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No. 37.

NOTE ON HOUSING IN THE TROPICS

BY

DR. ANDREW BALFOUR,

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Director-in-Chief, Wellcome Bureau of Scientific Research,



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NOTE ON HOUSING IN THE TROPICS.

The fact that, in the case of a house in the tropics, mere cooling of the air is not sufficient to ensure comfort is well exemplified by the conditions obtaining in the underground ventilated chambers found in dwellings in Mesopotamia and India. To these the native inhabitants are accustomed to resort during the hot hours of the day. On entering one of these subterranean *sirdabs* or *tykhanas*, as they are called, a pleasant sensation of coolness is experienced, for the temperature of the chamber is considerably below that of the external air. If, however, one remains for some time in the room a disagreeable feeling of heat and stuffiness develops and there is copious perspiration. These effects result from air stagnation and such a chamber can only be rendered bearable to the European by the introduction of an electric fan or punkah.

It is true that in the case of an assembly room or concert hall it might be possible with advantage to arrange for the air being cooled, but in the tropics there is undoubtedly apt to be a danger of chill from such artificially cooled air, and any method adopted on a large scale will be found expensive. Schilling in his book "Tropenhygiene" describes and figures the Linde system as recommended by Ranke for use in the tropics. An elaborate installation is, however, required and such a method can never be widely employed in tropical countries.

Whatever may be done in connexion with public buildings, there can be no doubt that the problem centres in the dwelling-house, and here fortunately elaborate cooling systems are not required.

A great deal can be accomplished by proper attention to site orientation, design, construction and those principles of hygiene in the daily use of a house which are easily understood but by no means always acted upon.

Conditions vary so much in the dry and the moist tropics and also in different parts of the world that it is not easy to lay down general rules to cover all contingencies. A few notes may, however, be useful at the present juncture.

In considering the erection of a healthy dwelling-house for Europeans in the tropics much will depend on whether the building can be regarded as a separate entity or has to be viewed as part of a settlement and its relation to its neighbours taken into account.

Site.—In choosing a site the following points require attention :—

1. The opportunities for securing a good water supply.
2. The facilities for existing food supply and for the removal of excreta and refuse.
3. *The direction of the prevailing winds*, especially with reference to the situation of any neighbouring swamps or native locations.

As regards the site itself it is desirable that—

1. The soil should be permeable and clean. "Made" ground must be avoided. Sandy or gravelly soil is best. Like clay, such soil bears weight well, but, unlike clay, it is porous and does not shrink or swell with changes in the weather. Such movements taking place in clay cause cracks in buildings placed upon it.

2. The situation should be elevated, preferably on a slope with good natural drainage, not in any hollow, dry and with a cheerful outlook. Sometimes the presence of dense bush makes it difficult to determine levels. In such a case the ground which keeps driest at the height of the rainy season should be selected, so long as it is not near a swamp. If such be the case, it may be better to choose a site on lower ground and effect a good clearance of vegetation between it and the swamp.

3. There should be sufficient air space, plenty of light, and a free circulation of air.

4. *It should permit of the house facing north and south.*

5. In order to avoid excessive humidity it should be a certain distance from the sea, from large bodies of water, and from swamps.

The evil results of placing houses too close to the banks of tropical rivers have frequently been apparent in the case of government and trading posts. To save the expense and trouble of transport, houses are too often erected near anopheline nurseries in swampy river stretches or in pools left by the falling river. Moreover, river banks are very apt to be polluted by natives and various nuisances thereby created in close proximity to European dwellings. Hence in places where no efficient sanitary staff exists a site near a river bank should only be chosen when a careful consideration of all the conditions shows that it is free from danger. It is interesting to note that Shilluk villages on the White Nile are almost invariably situated a long distance from the river bank.

6. It should be well away from marshes, rice fields, native quarters, stables, cow-sheds, and other places which are apt to be insanitary.

The level of the ground water should be constant, but, where this cannot, be secured, then the ground water at its lowest level should not approach to within less than 8 feet from the surface.

Materials.—Some of these possess a special hygienic importance in the tropics, for it must be remembered that in a hot country a house both absorbs and gives off heat. Under each condition the health and comfort of the inhabitants may be affected.

The materials themselves vary according to the country and the climate and require no detailed consideration here.

Unburnt brick is commonly used, either alone or worked up with chopped straw of some kind. When employed as a plaster it is frequently mixed with cow-dung. It may be utilized in the form of bricks or as a putty-like mass supported by wattle-work and allowed to set *in situ*. Bricks, stone, coral rock, concrete, and wood are other substances used for foundations and walls.

Pent roofs are often made of corrugated sheet iron. Thatch is also employed. In Arab countries the flat roof is made of mud, worked up with cow-dung or stable manure and laid on boarding or on straw matting and rope netting.

Sand bricks for house walls have a certain vogue in Egypt but do not weather very well. The use of concrete and cement blocks is increasing and they have many advantages. *Hollow concrete blocks are said to have little superiority over those which are solid.* They can, however, sometimes be employed with advantage for interior partition walls.

Houses built largely of wood are not very suitable as permanent dwellings. They rapidly fall into disrepair, are apt to be destroyed by termites where these exist, tend to harbour vermin and become very inflammable.

The woods used in house construction should, if possible, be indigenous. Whatever wood is used, it should be carefully seasoned. Other materials commonly entering into house construction are tiles, mortar, cement, plaster, asphalt, felt, canvas, and iron. The last, in the form of girders, is often used in roof construction in countries where flat roofs are the fashion. The use of rolled steel joists with brick-arching between and a waterproofing material over all has proved very satisfactory. In places where timber is scarce or has become very expensive, as in Burma, reinforced concrete has been used to replace wooden posts, girders, wall plates and quarterings, and is said to have proved highly successful. Reinforced concrete also finds a use as a building material in countries where earthquakes are common and severe.

Earthquake-proof buildings have now been erected in several tropical towns, as, for example, Kingston; Jamaica.

It should be noted that stone, brick, and wood are bad conductors of heat. They warm up slowly but retain the heat longer than good conductors, such as metals. The specific heat of wood compared to that of air is as 1 : 1.083.

The question of materials is unfortunately often governed chiefly by the local conditions rather than by strict hygienic considerations, but it is desirable not

to forget the latter even though one may be driven "to cut the coat to suit the cloth" and to employ whatever may be readily available and not too expensive.

In a dry country mud has many advantages. It permits ventilation through it and does not retain and radiate heat like brick or stone. It is cheap and houses can be easily constructed from it even when there is very little in the way of skilled labour. On the other hand, in countries where the rainfall is heavy it is better to employ brick or stone. Stone is cooler and more durable than brick but not so easily handled and its greater weight necessitates a stronger foundation. It is, as a rule, more impervious to driving rain than brick and usually has a better appearance. Door and window fittings are more easily adjusted in a brick or stone house than in a mud dwelling.

General considerations.—Before proceeding to the question of construction certain points should be considered. *One of these is the distance of the house from the equator, for the sun's movements are a determining factor in construction. At the equator the sun's rays strike a house at a different angle than is the case when the house is situated either north or south, near one of the tropics, and this fact must be taken into account when constructing roofs and verandahs. In latitudes some distance north of the equator the south side of the house must be protected, in those south of the line the northern aspect must be shielded from the sun.*

The direction of the prevailing winds has been mentioned in relation to the site. It has to be taken into account when building the house, for it is very important that the wind should blow through it, if possible in an oblique direction (Schilling).

Sometimes in planning the house arrangements can be made whereby the bedrooms get the benefit of the night winds, while the living rooms are cooled by the winds which blow through the day.

Such a lay-out is very desirable.

As a rule the long side of the house should run from east to west. Arab builders in desert countries sometimes design houses, the main bulk of which is to the east, the building tapering to the west, a very wise provision so far as coolness goes. The inconvenience of a house of this shape may, however, outweigh its hygienic advantages. Still the idea is worthy of consideration in designing European houses.

It has been said that, as a rule, the long side of the house should run from east to west, but in certain parts of the tropics this is not desirable, and in this connection one cannot do better than quote the remarks of Dr. Cameron Blair in his *Sanitary Report of the Northern Provinces, Nigeria, 1917*. He says:—

"Attempts are always made to have buildings—particularly residential ones—oriented correctly where possible. In the greater part of the Northern Provinces, however, the course of the sun is to the south of the straight line from east to west. Were a building, therefore, oriented truly instead of correctly, the result would be that, during practically two-thirds of the year, the sun would run parallel with the southern verandah; for the country lies between the equator and the Northern Tropic. The general practice aimed at, therefore, is to cant buildings round so that their length lies from E. N. E. to W. S. W. By this arrangement, the sun can only penetrate the eastern end of the southern verandah for a brief space in the early morning; and the western end of the northern one, for a brief space in the afternoon; the lateral walls thus receive a minimum of direct sun-rays."

Such an arrangement is, of course, of wide application.

It is a great matter to design a residence which shall be comfortable, for club life in the tropics too often tends towards alcoholism and a man is less likely to become a victim of this habit if he possesses a comfortable abode.

A house should not be too low, for a moderate height ensures better perfusion of air. In most parts of the tropics it is a distinct advantage to erect a two-storied house, because houses of one story are apt to be infested in the evenings by such insects as mosquitoes and chironomidæ. One can usually

be in the upper part of the dwelling. If a two-storied house can be obtained it is an advantage to protect the doorways and windows, or at least the windows of the lower story with iron gratings so that the doors and windows can be safely left open at night, permitting the entry of comparatively cool night air.

Construction.—Sometimes it is considered better to raise the house on pillars or arches which, like a plinth, protect to some extent against damp and vermin, especially termites; *render the house more accessible to breezes*, and make for privacy, as people cannot so easily see into it.

Pillars and arches permit free ventilation under the house, but too often the space beneath the superstructure becomes a receptacle for rubbish of all kinds or is neglected until it becomes unsightly. It is well to cover it with clean gravel if the latter can be obtained.

Double walls.—It is certainly an advantage to have double walls, but they are costly if built of brick. It is, however, possible to erect a thin outer and inner wall of cement. If the space between them be filled with sand or asphalt such walls are heat-proof and do not harbour rats.

Roof.—Whether this be flat or sloping, it is a great advantage to have an air space between it and the ceilings of the rooms. This space must be ventilated and must be rendered vermin-proof, especially in places where bats are prevalent. Hence all ventilation openings must be screened.

A corrugated or galvanized iron roof is hot, ugly unless painted an agreeable colour, and heavy rain falling on it makes such a noise that it may be impossible for the occupant of the house to get restful sleep. Moreover, if exposed to salt sea air in the tropics corrugated iron rapidly deteriorates. A wooden roof placed below the corrugated iron portion makes for coolness, while sometimes it is possible to place a thatch roof on the corrugated iron.

Flat roofs are hotter than pent roofs and do not adapt themselves so well to ventilation, but they possibly aid in the dissipation of heat during the night and they form excellent sleeping places in hot weather. When so used they should be provided with some kind of shed or shelter to protect from dust and rain and to shield against the early morning sun in the case of those who need not rise at daybreak or who are indulging in what is called a "European morning."

Attention may be directed to what are known as "Stoney's roofs," described in the *Tropical Diseases Bulletin*, Vol. 13, 1919. They are used in the buildings of the Madras Railway and are stated to be both cheap and cool.

The *verandah* is one of the most important parts of a tropical house. It should be at least $3\frac{1}{2}$ metres wide and should always be ventilated, as otherwise a cushion of hot, stagnant air lies up against the side of the house.

There are two methods of ventilating a verandah: (1) by attaching the shade roof of pillars well away from the house wall in such a manner that a free circulation of air is obtained; this method was adopted by the Germans in Dar-es-Salaam; (2) by constructing the verandah in two parts, *i.e.*, a narrow portion of the nature of an overlap projecting from the wall of the house, and the second or main portion which is not carried right up against the wall of the house. In this way a space is left between the lower portion of the overlap, which permits of the escape of hot air. The overlap must be sufficient to prevent rain from driving in through the aperture and the latter should be screened in order to exclude vermin.

Where the verandah is not of the stone portico type so common in India it is an advantage if its roof be double. The upper portion may consist of corrugated iron or wood covered with asphalted felt or tiles; the lower portion of boards, there being a closed space of about 4 inches depth between the two layers.

The side of the house most exposed to the sun (north of the equator, the south side and *vice versa*) must be provided with a wider verandah than the shady side. Sometimes the verandah is carried right round the house, but this is not a necessity if in other respects, *i.e.*, as regards windows, etc., the house is properly designed for tropical conditions.

The verandah floor should slope outwards to the parapet or balustrade so that rain driven in by the wind may quickly drain away through appropriate openings.

Care must be taken that the verandah does not make the rooms too dark, for mosquitoes and other noxious creatures love darkness rather than light. The exact degree of shade will vary in individual cases. It is usually possible to render a verandah more shady by means of venetian blinds, native mats or special screens fixed on rollers.

While verandahs are highly desirable they are not an absolute necessity in hot dry countries so far as securing coolness within the house is concerned. Houses with thick walls of mud or clay, whitewashed on the outside, with roofs of thick matting preferably plastered over and coloured light, can be kept wonderfully cool, provided the windows are shuttered and they and the doors are kept closed during the heat of the day. Ziemann records a case in Angola where in a house of this type the temperature was 22° C., while outside it was 54° C. In this instance the doors and windows were opened only at night.

The height of the rooms is an important matter in tropical houses. It should not be less than 10 feet and in one-story dwellings may with advantage be more, for the heat radiated from a roof is in inverse ratio to the square of its distance. The rooms themselves should be as large and airy as possible.

Clerestory windows may with advantage be placed high up in the walls of lofty rooms. They have been largely adopted in the case of the houses designed for the New Delhi.

Where houses are not provided with verandahs it is a mistake to make the windows too large, but where these can be properly shaded by means of verandahs and jalousies they should conform to the usual size, *i.e.*, a tenth or twelfth of the floor space.

For a climate like that of the Red Sea littoral Crossland has recommended the provision of *sliding* louvered shutters inside the glass frames and *sliding* doors louvered to the bottom so that the slats being set at an angle of 45°, the wind is deflected upwards by them and reaches the face and body of anyone seated in the room, thus making for coolness.

Sliding doors are apt to stick but this disadvantage can be obviated in large measure by placing their handles as low as possible and soaping, not greasing, the grooves in which they run.

The same author points out that, while it is necessary in the case of inland houses to close all windows and doors during the heat of the day, it may not be advisable to follow this procedure in the case of houses situated on the sea-coast. In such a situation every advantage should be taken of the air movements which are so frequent in close proximity to the ocean.

Opinions vary a good deal about the best colour for the external aspect of a tropical house. All agree that the roof should be light in order to reflect heat, but in practice it is very difficult to maintain a light-coloured roof. One should, however, approach to the ideal as far as possible. Walls should also theoretically be light-coloured, but questions of glare, of maintenance and of capacity for showing up dirt and stains have all to be considered. Probably a dull light yellow—a kind of cream colour—is really best. The internal surface of walls should be white or light-coloured.

Khas-khas tatties are largely used in India for rendering the air of a house cool, but they carry with them the risk of chill. The punkah is still used and the electricity-driven type is probably the best mechanical device for securing coolness.

Small electric fans have their disadvantages, but the large ceiling fans are very useful, though it is doubtful if they are better than punkahs. Clockwork and oil-driven fans are not very satisfactory.

Comparative absence of dust and a certain degree of coolness may be secured by planting sward grasses near or around the house. Those best suited for the purpose are Pahama or Dub grass, *Cynodon dactylon* (the Neghil grass of the Arabs commonly grown in the Sudan); St. Augustine grass,

Stenotaphrum americanum, vel *Secundatum* and *Axonopus compressus* (*Paspalum Platycaulon*, carpet grass). The last named does well under humid conditions such as obtain on littorals, while the St. Augustine grass is better for slightly saline soil and is said to stand a fairly dry climate.

ANDREW BALFOUR.