INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
I.C.T.P., P.O. BOX 586, 34100 TRIESTE, ITALY, CABLE: CENTRATOM TRIESTE

SMR.704 - 23

Workshop on Materials Science and Physics of Non-Conventional Energy Sources

(30 August - 17 September 1993)

"The Potentials of Adobe as a Building Material Towards Energy Saving in Ar-Riyadh (Hot Arid), Saudi Arabia"

S.A. Alajlan & A.A.M. Sayigh
Department of Engineering
University of Reading
Whiteknights, P.O. Box 225
Reading RG6 2AY
United Kingdom

These are preliminary lecture notes, intended only for distribution to participants.

THE POTENTIALS OF ADOBE AS A BUILDING MATERIAL TOWARDS ENERGY SAVING IN AR-RIYADH REGION (HOT ARID), SAUDI ARABIA

S.A. ALAJLAN , A.A.M.SAYIGH

DEPARTMENT OF ENGINEERING,UNIVERSITY OF READING,
WHITEKNIGHTS, P.O.BOX 225, READING,RG6 2AY,U.K.

ABSTRACT:

Adobe as a building material has several characteristics.These can be divided into technical and non technical.The non technical aspects are that Adobe is cheap and available.The technical advantages is that it is used as a building material (thermal regulator) which can contribute to saving energy by reducing the reliance on air conditioning systems. The other technical criteria is that easily usable.

In this paper, the authers will demonstrate the importance of Adobe as a building material in Saudi Arabia. Adobe advantages in comparison with other building materials used in Saudi Arabia such as cement, various kinds of insulating materials are: it is locally available ; it is easy to use in various molds or shapes and it does contribute to the indoor comfort in residential buildings which ends in saving a considerable amount of energy. These potentials will be demonstrated in various examples.

KEYWORDS

Energy saving; Adobe building; Thermal comfort; Ar-Riyadh; Traditional buildings;

1.Introduction:

Saudi Arabia has become a place where many construction companies from different parts of the world operate. Construction expenditure has been estimated at $ 11,845 million in 1978 [1]. This kind of building boom has created a kind of architecture which not indigenous to our environment and alien to our society. Buildings are designed to satisfy western climate requirements rather than the Saudi Arabian climate.

The result is the creation of expensive and inconvenient building projects. The most important factor for this result is the selection of building materials such as glass and cement.Their inconvenient comes in increasing our demand in energy for cooling and heating the spaces in order to get the internal comfort.In addition ,they are expensive and not available locally .

Many lessons can be learned from the traditional buildings and one of the important aspects which can be examined is the material used in building (Adobe) especially in Ar-Riyadh region (central region of Saudi Arabia).This material will be studied in term of its characteristics which has significant impact on energy saving. This impact can be seen in the traditional buildings where there was no air conditioning and at the same time ,people could achieve comfort inside the building. So, this paper attempts to explore the characteristics of mud as a building material and its contribution in reducing cooling and heating loads in Ar-Riyadh region.

2.Climate in Ar-Riyadh region:

Ar-Riyadh city is located at latitude 24.38 north and longitude 46.43 east.Generally,the climate in this region is extremely hot and dry in the summer.Low air temperature ,clear sky and moderate relative humidity are the conditions in winter. The hot period is from may to september,when the absolute maximum temperature often exceed 45 C.The average relative humidity is about 25% during the hot period and about 50% during the cold season [2].

3.Traditional buildings :

Traditional buildings in Ar-Riyadh region were built mainly with Adobe in which this material represented the dominant building material.The reason for using this material was that it was locally available (fig.1) and easy to use .Another important reason is the adaption to the local environment which is related to the thermal conductivity and thermal storage capacity.

One important lesson can be learned from the traditional buildings is their indoor thermal comfort the building bearing in mind that there was no air conditioning system in the houses (fig.2).It should be admitted that selection of the appropriate materials is not the only factor for achieving the internal comfort ,but there are other passive strategies incorporated.The main factors incorporated with the selection of the appropriate materials will be **briefly** exhibited as part of this subheading.

The traditional building design features can be divided to two main integrated levels.The first is on the house level as an individual block.In term of traditional house design, it can be seen how the house has been carefully adapted to the local environment. First of all,mud and wood have low thermal conductivity, and the thickness of the mud-brick walls adds to their thermal insulation properties [2].This means the heat absorbed by the wall will be stored during day time and will not reach inside until the night time comes (time lag and decrement factor) which the heat by that time is required.In addition, the shape of the house is rectangular where the length elevations are facing north and south in which the house absorbs the minimum possible heat during the day time.More over, number and size of the windows were selected in such a way to minimize the effects of the day time heat and prevent the dust from penetrating inside of the house (fig.3). Finally, the most important design feature in the house level is the inner courtyard .All rooms were arranged around a courtyard which has been explained in modern scientific terms as a regulator of temperature within the house[3]. Traditional courtyard houses are usually built of two storeys rather than one (fig.4) because it gives the courtyard a better three-dimensional form in a way that the proportions between its three dimensions (its length and width to its height) keep part of the courtyard floor area in the shade which contribute in reducing a horizontal surface temperature and air temperature as well.

The second level of the design features in the traditional buildings is the urban fabric (neighbourhoods level). The streets are generally narrow and irregular (fig.5) which are environmentally efficient.The narrowness of the streets means that many of them are in shade,and giving protection from the sun.The irregularity of the streets pattern minimizes the effect of winds and sand storms.The houses are also attached to each others ,so the number of walls exposed to the sun is reduced,then giving sufficient protection from the intense heat (fig.6).

Having said that, traditional buildings are strongly influenced by the harsh climate which proved that they are thermally efficient.

4.Contemporary buildings :

Saudi Arabia has passed through economical,social,political and industrial changes during the last four decades.These changes appeared as result of the discovery of the oil. Unfortunately, due to the rapid and unplanned growth of the building boom ,all building technologies have been copied as they are from the developed countries.Building materials and techniques have been transferred as they are, without examining them and finding out the appropriateness of these materials to the climate. Consequently ,new building materials and techniques such as cement,glass,reinforced concrete,hollow

and solid cement blocks, etc.replaced the existing traditional materials and techniques.It must be admitted that these new building materials and techniques are very essential for big scale projects such as dams,canals, roads, bridges and other important development projects .In some cases, modern building materials can be of use in Saudi Arabia, particularly in commercial buildings. However, these materials have some constraints in term of their thermal suitability in hot-dry climate.

It is very unfortunate that contemporary buildings have relied on high energy-consuming air conditioning systems(24 hours air-conditioning) to attain inside thermal comfort. As an example, fig.7 illustrates using the glass material in the west facade of the building. This example is one of many sad examples in Ar-Riyadh city which reflects a complete negligence of the climatic conditions. One can not imagine how big the air-conditioning load and the expense of the equipments . In a specific hotel, 800 tons of air conditioning is used to mantian comfort.The owner is paying all that amount of money because he wants his building to be different from the other buildings in the area (this is the only justification can be grasped from this example).

5.Analysis of the energy saving by using Adobe in the residential buildings:

Reviewing the annual report of the ministry of industry and electricity of Saudi Arabia for the year 1988 [4], **21.8%** is the average annual increase in the production of the electricity since 1975. In addition, 46.6% from the electricity produced has been consumed by residential buildings. In the central region (Ar-Riyadh region), nearly **60%** from the consumed electricity is used by residential buildings. It is obvious that air conditioning systems in the buildings represent a major part in the electrical consumption. Consequently, high percentage can be saved (see next subheading) by using conservation techniques in buildings in order to reduce the energy consumption.

5.1 Thermal Characteristics of ADOBE

It is of great importance to evaluate the mud or adobe in term of the thermal characteristics. Numerous studies have reported values of adobe thermal behaviour which varied widely. One of these studies found out that adobe is a thermal regulating material [5]. It is clear from table 1 that adobe has **low thermal conductivity** and **high thermal storage capacity**. The comparative

Table 1. ***Comparison of thermal and physical properties of commonly used materials in Saudi Arabia.***

Material	*Coefficient of thermal conductivity* (W/M^0C)	*Specific Heat* (KJ/Kg^0C)	*Density* (Kg/m^3)	*Thermal Storage* ($KJ/M^3{}^0C$)
Adobe	0.516	1.00	1730	1.73
Stone	1.8	0.92	2451	2.255
Reinforced concrete	1.728	0.96	2400	2.3
Hollow clay block	0.36	0.84	1029	0.86
Hollow cement block	1	0.84	1403	1.18
Solid cement block	1.1	0.84	1600	1.34
Therm. insulation material	0.0276	0.66	32	0.02

Source: Various such as agencies reports,manuals and technical papers.

materials such as stone and reinforced concrete are higher than the adobe's thermal conductivity by 3 times. In addition, adobe's thermal storage capacity is 3/4 of the stone's and reinforced concrete's thermal storage capacity. In the other hand, adobe's thermal storage capacity is 87 times that of insulation materials, but adobe's thermal conductivity is higher than insulation materials by 19 times. So adobe's thermal behaviour is more efficient than insulation materials in thermal storage capacity and more efficient than stone,reinforced concrete,hollow cement block and solid cement block in thermal conductivity.

Comparisons between adobe and modern building materials with building insulation materials have been made [5] in term of energy required (space cooling and heating load) (fig 8,9). The adobe model needs less energy for both space cooling and heating. According to fig. 8, 30% can be saved in summer by using adobe as a building material (excluding insulation materials), while 43% can be saved in winter. As an average, **36% from 60%** (electricity consumed by residential buildings in Ar-Riyadh region) can be easily saved by using adobe. In fact, the insulation materials model needs less energy than adobe model, but this small amount of energy can be neglected when we consider other associated factors such as the price of insulation materials.

6.Conclusion :

The analysis indicates that Adobe as a building material is thermally appropriate for Ar-Riyadh region. Significant part of electricity consumed can be saved. In addition, mud is locally available and the material needed for producing adobes are also available and can be made without sophisticated equipments. Moreover, mud building helps in maintaining a uniform and comfortable internal thermal environment which means reducing cooling and heating load. Since a substantial amount of energy is consumed within buildings, either to support human activities (eg. in lights,appliances etc.), or to maintain a comfortable atmosphere, most professionals dealing with building, engineers and architects in Saudi Arabia should recognize the potential of traditional architecture which can be coupled with advanced technological developments, to reduce the energy required in buildings.

References

1. Anil Agarwal. (1981). Mud,Mud; The Potential - Based Materials for Third World Housing. Earthscan.London.

2. Daghistani, A. (1985). Ar-Riyadh; Urban Development and Planning. Ministry of Information. Saudi Arabia.

3. Mousalli, M. Shaker,F. and Mandily, O. (1977). An Introduction to Urban Patterns in Saudi Arabia: The Central Region.AARP.London.

4. Ministry of Industry and Electricity. (1988). Electricity in The Kingdom of Saudi Arabia; Growth and Development until 1988.(General report).

5. M.A. Eben Saleh. (1990). Adobe as a Thermal Regulating Material. Solar Wind Technology ,7, 407 - 416.

6. Angelo Pesce . (1975). Colours of Arab Fatherland. Falcon Press. Italy.

Fig .1 Mud bricks in Al-Morabba complex (Ar-Riyadh) [3].

Fig .2 People are setting in the inner court floor of a palace in ArRiyadh [3].

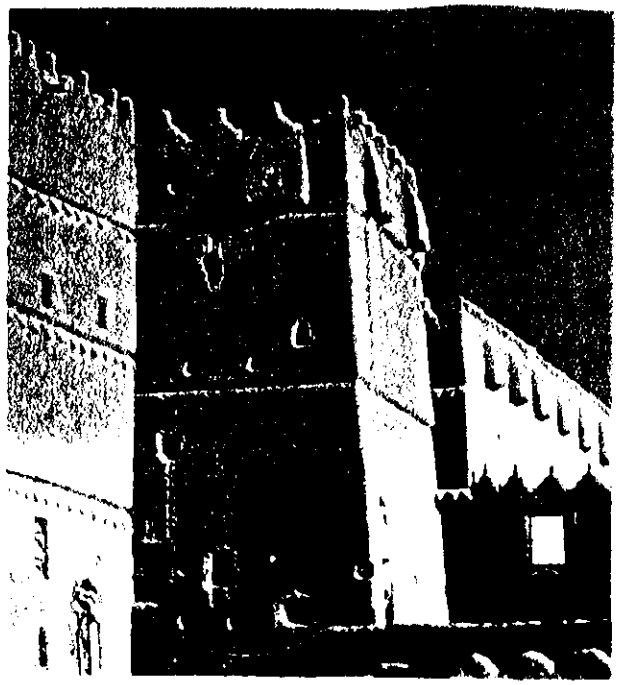

Fig.3. Small size of windows with minimum number of openings in Al-Morabba complex .

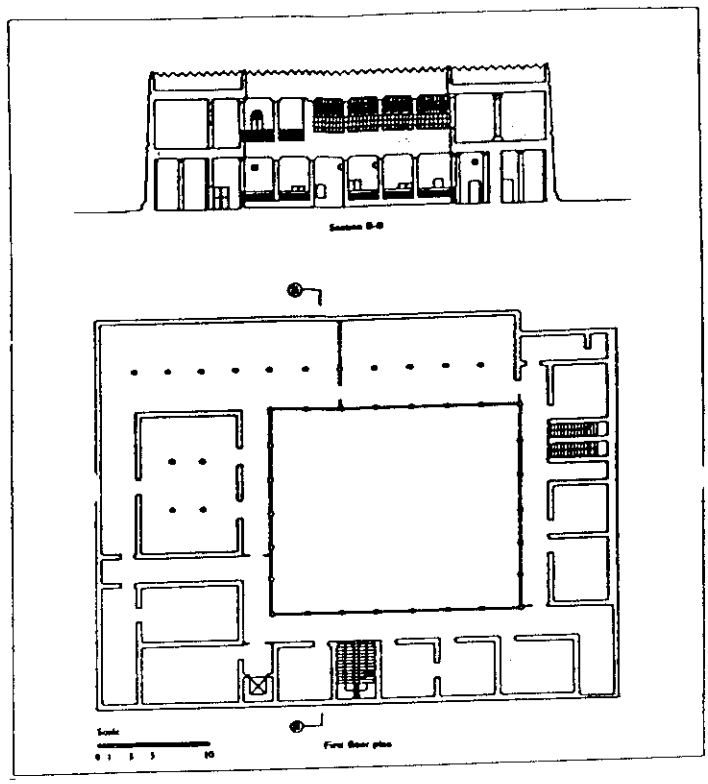

Fig.4. Al-Morabba, site plan, ground floor plan [3].

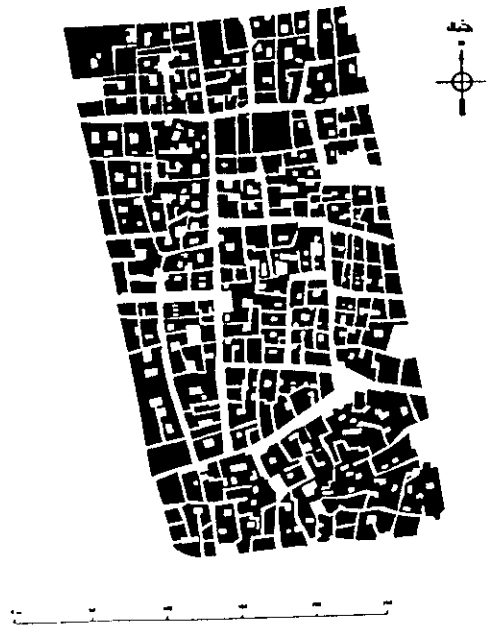

Fig.5. Traditional pattern of urban development in Ar-Riyadh [3].

Fig .7 Urban fabric of a traditional neighbourhood in Ar-Riyadh [3].

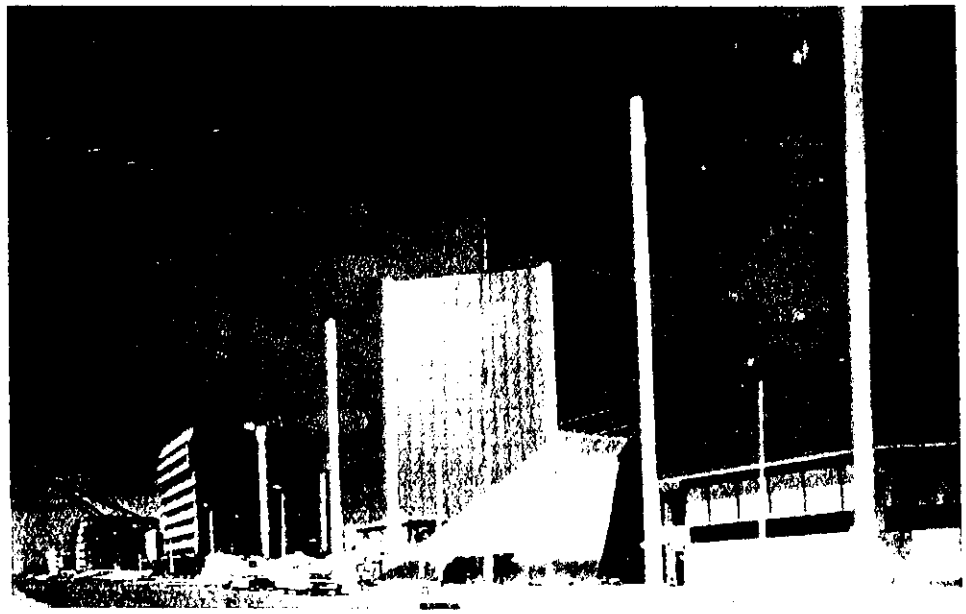

Fig .8 One of the modern buildings in Ar-Riyadh [3].

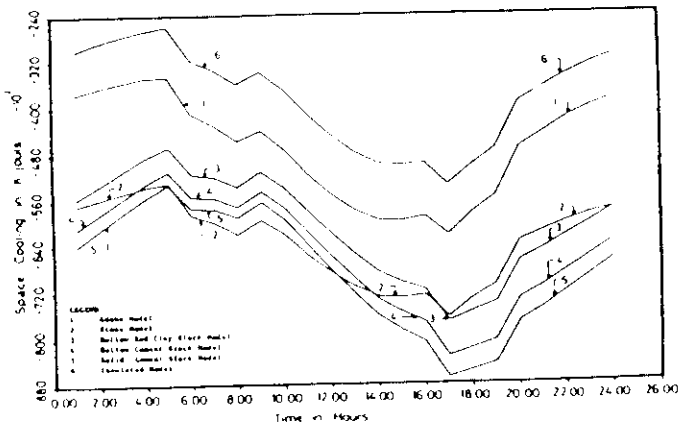

Fig.8 Space cooling load during the summer period for the six cases consid
[5].

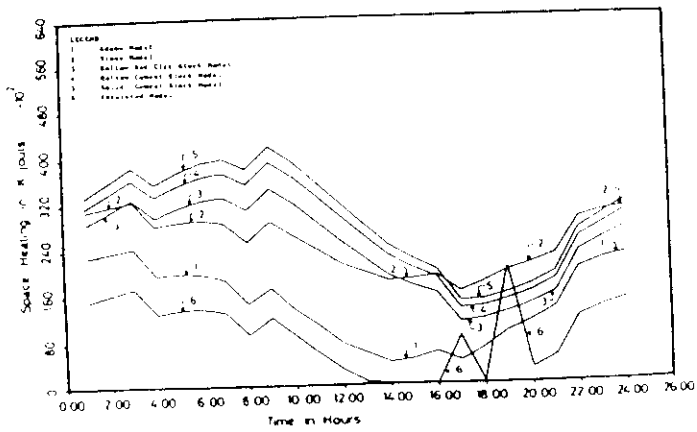

Fig.9 Space heating load during the winter period for the six cases conside
[5].