	Chanda (DAAT)	13348.16	6674.08	4,671.86	
9	Puppal guda	23713.19	11856.60	11,856.60	-276100
10	Kokapet -I plus	28935.86	14467.93	10,127.55	-683.00
11	Gandipet	10646.48	5323.24	3,726.27	-1270.00
12	Chanda nagar (DA)	26105.32	13052.66	9,136.86	-199100
13	Chilkoor	26690.48	13345.24	9,341.67	-8213.00
14	Chinamangalaram	28233.88	14116.94	9,881.86	2.00
15	Medi pally	15133.14	7566.57	7,566.57	143.00
16	Suran gal	31181.02	15590.51	10,913.36	-144.00
17	Sreeramnagar	29853.63	14926.82	10,448.77	-279131
	Grand Total	**614679.29**	**307339.65**	**222465.51**	**-36651.09**

** Negative indicates the amount of money that was revised after the mid-term review.

Table X.3 The impact on livelihood

Material and Labour (in rupees)

Sl no	Name of the school	Expenditure on		Total Expenditure
		Material	Labour	
I	**Shameerpet Mandal**			
1	Majeedpur	12,808.00	6,415.00	19,223.00
2	Turkapally	12,072.00	11,550.00	23,622.00
3	Anantharam	4,670.00	2,260.00	6,930.00
4	Lalgadi Malakpet	4,983.00	3,735.00	8,718.00
5	Jaggamguda	4,005.00	7,747.00	11,752.00
6	MCPally	3,995.00	1,440.00	5,435.00
7	Laxmapur	25,938.70	15,836.30	41,775.00
8	Keshav pur	9,058.00	4,250.00	13,308.00
9	Adras pally	13,456.00	8,240.00	21,696.00
10	Ponnal	6,652.00	10,241.00	16,893.00
11	Bommaras pet	8,712.00	5,700.00	14,412.00
12	Shameerpet	4,099.00	2,700.00	6,799.00
II	**Rajedranagar & Moinabad Mandal**			
1	Kismat pur	16,745.00	5,840.00	22,585.00
2	Himayatsagar	6,616.04	8,385.00	15,001.04
3	Dargakhalishkan	11,923.78	7,795.00	19,718.78
4	Hydersha kot	7,697.00	11,100.00	18,797.00
5	Narsinghi	12,151.00	8,500.00	20,651.00
6	Himayatnagar	23,433.00	20,850.00	44,283.00
7	Appoji guda	5,666.00	4,350.00	10,016.00
8	Chanda (DAAT)	2,985.00	2,850.00	5,835.00
9	Puppal guda	16,732.00	6,960.00	23,692.00
10	Kokapet	12,648.00	16,290.00	28,938.00
11	Gandipet	8,743.71	5,250.00	13993.71
12	Chanda (DA)	20,503.00	12,780.00	33,283.00
13	Chilkoor	23,258.00	7,600.00	30,858.00
14	Chinamangalaram	13,415.00	10,500.00	23,915.00
15	Medi pally	10,351.00	4,640.00	14,991.00
16	Suran gal	19,719.00	6,930.00	26,649.00
17	Sreeramnagar	17,267.31	10,900.00	28,167.31

Table X.4 The employment generation for construction workers (in rupees.)

Sl no	Name of the school	Labour charges in Rs
I	**Shameerpet Mandal**	
1	Majeedpur	6,415.00
2	Turkapally	11,550.00
3	Anantharam	2,260.00
4	Lalgadi Malakpet	3,735.00
5	Jaggamguda	7,747.00
6	MCPally	1,440.00
7	Laxmapur	15,836.30
8	Keshav pur	4,250.00
9	Adras pally	8,240.00
10	Ponnal	10,241.00
11	Bommaras pet	5,700.00
12	Shameerpet	2,700.00
II	**Rajedranagar & Moinabad Mandal**	
1	Kismat pur	5,840.00
2	Himayatsagar	8,385.00
3	Dargakhalishkan	7,795.00
4	Hydershakot	11,100.00
5	Narsinghi	8,500.00
6	Himayatnagar	20,850.00
7	Appoji guda	4,350.00
8	Chanda (DAAT)	2,850.00
9	Puppal guda	6,960.00
10	Kokapet	16,290.00
11	Gandipet	5,250.00
12	Chanda (DA)	12,780.00
13	Chilkoor	7,600.00
14	Chinamangalaram	10,500.00
15	Medi pally	4,640.00
16	Suran gal	6,930.00
17	Sreeramnagar	10,900.00

Table X.5 Money retained within the villages (in rupees)

Sl no	Name of the school	Money out of the village			Total cost of repair in Rs.
		Cement	Steel	Misc	
I	**Shameerpet Mandal**				
1	Majeedpur	980.00	-	5,000.00	19,223.00
2	Turkapally	920.00	-	12,983.00	23,622.00
3	Anantharam	125.00	-	1,832.00	6,930.00
4	Lalgadi Malakp	575.00	-	1,150.00	8,718.00
5	Jaggamguda	375.00	-	4,755.00	11,752.00
6	MCPally	125.00	-	650.00	5,435.00
7	Laxmapur	1,980.00	255.00	13,018.00	41,775.00
8	Keshav pur	330.00	-	1,000.00	13,308.00
9	Adras pally	1,380.00	-	3,000.00	21,696.00
10	Ponnal	1,100.00	500.00	2,500.00	16,893.00
11	Bommaras pet	315.00	-	1,500.00	14,412.00
12	Shameerpet	930.00	-	250.00	6,799.00
II	**Rajedranagar & Moinabad Mandal**				
1	Kismat pur	250.00	-	10,800.00	22,585.00
2	Himayatsagar	1,100.00	868.00	3,145.00	15,001.04
3	Dargakhalishk	1,775.00	500.00	500.00	19,718.78
4	Hydershakot	3,557.00	-	-	18,797.00
5	Narsinghi	2,625.00	1,426.00	-	20,651.00
6	Himayatnagar	5,940.00	-	2,000.00	44,283.00
7	Appoji guda	930.00	-	662.00	10,016.00
8	Chanda (DAA)	300.00	-	250.00	5,835.00
9	Puppal guda	1,424.00	-	7,609.00	23,692.00
10	Kokapet	1,200.00	-	4,149.00	28,938.00
11	Gandipet	1,445.00	788.00	3,356.00	13,993.71
12	Chanda (DA)	2,595.00	250.00	3,500.00	33,283.00
13	Chilkoor	1,400.00	500.00	4,600.00	30,858.00
14	Chinamangala	1,275.00	-	-	23,915.00
15	Medi pally	1,520.00	-	-	14,991.00
16	Suran gal	555.00	6,000.00	2,500.00	26,649.00
17	Sreeramnagar	240.00	6,000.00	12,532.00	28,167.31
	TOTAL	37,266.00	17,087.00	103,241.00	571,936.84

Table X.6 Analysis of Repair: Expenditure on Essential, Preventive and Miscellaneous (in rupees)

Sl no	Name of the school	Expenditure On Essential repair	Expenditure on preventive repair	Expenditure on miscellaneous	Total Expenditure
I	**Shameerpet Mandal**				
1	Majeedpur	5,500.00	6,423.00	7,300.00	19,223.00
2	Turkapally	10,625.00	6,497.00	6,500.00	23,622.00
3	Anantharam	1,200.00	3,630.00	2,100.00	6,930.00
4	Lalgadi Malakpet	2,250.00	4,468.00	2,000.00	8,718.00
5	Jaggamguda	5,700.00	5,252.00	800.00	11,752.00
6	MCPally	646.00	2,789.00	2,000.00	5,435.00
7	Laxmapur	22,518.00	11,257.00	8,000.00	41,775.00
8	Keshav pur	2,000.00	6,308.00	5,000.00	13,308.00
9	Adras pally	5,500.00	7,696.00	8,500.00	21,696.00
10	Ponnal	6,000.00	8,893.00	2,000.00	16,893.00
11	Bommaras pet	3,719.00	5,333.00	5,360.00	14,412.00
12	Shameerpet	900.00	5,399.00	500.00	6,799.00
II	**Rajedranagar & Moinabad Mandal**				
1	Kismat pur	11,831.90	6,271.10	4,482.00	22,585.00
2	Himayatsagar	10,271.04	4,730.00	-	15,001.04
3	Dargakhalishkan	13,300.28	5,038.50	1,380.00	19,718.78
4	Hydershakot	2,700.00	14,997.00	1,100.00	18,797.00
5	Narsinghi	6,926.00	13,725.00	-	20,651.00
6	Himayatnagar	19,305.00	12,478.00	12,500.00	44,283.00
7	Appoji guda	3,462.00	4,954.00	1,600.00	10,016.00
8	Chanda (DAAT)	2,025.00	3,810.00	-	5,835.00
9	Puppal guda	12,109.72	11,582.28	-	23,692.00
10	Kokapet	22,092.00	6,846.00	-	28,938.00
11	Gandipet	9,895.71	4,098.00	-	13,993.71
12	Chanda (DA)	13,875.00	2,058.00	17,350.00	33,283.00
13	Chilkoor	8,225.00	9,773.00	12,860.00	30,858.00
14	Chinamangalaram	12,800.00	4,915.00	6,200.00	23,915.00
15	Medi pally	2,205.00	5,250.00	7,536.00	14,991.00
16	Suran gal	5,089.30	11,059.70	10,500.00	26,649.00
17	Sreeramnagar	3,935.00	13,118.31	11,114.00	28,167.31

Total expenditure on		
Essential repair	preventive repair	Miscellaneous
226,605.95	208,648.89	136,682.00

Table X.7 The Essential Repair - Design, Materials and Workmanship (in rupees)

Sl no	Name of the school	Design	Materials	Workmanship	Total
I	Shameerpet Mandal				
1	Majeedpur	2,500.00	-	3,000.00	5,500.00
2	Turkapally	2,125.00	-	8,500.00	10,625.00
3	Anantharam	-	1,200.00	-	1,200.00
4	Lalgadi Malakpet	-	1,250.00	1,000.00	2,250.00
5	Jaggamguda	2,500.00	1,000.00	2,200.00	5,700.00
6	MCPally	646.00	-	-	646.00
7	Laxmapur	10,518.00	2,000.00	10,000.00	22,518.00
8	Keshav pur	2,000.00	-		2,000.00
9	Adras pally	2,000.00	3,500.00	-	5,500.00
10	Ponnal	4,000.00	2,000.00	-	6,000.00
11	Bommaras pet	2,184.00	-	1,535.00	3,719.00
12	Shameerpet	600.00	300.00	-	900.00
II	Rajedranagar & Moinabad Mandal				
1	Kismat pur	910.00	5,776.90	5,145.00	11,831.90
2	Himayatsagar	10,271.04	-	-	10,271.04
3	Dargakhalishkan	5,355.28	2,945.00	5,000.00	13,300.28
4	Hydershakot	1,200.00	1,000.00	500.00	2,700.00
5	Narsinghi	-	-	6,926.00	6,926.00
6	Himayatnagar	6,005.00	5,000.00	8,300.00	19,305.00
7	Appoji guda	2,100.00	700.00	662.00	3,462.00
8	Chanda (DAAT)	1,355.00	670.00	-	2,025.00
9	Puppal guda	6,009.72	6,100.00	-	12,109.72
10	Kokapet	18,992.00	3,100.00		22,092.00
11	Gandipet	7,895.31	-	2,000.00	9,895.31
12	Chanda (DA)	13,875.00	-	-	13,875.00
13	Chilkoor	-	7,340.00	885.00	8,225.00
14	Chinamangalaram	4,800.00	8,000.00		12,800.00
15	Medi pally	-	2,205.00	-	2,205.00
16	Suran gal	2,549.30	2,540.00	-	5,089.30
17	Sreeramnagar	935.00	-	3,000.00	3,935.00

Total expenditure on		
Design	Materials	Workmanship
111,325.65	56,626.90	58,653.00

Table X.8 The Indication of Sustainability: Community Contribution (in rupees.)

Sl no	Name of the school	Community contribution	DRD contribution
I	**Shameerpet Mandal**		
1	Majeedpur	9,300.00	19,223.00
2	Turkapally	2,500.00	23,622.00
3	Anantharam	2,000.00	8,718.00
4	Lalgadi Malak	-	11,752.00
5	Jaggamguda	1,500.00	6,930.60
6	MCPally	1,000.00	5,435.00
7	Laxmapur	3,500.00	41,775.00
8	Keshav pur	5,000.00	13,308.00
9	Adras pally	-	18,574.00
10	Ponnal	-	16,893.00
11	Bommaras pe	3,500.00	14,412.00
12	Shameerpet	-	6,799.00
II	**Rajedranagar & Moinabad Mandal**		
1	Kismat pur	3,000.00	22,585.00
2	Himayatsagar	1,500.00	15,001.04
3	Dargakhalishk	2,800.00	19,718.78
4	Hydershakot	-	18,797.00
5	Narsinghi	-	20,651.00
6	Himayatnagar	2,100.00	44,283.00
7	Appoji guda	1,500.00	10,016.00
8	Chanda (DAAT	-	5,835.00
9	Puppal guda	-	23,692.00
10	Kokapet	-	17,239.00
11	Gandipet	-	13993.71
12	Chanda (DA)	-	33,283.00
13	Chilkoor	-	30,858.00
14	Chinamangala	-	23,915.00
15	Medi pally	-	14,991.00
16	Suran gal	1,000.00	26,649.00
17	Sreeramnagar	2,000.00	28,167.31
TOTAL		42,200.00	557,116.44

PART II –LIFE CYCLE IMPACTS OF THE REPAIR AND UPGRADING

Basis of life cycle cost calculations (Discount 13% and Inflation 8%, building life 50 years)

Ndr = [(1+ discount %)/(1+inflation%)-1], i.e., Ndr =1.046, Nett Present Value (NPV) can be expressed as;

NPV = IC + RC1/ (1+Ndr) + RC2/ $(1+Ndr)^2$ + RC3/ $(1+Ndr)^3$ .....)

C- estimated cost in year t, r- discount rate, T-period of analysis in years, Ndr- the 'Nett of inflation discount rate

IC → initial cost, RC → recurring costs in year 1, year 2 ..... (for detail refer to chapter 5, section 5.5.4)

Table X.9 Initial cost of construction and discounted recurring cost

Name of the school	Initial total cost in rupees per square metre	Total recurring discounted cost in rupees per square metre
Suran gal	1537.9885	429.07
Chilkoor	1624.5571	438.25
Medi pally	1371.1927	418.42
Chinamangalaram	1534.1905	746.89
Sreeramnagar	1359.0178	471.80
Laxmapur	1619.9986	703.74
Ponnal	1854.336	405.30
Himayatsagar	1932.2235	658.25
Puppal guda	1565.9141	562.20
Kokapet	1664.1902	604.89
Gandipet	2346.8241	572.78
Jaggamguda	1682.4734	673.41
Turkapally	1595.0625	420.68
Anantharam	1671.6033	231.45
Lalgadi Malakpet	1492.193	425.36

Table X.10 The life cycle essential and preventive costs in rupees

Name of the school	Expenditure Essential	Expenditure preventive	Expenditure misc.	Initial total	Life cycle (discounted)	
					essential	preventive
Suran gal	5,089.30	11,059.70	10,500.00	208,582.00	12,197.45	45,993.59
Chilkoor	8,225.00	9,773.00	12,860.00	223,734.00	19,712.73	40,642.63
Medi pally	2,205.00	5,250.00	7,536.00	88,867.00	5,284.69	21,832.99
Chinamangalaram	12,800.00	4,915.00	6,200.00	105,000.00	30,677.56	20,439.84
Sreeramnagar	3,935.00	13,118.31	11,114.00	184,310.00	9,430.95	54,554.66
Laxmapur	22,518.00	11,257.00	8,000.00	232,000.00	53,968.55	46,814.09
Ponnal	6,000.00	8,893.00	2,000.00	235,000.00	14,380.11	36,983.01
Himayatsagar	10,271.04	4,730.00	-	130,000.00	24,616.44	19,670.49
Puppal guda	12,109.72	11,582.28	-	215,000.00	29,023.18	48,166.82
Kokapet	22,092.00	6,846.00	-	224,000.00	52,947.56	28,470.22
Gandipet	9,895.71	4,098.00	-	167,000.00	23,716.90	17,042.21
Jaggamguda	5,700.00	5,252.00	800.00	88,700.00	13,661.10	21,841.31
Turkapally	10,625.00	6,497.00	6,500.00	199,000.00	25,464.78	27,018.85
Anantharam	1,200.00	3,630.00	2,100.00	129,800.00	2,876.02	15,095.95
Lalgadi Malakpet	2,250.00	4,468.00	2,000.00	84,100.00	5,392.54	18,580.92

Table X.11 The total investment on repair and the total retention in the villages

Name of the school	Total cost of repair in rupees	money-retained in rupees	Covered area in square metre	Repair in rupees per square metre	
				Investment	Retained
Suran gal	26,649.00	18,577.25	135.62	196.50	136.98
Chilkoor	30,858.00	24,643.00	137.72	224.06	178.94
Medi pally	14,991.00	13,699.00	64.81	231.31	211.37
Chinamangalaram	23,915.00	22,831.25	68.44	349.43	333.60
Sreeramnagar	28,167.31	10,331.31	135.62	207.69	76.18
Laxmapur	41,775.00	26,857.25	143.21	291.70	187.54
Ponnal	16,893.00	13,033.00	126.73	133.30	102.84
Himayatsagar	15,001.04	10,183.24	67.28	222.96	151.36
Puppal guda	23,692.00	14,872.60	137.30	172.56	108.32
Kokapet	28,938.00	23,769.00	134.60	214.99	176.59
Gandipet	13,993.71	8,739.66	71.16	196.65	122.82
Jaggamguda	11,752.00	6,678.25	52.72	222.91	126.67
Turkapally	23,622.00	9,857.00	124.76	189.34	79.01
Anantharam	6,930.00	4,991.75	77.65	89.25	64.29
Lalgadi Malakpet	8,718.00	7,079.25	56.36	154.68	125.61

Table X.12 Life cycle labour costs on essential and preventive repair

Name of the school	Initial total labour cost per square metre	Life cycle (discounted) per square metre	
		Essential	Preventive
Suran gal	144.57	23.39	109.40
Chilkoor	152.71	35.25	90.16
Medi pally	109.70	25.24	129.34
Chinamangalaram	122.74	196.80	162.66
Sreeramnagar	163.08	26.91	193.10
Laxmapur	200.88	142.86	153.72
Ponnal	229.94	68.79	219.45
Himayatsagar	357.46	204.51	202.72
Puppal guda	297.52	62.10	127.84
Kokapet	316.20	221.44	147.70
Gandipet	492.83	125.04	111.46
Jaggamguda	538.39	170.82	338.77
Turkapally	510.42	99.80	131.35
Anantharam	885.95	12.08	78.65
Lalgadi Malakpet	477.50	40.99	175.21

Table X.13 Essential, Preventive and Miscellaneous repair costs in rupees per square metre

Name of the school	Expenditure Essential	Expenditure preventive	Expenditure misc.
Suran gal	37.53	81.55	77.42
Chilkoor	59.72	70.96	93.38
Medi pally	34.02	81.01	116.28
Chinamangalaram	187.03	71.81	90.59
Sreeramnagar	29.01	96.73	81.95
Laxmapur	157.24	78.60	55.86
Ponnal	47.34	70.17	15.78
Himayatsagar	152.66	70.30	-
Puppal guda	88.20	84.36	-
Kokapet	164.13	50.86	-
Gandipet	139.06	57.59	-
Jaggamguda	108.12	99.62	15.17
Turkapally	85.16	52.08	52.10
Anantharam	15.45	46.75	27.04
Lalgadi Malakpet	39.92	79.28	35.49

Basis of life cycle embodied energy calculations

The average of four years for preventive repair and ten years for essential repair, i.e., seven years, has been assumed for calculating the life cycle embodied energy (Chapter 5, section 5.5.4)

Table X.14 Initial and life cycle embodied non-renewable energy in Mega Joules per square metre

Name of the school	Non-renewable	
	Initial	Life cycle
Suran gal	1,613.66	999.28
Chilkoor	1,852.26	293.77
Medi pally	1,537.09	505.26
Chinamangalaram	1,679.75	401.34
Sreeramnagar	1,121.61	949.25
Laxmapur	1,186.46	334.53
Ponnal	1,195.67	268.25
Himayatsagar	1,141.23	617.92
Puppal guda	1,065.45	223.44
Kokapet	1,213.31	192.07
Gandipet	1,572.19	665.52
Jaggamguda	1,069.90	153.24
Turkapally	889.76	158.86
Anantharam	914.41	34.68
Lalgadi Malakpet	1,109.47	219.79

APPENDIX XI

SUMMARY: COMMUNITY-BASED REPAIR AND UPGRADING PROGRAMME

Following are the highlights of the Community-Based Repair and Upgrading programme of the primary schools constructed using various Cost Effective Construction Technologies in Ranga Reddy district.

1. Capacity building of the School Committees
2. Ownership of the School Committees, students and teachers
3. Cost reduction
4. Changed perception of community on maintenance
5. School as a source of learning for the community
6. Transparency of the process
7. Analysis of rates for repair work
8. Defects due to faulty Planning, Design, Skills etc.
9. Alternative Implementation Agency For Maintenance
10. Cross cutting issues
11. A step towards assessing Whole Life cost of buildings

Figure XI-1 The following photographs show the process of repair and upgrading.

1.	Capacity Building	cxliii
2.	Ownership	cxliii
3.	Cost Reduction	cxliii
4.	Changed Perception of Community on Maintenance	cxliv
5.	School as a Source of Learning for the Community	cxliv
6.	Transparency	cxliv
8.	Defects due to faulty Planning, Design, Skills Etc.	cxlv
9.	Alternative Implementation Agency for Maintenance	cxlv
10.	Cross Cutting Issues	cxlvi

1. Capacity Building



Capacity building of the schoolteachers at Surangal

- Housekeeping, that will reduce building distress.
- Detection of distress in buildings
- Site level management for the repair work.
- Quality control of the construction work
- Maintaining accounts.
- Estimate for repair with reference to the site book.

2. Ownership



Headmaster at Shameerpet participating in construction of brick jaali





Students helped to the best of their abilities in the repair and upgrading of their school and in creating a better learning environment – Surangal and Shameerpet

3. Cost Reduction



Headmaster engaged in white washing the classroom at MCPally.

Active participation of the schoolteachers and students in construction work like painting of doors, windows, white washing etc had reduced costs considerably.



Headmaster of Sreeramnagar and PRED engineer negotiating with a carpenter. Community's involvement in decision making has reduced the cost of materials and labour costs.

4. Changed Perception of Community on Maintenance



Schoolteacher at Keshavpur engaged in creating interesting teaching-learning aids.

The community had little or no interest in maintenance of primary school since it is usually restricted to plastering, painting and the like. The present programme went beyond the repair works. It was integrated with improvement of school environment by creating interesting teaching learning materials, which were cost-effective and designed by the community.

Chairperson of school committee (Puppalguda) replacing a micro-concrete tile



Community's perception that maintenance required lot of money and labour was changed. They realised that motivation was the primary requirement

5. School as a Source of Learning for the Community



Schoolteacher at Majeedpur explaining the process of purification of drinking water to the community, using a mural in the school.



Schoolteacher at Keshavpur painting the village map on the wall, which was developed during micro planning exercise. This effort was appreciated by the villagers



Headmaster, teacher and a student at Majeedpur designing a campaign for education of girl child on the school walls, to increase the awareness of the community.

6. Transparency



Meeting of school education committee at Keshavpur (above) and Majeedpur (below), for settlement of accounts of the repair works.

Periodic meetings with the communities regarding financial expenditure had contributed to transparency in the process. In general the increased involvement of the schoolteachers had contributed a lot to the transparency. Vigilance of the community had been the other factor.



Ownership developed through the repair and maintenance programme. A tremendous enthusiasm was observed within the community. The entire work planning was based on constant interaction with the community so that a correct understanding of their requirements could be understood by the consultants and engineers.

7. Analysis of Rates for Repair Work

Analysis of rates for the repair work has always been the weakest component of maintenance. For some unknown reasons, the rates of the standard schedule were not workable for the contractors to carry out repair work. Therefore, the quality of construction had always been low. The present programme had established workable analysis of rates for the different technologies.

8. Defects due to faulty Planning, Design, Skills Etc.



Lack of basic housekeeping in Surangal could have led to long term problems.

Analysis of the deficiency survey data revealed that the problems were due to faults in design/detailing, improper quality of materials and workmanship and lack of housekeeping. The results of the research helped in creating improved and more durable and cost-effective infrastructure in future.

9. Alternative Implementation Agency for Maintenance



At present the maintenance of education infrastructure is carried out by appointing local contractors, whose general focus is on maximising profit. The quality of such repair work is bound to suffer, especially when the contractor works with impractical rates as mentioned in item no.7

The present project had proved that school committee as implementation-agency eliminated most of such problems.

10. Cross Cutting Issues

Wirecut brick was popularised by its wide use in Ranfa Reddy district in 1995-96. Contrary to the traditional belief, wirecut brick masonry worked out cheaper than 345mm. thick country brick masonry wall. Within two to three years after the programme was over, a few wirecut brick fields had been established in Ranga Reddy district to support the increased demand.



11. A Step towards Assessing Whole Life cost

Inadequate information on Whole Cycle Cost has been one of the gaps in disseminating Cost Effective Construction Technologies. Many people have doubts about the performance of these technologies over time. Hence there is a need for facts and figures to establish sustainability of the technologies. Ten different types of roofing systems, five walling system and three types of foundations had been adopted in thirty-two school buildings. The buildings have endured the environment for four years and hence, the present exercise has provided a reliable set of data for calculating the Whole Life cost of all the technologies.

<u>Let us now focus on the problems faced in the repair and upgrading programme.</u>

The chapter 5 has presented the process of community- based repair and upgrading that appeared to have worked well in Andhra Pradesh. The existing model has the potential of being adopted by the District Primary Education Programme in the near future. At this point, it is important to look at the problems faced during the present programme in Ranga Reddy district, which may be broadly categorised as follows.

a. Funding
b. Administrative and Management
c. Technical
d. Attitudinal

a. Funding

- Lack of fund at national level is the major constraint.

- Being under non-planned budget (e.g. other recurring expenditure like salaries etc), maintenance has been a low priority - there is a tremendous shortfall of fund for providing the required salary.

- Inadequate finance has been a major problem as asset management budgets are easier to curtail when money is scarce. The problem is compounded with bad management and poor building design.

b. Administrative and Management

- Volume of repair work is small but requires intensive supervision - the state govt. engineers are already overloaded with the regular departmental jobs.

- Cost of mobilisation and overhead of repair is higher than the standard schedule of rates for similar items in new construction. The existing system did not have any provision to allow different rates in repair works.

c. Technical

- Needs expert knowledge to diagnose – needs capacity building.
- Difficult to estimate the repair items.

d. Attitudinal

- New projects are easy to implement since everything is pre-calculated. Repair is uncertain since the scope of work may change even during implementation and the slow reaction time of the institutional system hampers the speed of the work. New construction has more visual impact and hence, politically more attractive.
- Lack of interest of engineers on repair – no sense of achievement.
- Inability of all concerned to understand that maintenance prolongs the life of buildings. Sometimes, revitalisation of existing buildings is more cost effective than creating new infrastructure.

Suggestions on the dissemination of the experience.

- Manuals for the end users on aspects like housekeeping and diagnosing essential repairs, estimation of materials, manpower, tools, costing etc.
- Posters that can be displayed in the teachers' room (checklist for maintenance)
- Travelling exhibition of the present process across the states who have implemented District Primary Education Programme.
- Use of the video film.

Figure XI-2 The following photographs show the schools constructed in 1995-96 and after the repair and upgrading programme in 1999-2000

- Construction of New Classrooms, 1995-1996 cxlviii
  Ranga Reddy District, Andhra Pradesh
- Repair and Upgrading 1999-2000 cxlix

CONSTRUCTION OF NEW CLASSROOMS, 1995-1996

RANGA REDDY DISTRICT, ANDHRA PRADESH

Prototype primary school buildings were constructed in Ranga Reddy district using cost effective construction technologies, funded by DFID (formerly ODA) in 1995-96 under Andhra Pradesh Primary Education Project. Following are some of the school buildings based on different construction technologies

Ponnal, Ranga Reddy East
Folded filler slab and rat-trap masonry wall





MC Pally, Ranga Reddy East
Hybrid slab and rat-trap masonry wall



Majeedpur, Ranga Reddy East
Brick pyramid roofing and rat-trap masonry wall



Ferrocement channel roof



Micro-concrete tile roofing

REPAIR AND UPGRADING 1999-2000

The project was completed in May 2000, and the twenty-nine prototype primary school buildings of APPEP got a new lease of life. Community-Based repair and management proved to be an efficient alternative model to the existing contractor-based system.

Following pictures provide a few glimpses at the end product of the project.



Brick pyramid and brick walling at Turkapally and Jaggamguda, Ranga Reddy East





Puppalguda, Ranga Reddy West - Jackarch roof + Micro concrete roof+ cement stabilised masonry wall



APPENDIX XII

SCORING – NEW CONSTRUCTION

BASIS OF CALCULATIONS

1068 Classroom Units Adopting 66 Combinations of 11 Roofing and 6 Walling Technologies. Carpet Area of each Classroom 5.5 Metres x 5.5 Metres.

Discount		13%
Inflation		8%
Group Weighting		
Socio-Economic	GW-1	1
Environmental	GW-2	1

Table XII.1 Indexes for new construction of 1068 classroom units **- all weights = 1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	73 08	70 30	58 60	**47.38**	55 67	63 01
RCC plank- joist	75 31	73 00	61.43	52.05	58.46	65 43
RCC channel	74 90	72.57	61 02	51 62	58 05	65 02
FC channel	74 34	72.50	61.48	53 06	58 18	64 81
MCT roofing	77 32	77.88	69 06	62.64	64 52	69 62
Hybrid slab	79 28	76 64	64 51	52.91	61.37	69 44
Filler slab	77 03	75 84	66.70	56 93	63 42	69 84
stone roof	76 49	73 48	61.10	52.26	58 65	66 49
Jack arch	81.19	79 03	66 62	57.39	63 51	71 20
corbelled arch	97.73	100 00	90 20	89 67	86 23	92.34
corbelled pyramid	91.91	93.17	82.76	80.30	78 99	85 30

Table XII.2 Indexes for new construction of 1068 classroom units - weight of **unit cost= 128 and others =1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	59 82	64 85	64.29	72.59	64 39	51.52
RCC plank- joist	63.17	68 88	68 32	77 68	68 37	54 28
RCC channel	62.51	68 09	67 53	76 69	67.59	53 74
FC channel	63 13	68 86	68.33	77 74	68 36	54 26
MCT roofing	78 51	86 93	86 54	100 00	86.35	67.15
Hybrid slab	60 45	65 56	64 97	73 34	65 06	52.11
Filler slab	68 08	73 40	72.97	81 92	73 19	59 05
stone roof	54.70	58.76	58 15	65.13	58 34	**47.35**
Jack arch	62.83	68 42	67.82	76 99	67 87	54 06
corbelled arch	74 76	79 57	79.10	87 95	79 52	65 57
corbelled pyramid	72.25	77.50	77.00	86 24	77.30	62.99

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Table XII.3 Indexes for new construction of 1068 classroom units - weight of **skilled masons= 128 and others =1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	56.56	56 00	62.55	29 34	54.35	68 88
RCC plank- joist	65 66	65.12	71.68	38 08	63 29	78 91
RCC channel	60 03	59 49	66.06	32.75	57 78	72.71
FC channel	56 16	55 65	62.24	**29.18**	54.02	68 46
MCT roofing	72.78	72.43	78.42	47.58	70.51	86.13
Hybrid slab	62 05	61.50	68 03	34 52	59 71	74 92
Filler slab	73.10	72.70	77 95	49 91	70 80	85 77
stone roof	71.24	70 66	77 18	43 32	68.71	85 05
Jack arch	64 11	63.58	70.10	36 60	61.74	77.17
corbelled arch	87.35	87 21	91 00	68 69	84 95	100 00
corbelled pyramid	81 56	81 33	85 81	60 71	79.18	94 33

Table XII.4 Indexes for new construction of 1068 classroom units - weight of **semi-skilled masons= 128 and others =1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	64.31	58 08	41 08	23 74	37 66	40 04
RCC plank- joist	70 21	64.00	47.01	29 45	43.47	46.54
RCC channel	69 05	62 84	45.85	28 36	42.33	45 27
FC channel	65 64	59 45	42 49	25 22	39 02	41 52
MCT roofing	49 66	44 20	28 99	**14.03**	25 99	26 97
Hybrid slab	76 79	70.57	53 55	35 54	49 87	53 78
Filler slab	67.06	62.13	48 54	33 85	45 46	49 20
stone roof	60 33	54 08	37.05	20 05	33 73	35 63
Jack arch	71.44	65 24	48 20	30 61	44 64	47.86
corbelled arch	100 00	96 46	86 12	72 92	82.78	91.53
corbelled pyramid	73.10	68 89	56 88	43 64	53 88	58 81

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Table XII.5 Indexes for new construction of 1068 classroom units - weight of **unskilled masons= 128 and others =1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	63 52	59.73	66.48	41.79	70.70	91.49
RCC plank- joist	66 00	62.23	68 99	44.27	73 16	94 22
RCC channel	70 63	66 85	73 61	48 65	77 69	99 32
FC channel	70 41	66 66	73 45	48 54	77 51	99.10
MCT roofing	52.75	49 49	55 66	**33.89**	59 46	77.47
Hybrid slab	65.31	61.52	68 25	43 47	72 43	93 44
Filler slab	63 77	60 79	66.20	45 78	69 29	87.43
stone roof	71.25	67.44	74 16	49 20	78 26	100 00
Jack arch	67.59	63 82	70 54	45 76	74 68	95 93
corbelled arch	69 86	67.78	71 69	55 66	73 53	89 66
corbelled pyramid	74 83	72.33	76 95	58 44	79 25	97.34

Table XII.6 Indexes for new construction of 1068 classroom units - weight of **retention= 128 and others =1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	94 24	82.45	58.58	48 88	54 59	83 89
RCC plank- joist	81.57	69 81	45 94	37.01	42 20	69 91
RCC channel	81 61	69 85	45 98	37 05	42 24	69 96
FC channel	76.70	64 97	41.13	**32.50**	37 47	64 56
MCT roofing	76 73	66 29	44 88	36 80	41.37	66 60
Hybrid slab	100 00	88 22	64 33	54 32	60 22	90.23
Filler slab	86 01	76 63	57.55	49 23	54.11	78 77
stone roof	93 95	82.15	58 25	48 69	54 29	83.56
Jack arch	93 66	81.91	58 00	48 45	54 01	83 21
corbelled arch	76 52	69 65	55.19	48 77	52.33	72 13
corbelled pyramid	81.85	73 77	56 94	49.69	53 79	76 06

Table XII.7 Indexes for new construction of 1068 classroom units- weight of **non-renewable energy= 128 and others =1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	33.28	36 82	30 68	28.53	26 67	26 92
RCC plank- joist	34 06	37 80	31.40	29 26	27.24	27.51
RCC channel	34 03	37.77	31.37	29 23	27.21	27.48
FC channel	37 38	42.11	34 32	31.73	29 29	29 82
MCT roofing	54.04	64 22	48 92	43 94	39 67	41 44
Hybrid slab	37 53	42.20	34 40	31.66	29 40	29 99
Filler slab	46 54	52.71	42.93	39 62	36 52	37.14
stone roof	28 65	31.02	26 54	25.13	23 65	**23.61**
Jack arch	39 67	45 01	36 26	33.31	30 72	31.48
corbelled arch	83 24	100 00	75 25	67 61	60.56	63 49
corbelled pyramid	71 30	85.41	64 40	57 84	51.93	54 44

Table XII.8 Indexes for new construction of 1068 classroom units-weight of **renewable energy= 128 and others =1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	14 11	15 22	14 63	19 35	14 89	13 36
RCC plank- joist	19 59	22.53	21 94	38.16	22 62	19 37
RCC channel	19.57	22.50	21.92	38.14	22 60	19 35
FC channel	21.29	25 04	24 48	47 75	25 32	21.35
MCT roofing	24 18	28 88	28 43	58 52	29 41	24 54
Hybrid slab	14 27	15 35	14 74	19 24	14 98	13 53
Filler slab	12.14	12.68	12 22	14 07	12.31	**11.36**
stone roof	20 97	24 46	23 84	45 16	24 68	20 94
Jack arch	20.74	24 05	23 43	42.76	24 18	20 63
corbelled arch	36 97	44 94	44 45	100 00	46 26	38 13
corbelled pyramid	32.10	38 90	38 38	85 93	39 91	33 00

Table XII.9 Indexes for new construction of 1068 classroom units - weight of **waste energy= 128 and others =1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	77 48	65.07	3 11	**2.53**	2 96	3 34
RCC plank- joist	77 48	65 09	3 13	2 66	2 99	3 34
RCC channel	77.46	65 06	3 11	2 64	2 97	3 32
FC channel	77.40	65.03	3 11	2 68	2.95	3 28
MCT roofing	70 23	59 21	3 53	3 21	3 31	3 57
Hybrid slab	89 92	77.51	15 53	14 30	15 13	17.05
Filler slab	65 70	55.82	6 26	5 61	6 04	6 72
stone roof	90 75	78.33	16.33	15.18	15 95	17 97
Jack arch	100 00	87 62	25.62	23 98	25 02	28 15
corbelled arch	92 70	85 45	48.13	45 80	47.06	52.74
corbelled pyramid	98 11	89 58	46.10	43 76	45 07	50 55

Table XII.10 Indexes for new construction of 1068 classroom units - weight of **CO_2 emission= 128 and others =1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	39 17	45 28	61 95	59 66	57 13	54 26
RCC plank- joist	40.05	46 49	64 26	61 83	59 06	56.17
RCC channel	40.12	46 59	64 50	62.03	59 25	56 36
FC channel	43 10	50 85	73 63	70 09	66 66	63 81
MCT roofing	52.74	63 90	100.00	93 42	88.19	85 34
Hybrid slab	38 65	44.45	59 98	57 91	55 52	52.70
Filler slab	47.20	54 56	74 30	71 94	68 75	65 04
stone roof	**34.10**	38 37	48 87	47.91	46 06	43 41
Jack arch	38 09	43 68	58 35	56 57	54.17	51.35
corbelled arch	49 77	55 63	68 81	68 70	65 59	61.18
corbelled pyramid	46 48	52 44	66 53	65 88	62.89	58 93

Table XII.11 Sensitivity analysis of the varying weightings – showing lowest indexes – new construction

Weights / Parameters	1	2	4	8	16	32	64	128	256	512	1024
Unit cost	47.38	52.21	59.39	63.16	58.68	52.64	49.20	47.35	46.39	45.90	45.65
Skilled	47.38	45.72	43.32	39.07	34.99	32.10	30.33	29.18	28.51	28.16	27.99
Semiskilled	47.38	44.36	40.15	35.03	27.44	20.63	16.40	14.03	12.77	12.12	11.79
Unskilled	47.38	48.74	49.83	48.40	44.47	39.51	35.90	33.89	32.85	32.32	32.05
Retention	47.38	49.63	51.07	46.53	40.43	36.30	33.85	32.50	31.79	31.43	31.25
Non-renewable	47.38	44.80	41.24	37.24	32.51	28.35	25.34	23.61	22.51	21.94	21.65
Renewable	47.38	47.09	41.15	33.96	26.53	19.47	14.28	11.36	9.82	9.02	8.62
waste	47.38	42.13	34.20	24.52	15.37	8.83	4.77	2.53	1.35	0.69	0.35
CO_2	47.38	52.16	59.35	58.34	50.03	41.62	36.74	34.10	32.73	32.02	31.67

APPENDIX XIII

SCORING – LIFE CYCLE

BASIS OF CALCULATIONS

1068 Classroom Units Adopting 66 Combinations of 11 Roofing and 6 Walling Technologies. Carpet Area of each Classroom 5.5 Metres x 5.5 Metres.

Discount		13%
Inflation		8%

Group Weighting

Socio-Economic	GW-1	1
Environmental	GW-2	1

Table XIII.1 Life cycle indexes of 1068 classroom units **- all weights = 1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	83.36	79 03	70.74	**59.69**	67 38	73 57
RCC plank- joist	84 71	80 93	72.68	61 91	69 27	75 34
RCC channel	84 34	80.54	72 31	61.53	68 89	74 95
FC channel	84 43	81 71	74 80	63 66	70 38	76.13
MCT roofing	87.91	90 32	84.45	75.38	78 69	82 70
Hybrid slab	87 33	83 62	75 06	64 05	71 51	77.96
Filler slab	85 72	82.60	75 88	66 54	72.84	78.46
stone roof	87.76	82.62	73 49	62 69	70 97	79 04
Jack arch	88 38	85.33	76 60	66 07	73 07	79 45
corbelled arch	97.40	100.00	94 24	89 38	91.38	96 21
corbelled pyramid	94 36	95.34	89 04	82 75	86.10	91.44

Table XIII.2 Life cycle indexes of 1068 classroom units - weight for **unit cost = 128, all others = 1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	58 35	66.14	65 42	71.53	65 97	54 39
RCC plank- joist	60 74	69 32	68 57	75.19	69 12	56 74
RCC channel	60.27	68 70	67.95	74 47	68.50	56 28
FC channel	60 73	69 36	68 67	75 28	69 18	56 78
MCT roofing	77.33	90 90	90 06	100 00	90.58	72.87
Hybrid slab	59 90	68.16	67.41	73 81	67.95	55 92
Filler slab	63 40	70 73	70.11	76 28	70 81	59 03
stone roof	49.23	54 34	53 68	58 02	54 22	**45.69**
Jack arch	61.35	70.10	69 32	76 05	69 87	57 35
corbelled arch	71 99	79.21	78 66	85 26	79 56	67.10
corbelled pyramid	67.78	75 21	74 62	81.08	75 41	63 23

Table XIII.3 Life cycle indexes of 1068 classroom units - weight for **skilled masons = 128, all others = 1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	72.35	65.30	71.90	42.84	63.78	76.95
RCC plank- joist	79.74	72.72	79.32	49.89	71.05	85.11
RCC channel	75.15	68.13	74.73	45.54	66.55	80.05
FC channel	71.50	64.53	71.19	**42.19**	63.04	76.08
MCT roofing	82.65	76.60	82.62	55.62	74.84	88.70
Hybrid slab	74.57	67.55	74.13	44.98	65.96	79.40
Filler slab	86.19	80.57	85.84	61.13	78.78	92.73
stone roof	87.39	80.30	86.86	57.03	78.48	93.57
Jack arch	76.63	69.64	76.21	46.97	68.01	81.68
corbelled arch	92.21	88.23	92.15	72.34	86.31	100.00
corbelled pyramid	90.84	86.10	90.70	68.39	84.21	98.22

Table XIII.4 Life cycle indexes of 1068 classroom units - weight for **semi-skilled masons = 128, all others = 1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	82.67	68.78	58.75	38.71	54.31	57.93
RCC plank- joist	86.73	72.87	62.84	42.60	58.32	62.42
RCC channel	85.93	72.07	62.04	41.84	57.53	61.54
FC channel	77.66	63.85	53.88	34.11	49.49	52.46
MCT roofing	58.40	46.21	37.26	**20.14**	33.46	34.59
Hybrid slab	88.07	74.21	64.17	43.85	59.61	63.88
Filler slab	85.15	74.05	66.03	49.01	62.09	67.25
stone roof	70.93	57.00	46.93	27.54	42.77	45.00
Jack arch	84.95	71.12	61.07	40.95	56.58	60.45
corbelled arch	100.00	91.92	85.86	71.37	82.19	90.35
corbelled pyramid	86.21	76.68	69.64	54.27	65.97	71.83

Table XIII.5 Life cycle indexes of 1068 classroom units - weight for **unskilled masons = 128, all others = 1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	81.16	68.23	74.44	52.10	76.24	93.45
RCC plank- joist	83.01	70.10	76.32	53.89	78.08	95.50
RCC channel	86.49	73.58	79.80	57.19	81.49	99.34
FC channel	83.96	71.11	77.39	54.89	79.08	96.61
MCT roofing	64.74	53.40	59.07	**39.48**	60.74	75.05
Hybrid slab	79.39	66.49	72.69	50.45	74.52	91.50
Filler slab	81.14	70.81	75.78	57.07	76.89	92.58
stone roof	87.07	74.10	80.27	57.64	82.00	100.00
Jack arch	81.45	68.58	74.77	52.45	76.56	93.79
corbelled arch	76.64	69.13	72.82	58.14	73.34	86.88
corbelled pyramid	84.17	75.32	79.64	62.71	80.36	95.61

Table XIII.6 Life cycle indexes of 1068 classroom units - weight for **retention = 128, all others = 1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	86.46	73.79	54.85	46.97	51.41	75.36
RCC plank- joist	76.28	63.63	44.70	37.38	41.46	64.15
RCC channel	76.31	63.66	44.73	37.41	41.49	64.18
FC channel	72.73	60.14	41.27	**34.12**	38.05	60.29
MCT roofing	69.48	58.38	41.41	34.84	38.36	58.74
Hybrid slab	90.01	77.36	58.41	50.36	54.90	79.28
Filler slab	79.77	69.65	54.49	47.66	51.53	71.92
stone roof	100.00	87.29	68.31	59.74	64.64	90.33
Jack arch	85.00	72.39	53.43	45.67	50.01	73.77
corbelled arch	68.31	60.96	49.56	44.17	47.17	63.34
corbelled pyramid	73.69	65.01	51.73	45.69	49.07	67.30

Table XIII.7 Life cycle indexes of 1068 classroom units - weight for **non-renewable = 128, all others = 1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	48.20	53.31	47.37	44.05	42.34	41.50
RCC plank- joist	48.95	54.25	48.14	44.72	42.96	42.14
RCC channel	48.92	54.22	48.11	44.69	42.93	42.12
FC channel	58.61	66.80	57.80	52.53	50.19	49.95
MCT roofing	83.35	100.00	82.53	72.41	68.53	69.84
Hybrid slab	52.71	59.01	51.85	47.77	45.81	45.21
Filler slab	54.31	59.58	53.60	50.47	48.46	47.10
stone roof	28.37	29.63	27.62	26.79	26.15	**25.05**
Jack arch	53.51	60.05	52.66	48.47	46.45	45.88
corbelled arch	72.63	80.22	72.16	68.19	65.14	63.23
corbelled pyramid	62.98	69.46	62.44	58.91	56.36	54.79

Table XIII.8 Life cycle indexes of 1068 classroom units - weight for **renewable = 128, all others = 1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	24.32	33.10	32.70	37.84	33.06	30.64
RCC plank- joist	26.25	37.23	36.83	43.49	37.25	34.54
RCC channel	26.23	37.21	36.81	43.48	37.23	34.52
FC channel	26.27	37.33	37.00	43.67	37.37	34.64
MCT roofing	34.57	55.96	55.68	70.33	56.24	52.30
Hybrid slab	26.47	37.57	37.16	43.90	37.57	34.87
Filler slab	**24.10**	30.30	29.98	33.52	30.32	27.99
stone roof	28.75	42.91	42.47	51.57	43.01	40.06
Jack arch	29.15	43.98	43.56	53.12	44.06	40.97
corbelled arch	49.23	79.46	79.18	100.00	80.27	74.43
corbelled pyramid	42.74	68.61	68.31	86.08	69.22	64.27

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Table XIII.9 Life cycle indexes of 1068 classroom units - weight for **waste= 128, all others = 1**

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	54.57	45.95	3.50	**2.97**	3.34	3.65
RCC plank- joist	54.55	45.96	3.52	3.00	3.35	3.65
RCC channel	54.54	45.94	3.50	2.98	3.34	3.63
FC channel	54.52	45.98	3.60	3.06	3.39	3.66
MCT roofing	49.67	42.22	4.09	3.65	3.82	4.01
Hybrid slab	63.07	54.48	12.02	11.04	11.68	13.03
Filler slab	46.47	39.59	5.63	5.08	5.45	5.96
stone roof	100.00	91.34	48.85	45.93	47.83	53.80
Jack arch	69.96	61.40	18.93	17.62	18.46	20.64
corbelled arch	64.82	59.90	34.39	32.57	33.65	37.56
corbelled pyramid	68.58	62.74	33.00	31.18	32.29	36.08

Table XIII.10 Life cycle indexes of 1068 classroom units - weight for **CO_2 emission** = 128, all others =1

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone concrete block masonry	380mm CRS masonry
RCC slab	37.19	42.46	53.93	53.71	50.49	47.49
RCC plank- joist	37.81	43.31	55.32	55.06	51.70	48.66
RCC channel	37.86	43.38	55.46	55.19	51.81	48.77
FC channel	46.32	55.50	78.69	76.94	70.88	67.73
MCT roofing	54.89	67.28	100.00	97.04	88.49	85.11
Hybrid slab	36.99	42.16	53.24	53.06	49.93	46.95
Filler slab	40.13	45.03	54.94	55.27	52.24	48.73
stone roof	**22.29**	23.56	25.76	25.98	25.22	23.58
Jack arch	36.11	40.98	51.20	51.13	48.18	45.26
corbelled arch	41.10	44.98	51.59	52.66	50.09	46.31
corbelled pyramid	40.20	44.51	52.36	53.13	50.40	46.79

Table XIII.11 Sensitivity analysis of the varying weightings – showing lowest indexes – life cycle (showing the three groups).

Weights / Parameters	1	2	4	8	16	32	64	128	256	512	1024
Unit cost (1)	59.69	63.21	65.68	66.35	58.36	51.70	47.81	45.69	44.59	44.03	43.74
Skilled (1)	59.69	58.27	55.43	51.32	47.76	45.18	43.26	42.19	41.62	41.33	41.18
Semi-skilled (2)	59.69	57.36	51.78	43.90	34.93	27.37	22.73	20.14	18.77	18.06	17.70
Unskilled (1)	59.69	61.29	61.39	59.26	51.84	45.39	41.56	39.48	38.38	37.83	37.54
Retention (1)	59.69	61.28	58.19	50.25	43.33	38.56	35.70	34.12	33.29	32.86	32.64
Non-renewable (2)	59.69	59.13	54.15	44.97	37.22	31.84	27.69	25.05	23.66	22.95	22.59
Renewable (2)	59.69	58.29	56.24	50.11	41.07	32.42	27.10	24.10	22.52	21.71	21.30
Waste (3)	59.69	54.76	44.31	30.27	18.55	10.48	5.64	2.97	1.53	0.78	0.40
CO_2 (2)	59.69	62.35	56.24	45.81	37.23	31.38	25.53	22.29	20.59	19.72	19.28

APPENDIX XIV

IMPACTS OF CONSTRUCTING 1068 CLASSROOMS IN A DISTRICT

CARPET AREA OF EACH ROOM IS 5.5M X 5.5M

Table xiv.1 Total number of one class room unit for new construction, carpet area 5.5m x 5.5m and investment on infrastructure Rs 100,000,000. The roof and wall cost is Rs.58,000,000

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	1372.14	1494.20	1494.96	1721.99	1506.57	1169.04
RCC plnk- joist	1448.56	1585.27	1586.13	1837.17	1597.23	1230.03
RCC channel	1433.57	1567.33	1568.17	1814.38	1579.38	1218.09
FC channel	1448.75	1585.50	1586.36	1837.46	1597.46	1230.18
MCT roofing	1804.33	1997.43	1998.66	**2348.47**	2009.93	1518.05
Hybrid slab	1379.73	1503.20	1503.97	1733.31	1515.53	1175.11
Filler slab	1561.92	1687.45	1688.23	1931.73	1704.57	1334.14
stone roof	1246.71	1346.66	1347.28	1538.07	1359.41	**1068.04**
Jack arch	1433.60	1567.37	1568.20	1814.43	1579.42	1218.12
corbelled arch	1693.01	1801.98	1802.64	2034.46	1825.63	1456.25
corbelled pyramid	1641.52	1762.06	1762.80	2005.33	1782.30	1406.05

Table xiv.2 Total cost of1068 classrooms using different technologies (in million rupees)

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	43 63	39 94	39 92	34 88	39.76	50.66
RCC plnk- joist	41.25	37.56	37.54	32.62	37.43	48.04
RCC channel	41.70	38.01	37.99	33.04	37 87	48.53
Ferrocement channel	41.24	37.56	37.54	32 62	37.42	48.03
MCT roofing	32 82	29.50	29.48	**25.28**	29 46	38.48
Hybrid slab	43 38	39.70	39 67	34 64	39 52	50.39
Filler slab	38.15	35.20	35.18	30.97	34.99	44.11
stone roof	48.17	44.49	44 47	39.18	44.21	**55.68**
Jack arch	41.70	38.01	37.99	33 04	37.86	48.53
corbelled arch	35.08	32.86	32.85	29 35	32.58	40.21
corbelled pyramid	36 22	33 64	33 63	29.79	33.40	41.73

Table xiv.3 Total skilled mason-years employment generated by 1068 classrooms using different technologies

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	130.91	129.86	147.55	66 72	127.60	162 65
RCC plnk- joist	153.15	152.10	169.79	87.78	149.39	187.18
RCC channel	139.28	138.23	155 91	74.64	135 80	171 88
Ferrocement channel	129.77	128.72	146.40	**65.64**	126.48	161 39
MCT roofing	170 54	169.59	185.51	109 97	166 50	204 54
Hybrid slab	143.74	142.69	160.37	78 86	140.16	176.79
Filler slab	171.35	170.51	184 65	116 46	167.36	203 61
stone roof	166 82	165.76	183.45	100 72	162.78	202.25
Jack arch	148 60	147.54	165.23	83.47	144 93	182.16
corbelled arch	204.04	203.41	214 02	158 88	199 54	**236.04**
corbelled pyramid	190 45	189 72	202.10	140.28	186.15	222.86

Table xiv.4 Total semi-skilled mason-years employment generated by 1068 classrooms using different technologies

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	203.53	183.08	128.00	71.70	117.01	123.75
RCC plnk-joist	222.94	202.49	147.42	90.09	136.03	145.18
RCC channel	219.13	198.68	143.60	86.47	132.29	140.97
FC channel	207.76	187.31	132.23	75.70	121.15	128.42
MCT roofing	153.63	135.23	85.65	**36.55**	76.35	78.79
Hybrid slab	244.37	223.92	168.84	110.37	157.02	168.81
Filler slab	212.09	195.73	151.67	104.02	141.88	153.36
stone roof	189.58	169.13	114.05	58.49	103.34	108.37
Jack arch	226.08	205.63	150.55	93.05	139.10	148.63
corb bk arch	**319.14**	306.87	273.82	229.61	263.28	291.61
corb bk pyramid	229.84	215.52	176.97	132.93	167.52	183.01

Table xiv.5 Total unskilled worker-years employment generated by 1068 classrooms using different technologies

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	816.38	766.46	866.81	537.59	926.48	1205.14
RCC plnk-joist	848.67	798.75	899.10	568.17	958.13	1240.76
RCC channel	912.08	862.16	962.51	628.21	1020.26	1310.71
FC channel	909.48	859.56	959.92	625.76	1017.72	1307.84
MCT roofing	666.42	621.49	711.80	**419.12**	766.87	1009.24
Hybrid slab	836.47	786.55	886.90	556.61	946.17	1227.29
Filler slab	817.06	777.12	857.40	585.34	901.85	1144.98
stone roof	919.52	869.60	969.96	635.27	1027.56	**1318.92**
Jack arch	866.24	816.31	916.67	584.80	975.34	1260.13
corb bk arch	885.71	855.76	915.97	697.46	943.84	1159.82
corb bk pyramid	957.61	922.67	992.91	742.00	1026.95	1269.59

Table xiv.6 Total amount of retention for 1068 classrooms using different technologies (in million rupees)

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	15.71	13.69	9.65	8.07	8.99	14.01
RCC plnk- joist	13.50	11.48	7.43	5.97	6.81	11.56
RCC channel	13.51	11.49	7.44	5.98	6.82	11.57
Ferrocement channel	12.66	10.64	6.60	5.17	5.99	10.64
MCT roofing	12.64	10.82	7.18	**5.84**	6.61	10.95
Hybrid slab	**16.60**	14.64	10.60	8.96	9.91	15.05
Filler slab	14.25	12.64	9.40	8.05	8.84	13.06
stone roof	15.63	13.61	9.57	7.99	8.91	13.92
Jack arch	15.54	13.52	9.48	7.91	8.82	13.82
corbelled arch	12.42	11.21	8.79	7.68	8.33	11.71
corbelled pyramid	13.40	11.99	9.16	7.92	8.64	12.45

Table xiv.7 Total amount of non-renewable embodied energy in Giga Joules for 1068 classrooms using different technologies

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	29297.20	26061.45	31284.86	33176.80	36337.77	36524.18
RCC plnk- joist	28652.25	25416.50	30639.92	32566.01	35705.75	35812.67
RCC channel	28660.74	25424.99	30648.41	32574.06	35714.07	35822.04
FC channel	25790.19	22554.44	27777.86	29855.56	32901.02	32655.23
MCT roofing	17301.35	14389.17	19090.24	21273.22	23819.48	22869.96
Hybrid slab	25860.19	22624.44	27847.85	29921.84	32969.61	32732.45
Filler slab	20333.91	17745.31	21924.05	23602.01	26028.55	25795.17
stone roof	34975.56	31739.81	36963.22	38554.37	41902.38	**42788.57**
Jack arch	24376.66	21140.91	26364.32	28516.90	31515.81	31095.82
corbelled arch	11078.32	**9136.87**	12270.92	13750.38	15432.88	14743.67
corbelled pyramid	13013.78	10748.76	14405.15	16126.48	18092.32	17299.23

Table xiv.8 Total amount of renewable embodied energy in Giga Joules for 1068 classrooms using different technologies

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	11008.14	9832.24	9832.24	6772.63	9501.44	11271.64
RCC plnk- joist	7270.27	6094.36	6094.36	3232.75	5838.44	7148.00
RCC channel	7270.27	6094.36	6094.36	3232.75	5838.44	7148.00
FC channel	6547.74	5371.84	5371.84	2548.50	5130.39	6350.90
MCT roofing	5662.19	4603.88	4603.88	2075.10	4391.20	5461.22
Hybrid slab	11172.98	9997.08	9997.08	6928.74	9662.97	11453.49
Filler slab	13910.07	12969.35	12969.35	10251.32	12602.47	**14647.58**
stone roof	6709.22	5533.31	5533.31	2701.42	5288.63	6529.04
Jack arch	6899.71	5723.80	5723.80	2881.82	5475.31	6739.19
corbelled arch	3584.53	2878.98	2878.98	**1203.21**	2741.01	3430.91
corbelled pyramid	4181.17	3358.03	3358.03	1403.00	3197.08	4001.86

Table xiv.9 Total amount of embodied waste energy in Giga Joules for 1068 classrooms using different technologies

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	40704.58	33933.53	79.55	75.50	80.05	87.80
RCC plnk- joist	40640.36	33869.30	15.32	14.68	17.12	16.95
RCC channel	40640.31	33869.26	15.28	14.63	17.07	16.90
FC channel	40626.01	33854.96	0.98	1.09	3.06	1.13
MCT roofing	36586.74	30492.79	24.21	23.07	25.61	26.75
Hybrid slab	47394.37	40623.32	6769.34	6410.93	6635.83	7468.01
Filler slab	34093.94	28677.10	1593.92	1509.62	1563.66	1758.45
stone roof	47930.51	41159.46	7305.48	6918.67	7161.23	8059.49
Jack arch	**52901.27**	46130.21	12276.24	11626.12	12032.41	13543.25
corbelled arch	48411.06	44348.43	24036.04	22762.93	23555.79	26516.70
corbelled pyramid	51560.63	46820.89	23123.11	21898.38	22661.35	25509.56

Table xiv.10 Total amount of CO_2 emission in tons for 1068 classrooms using different technologies

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	9781.489	8315.29	5880.36	6057.04	6386.88	6792.13
RCC plnk- joist	9572.87	8106.68	5671.74	5859.47	6182.44	6561.98
RCC channel	9549.20	8083.00	5648.07	5837.05	6159.24	6535.86
FC channel	8819.30	7353.11	4918.17	5145.82	5443.96	5730.64
MCT roofing	7104.91	5785.34	**3593.90**	3842.87	4083.78	4239.20
Hybrid slab	10017.35	8551.15	6116.22	6280.40	6618.01	7052.33
Filler slab	8011.48	6838.52	4890.57	5022.05	5292.05	5639.21
stone roof	**11478.04**	10011.85	7576.92	7663.73	8049.45	8663.78
Jack arch	10210.33	8744.13	6309.20	6463.16	6807.12	7265.23
corbelled arch	7740.04	6860.32	5399.36	5406.25	5665.79	6139.53
corbelled pyramid	8295.22	7268.89	5564.43	5611.40	5889.98	6352.13

APPENDIX XV

LIFE CYCLE IMPACTS OF 1068 CLASS ROOMS IN A DISTRICT

CARPET AREA OF EACH ROOM IS 5.5M X 5.5M : BUILDING LIFE IS 50 YEARS

Table xv.1 Total life cycle cost of1068 classrooms using different technologies (in million rupees)

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	57.9	50 4	50.7	45.8	50.1	61.8
RCC plnk- joist	55.5	48.1	48.3	43 5	47.8	59.2
RCC channel	55 9	48.5	48 8	44 0	48.2	59.7
Ferrocement channel	55.5	48.1	48.3	43.5	47.8	59 2
MCT roofing	43.0	36.3	36 6	**32.6**	36 2	45.6
Hybrid slab	56.5	49.0	49.3	44.5	48.7	60.3
Filler slab	53 0	47.1	47.3	43.0	46 7	56.9
stone roof	69 9	62.4	62.7	57.2	61.9	**75.1**
Jack arch	55 1	47.6	47.9	43.1	47.4	58.7
corbelled arch	46 7	42.3	42.4	38 8	41.8	50.3
corbelled pyramid	49.7	44 5	44 7	40 8	44.1	53.4

Table xv.2 Total skilled mason-years employment generated by the life cycle of 1068 classrooms

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	207.52	186.74	207.98	121.39	183.82	222 89
RCC plnk- joist	229.76	208.98	230.22	142.45	205 61	247.43
RCC channel	215 88	195.11	216.34	129 31	192.02	232.12
Ferrocement channel	204.79	184 02	205.25	**118.81**	181.15	219 89
MCT roofing	238.12	219.42	238.53	157 88	215.76	257.26
Hybrid slab	213 68	192.90	214.14	127.22	189.86	229 69
Filler slab	249 20	232.58	249 57	175 89	228.58	270.09
stone roof	252.54	231.76	253 00	164 02	227.94	272.56
Jack arch	219 77	199 00	220 23	132.99	195 83	236.41
corbelled arch	265 78	253.32	266.06	206.62	248 73	**289.59**
corbelled pyramid	262.06	247.52	262.38	195 58	243.13	284 88

Table xv.3 Total semi-skilled mason-years employment generated by the life cycle of 1068 classrooms

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	382.27	315 80	269.00	174.20	248.19	264.33
RCC plnk- joist	401.68	335 21	288.42	192.59	267.21	285.75
RCC channel	397.87	331.40	284.60	188.98	263.47	281.54
Ferrocement channel	357.66	291.19	244.40	150 90	224.07	237.18
MCT roofing	263.31	203.49	161.37	**80.33**	144.26	148 83
Hybrid slab	407.56	341.09	294 29	198.15	272.97	292.23
Filler slab	393.75	340.58	303.14	222 64	284.73	308 48
stone roof	324.19	257.72	210 93	119 20	191.27	200.26
Jack arch	392.15	325.68	278 89	183 57	257 88	275.24
corbelled arch	**463.20**	423.31	395 24	325 97	378 06	416.56
corbelled pyramid	396 92	350.40	317.64	244 43	300.48	327.72

Table xv.4 Total unskilled mason-years employment generated by the life cycle of 1068 classrooms

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	1398 47	1167.82	1287.68	892.29	1323 27	1629 83
RCC plnk- joist	1430.76	1200.11	1319 97	922.87	1354 92	1665.45
RCC channel	1494.17	1263 51	1383 38	982 92	1417.05	1735 40
Ferrocement channel	1448 30	1217.65	1337.51	939 48	1372.10	1684 80
MCT roofing	1096 69	889.10	996 98	**649.70**	1032.25	1288 20
Hybrid slab	1362 94	1132.29	1252.15	858 64	1288.45	1590.63
Filler slab	1396 00	1211 48	1307.37	976.37	1330.29	1609.70
stone roof	1501.77	1271.12	1390 98	990.12	1424.51	**1743.79**
Jack arch	1399.34	1168 68	1288.55	893.11	1324.12	1630.79
corbelled arch	1304 14	1165.75	1237.67	975 80	1249.71	1490.96
corbelled pyramid	1443.46	1282.01	1365 91	1064.53	1381.52	1653 36

Table xv.5 Total amount of life cycle retention of 1068 classrooms (in million rupees)

Walls / Roofs	230mm solid brick masonry	230mm rat-trap brick masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	17.86	15.16	11.14	9.55	10.43	15.55
RCC plnk- joist	15 64	12 94	8.92	7.45	8.26	13.11
RCC channel	15.65	12 95	8 93	7.46	8.27	13.12
Ferrocement channel	14.87	12.17	8.16	**6.73**	7.51	12.26
MCT roofing	14.13	11.70	8 09	6.76	7.49	11.86
Hybrid slab	18.58	15 88	11.87	10.24	11.14	16.36
Filler slab	16.38	14 22	11.01	9.63	10.40	14 76
stone roof	**20.74**	18.04	14 03	12.29	13 26	18 74
Jack arch	17.49	14 79	10.77	9.20	10.07	15.15
corbelled arch	13.78	12.16	9.75	8 63	9 26	12.72
corbelled pyramid	14 98	13 09	10 28	9 03	9.73	13.62

Table xv.6 Total amount of life cycle embodied non-renewable energy of 1068 classrooms (in Giga Joules)

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	42419.8	37870 8	42640.4	45527.0	47943.4	49381.3
RCC plnk- joist	41774.9	37225.9	41995 5	44916.2	47311.4	48669 8
RCC channel	41783.3	37234.3	42004 0	44924 3	47319.7	48679 2
Ferrocement channel	34368 9	29819.9	34589 5	37902.6	40053 8	40499.5
MCT roofing	23693.7	**19599.6**	23892.3	27257.5	28955.1	28464.3
Hybrid slab	38643 8	34094 8	38864.4	41951.0	44243 0	45215 6
Filler slab	37352.9	33713 7	37529.4	39657.6	41703 3	43274 8
stone roof	77612.2	73063.2	77832.8	78855.3	82430.8	88205.8
Jack arch	38058.1	33509 1	38278 7	41396.4	43669.1	44569 5
corbelled arch	27591.3	24861.9	27723.7	29342.3	30862 6	31989 0
corbelled pyramid	32081.1	28896 8	32235 6	34129 7	35899 8	37200 6

Table xv.7 Total amount of life cycle embodied renewable energy of 1068 classrooms (in Giga Joules)

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	44501 0	30860 5	30860 5	25855 2	30320.7	33365.1
RCC plnk- joist	40763.1	27122 6	27122.6	22315.4	26657.7	29241.4
RCC channel	40763 1	27122 6	27122.6	22315.4	26657.7	29241.4
Ferrocement channel	40708 8	27068 3	27068.3	22263 9	26604.5	29181.5
MCT roofing	29791.7	17515.3	17515.3	13554.0	17235.0	18710.6
Hybrid slab	40589 6	26949 2	26949 2	22151.1	26487.7	29050.1
Filler slab	45248.2	34335 9	34335 9	29820 6	33710.8	37335 2
stone roof	36860 9	23220 4	23220 4	18619.9	22833.7	24936 5
Jack arch	36316 4	22675 9	22675 9	18104.2	22300.1	24335.8
corbelled arch	20295 9	12111 6	12111 6	9447.7	11916.0	12953.3
corbelled pyramid	23669 1	14120 8	14120.8	11013 4	13892.8	15101 9

Table xv.8 Total amount of life cycle embodied waste energy of 1068 classrooms (in Giga Joules)

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	40705 2	33934.1	80.1	76.0	80 6	88.4
RCC plnk- joist	40641 0	33869 9	15 9	15 2	17.7	17.6
RCC channel	40640 9	33869.8	15 8	15.1	17 6	17.5
Ferrocement channel	40626 3	33855.2	1.1	1.2	3 3	1.3
MCT roofing	36586 9	30492 9	24 3	23 2	25.7	26.9
Hybrid slab	47395 0	40623 9	6769 9	6411.4	6636 4	7468 6
Filler slab	34094 8	28677.9	1594.7	1510 3	1564 4	1759 3
stone roof	77110 9	70339 8	36485 8	34553 2	35757.0	40251.3
Jack arch	52901 9	46130 8	12276 8	11626 7	12033.0	13543 9
corbelled arch	48411.9	44349.2	24036 8	22763.7	23556.6	26517.6
corbelled pyramid	51561 4	46821.6	23123 8	21899 0	22662.1	25510 4

Table xv.9 Total amount of life cycle CO_2 emission of 1068 classrooms (in tons)

Walls / Roofs	230mm solid brick masonry	230mm rat-trap masonry	CSMB masonry	150mm ICSMB masonry	Stone conc block masonry	380mm CRS masonry
RCC slab	12633 3	10840 6	8295.1	8243 6	8869.7	9536.3
RCC plnk- joist	12424 7	10632 0	8086.4	8046 0	8665.2	9306.2
RCC channel	12401 0	10608 4	8062 8	8023 6	8642.0	9280.1
Ferrocement channel	9918 8	8126.2	5580.6	5673.0	6209.6	6541 7
MCT roofing	8272.7	6659 3	4368.3	4486.0	4947.5	5165 8
Hybrid slab	12782.4	10989 8	8444.2	8384.8	9015.8	9700.8
Filler slab	11641.4	10207.3	8170 9	8048.4	8599.8	9322.3
stone roof	23196.8	21404 2	18858 6	18247.6	19221.6	21190.1
Jack arch	13158 0	11365.4	8819 8	8740 6	9383 9	10115.3
corbelled arch	11508 8	10433.2	8905.9	8666.9	9171.9	10056.1
corbelled pyramid	11753 8	10499 0	8717.1	8526.9	9061.0	9886.4

per cum	24 675		**RS**	246 75	0 00	0	0	0	0
Labourers				/10 cum					
			skilled	0 00	Rs/ 10 cum				
			semi-skilled	0 00	Rs/ 10 cum				
			unskilled	246 75	Rs/ 10 cum				

Table XVI.3 Analysis of rates for 1.00 cum cc 1:5:10 proportions using 40mm metal

including curing, cost, conveyance

of all materials and labour charges, segnorage charges etc complete

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
cost of 40mm metal	0 96	cum	278 40	267.26	121 97	525 81	0 00	0 23	63 97
cost of 1:5 CM	0 48	cum	931.24	447.00	66 34	648.05	0 00	0 04	148 10
Less off site labour				**-29.40**					
LABOUR									
Off site									
Skilled 40mm metal				10 69					
unskilled 40mm metal				18 71					
On site									
1st class mason	0 06	working days	71 50	4 29					

2nd class mason	0.14	working days	55 00	7 70					
Men+women mazdoor	3 20	working days	37.80	120 96					
			total	847 21	**188.30**	1173 87	0 00	0 27	212.07
ALL ITEMS PER CUM	%	19.16	Labour	162 35					
	%	80 84	material	684 86					
	%	9 23	skilled	14.98	Rs /cum				
	%	4 74	semi-skilled	7.70	Rs /cum				
	%	86 03	unskilled	139 67	Rs /cum				
		100 00		162 35					

Table XVI.4 Analysis of rates for Filling foundation , plinth with sand compacted with water and rammed - **Data for 10 cum**

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
50% of earth work				123 38					
add diff cost									
			total	123 38	**0.00**	0 00	0	0	0
for 1 00 cum	%	100 00	Labour	123 38					
	%	0 00	material	0 00					
	%	0.00	skilled	0 00	Rs/ 10 cum				
	%	0 00	semi-skilled	0 00	Rs/ 10 cum				
	%	100 00	unskilled	123 38	Rs/ 10 cum				

Table XVI.5 Analysis of rates for 1.00 CUM CRS masonry in CM (1:6) using second sort including curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
cost of CR stone	0 6	cum	281 75	169 05	122.10	10 77	0 00	0 00	1.17
cost of RR stone	0 5	cum	148 65	74.33	55 55	8 97	0 00	0 00	0 97
cost of 1 6 CM	0.32	cum	821.80	262 98	38 97	367.37	0 00	0.02	83 07
Less off site labour				**-15.29**					
LABOUR									
Off site									
Skilled labour for CR				0 00					
Unskilled labour for CR				0 42					
Skilled labour for RR				0 00					
Unskilled labour for RR				14 87					
On site									
Skilled mason	0 75	working days	71 50	53 63					
Semi-skilled mason	1.75	working days	55 00	96.25					
Helper	2 80	working days	37 80	105 84					
			total	762 07	**216.62**	387.11	0 00	0.02	85 22
ALL ITEMS PER CUM	%	35 56	Labour	271.00					
	%	64 44	material	491 06					
	%	19 79	skilled	53 63	Rs/cum				

	%	35 52	semi-skilled	96 25	Rs/cum				
	%	44 70	unskilled	121 13	Rs/cum				

Table XVI.6 Analysis of rates for 1.00 cum masonry using wirecut bricks inclusive of all materials and labour charges, segnorage charges etc complete

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
cost of wirecut bricks	480	nos	1.30	624 00	541 66	13 29	0 00	2405 16	262 79
Less labour for brick making				**-74.83**					
cost of 1:6 CM	0 27	cum	821.8	221 89	32 88	309 97	0 00	0 02	70 09
scaffolding charges	1	cum	23 32	23 32	9 08	0 14	69 62	0 00	0 02
Less scaffold labour				**-14.18**					
LABOUR									
Off stie									
Skilled for brickmaking				24 02					
Unskilled for brickmaking				50 80					
Onsite									
Skilled mason	0 42	working days	71 50	30 03					
Semi-skilled mason	0 98	working days	55 00	53 90					
Helper	2 80	working days	37 80	105 84					
Helper for scaffolding				14 18					
curing t&P 5%				10.20					

			total	1069.17	583.63	323.39	69.62	2405 18	332.90
ALL ITEMS PER CUM	%	27 03	Labour	288 97					
cost per sqm	%	72 97	material	780 20					
245 91	%	18 71	skilled	54 05	Rs/cum				
	%	18 65	semi-skilled	53 90	Rs/cum				
	%	62 64	unskilled	181 02	Rs/cum				

Table XVI.7 Analysis of rates for 10 sq.m. flush pointing

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
cost of 1:3 CM	0 06	cum	1369 00	82 14	12 23	129 51	0 00	0 01	30 26
scaffolding materials	2 3	cum	23 32	53 63	20 89	0 32	160 12	0 00	0 03
Less scaffold labour				**-32.60**					
Skilled mason	0 48	working days	71 50	34 32					
Semi-skilled mason	1.12	working days	55 00	61 60					
Helper	1 60	working days	37 80	60 48					
Helper for scaffolding				32 60					
			total	292 17	**33.12**	129 83	160.12	0 01	30 29
	%	64 69	Labour	189 00					
	%	35 31	material	103 17					

	%	18 16	skilled	34 32	Rs/sq m				
	%	32 59	semi-skilled	61 60	Rs/sq m				
	%	49 25	unskilled	93 08	Rs/sq m				

Table XVI.8 Analysis of rates for 1.00 cum plain CC 1:2:4 proportions including curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete.

					volume of concrete		1 000	cum	
					diesel consumption		1 200	litres/ plank	
						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
cost of 20mm metal	0 92	cum	411 50	378 58	225 87	503 90	0 00	0 22	61 30
cost of 1 2 CM	0 46	cum	1906 30	876 90	131 53	1457 70	0 00	0 10	344 52
Diesel - mixer and vibrator	1 000	litre	15 00	15 00	1 50	44 55	0 00	0 00	2 80
Mixing machine and vibrator charges Rs 250/10 cum				25 00	12 50				
Less off site labour				-41.64					
LABOUR									
Off stie									
Skilled worker - 20mm metal				15 14					
Unskilled worker - 20mm metal				26 50					
On stie									
Skilled mason	0 12	working days	71 50	8 58					
Semi-skilled mason	0.28	working days	55 00	15 40					

Helper	5 60	working days	37 80	211 68					
			total	1531 14	357.40	1961.60	0.00	0 32	405 82
ALL ITEMS PER CUM	%	18.11	Labour	277 30					
	%	81.89	material	1253 83					
	%	8 55	skilled	23 72	Rs/cum				
	%	5 55	semi-skilled	15.40	Rs/cum				
	%	85 89	unskilled	238 18	Rs/cum				

Table XVI.9 Analysis of rates for 10 sqm of Impervious coat with CM (1:3) 20mm thick including curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete

					For flat surface				
					on RCC pink and joist RCC challen Hybrid etc.				
						Embodied energy			**Emission**
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
cost of 1:3 CM	0 21	cum	1369 00	287 49	42 81	453 28	0 00	0 03	105 90
Water proofing compound	2 1	kg	25	52.50	5 25	142 01	0 00	0 00	15 41
LABOUR									
Skilled mason	0 66	WD	71 50	47.19					
Semi-skilled mason	1.54	WD	55 00	84 70					
Helper	3 70	WD	37 80	139 86					
			total	611 74	**48.1**	**595.3**	**0.0**	**0.0**	**121.3**

	%	44 42	Labour	271 75					
	%	55.58	material	339 99					
	%	17.37	skilled	47.19	Rs/ 10 sq				
	%	31.17	semi-skilled	84 70	Rs/ 10 sq.				
	%	51.47	unskilled	139 86	Rs/ 10 sq.				

Table XVI.10 Analysis of rates for 10 Sq.m impervious coat with CM (1:3) 20mm thick including scaffolding, curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete (For non flat roof labour increased by 10%)

sqm at Turkapally roof plastering		269 056		145 247	sqm roof plastering				
sqm covered area		124 76		77 65	anantharam plan area (covered)				
increament factor on plan area		2 157		1.871	increament factor on plan area				
						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
cost of 1 4 CM	0 21	cum	1095 40	230 03	34.19	347.18	0 00	0.02	80 21
Water proofing compound	2 1	kg	25 00	52 50	5 25	142 01	0.00	0 00	15.41
Skilled mason	0 73	WD	71.50	51.91					
Semi-skilled mason	1.69	WD	55 00	93.17					
Helper	4 07	WD	37 80	153 85					
			total	581 46	**39.44**	**489.20**	**0.00**	**0.02**	**95.62**
	%	51 41	Labour	298 93					

	%	48 59	material	282 53					
	%	17 37	skilled	51 91	Rs/ 10 sq				
	%	31 17	semi-skilled	93 17	Rs/ 10 sq.				
	%	51 47	unskilled	153 85	Rs/ 10 sq.				

Table XVI.11 Analysis of rates for 10 sqm plastering with sponge finish 12mm thick of two coats- first coat in CM(1:5) proportion 8 mm thick and second coat CM(1:3) proportion 4mm thick including curing, cost of all materials and labour charges, segnorage charges etc complete

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
cost of 1:5 CM	0.11	cum	931 24	102 44	15 20	148 513	0 000	0 009	33 940
cost of 1:3 CM	0 04	cum	1369 00	54.76	8.15	86 339	0 000	0 006	20.171
scaffolding charges	2 3	cum	23 32	53 63	20 89	0 318	160.121	0 000	0 035
Less scaffold labour				**-32.60**					
Skilled mason	0 63	working days	71.50	45 05					
Semi-skilled mason	1.47	working days	55 00	80 85					
Helper	3.10	working days	37 80	117.18					
Helper for scaffolding				32.60					
			total	453 90	**44.25**	235.17	160.12	0 01	54.15
	%	60 73	Labour	275 68					
	%	39 27	material	178 23					

	%	16.34	skilled	45 05	Rs/10 sqm				
	%	29 33	semi-skilled	80 85	Rs/10 sqm				
	%	54 33	unskilled	149 78	Rs/10 sqm				
		100.00		275 68					

Table XVI.12 Analysis of rates for 10 sq.m. cement pointing with CM (1:3) including curing for rough Tandur stone flooring, curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
Cost of 1:3 CM	0.06	cum	1369 00	82.14	12 23	129 51	0 00	0 01	30 26
Deduct cost of 1:3CM	0.04	cum	1369 00	-54 76	-8 15	-86 34	0.00	-0 01	-20 17
Skilled mason	0 24	working days	71 50	17.16					
Semi-skilled mason	0 56	working days	55 00	30 80					
Helper	0 80	working days	37 80	30 24					
			total	105 58	**4.08**	**43.17**	**0.00**	**0.00**	**10.09**
	%	74 07	Labour	78 20					
	%	25 93	material	27 38					
	%	21 94	skilled	17.16	Rs /10 sqm				
	%	39 39	semi-skilled	30.80	Rs /10 sqm				
	%	38 67	unskilled	30 24	Rs./10 sqm				

Table XVI.13 Analysis of rates for 10 sqm of flooring with 25mm thick Tandur stone flooring including pointing in 1:3 CM , curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
Cost of shahabad stone	10 5	sqm	45 00	472 50	94 50	122 48	0 00	0 00	13 29
Pointing in CM(1:3)-10 sqm	0 017	cum	1369 00	23 66	3 52	37.30	0 00	0 00	8 71
6X0 6M rows- same cols									
Skilled mason	0.96	working days	71 50	68 64					
Semi-skilled mason	2 24	working days	55 00	123 20					
Helper	3 30	working days	37.80	124 74					
			total	812 74	98.02	159 77	0 00	0 0024	22 004
	%	38 95	Labour	316 58					
	%	61 05	material	496 16					
	%	21.68	skilled	68 64	Rs /10 sqm				
	%	38 92	semi-skilled	123 20	Rs./10 sqm				
	%	39 40	unskilled	124 74	Rs /10 sqm				

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Table XVI.14 Analysis of rates for 10 sqm of flooring with 25mm thick shahabad stone flooring including coat and 6mm thich 1:3 CM as second coat including forming of 0.5com beading of 12mm thick including cost of painting , cost of conveyance of all materials and labour charges, segnorage charges etc complete.

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
First coat 16mm thick in CM(1:3) proportion									
Cement Mortar(1:3)	0 2	cum	1369 00	273.80	40 77	431 69	0 00	0.03	100 86
Skilled mason	0 30	working days	71 50	21.45					
Semi-skilled mason	0.70	working days	55 00	38 50					
Helper	2.30	working days	37 80	86.94					
Second coat 6mm thick in CM(1:2) proportion									
cost of CM(1:2)	0 075	cum	1906 30	142 97	21 45	237 67	0 00	0 02	56 17
Blackboard paint (25% extra cost)	1.875	litre	100 00	187.50	18.75	162 95	0 00	0 00	17 68
Skilled mason	0 17	working days	71 50	11 80					
Semi-skilled mason	0 39	working days	55 00	21 18					
Helper	0 80	working days	37 80	30 24					
			total	814.38	**80.97**	832.31	0 00	0.04	174.71
	%	25 80	Labour	210 10					
	%	74 20	material	604 27					
	%	15 82	skilled	33 25	Rs /10 sqm				
	%	28 40	semi-skilled	59 68	Rs /10 sqm				
	%	55 77	unskilled	117.18	Rs /10 sqm				

Table XVI.15 Analysis of rates for 10 sqm of painting to new wood work in two coats ready made mixed enamel paint including cost and conveyance of all materials and labour charges, segnorage charges etc complete

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
Paint	1.25	litre	80 00	100.00	10 00	108 63	0 00	0 00	11 79
Painter	0 36	working days	71.50	25 74					
Semi-skilled helper	0.84	working days	55.00	46 20					
			total	171 94	**10.00**	**108.63**	**0.00**	**0.00**	**11.79**
	%	41 84	Labour	71.94					
	%	58 16	material	100 00					
	%	35.78	skilled	25.74	Rs / 10 sq m				
	%	0 00	semi-skilled	0	Rs / 10 sq m				
	%	64 22	unskilled	46 20	Rs / 10 sq m				

Table XVI.16 Analysis of rates for 10 sqm of lime washing - three coats including cost and conveyance of all materials and labour charges, segnorage charges etc complete

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
Lime	2 5	kg	3 00	7 50	1.88	13 00	0 00	0 00	3 37
scaffolding materials	2 3	cum	23.32	53 63	20 89	0.32	160.12	0 00	0 03
Less scaffold labour				**-32.60**					
Painter	0.18	working days	71.50	12 87					
Semi-skilled painter	0 42	working days	55 00	23 10					
Helper	0 64	working days	37.80	24.19					
Scaffolding labour				32 60					
			total	121 30	**22.77**	**13.32**	**160.12**	**0.00**	**3.41**
	%	76 48	Labour	92.76					
	%	23 52	material	28 53					
	%	13 87	skilled	12.87	Rs / 10 sq m.				
	%	24 90	semi-skilled	23.10	Rs / 10 sq m.				
480	%	61 22	unskilled	56.79	Rs / 10 sq m.				

Table XVI.17 Analysis of rates for 1.00 cum of brick masonry arch in CM (1:6) including curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete

				per cum of arch Rs 450					
volume of one arch = 1 2x0.23x0 115 x 1 15= 0 037 cum				1 2mx 2 nos 25 mm thk and 250mm highl e. 0 6 sqm					
						Embodied energy			**Emission**
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
Bricks	17.76	nos	1 30	23 09	20.04	0 49	0 00	88 99	9 72
1 6 cement mortar	0 010	cum	821 80	8 21	1.22	11 47	0 00	0 00	2.59
Centering material charges	0 60	sqm	73 75	44 25	32.52	2 45	65 00	1 11	0 56
Less off site labour				**-12.64**					
LABOUR									
Off site									
Skilled for brickmaking				0 89					
Unskilled for brickmaking				1 88					
On site									
Skilled mason	0 03	working days	71.50	1.98					
Semi-skilled mason	0 06	working days	55 00	3 56					
Helper	0 16	working days	37 80	5 87					
Skilled centring labout extra (0 6 sq m)				5 63					
Helper centring labout extra (0 6 sq m)				4 23					
			total	86 97	**53.78**	**14.41**	**65.00**	**90.10**	**12.87**

Cost/ cum	**2350.48**	27.66	Labour	24 06					
Retained/ cum	**1453.57**	72 34	material	62 91					
skilled mason/ cum	**229.891**	35.36	skilled	8 51	Rs/ cum				
semi-skilled mason/ cum	**96.250**	14 80	semi-skilled	3 56	Rs/ cum				
helper/ cum	**323.995**	49 83	unskilled	11 99	Rs/ cum				
Non-renewable energy/cum	**389.406**	100.00		24.06					
Renewable energy/ cum	**1756.640**								
waste based energy/ cum	**2435.261**								
CO2 emission/cum	**347.886**								

Table XVI.18 Analysis of rates for 1.00 CUM CC 1:3:6 proportions using 40mm metal including curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete.

			0 83m width x 150 thickness of foundation - length = 8m x 2 x 0.15= 2 4 sqm						
						Embodied energy			**Emission**
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
cost of 40mm metal	0 92	cum	278 40	256.13	116 88	503 90	0 00	0 22	61 30
cost of 1:3 CM	0 46	cum	1369 00	629 74	93 78	992 90	0 00	0 06	231 97
Shuttering for 2 4 sqm area - no props	2 40	sqm	46 94	112.66	71 42	9 746	207 298	4 452	2.118
Less off site labour				**-61.97**					
MATERIAL									
Off site									

Skilled worker for 40mm metal				10 25					
Unskilled worker for 40mm metal				17 93					
On site									
Skilled mason	0 06	working days	71.50	4 29					
Semi-skilled mason	0.14	working days	55 00	7 70					
Helper	3 20	working days	37.80	120 96					
Skilled mason for shuttering				22 53					
Helper for shuttering				11.27					
			total	1131.48	**282.09**	**1506.55**	**207.30**	**4.74**	**295.39**
	%	17.23	Labour	194 92					
	%	82.77	material	936 56					
	%	19 02	skilled	37 07	Rs /cum				
	%	3 95	semi-skilled	7 70	Rs /cum				
	%	77 03	unskilled	150.15	Rs /cum				

Table XVI.19 Analysis of rates for .00 cum DPC with CC 1:2:4 proportions using 20mm metal and using 2 kgs of WP compound per bag of cement including curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete.

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
Material CC 1:2:4	1	cum	1255 48	1255 48	357.40	1961 60	0.00	0 32	405 82
Waterproofing compound	6 6	kg	25.00	165 00	16.50	446 33	0 00	0 00	48 431
Less off site labour				**-41.64**					
LABOUR									
Off site									
Skilled labour for 1:2:4 CC				15 14					
Unskilled labour for 1:2 4 CC				26 50					
On site									
Skilled mason				8 58					
Semi-skilled mason				15.40					
Helper				211 68					
			total	1656 14	**373.90**	2407 94	0 00	0 32	454 26
	%	16 74	Labour	277.30					
	%	83 26	material	1378 83					
	%	8 55	skilled	23 72	Rs/ cum				
	%	5 55	semi-skilled	15 40	Rs/ cum				
	%	85 89	unskilled	238 18	Rs/ cum				

Table XVI.20 Analysis of rates for 10 .00 sqm of IPS skirting on 25mm thick 1:6 CM with cement finish including curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete.

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
Sand	0 015	cum	264 70	3 97	0.60	2 06	0 00	0 00	0 22
Cement	6.400	kg	2 28	14 59	2.19	26 95	0 00	0 00	6 52
Cement for floating coat	1 486	kg	2 28	3 39	0 51	6 26	0 00	0 00	1.51
1st class mason	0.10	WD	71 50	7.15					
Helper	0 25	WD	37 80	9 45					
curing labour 10%				1.66					
			total	40 21	**3.29**	**35.27**	**0.00**	**0.00**	**8.26**
Unit cost in Rs./sqm	**40.21**	45 41	Labour	18 26					
Money retained Rs/sqm	**3.29**	54 59	material	21 95					
Skilled worker Rs./sqm	**7.15**	39 16	skilled	7.15					
Semi skilled Rs./sqm	**0.00**	0 00	semi-skilled	0 00					
Unskilled Rs./sqm	**11.11**	60 84	unskilled	11.11					
Non ren Mega Cal/sqm	**35.27**	100 00		18 26					
Ren Mega Cal/sqm	**0.0000**								
Waste Mega Cal/sqm	**0.0023**								
CO2 in kg/sqm	**8.2636**								

Table XVI.21 Analysis of rates for Brick Bat Coba area 12.05mx5.54m = 66.757 sqm including curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete.

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
cement 53 89 bags	2694.5	kg	2 28	6143 46	921.52	11344.35	0.00	0 77	2747.021
sand	6 89	cum	264.70	1823.78	273.57	947.93	0 00	0 00	102 859
Waterproofing compound	53 89	kg	25.00	1347 25	134 73	3644 37	0 00	0 00	395 450
Bitumen	30 00	kg	7.00	210 00	21 00	1326 79	0.00	0 00	143 969
brick bats	2600 00	nos	1 30	3380 00	2934 01	71 97	0 00	13027 97	1423 45
Less labour for birk making				**-405.31**					
B. LABOUR									
Off site									
Skilled worker for brick making				130 13					
Unskilled worker for brick making				275 18					
On site									
Skilled mason	7.50	working days	71 50	536 25					
Labour	33 00	working days	37.80	1247.40					
Unit cost in Rs./sqm	220 02		total	14688 14	**4284.82**	**17335.41**	**0.00**	**13028.74**	**4812.75**
Money retained Rs/sqm	64 19	14 90	Labour	2188 96					
Skilled worker Rs./sqm	9 83	85.10	material	12499 18					
Semi skilled Rs./sqm	0 00	30 44	skilled	666 380					

Unskilled Rs./sqm	22.47	0.00	semi-skilled	0.000					
Non ren Mega Cal/sqm	255 85	69 56	unskilled	1522 584					
Ren Mega Cal/sqm	0 00	100 00		2188 964					
Waste Mega Cal/sqm	192 2863								
CO2 in kg/sqm	71 03								

Table XVI.22 Analysis of rates for Khurra 4 nos including curing, cost, conveyance of all materials and labour charges, segnorage charges etc complete

						Embodied energy			**Emission**
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. MATERIALS									
Polyethelene sheet	4	sqm	44 00	176 00	17.60	551.50	0 00	0.00	59 84
CC 1:2 4 material only	0 051	cum	64 03	64.03	18 23	100 04	0 00	0 02	20 70
100 dia PVC pipe 2 36 kg/m	2.10	m	49 21	103 35	10 33	776 64	0 00	0 00	101.12
Less off site labour				**-2.12**					
LABOUR									
Off site									
Skilled worker-20mm aggregate				0 77					
Unskilled worker-20mm aggregate				1.35					
On site									
Skilled CC				0 44					

semiskilled CC				0.79					
unskilled CC				10 80					
1st class mason	1.00	working days	71.50	71 50					
Labour	4 00	working days	37.80	151.20					
Unit cost in Rs./m	144 52		total	578 09	**46.16**	1428.18	0.00	0 02	181.66
Money retained Rs/m	11.54	40 97	Labour	236 84					
Skilled worker Rs./m	18.18	59 03	material	341.25					
Semi skilled Rs./m	0 20	30.70	skilled	72 71					
Unskilled Rs./m	40.84	0.33	semi-skilled	0.79					
Non ren Mega Cal/m	357.04	68 97	unskilled	163 35					
Ren Mega Cal/m	0 00	100 00		236 84					
Waste Mega Cal/m	0 00								
CO2 in kg/m	45.42								

Table XVI.23 Analysis of rates for PVC pipe

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
100 dia PVC pipe	8 00	m	49 21	393 70	39 37	2958 61	0 00	0 00	385 22
Nails, straps etc	3 00	kg	20 00	60 00	9 00	108 96	0 00	0 00	12 61

mason	1		71 50	71 50					
labour	1		37.80	37 80					
			total	563 00	39 37	3067.57	0 00	0 00	397 84
Unit cost in Rs./m	70 37		Labour	109 30					
Money retained Rs/m	4 92		material	453 70					
Skilled worker Rs./m	8 94		skilled	71 50	65 42	%			
Semi skilled Rs./m	0 00		semi-skilled	0.00	0 00	%			
Unskilled Rs./m	4 73		unskilled	37 80	34 58	%			
Non ren Mega Cal/m	383 45			109.30	100.00	%			
Ren Mega Cal/m	0 00								
Waste Mega Cal/m	0 00								
CO2 in kg/m	49 73								

Table XVI.24 Analysis of rates for 1.00 cum pyramid underside treatment with 1:6 CM inclusive of all materials etc complete.

volume of pyramid = cum	13 376	Area of majeedpur		48 32714	sqm				
						Embodied energy			**Emission**
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
Metrials									
cost of CM(1 6)	0 06	cum	821 80	49 31	7 31	68 88	0 00	0 00	15 58
Scaffolding materials (1/2 solid wall)	1 00	cum	23.32	23.32	9 08	0.14	69 62	0 00	0 02
Less scaffolding charges				**-14.18**					

Skilled mason	0 5	WD	71 5	35 75					
Labour	1	WD	37 80	37 80					
Curing	2	WD	37 80	75.60					
Scaffolding charges 25% due to extra height				14 18					
			total	221.78	**16.39**	**69.02**	**69.62**	**0.00**	**15.59**
Unit cost in Rs./cum	**16.58**		Labour	163 33	73 64				
Money retained Rs/cum	**1.23**		material	58.45	26 36				
Skilled worker Rs./cum	**2.67**		skilled	35 75	21 89				
Semi skilled Rs./cum	**0.00**		semi-skilled	0.00	0 00				
Unskilled Rs./sqm	**9.54**		unskilled	127 58	78 11				
Non ren Mega Cal/sqm	**5.16**			163 33	100 00				
Ren Mega Cal/sqm	**5.20**								
Waste Mega Cal/sqm	**0.00**								
CO2 emission/ cum	**1.17**								

Table XVI.25 Analysis of rates for 10sqm. of roof treatment using sailo-xe-crete polymer based elastomeric chemical compound

cost of chemical Rs 135 /kg less 12% discount						**It is assumed to be on FC channel for the time being**				
							Embodied energy			**Emission**
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. Materials										
sailo-xe-crete	3 5	kg	118 00	/Kg	413 00	41.3	236 25	0 00	0 00	0 00
Cement	4.14	Kg	2 28	/Kg	9 44	1 42	17 43	0 00	0 00	4.22
screened Sand 5 time D17	0 003	Cum	1323.50	/Cum	3 97	0 60	0 41	0 00	0 00	0 04
brush broom etc 1%					4 26	4 26				
B. Labour										
painter	0.46	MD	71.50	/day	32.89					
helper	0 982	MD	37.80	/day	37.12					
				total	**500.68**	47 58	254 09	0 00	0 00	4 27
Latex based + cement paint				**lab**	**70.01**	**13.98**	**%**			
Unit cost in Rs./sqm	**50.07**			**mat**	**430.67**	**86.02**	**%**			
Money retained Rs/sqm	**4.76**			sk	32 89	46 98	**%**			
Skilled worker Rs./sqm	**3.29**			semi	0	0 00	**%**			
Semi skilled Rs./sqm	**0.00**			unskill	37.12	53 02	**%**			
Unskilled Rs./sqm	**3.71**				70 01	100 00	**%**			
Non ren Mega Cal/sqm	**25.41**									
Ren Mega Cal/sqm	**0.00**									
Waste Mega Cal/sqm	**0.00**									
CO2 in kg/sqm	**0.43**									

Table XVI.26 Analysis of rates for 10sqm. of roof treatment using sailo-xe-crete polymer based elastomeric chemical compound

							Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
A. Materials										
chohsiohna	0 4	kg	345 00		138 00	13 80	27.00	0 00	0 00	0 0000
misc 10%					13 80	13 80				
B. Labour										
painter	0 533	nos	71 50		38.11					
helper	1 066	nos	37 80		40 29					
					230.2	**27.6**	**27.0**	**0.0**	**0.0**	**0.0**
Unit cost in Rs /sqm	**23.02**			**lab**	**78.40**					
Money **retained** Rs/sqm	**2.76**			**mat**	**151.80**					
Skilled worker Rs /sqm	**3.81**			sk	38.11	48 61				
Semi skilled Rs /sqm	**0.00**			semi	0 00	0 00				
Unskilled Rs /sqm	**4.03**			unskill	40.29	51.39				
Non ren Mega Cal/sqm	**2.70**				78.40	100 00				
Ren Mega Cal/sqm	**0.00**									
Waste Mega Cal/sqm	**0.00**									
CO2 in kg/sqm	**0.00**									

Table XVI.27 Analysis of rates for replacement of 5% MCT after every 10 years

36.446 sqm MCT roofing							**Embodied energy**			**Emission**
Description	**Quantity**	**Unit**	**Rate**	**Unit**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
MCT material	**26.20**	nos	1 81	pc	47 5	11 12	73 80	0 00	0 01	16 98
B. Labour										
Skilled mason for MCT	26 20		0 48		12 6					
Unskilled mason for MCT	26 20		0 82		21 6					
skilled worker	1	Working-day	71 50		71 5					
Helper	1 00	Working-day	37 80	/day	37 8					
					190.9	11.12	73 80	0.00	0 01	16 98
cost of MCT roofing		**%**	**75.13**	**lab**	**143.44**					
Unit cost in Rs /sqm	**5.24**	**%**	**24.87**	**mat**	**47.49**					
Money **retained** Rs/sqm	**0.31**	**%**	58 60	sk	**84.06**					
Skilled worker Rs /sqm	**2.31**	**%**	0 00	semi	**0.00**					
Semi skilled Rs /sqm	**0.00**	**%**	41 40	unskil	**59.38**					
Unskilled Rs /sqm	**1.63**		**100.00**		**143.44**					
Non ren Mega Cal/sqm	**2.025**									
Ren Mega Cal/sqm	**0.000**									
Waste Mega Cal/sqm	**0.000**									
CO2 in kg/sqm	**0.466**									

APPENDIX XVII

SITE LEVEL DATA COLLECTION FORMS

Site level data collection forms for the new construction (1995-96) of school buildings under the Andhra Pradesh Primary Education Project. These forms are to be read in conjunction with Figure 1.4 of chapter 1.

Table XVII.1 General format for data collection on complete units such as walls and roofs.

	Consumption / use				Number of workers			Miscellaneous - equipment used if any, curing labour extra	Volume of work done	Total expenditure with break-down of materials and labour components
	Number of bricks/blocks / precast units	Level-1 materials such as cement, sand, steel, mud, shuttering, scaffolding			Skilled mason	Semi-skilled mason	Unskilled worker			
Day-1										
Day-2										
...										
Find out the average of all the columns (second onwards) and write a report on it explaining the process or information that could not be covered in the above table										

Table XVII.2 Example: Rat trap bonded wire cut brick masonry in 1:6 cement sand mortar.

	Consumption / use				Number of workers			Miscellaneous - equipment used, if any, curing labour extra	volume of work done	Total expenditure with break-down of materials and labour components
	Bricks - numbers	Cement - kilogram	sand cubic metre	Scaffolding	Skilled mason	Semi-skilled mason	Unskilled worker			
Day-1										
Day-2										
...										
Find out the average of all the columns (second onwards) and write a report on it explaining the process or information that could not be covered in the above table										

Note: Record activities such as water curing, removing scaffolding, etc. till the product is ready.

Table XVII.3: General format for data collection on pre-cast element production such as cement stabilised mud block, interlocking cement stabilised mud block, micro concrete tile, ferrocement channel, reinforce cement concrete channel, plank and joist.

Number of units per production shift									
	Consumption / use			Number of workers			Miscellaneous - any special equipment used, if any, curing labour extra.	Volume of work done.	Total expenditure with break-down of materials and labour components
	Materials such as cement, sand, steel, mud, shuttering, scaffolding	Mould detail	Detail of equipment such vibrator, mixing including petrol/diesel	Skilled mason	Semi-skilled mason	Unskilled worker			
Day-1									
Day-2									
...									
...									
Find out the average of all the columns (second onwards) and write a report on it explaining the process or information that could not be covered in the above table									

Note: Record activities such as water curing, wrapping with plastic sheet, moving, loading, unloading, etc. till the product is ready.

Table XVII.4 Example: One pre-cast reinforced cement concrete joist of average length 2470 mm, section 150 mm x150 mm and weight 136 kilogram.

	Consumption/use								Number of workers			Miscellaneous - any special equipment used, if any, curing labour extra.	Volume of work done	Total expenditure with break-down of materials and labour components
	Cement -kilogram	Sand -cubic metre	12mm aggregate-cubic metre	6mm aggregate-cubic metre	Binding wire-kilogram	Steel reinforcement-kilogram	Steel mould -kilogram	Diesel - mixer and vibrator	Skilled mason	Semi-skilled mason	Unskilled worker			
Day-1														
...														
Find out the average of all the columns (second onwards) and write a report on it explaining the process or information that could not be covered in the above table														

Note: Record activities such as water curing, wrapping with plastic sheet, moving, loading, unloading, etc., till the product is ready.

Site level data collection forms for the Repair and Upgrading programme (2000) of the school buildings constructed under the Andhra Pradesh Primary Education Project in 1995-96. These forms are to be read in conjunction with Figure 1.6 of chapter 1.

Table XVII.5 Data Collection Book: Repair and Upgrading Programme of the cost effective schools constructed under the Andhra Pradesh Primary Education Project at Ranga Reddy district.

A. Cash Book: Receipts

Serial Number	Date	Amount	Cheque Number	Drawn on Bank	Deposited on	Remarks / signature of School Committee Member and the headmaster

Note: The cheques were sent by the executive engineer to the School Committees through the site supervisors. The cheques were deposited to the respective bank accounts of the schools by the headmasters.

B. Cash Book: Expenditure

Serial Number	Date	Material	Quantity	Voucher number & Date	Rate	Amount	Remarks / signature of School Committee Member, and the headmaster

Note: The expenditures were recorded by the headmasters. The records were checked by the School Committee members. The summary of cash expenditures were displayed on notice boards to inform the communities about the spending on Repair and Upgrading.

C. Daily Progress Report

Serial Number	Date	Description of Work	Quantity	Number of Masons	Number of Labourers	Quantities of materials	Remarks / signature of School Committee Member and the headmaster

Note: This was filled up by the headmaster with the help of the school masters and School Committee members.

APPENDIX XVI

SUPPORTING CALCULATIONS: ANALYSIS OF RATES

Table XVI.1 Analysis of rates for different types of mortar

Cement mortar	Cement quantity (kg)	Cost of cement	Cost of sand	Mixing charges	Total cost Rs./ cum	Money with-in	Non-ren	Ren	Waste	CO2
1:1.5	960	2188 80	264 70	0	2453 50	368 03	4179 36	0 00	0 28	993 64
1:2	720	1641 60	264 70	0	1906.30	285 95	3168 92	0 00	0 21	748 96
1:3	480	1094 40	264 70	9 90	1369 00	203 87	2158 47	0.00	0 14	504 28
1:4	360	820 80	264 70	9 90	1095 40	162 83	1653 25	0 00	0 10	381 95
1 5	288	656 64	264 70	9 90	931 24	138.20	1350.11	0 00	0 08	308 54
1:6	240	547.20	264 70	9 90	821 80	121.79	1148 03	0 00	0 07	259 61
1 8	180	410 40	264 70	9 90	685 00	101 27	895 41	0 00	0.05	198 44

Table XVI.2 Analysis of rates for 10 cum earth work in excavation

lead of 10 mts and lift of 2mts in loamy, clayey soils, BC soils, red earthy

and OG soils as per 20-B for foundation

						Embodied energy			Emission
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Money retained**	**Non renewable**	**Renewable**	**Waste**	**CO2**
10 cum initial cost	10	cum	16 45	164 50					
add 50% extra for foundation				82 25					