4.9 Construction

One of the requirements for archive buildings in the tropics is that the building materials should be able to withstand all possible hazards and nuisances, from earthquakes to insect pests. Another, more recent, demand is that construction fabric should have a high insulation value in order to help control the interior climate. Noise pollution, a serious problem in many libraries, is another factor that can be reduced by choosing the right absorbent materials (Singh, 1982). Other requirements are low initial cost, low maintenance, appropriate surrounding buildings, and building materials with good weathering and durability quality. (Ozowa, 1988).

In passive building in South Africa the use of appropriate insulating materials is highly encouraged. It is both economically and practically counter-productive to import products where local alternatives can serve the same thermodynamic purposes (Rowoldt, 1993 and 1994). Local materials are always less costly than the usual reinforced concrete, and may often prove to be superior insulators. There is also less noise from such materials as mud and wattle, or clay (Havard-Williams et al., 1987), but for some reason builders prefer expensive imported materials. In Nigeria most library buildings are built in concrete (Ozowa, 1988). It is unfortunate that during the last decade general interest in the use of appropriate technology seems to have declined.

Selection of building materials is no doubt the responsibility of the architect and not the librarian. But it behoves the librarian to advise the architect because of the discomfort a wrong choice of materials can cause library users, (Ozowa, 1988). Strangely enough Ozowa forgets to mention the impact of a wrong choice on environmental conditions. For all elements of the fabric have a part to play in seeking a total preservation environment – the walls, doors, roof, floors and windows. They should all be designed to come together to form an integrated and sealed unit (Ling, 1998). Or as Daniel puts it: the first task of the building fabric is to reduce the impact of climate loads on the building (Daniel et al., 2000).

In hot climates, load reduction is achieved primarily by shading and ventilation, which serves to produce a more agreeable interior climate. Next, appropriately designed buildings will also reduce the impact of daily extremes of ambient temperature and humidity (Daniel et al., 2000; Toledo et al., 1998a). Some time ago the prevailing idea was that with the introduction of concrete technology and air-conditioning any local climatic conditions maybe ignored, or subjugated (Plumbe, 1959b). Today those views are considered superseded (see also section on Storage – Air-conditioning).

Wooden constructions should be made insect-proof or reinforced with metal. However, in buildings near the sea metal constructions should be given additional treatment against corrosion (Duchein, 1980). A very early publication on wood preservation appeared before the second World War in Jamaica (Edwards, 1939); see also Benoit, 1954a and 1954b; Fortin et al., 1976; Grenou et al., 1951; Keenan et al., 1984; Rauch, 1984; Sierig, 1991a and 1991c; Tack, 1980 (for more see the section on Integrated Pest Management).

For bibliographies of building materials for (western) libraries see Blair, 1993 and for developing countries in general see Sierig, 1991b. An older work on building materials and appropriate technology is the number 12 monograph on appropriate industrial technology; more recent ones have been published by SKAT (Anonymous, 1980b; Stulz et al., 1993). See also Anonymous, 1995b; DBR, 1954; Frick, 1989; Hunderman, 1988; Macleod, 1993; Pama et al., 1978. The website of the Canadian Conservation Institute is worth checking, as they intend to pay more attention to research into construction materials in the future.

4.9.1 Walls

A most interesting and comprehensive study of the influence of absorbent materials on relative humidity is the Ph.D.thesis by Tim Padfield. The moderating influence of absorbent materials in small enclosures has been known for a long time. The extension of the concept to moderating relative humidity levels in large, leaky enclosures like houses, has been unaccountably neglected. This failure in building technique has not only neglected the potential for humidity buffering that lies in common materials, but has also generated an array of condensation problems, both within buildings and in the structure of walls and roofs. A strict standard for permissible fluctuation in relative humidity has discouraged any experiments in passive methods of humidity stabilisation, because such methods can not achieve absolute constancy. In buildings with a very low air exchange rate, such as archives and stores, buffering by absorbent walls is so effective that it evens out the annual cycle of relative humidity, without needing help from mechanical air-conditioning. Padfield tested the performance of different materials and studied their behaviour in situ (Padfield, 1999). He published quite a few interesting studies on passive climate control, one being a scientific analysis of an old Himalayan legend (Padfield, 1987).

The importance of absorbent walls is corroborated by the results in the Vanuatu Cultural Centre, Pacific where the internal climate conditions were monitored for some time. Data analysis indicated that surfaces in the storage room may have higher relative humidity than the air in the room and the air exterior to the building. There was a tendency for this to lead to condensation (Asperen-de Boer, 1968; Daniel et al., 2000). In this context Christofferson developed an interesting factor to define materials capabilities in buffering thermal and
humidity variations: The Buffering Capacity Factor (Christofferson, 1995) (see also section Storage - Passive climate control).

Today archive buildings are required to have a high degree of thermal inertia so that the interior temperature and relative humidity remain reasonably stable and unaffected by fluctuations in exterior conditions. The fabric of a building and its effect on internal conditions is an area that requires much more research. The potential for passive control of a building’s internal conditions by managing the transference of external ambient levels is an exciting one. The current reliance on larger and larger air-conditioning systems is becoming a farce. The ability to control large spaces for twenty-four hours a day is there, but the initial as well as running cost are very high (Rhys-Lewis, 1999).

Hollow bricks made of local materials also provide an insulating effect. In Columbia, for example, an archival facility was built with exterior walls consisting of three layers of hollow brick with air-spaces between, and with steel reinforcement against earthquakes. Light coloured stucco also helps moderate excessive heat, while protecting the building materials beneath from the weather (Bellardo, 1995). Indigenous construction materials, e.g. adobe, can serve as a heat and humidity buffer too (Schüller, 2000).

In Germany the maximum indoor stability of the climate with only very slow changes is achieved by means of the buffer capacity of the brick walls, next to the system of natural air-conditioning (Buchmann, 1998). As the preferred orientation of the building is to the north, the opposite wall facing south has to be well protected from the sun by large projections, balconies or sun-breakers which allow light but exclude direct sunrays and heat. In hot-dry zones west facing walls in particular need to be thick. A 13.5 inch thickness of walls normally provides a ten-hour time lag. Alternatively, cavity walls are considered effective for blocking out heat transmission. East and south walls can be of light construction if protected by overhangs or sun-breakers. In general thick walls will protect the building from solar radiation but external walls need protection from the rains (Agrawal, 1974).

4.9.2 Windows

Opinions are divided on the desirability of windows in storage areas. On the one hand, opening windows can reduce heat and humidity, but on the other hand the existence of windows can increase inside temperatures when the sun is shining. In the industrial world, windows are being used less and less in archives and library storage areas (MacKenzie, 1996). In traditional buildings designers place windows at certain points to create a current of air (see this chapter, section on Traditional Building). The idea is that at certain times of the year ventilation is often necessary to improve climatic conditions in storage rooms. Even when an air-conditioning system is installed sliding windows are preferred to fixed windows in case of power failure (Nwamefor, 1975).

The inconvenience of total darkness as in underground buildings must not be underestimated. It is quite possible to avoid such problems and at the same time provide satisfactory protection for severely limited glass surfaces. The following proportions are suitable in tropical countries: 1–5% of the total surface of the sun facing facades and 1–10% of the total surface not facing the sun. All glass surfaces should be furnished with a protective device (sunshades, screens) in order to avoid the sun’s direct penetration into the premises (Karım, 1988). For example in Malaysia the Record Service Center of the National Archives is provided with only small, well insulated glass windows at the top of the wall and these are protected from direct sunlight by sunbreakers (Ismail, 1981).

In monsoon zones windows should be in generous proportions as compared to hot-dry and dry zones. Pierced screens covering the windows or veranda are very useful in this climate, allowing enough ventilation in the rainy season but cutting down direct sun rays as well as solar radiation from the sky and the ground. But behind the pierced screens, it is necessary to provide shutters to the windows, which can be closed when necessary to keep out the sun, cold wind and dust prevalent in this zone (Agrawal, 1974).

Opening a window, lets in dust and sunlight. Simple but effective ways to block the sunlight include blinds, shutters and curtains. Venetian blinds however have the undesirable effect of shutting out the air as well as the natural light, thereby necessitating the use of electric light most of the time (Nwamefor, 1975).

To keep insects out the windows must have screens. Fine wire mesh made from metal or plastic placed over the windows is effective against flying insects. Where there is a danger of hurricanes the windows should be strong and protected by a method of sealing designed to prevent glass breaking, like cyclone shutters, and keeping the water and flying debris out (Duchéin, 1988; Ling, 1998). The angles of sun-breakers and window projections need particular care because they should not obstruct the breeze (Agrawal, 1974). Windows must also be designed to withstand heavy rains, especially when driven horizontally by strong winds, or sea-spray (Plumbe, 1987b).

Today, dust contains exhaust gas, which causes new problems. A special window panel was invented in Japan to eliminate particulate matter. The panel has a compound structure: nylon filters are attached to both
outer sides to eliminate particulate matter containing exhaust gas. Inside the nylon filters there are micro filters which eliminate bacteria and mould spores. The innermost part consists of honeycomb papers (Kenjo, 1997). This might also be a solution for the accelerated corrosion of metal caused by volcanic gases, at least for internal climatic conditions (Plumbe, 1987b).

Planting trees around the building is one way of controlling the temperature in repositories and keeping the sunlight out as well. The State Archives Department of Vietnam recognised this and put the idea into practice (Tam, 1997). A comprehensive list of shade giving trees is given in Gut et al., 1993. The usual advice is to clear an area of vegetation around the building, of at least a few meters, so as not to attract insects that can easily become a problem for archives (Duchein, 1980). Trees can also form a security risk providing easy access to windows as well as the roof (Agrawal, 1974). Big shade giving trees that are not attractive for insects should be sought possibly with the help of ethno-botanists. Trees, green lawns and fountains are a great help in the dry season in monsoon climate zones in cooling the surroundings and reducing solar radiation (Agrawal, 1974).

A simple way to reduce the heat-gain of the building is for the windows to catch the prevailing breezes (Plumbe, 1987b), which should be large according to Agrawal (1974).

4.9.3 Roofs
Pitched or sloping roofs are recommended, specially designed to stand the many and sudden tropical showers as well as the violent winds, from gusty to cyclonic. It is essential that storm water should be thrown off sufficiently far away from the walls so that they are not splashed. A near vertical sun during the hottest hours of the day causes the roof to bear the greatest intensity of heat (Plumbe, 1987b).

The roofing should be tightly fixed and the material should insulate the building from both excessive heat and humidity. Traditional big eaves are recommended as they create plenty of shade around the building and protect the outer walls from getting soaked. Double roofing is an excellent way to create an extra airflow and thus control the inner climate (see the section on Traditional Building), but the construction must be storm-proof (Duchein, 1980; Schüller, 2000). The ill effects of a thin pitched roof on a museum environment are well illustrated by a Brazilian case study (Toledo et al., 1998a and 1998b). Metal roofs made from aluminium, zinc, copper or stainless steel have the disadvantage of being very effective heat conductors, as well as possibly suffering from corrosion caused by contact with sulphur dioxide in the atmosphere (Duchein, 1988). Generally all metallic elements exposed to the outside air particularly in maritime zones must be specially treated against corrosion. Flat roofs are not advisable because of the risk of leaking in heavy rains (Karim, 1988). Flat roofs made of concrete with or without a false ceiling are often subject to cracking due to contraction and expansion (Plumbe, 1987b).

The construction of secondary roofs and facades, with a gap of several feet between the primary and secondary surfaces, to allow for ample airflow around the primary building, is very important. This prevents sunlight from shining on and directly heating the outside surfaces (Schüller, 2000; see also the section on Traditional Building). Thermal insulation or the construction of a false ceiling will have a similar positive effect. In hot-dry climates a 4.5 inch thick reinforced concrete slab with 3 to 4 inch lime-concrete or mud-concrete layer provides an eight-hour time-lag for flat roofs. High ceilings do not make any apparent difference to the temperature unless there is a double roof. Compact courtyard planning is effective for this zone; enclosed courtyards retain heat during winter and allow quick radiation of heat and cooling during summer. A pierced screen covering the yard will help to reflect solar radiation from the sky (Agrawal, 1974).

See also the roofing primer by Stulz, 2000 and Anonymous 1985a; Koenigsberger et al., 1965; Landaeta et al., 1987.