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STUDY REPORT ON LOCALLY AVAILABLE MATERIALS AND THEIR USE IN BUILDING CONSTRUCTION

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Abstract :

Economical advancement of the nation depends on infrastructure development. In the infrastructure development, a lot of materials are used which require high energy consumption. The energy losses are bound to be significant when energy consumptions are high. In order to mitigate this situation there is a need to look for alternative materials. The alternative materials which are drawn from local areas would be compatible with the environment and would result in saving considerable energy. In this aspect, a survey has been under taken to identify different types of materials available in Kadapa district of Rayalaseema Region, Andhra Pradesh. Accordingly, an attempt is made to find out some important properties of these locally available materials and then make use in building construction. The materials identified are Granite, Mud (Red earth, Mud with gravel, Tank silt), Sand, Country Bricks, Lime, Kadapa Stones & Slabs, Fly ash and Flay ash Bricks. These building materials are traditionally used in these areas and are slowly becoming obsolete as the stakeholders are turning their preferences to energy consuming techniques owing to popularity and facility of construction. If these materials are used coupled with latest techniques of building construction would help in mitigating the grim situation of overall environmental destruction. A Scientific methodology and possible improved technical design are proposed based on the survey conducted.

Keywords: Alternative materials, construction technologies, energy saving, locally available materials, sustainable technology.

Introduction:

The rapid urbanization, growing population and need for economic development are principally responsible for a number of environmental issues in India as a consequence of uncontrolled growth of urban sprawl and industrialization, expansion and massive intensification of agriculture degradation and deforestation. Major environmental issues are degradation of land, resource depletion (water, mineral, forest, sand, rocks etc.), environmental degradation, public health, loss of biodiversity, loss of resilience in ecosystems, livelihood security for the poor.

Similarly, the construction sector poses a major threat to the environment. Globally, buildings are responsible for at least 40% of energy use. An estimated 42% of the global water use and 50% of the raw materials is consumed by buildings when taking into account the manufacture, construction, and operational period of buildings. In addition, building activities contribute an estimated 50% of the world's air pollution, 42% of its greenhouse gases, 50% of all water pollution, 48% of all solid wastes and 50% of all Chlorofluorocarbons (CFCs) to the environment.

Today, India is the second fastest growing nation in the world. Construction is the second largest economic bustle after agriculture. The Indian construction industry is an essential part of the economy and a channel for a substantial part of its development investment, is poised for growth on account of industrialization, urbanization, economic development and people's rising expectations for improved quality of living. Construction activities contribute annually about 10% of the Gross National Product (GNP), thus playing a major role in the development of the national economy. On an average 50% of the total expenditure of Five Year Plans is invested in construction works because development plans for every sector of our economy involve construction activities.

The rapid growing building sector in India poses a major challenge to the environment. The gross built-up area added to commercial and residential spaces was about 40.8 million square meters in 2004–05, which is about 1% of annual average constructed floor area around the world and the trends show a sustained growth of 10% over the coming years. With a near consistent 8% rise in annual energy consumption in the residential and commercial sectors, building energy consumption has seen an increase, from a low 14% in the 1970s to nearly 33% in 2004–05. Energy consumption would continue to rise unless suitable actions to improve energy efficiency are taken up immediately.

Building material production consumes energy, the construction phase consumes energy, and operating a completed building consumes energy for heating, lighting, power and ventilation. In addition to energy consumption, the building industry is considered as a major contributor to environmental pollution *(Yahya et al, 2010)*, a major consumption of raw materials, with 3 billion tons consume annually or 40% of global use *(A Worldwatch Institute Report, 2012)* Buildings consume energy and other resources at each stage of building project from design and construction through operation and final demolition *(Schimschar et al, 2011).*

Studies on sustainable construction materials are on the rise with their environmental, social, and economic benefits. The study recognizes the key indicators for evaluating sustainable construction materials. The design used for the study was that of a survey which relied on a questionnaire with five-point *Likert* rating scale to produce data for the analysis. For this purpose, 25 pointers from the three dimensions (environmental, social, and economic) identified from the literature were presented to the respondents in a structured questionnaire, and responses were collected and analyzed. The study identified three key environmental indicators for measuring sustainable construction materials, and these indicators are human toxicity, climate change, and solid waste. Furthermore, adaptability, thermal comfort, local resources, and housing for all were identified as the four key social indicators for sustainable construction materials. In addition, maintenance cost, operational cost, initial cost, long-term savings, and life span were found to be the five key economic indicators for measuring sustainable construction materials. The study therefore suggests that certain indicators need to be considered in future studies that seek to measure sustainable construction materials *(Danso, 2018).*

In the field of construction, sustainability is of great concern due to huge capital injunction and environmental factors coupled with societal adaptability. Construction materials and methodologies applied in building of structures have great influence in the sustainable development issues in the field of construction. Sustainable buildings take advantage of the natural resources available and depend on a "green" choice of materials *(Buildabroad, 2017).* According to Buildabroad (2017), the availability of sustainable construction materials is on the rise, with new innovations and sourcing of materials that are not detrimental to the environment and are designed to enhance the energy efficiency of buildings *(Danso et al,2015)* reviewed the existing published works on the effect of stabilizers (fibers and binders) on technical performance of soil blocks or bricks using parameters such as compressive strength, water absorption, and flexural strength To ensure sustainability, building materials must build in adaptability to both its existing and new buildings. Buildings are more likely to be occupied and reused if they can be easily adapted to meet changing needs *(Annex, 2015).* Buildings which are unable to adapt with such changing needs will become obsolete or require substantial refurbishment or demolition, where neither option may create a sustainable built environment *(Manewa et al,2015).*

Need for use of sustainable materials:

The sustainable development envisages development process that meets the needs of the present generation without compromising the necessities of future generations. It advocates use of locally available construction materials which are energy efficient and durable. It provides an opportunity to living inhabitants to live with healthy, comfortable conditions throughout the buildings full life cycle in compliance with the environment. The objective of sustainability is to achieve efficient use of resources, viz. energies, water, and construction materials with minimum impact on the environment of buildings (Patil and Patil, 2017).However, because of the complexity of sustainability and the fragmentation of the construction industry, the level of implementation of sustainable construction practices is still low.

Details of survey conducted:

A survey has been conducted to study on traditional houses, construction methods and locally available materials in Rayachoti , Lakkireddy Palli and Kadapa Constituency areas of Kadapa District in Andhra Pradesh . Topography of Kadapa District is located at 14.47°N & 78.82°E about 412 km from Hyderabad, in the Rayalaseema region of Andhra Pradesh. It has an average elevation of 138 meters (452 ft). District map is shown in Figure 1.

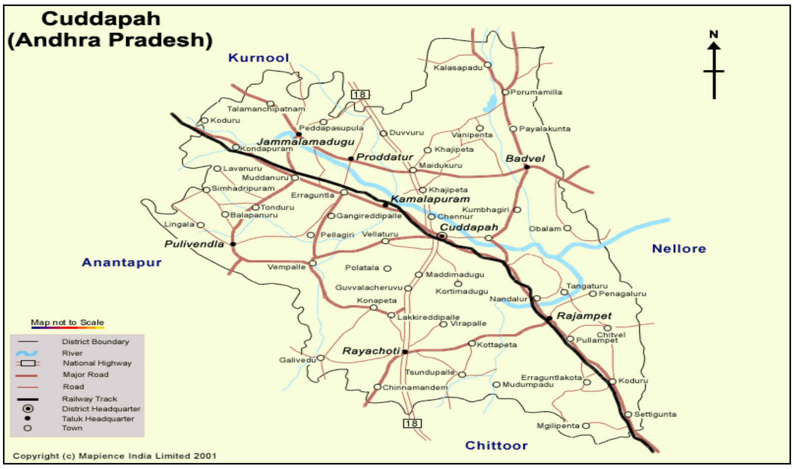

Figure –1 : Kadapa District map

Location & Geographical area:

The Geographical area of the District is 15,359 Sq.Kms. with 3 Revenue Division, 51 Mandals, 804 Gram Panchayats, 1032 Revenue villages and 4954 Habitations. The Y.S.R.District is surrounded by Kurnool District on the North, Chittoor District on the South, Nellore on the East and Anantapur on the West.

Kadapa district is the repository of mineral wealth. The important minerals that are available in the district are barytes, asbestos and lime stone. Limestone is available in Yerraguntla, Kadapa is also famous for its stone called as "**Kadapa stone**" used in building construction and for slabs especially in the south India. Limestone deposits are also found in Jammalamadugu, Kamalapuram and S.Mydukur mandals. There are extensive outcrop of Lime Stones, Dolomites', Granite and Quartzite's in major parts of the district, which could be utilised as building material. Major cement companies like Bharati Cements, Dalmia Cements, Zuari Cements, India Cement Ltd are produce thousands of tones of Fly ash and availability of minerals are shown in Table 1.

Table- 1 : Availability of minerals

MAJOR MINERALS		
S.N0.	**NAME OF MINERAL**	**PRODUCTION in tones 2011-2012**
1.	Barites'	7,58,786 M.T
2	Iron ore	5,15,349 MT
3	White clay	41,422 M.T
4	Quartz	41,422 M.T
5	Dolomite	25,412 M.T
6	Lime stone (c grade)	96,83,300 M.T
7	Feldspar	10,200 M.T
8	Asbestos	274 M.T
9	Yellow oak red	87,935 M.T
MINOR MINERALS		
1	Sand	80,000 C.M.T
2.	Napa slabs	6,25,844 Sq.mtr.
3.	Mosaic chips	2,450 M.T
4.	Gravel	4,500 MT

SOURCE:- Statistical Abstract, Govt of AP, 2011

The scope of the survey includes the flowing features.
- Traditional practices in housing and their design.
- Locally available materials and unit cost.
- Kadapa stones and its importance.
- Possibility to recommend new design, which would be cost effective.

Traditional practices in housing:

The survey has indicated that the traditional practices in housing generally comprise of the following typical patterns
- Mangalore tile roofs on brick wall.
- Thatched roof on mud wall/brick with mud mortar/ construction.
- Pre-cast beams with Kadapa stones as slabs.
- Kadapa stones being used from foundation to roof in different geometrics for dimensional stability.
- Kadapa slabs on cement brick walls
- Madras terrace on brick wall with lime mortar
- Asbestos roof on brick with mud/lime mortar
- Tiled roof on wooden rafters placed on wall with mud mortar
- Thatch roof with mud walls

The locally practices depend upon :-
- Locally available materials
- Local skills and manpower
- Financial status of the individual family.

The above three factors influence the type of house in rural areas. Here the people are generally constructing the hut houses with circular shape, sloped roof, houses with asbestos sheets roof. The construction practices make use of locally available materials or manufactured locally at lower production cost.
The typical features related to house planning are indicated in Table 2 and locally available materials with approximate cost is shown in Table 3. Plates 1-2 defects local methods of housing in rural areas. Plate 3 present improve construction technologies with locally available materials.

Table – 2 : Technical and geometrical features of the houses.

Type of House	Family Income/ Year	No. of family members	Type of Roof	Type of walls	Plinth area
HUT (Circular)	20000	3-4	Thatch	Mud walls with 15" thick	12 m^2
Tile Roof House (Rectangular	40000	4-6	Mangalore Tiles	Brick walls with 15" thick	16 m^2
Kadapa stone Slab House	40000	4-6	Pre cast concrete Beams with Kadapa stone slabs	Kadapa stones With 15" thick	20 m^2

Table - 3 : Locally Available Materials with approximate cost

Material		Approximate market cost
Granite		Rs. 150.00 per stone (6"x6"x4')
Sand		Rs. 1500 to 1700 per Tractor Load
Bricks		Rs. 5.10 per brick
Red Earth		
Red Earth		Rs. 1000 per Tractor Load
with Gravel		Rs. 1000 per Tractor Load
Tank silt		Rs. 800 per Tractor Load
Lime		Rs. 2.50 Per Kg
Fly ash		Available at free of cost
Kadapa slabs		Rs. 15.00 to 20.00 per sft


Survey with Villagers at Rayachoti Constituency


Survey with Villagers at Lakki Reddy Pally


View of Village Road


Family with Thatched House


Thatched House with Mud walls


Hut without walls

PLATE 1 – Pictures depicting local methods of housing in rural scenario

Thatched Roof with Mud walls

Mud walls with kadapa slab roof

A family with their home

Tatched Roof with Granite Stones

Kadapa slabs with Precast Beams

Cement Bricks with A.C. Sheets

PLATE 2– Pictures depicting local methods of housing in rural scenario

PLATE 3 – Alternative Construction Technologies

The materials used and their properties are presented in Tables 4-5.

Table - 4 : Rayachoti & Lakkireddy Palli Constituency area

Type of Materials	Quality	Compressive Strength	Application
Granite	Good	Crushing value is found to be < 20 % (I.S. 2386 1963)	Foundation, Lintels and slab materials etc.
Cement Bricks	Average	46 Kgs per sqcm	Walls
Mud	Good	% of gravel – 11.6 % of sand – 61.8 % of silt + clay – 26.6 % of Liquid Limit – 25 % of Plastic limit - 16 Plasticity index – 9 Indian Standard classification = SC(Clayey Sand). In view of reasonable plasticity, the soil possess desired binding properties (IS 1496 - 1970)	Brick Making and stabilized mud bricks making
Country Bricks	Average	28 Kgs per sqcm Water absorption = 15% BIS (1077 – 1957)	Walls

Table -5 : Kadapa Constituency area

Type of Materials	Quality	Compressive Strength	Application
Lime	Class B	----	Cementing material, White washing.
Fly ash	Good	Pozzolanic	Brick making, Village roads for base course and sub base course
Kadapa Stone	Good	----	Lintels roofing, walls and flooring
Fly ash brick	Good	123 kgs/ sq.cm with Hydraulic compression	Walls

Use of local material particularly Kadapa stone and its importance:
The most popular building materials in this region is kadapa Stone. It has numerous applications such as in lean concrete, as foundation material, for wall construction and also as roofing material. In other words, it can be used all components of building and hence a small house can be constructed with the kadapa stone without any technical deficiency. Owing to its significant strength both in compression and expansion not normally brake, even cut in to thin sections. As it is abundant, available, it is an economic building material. Its only disadvantage perhaps is its absorption of heat and hence resulting radiation.

Cost effective methods of designs and construction:

Based on survey conducted and properties of locally available materials, the following suggestions are made.
- The foundation may be laid at a depth of 1.00 m depth after stabilizing the ground depending on the type of soil.
- A lean concrete of 1:5:10 with stone as coarse aggregate may be adopted, the thickness of which may be 10 cm.
- Load bearing walls with Rat Trap bond is suggested. This is being recommended keeping in view the heat wave conditions that prevails overlong of time.
- Since fly ash is locally available, it use can be exploited in the manufacturing of bricks and the other compendious applications.
- Granite lintels would provide additional stability to the building and hence their use is to fully exploit.
- Brick arches also can be used over the openings with limited training to artisans.
- To prevent radiation and reduce the heat of flow sun shades with kadapa slabs are to used.
- The existing practices with the slab can be continued.
- Filler RCC slab construction is recommended as it reduces the heat and proves to be cost effective.
- The brick bats with cement mortar can be used for floor constructions, In addition to the existing use of Kadapa slabs.

Suggested Plans:

Since most of the traditional practices are seen to be more of routine nature than systematic planning, the same plinth area can be planned such that every square inch of space can be used with advantage. Some of the typical plans (1-2) are indicated in Figures 2-4.

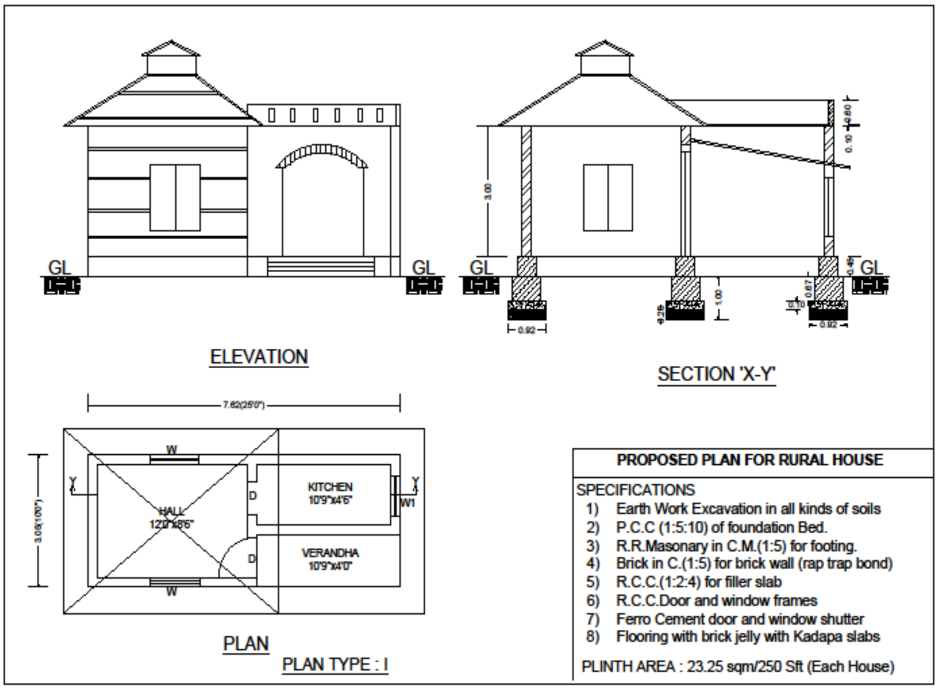

Figure 2: Typical Plan: 1

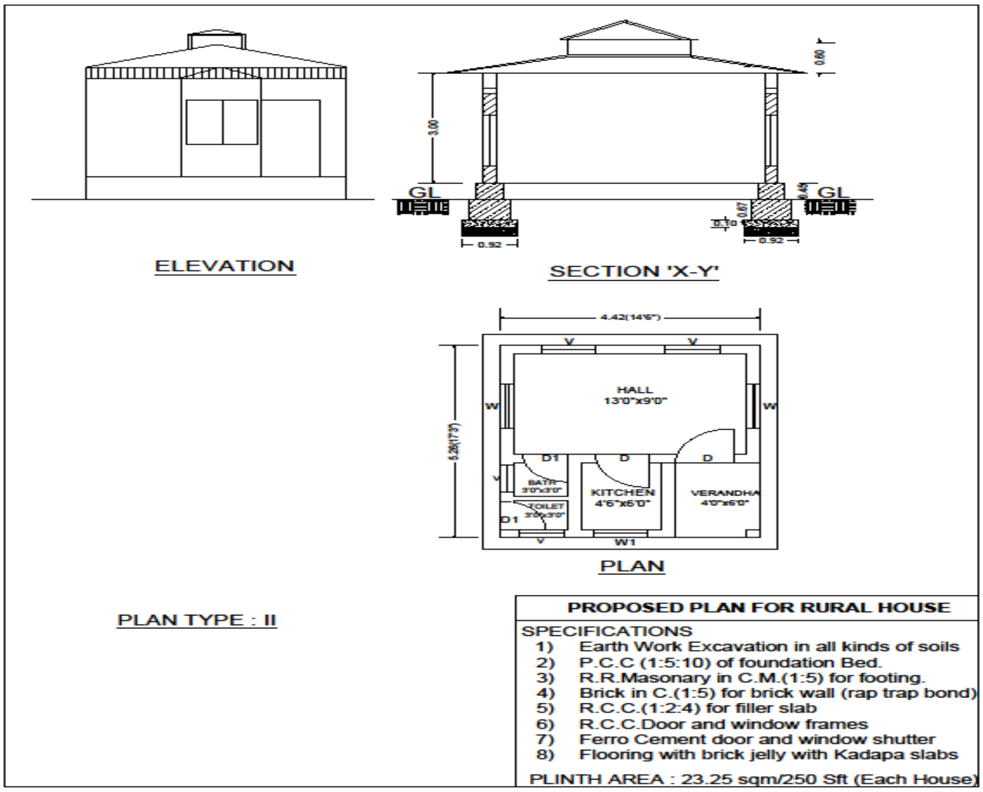

Figure: 3 Typical Plan: 2

Cost Comparison:

Table – 6: Details of quantity of items and abstract estimate for Plan - I
(With traditional technologies as per SSR – 2017 – 18)

Item No:	Description	Quantity	Rate (Rs. P)	Per	Amount (Rs. P)
1	Earth work excavation	22.44 Cum	206.80	Cum	4,642.00
2	Sand filling	13.70 Cum	447.70	Cum	6,133.00
3	P.C.C. (1:5:10) for foundation bed	2.24 Cum	3596.50	Cum	8,055.00
4	R.R. Masonry in C: M (1:5)	4.92 Cum	3344.50	Cum	16,452.00
5	Brick Masonry in C:M (1:5)	13.73 Cum	4914.09	Cum	67,449.00
6	R.C.C. (1:2:4) for Slab	5.20 Cum	17961.00	Cum	93,397.00
7	RCC Lintels	0.47 Cum	16598.40	Cum	7,810.00
8	Country wood Doors & Windows	5.94 Sqm	3000.00	Sqm	18,000.00
10	RCC Jollies for ventilators (2' x 1'6'')	0.54 Sqm	661.40	Sqm	357.00
11	Granolithic Cement concrete Flooring PCC (1:5:10) flooring Bed	17.86 Sqm 1.786 Cft	300.00 3596.50	Sqm Cum	5,358.00 6,423.00
12	12 mm thickness plastering in C: M (1:6)	128.00 Sqm	348.80	Sqm	43,904.00
13	3 Coats with White washing	128.00 Sqm	51.80	Sqm	6,566.00
14.	2 Coats enamel painting to doors & windows	13.36 Sqm	170.00	Sqm	2,272.00
				Total	**2,86,808.00**
Summary					
Total Plinth Area		250 sft			
Total cost of building		2,86,808.00			
Cost per sq.ft		**Rs. 1147.00**			

Table – 7 : Details of quantity of items and abstract estimate for Plan - I
(With Alternative Building construction Technologies as per SSR – 2017 – 18)

Item No:	Description	Quantity	Rate (Rs. P)	Per	Amount (Rs. P)
1	Earth work excavation	22.44 Cum	206.80	Cum	4,642.00
2	Sand filling	13.70 Cum	447.70	Cum	6,133.00
3	P.C.C. (1:5:10) for foundation bed	2.24 Cum	3596.50	Cum	8,055.00
4	R.R. Masonry in C: M (1:5)	4.92 Cum	3344.50	Cum	16,452.00
5	Rat Trap Bond Brick Masonry in C:M (1:5)	13.73 Cum	4250.00	Cum	58,325.00
6	R.C.C. (1:2:4) for Filler Slab	3.95 Cum	14040.00	Cum	55,358.00
7	Granite Lintels (9'' x6'')	6.00 Rm	300.00	Rm	1,800.00
8	R.C.C Doors Frames	0.046 Cum	14040.00	Cum	645.00
9	R.C.C Window Frames	0.138 Cum	14040.00	Cum	1,937.00
10	Cement Jollies for ventilators	0.54 Sqm	661.40	Sqm	357.00
11	Ferro Cement Door and Window Shutter	5.50 Sqm	1300.00	Sqm	7,150.00
12	Flooring with Brick jelly with Kadapa slabs	17.86 Sqm	384.00	Sqm	6,858.00
13	12 mm thickness plastering in C: M (1:6)	89.00 Sqm	348.80	Sqm	30,972.00
14	3 Coats with White washing	89.00 Sqm	51.80	Sqm	4,610.00
15	2 Coats enamel painting to doors & windows	13.36 Sqm	170.00	Sqm	2,272.00
				Total	**2,05,566.00**
summary					
	Total Plinth Area	250 sq.ft			
	Total cost of building	2,05,566.00			
	Cost per sq.ft	Rs. 822.00			
	Cost saving per sq.ft	**R. 1147-822 = Rs. 325/- per sq.ft**			

Conclusion:

A limited effort is made to bring out cost comparison of the all the 4 types considered for a given extent of 250 sq.ft. It may be seen from the Tables 6 & 7 , that the cost of construction using conventional technologies is Rs. 2,86,808.00 and for the case of Alternative building technology , the cost is Rs. 2,05,566.00. This turns out that the alternative building technology results in a cost of saving of 28% , which is quite significant**.**

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