THE USE OF BUILDING LIMES IN ECOLOGICAL CONSTRUCTION

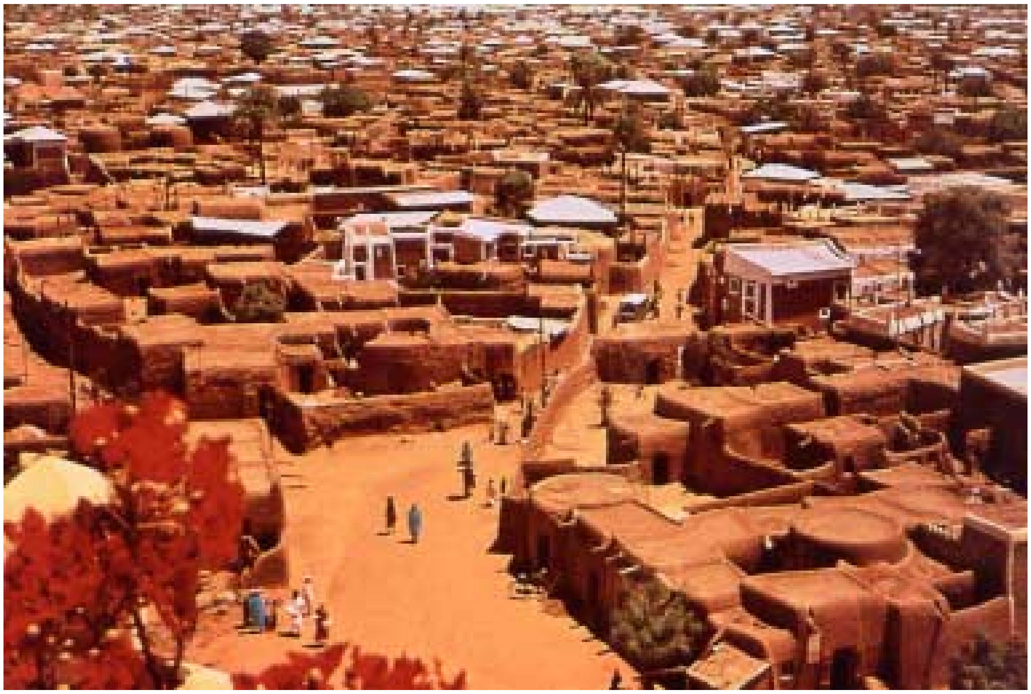
PART 2

STAFFORD HOLMES: CASE STUDIES

Photographs by S.D. Holmes unless otherwise acknowledged

EARTH STRUCTURES – NORTHERN NIGERIA AND BRAZIL

Slide 16 – Kano City



(Photo by Magwan Textiles, Kano)

A view of Kano City, the state capital, from one of the mosque minarets. The traditional buildings of this walled ancient city are constructed of local lateritic soil. This is a red soil found in the tropics often, but not always, clay rich and with a ferrous content. The principal load bearing structural walls are built up by hand with the laterite in a damp state which is then allowed to dry. The nature of laterite is that it is pliable when wet but when dried it becomes hard and durable. Roofs are usually flat or domed and constructed of the same material reinforced with joists cut from palm logs.

Slide 17 – Hausa Vernacular Architecture

(Photo from Des Architectures De Terre)

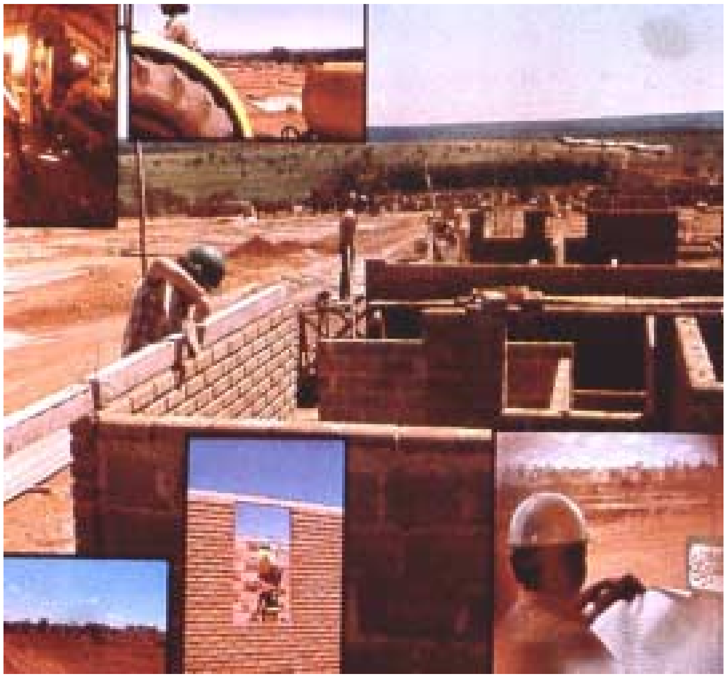
Traditions, built up over centuries, are reflected in the architecture of the Hausa in northern Nigeria. Colours, patterns, texture and materials are combined to produce an organic architecture with its own special delight and identity. The laterite construction is suitable for the climate and weathers well in dry conditions. The buildings provide a cool environment during the day. During the short rainy season, however, close attention is required to repairs and maintenance. There are techniques for protecting the earth structures against damage by heavy rain which include the introduction of organic oils but the traditional crafts and skills required are dying out.

It is not unknown for there to be prolonged spells of continuous and heavy rain at the height of the rainy season. This could well result in a roof collapse. I was saddened to see the effect of the essential need for shelter being met by using materials quite alien to this environment. The replacement materials, mainly corrugated aluminium roof sheeting and concrete block walls, increasingly introduced over the years, destroy the beauty of the traditional Hausa architecture and the flowing intimacy of the cityscape.

Slide 18 – Earth Stabilisation

In 1978 research was carried out on methods of stabilising the local lateritic soils with a view to conserving this unique architectural vernacular. The most readily available stabiliser was Portland cement. A range of standard sandcrete block making machines was also available and one of these was adapted to vibro-compact solid stabilised laterite blocks. The blocks were tested by immersing them under water for 28 days. Three types of laterite were examined to determine the minimum cement required for stabilisation. This ranged from between 7% down to as little as 3%. An experimental building was constructed to demonstrate the viability of this process.

Slide 19 – Brazilia Satellite Towns



(Photo by Tecmor, Brazil)

Research into cement stabilised lateritic soils lead to Brazil. In association with construction of the new capital city, Brazilia, outlying satellite service towns and villages have been built using cement stabilised lateritic bricks and blocks. The site shown is at Cidade Ocidental Brazilia. There are a number of manufacturers producing machines for this process in Brazil, including Tecmor, Supertor and Torsa plus a German manufacturer, Zenith. These firms collaborated with the Universidade Federal de Sao Carlos for monitoring, research and testing.

The major advantage of this construction method is the substantial use of local, low cost bulk material. Limestone and clay are the principal raw materials for Portland cement. Stabilisation with Portland cement, however, perpetuates the use of a stabiliser which has the disadvantages of being fired at high temperatures (1400°C +), requires fine grinding, is usually produced on a large scale with complex equipment. Due to the preference for mass production it is usually transported over long distances. An alternative method of soil stabilisation, particularly for clay rich soils, is with lime. Small-scale local production of lime is economically viable and the end products tend to be less brittle, more permeable and more flexible than those using cement. Lime can be produced at 900°C.

LIME STABILIZATION OF ROADS

Slide 20 – Construction of the M25 London Orbital Motorway

The last section of the six lane motorway orbiting London was constructed with a road sub-base of lime stabilised soil. Road engineering principles of stabilising clay rich soils with lime are well established and have been practised in America and Europe for the construction of airport runways and roads over the last 50 years.

Slide 21 – Warwick Castle

Warwick Castle is considered the finest medieval castle in England and it is set in grounds and gardens extending to over 100 acres. Many lessons have been learned here about the way in which traditional materials and skills can provide valuable information for ecological construction methods.

Slide 22 – Warwick Castle Estate Road

Not quite the size of the M25! Learning from the construction of the M25, however, the Estate road was rotavated to a depth of 6" and approximately 5% quick lime added for stabilization. This was compacted and the finished result gave the desired appearance and quality for an Estate road in the grounds of a medieval castle. The road was used unsurfaced for approximately 5 years following which, due to increasing traffic, it was decided to surface dress. The sub-base and wearing surface are still in use today.

TRADITIONAL USE OF BUILDING LIMES IN ZANZIBAR

Slide 23 – Ithnashery Dispensary, Zanzibar

Construction of this remarkable building commenced in 1887. The timber balconies disguise the main construction which exemplifies the conservative use of lime in conjunction with other materials. Unfortunately, due to major political change and subsequent neglect of the drainage system over the last 30 years, lack of maintenance caused major deterioration. The building has now been renovated by the Agah Khan Trust.

Slide 24 – Typical Zanzibar Construction

Erosion on the front elevation of the Ithnashery Dispensary reveals the construction method of roughly dressed coral ragstone set in lime stabilised lateritic mortar. This forms the structural base and background for the lime stabilised lateritic render. The same mix is used both as a base coat for the plain render and for relief modelling which is supported on nail armatures. The decorative work of the corbel below the timber balcony support is executed in lime stabilised earth stucco. The rendered and modelled surfaces are then finished with an almost neat lime render skim and limewash.

Slide 25 – Building with Lime

A current practice when building houses in rural areas of Zanzibar is to add hydrated lime to the lateritic earth before daubing it into a double framed lattice of saplings. This construction is used for both external walls and internal partitions which are protected by the palm frond thatched roof above.

Slide 26 – Small-Scale Lime-Burning

Lime is still being burnt in Zanzibar on a small-scale today. The traditional method consists of heap burning small pieces of broken coral ragstone on a circle of palm tree logs.

<u>Slide 27 – Lime Hydrate</u>

After burning the quicklime is slaked to a dry hydrate and stored in a heap under an open thatched canopy. Stored like this the hydrate air slakes, particularly over a long period in a hot, moist climate and looses its binding properties. Following a request from the Zanzibar Stone Town Conservation and Development Authority, we gave advice on behalf of the Intermediate Technology Development Group. During the training and demonstration courses we advised on ways in which lime production could be improved and the lime stored to ensure optimum quality and to maintain its binding properties.

Slide 28 – Slaking to Putty

The STCDA lime putty settlement tanks

The advice given to improve the end product was to slake the lime to putty. This was demonstrated on the first visit by using empty oil drums as slaking vessels. Subsequently, the STCDA built their own slaking tanks.

Slide 29 – Bharmal Building Plaster

The Bharmal Building was one of the first major landmark buildings in Zanzibar Stone Town to be completed by the Development Authority following a long period of neglect.

The lime putty produced by the Authority mixed with sand made good lime plaster. This illustration shows the successful lime plaster wall finish inside the Bharmal building.

CLAY LUMP IN ENGLAND

Slide 30 – Clay Lump Preparation in Norfolk

The SPAB (Society for the Protection of Ancient Buildings) organised a clay lump day in Norfolk to demonstrate clay lump construction techniques. This is a common traditional form of construction used for many of the older buildings in the area. It is often unrecognised due to the practice of rendering and painting externally and plastering internally. Clay lump construction techniques had almost been forgotten and it was important to relearn these if repairs were to be successful. Existing clay lump was analysed and the mix reproduced. The ingredients and their proportions tend to vary from one part of the county to another, but mainly consist of clay, silt, sand and coarse aggregate with some straw or cow dung as a binder. The mixture may or may not contain a small proportion of chalk and lime. The demonstration course showed mixing the ingredients to the right consistency by watering and treading in and then compacting the clay lump in moulds.

Slide 31 – Clay Lump Wall Construction

Construction of clay lump walling was demonstrated by bedding the dried lumps (blocks) onto a solid base and to each other with a clay lump mortar, rendering the face with a clay lump render of a similar mix and finishing the surface with limewash.

Slide 32 – Clay Lump House, Norfolk

A clay lump house built in Norfolk in the 1930s completed with render and painted. This is difficult to distinguish from many other rendered houses constructed with more "conventional" materials.

HOLNICOTE ESTATE BUILDING MATERIALS

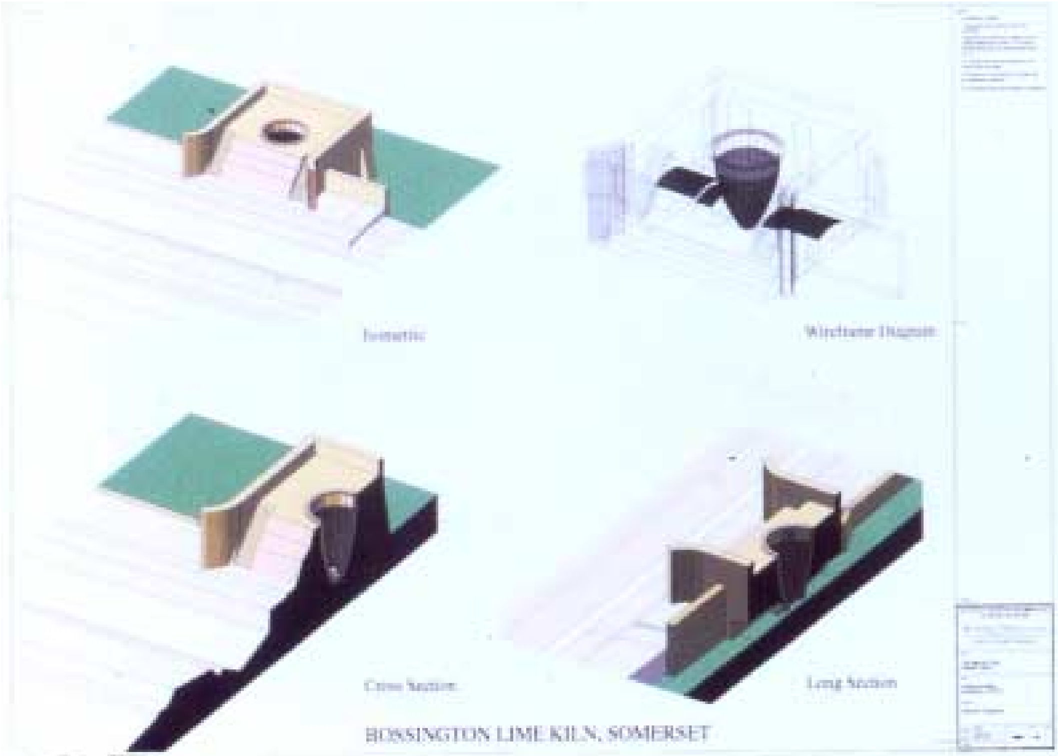
Slide 33 – Holnicote Estate, Somerset

This house and Packhorse Bridge at Allerford typify traditional construction methods found throughout the Holnicote Estate. Probably from Saxon times or earlier, the area has been largely self sufficient and its buildings exemplify the use of local resources. The house is constructed of local sandstone and was originally thatched with local reed. The timber used is from the Estate forests and the sand for the mortar was taken from the adjacent river. An outcrop of blue lias limestone at the centre of the Estate completes a full compliment of building materials.

Slide 34 – Bossington Lime Kilns, Holnicote Estate

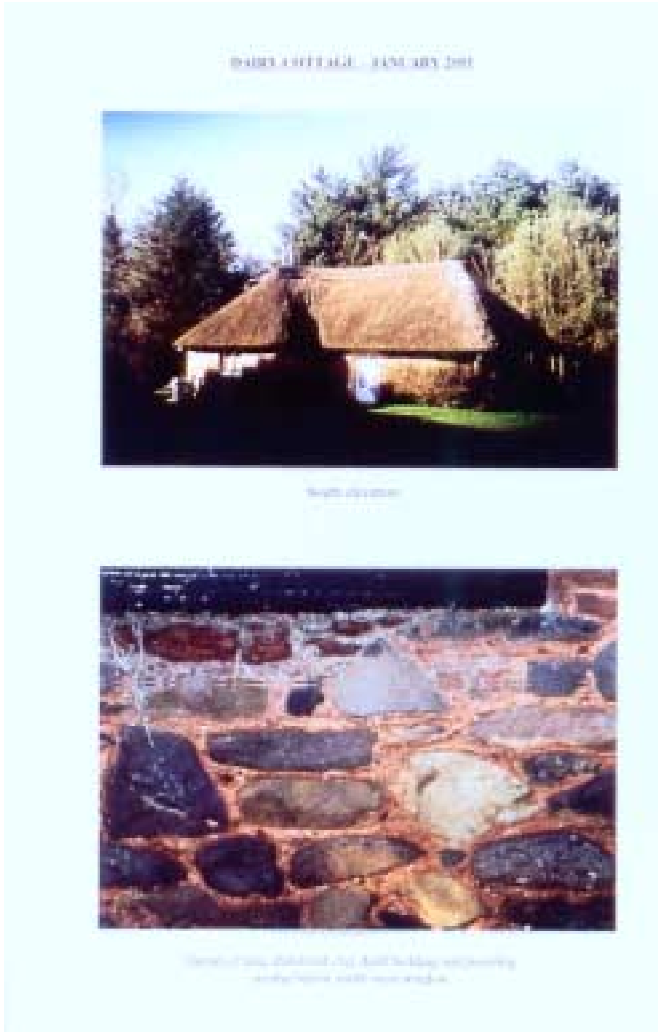
Similar to many parts of England where limestone is present, the Estate contains the remains of a number of lime kilns. These indicate the importance of lime production to the local economy. Over the centuries lime has been used for a wide range of industry, for agriculture and for building. Most kilns were small-scale by today's standards and usually built of local materials. This kiln is located at the edge of the beach and is constructed of beach boulders and stones bonded with blue lias hydraulic lime mortar.

Slide 35 – Kiln Survey and Interpretation



The kiln was surveyed for the National Trust with a view to its conservation. The general configuration including the conical shaft is typical of many kilns built in England, and elsewhere, during the 18th and 19th centuries. The form of the product varied and probably included dry hydrate and putty, both of which are produced with modern equipment today. As the kilns were fired on a regular basis, fresh quicklime (Calcium Oxide) was also readily available.

Slide 36 – Holnicote Estate Survey and Repair Revelations



Some of the buildings on the Estate date back to before the 17th century. Many examples of lime stabilised clay daub bedding mortars were encountered during the course of a survey of over 200 buildings as seen here on the south wall of Dairy Cottage.

Slide 37 – Wilsden Cottage Daub Plaster

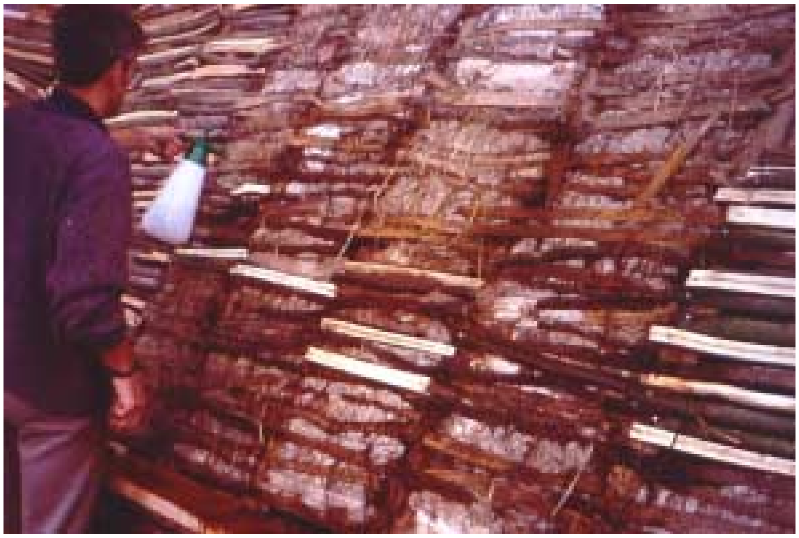
Overdue thatching repairs resulted in holed thatched and subsequent damage to the roof timbers of Wilsden Cottage. When the damaged areas were carefully opened up from the inside for inspection prior to repair, stabilised clay daub plaster to all interiors was found together with a similar material used for bedding mortar and ceiling plaster. Prior to opening up the presence of this material was not known as it was covered by lime plaster and limewash finishes.

MOTSLOW HILL COTTAGE, WARWICKSHIRE

<u>Slide 38 – Motslow Hill Cottage Prior to Repair</u>

This is a 16th century timber framed building. The new owners, Mr. & Mrs. D. Anderson, were anxious to ensure that entirely compatible and traditional materials were used for its repair after purchase. The cause of much of the damage was lack of maintenance particularly to the thatched roof which was holed in a number of places. Again, water damage from the leaking roof had caused severe rot to structural timbers. Due to the extent of thatch decay and timber repairs required, it was decided to carefully strip the existing and re-thatch.

Slide 39 – Clay Daub Ceiling Plaster



Following removal of the thatch, the original clay daub ceiling plaster on riven lath was revealed. This was analysed by Ty Mawr Lime and found to be a mixture of clay, sand, straw and hair with a very small percentage of lime.

Slide 40 – Wattle and Daub External Wall Panels

The timber frame and rafters were repaired with English Oak of similar section to the existing where water damage had occurred. All the infill panels on the front north wall had been replaced gradually over previous centuries with local brick. This had not been done, however, on the rear south elevation where complete wattle and daub panels have survived. Some of the panels had been coated over with Portland cement based mixes or infilled with concrete blockwork and cement render. Defective wattle and daub panels were carefully repaired using material to match the original which included quicklime stabilised clay daub on wattle, lime render skim coat and a limewash paint finish.

<u>Slide 41 – Existing Interior Finishes</u>

A view of the first floor ceiling reveals lime skim coats or limewash on clay daub ceiling plaster on riven laths which are fixed to the round oak rafters. A limewash finish had been taken across all interior timbers.

Slide 42 – Conservative Roof Repairs

An interior view to the underside of the roof and dormer window showing repairs with matching timber structure and rafters hand finished with an adze, and riven laths for the plaster support. The sound existing daub plaster and limewash finish has been carefully retained.

Slide 43 – Completed External Envelope

A view of Motslow Hill Cottages from the north following re-thatching and repointing of brickwork with a lime mortar using local sand. The external envelope was completed first to assist protection of the building fabric and drying out prior to all internal repairs which were treated as a second and later phase of the project.

Slide 44 – Local Clay

The second phase of repairs included installation of new bathrooms and drainage. Excavation of the drainage trenches revealed a rich clay subsoil closely matching, and presumably used for, the original daub. In order to prepare the daub for repairing the external wattle and daub panels, the material was mixed by hand, including the addition of 5% quicklime. This was heavy manual work but not a major problem due to the relatively small quantity required. When it came to Phase 2, however, the extent of repairing and replacing plasterwork to the interior ceilings and walls was another matter! The plasterers, Trumpers Limited, experimented with mixing methods that were less labour intensive. Initially it was assumed that the clay daub would be too stiff and cohesive to be turned in a conventional drum mixer. During the course of trials it was found that provided the daub was well wetted to plastering consistency, this could be successfully mixed mechanically. The secret was to add the quicklime at the end of the mixing process and then to ensure continuous mixing for the minimum time to achieve a consistent and even distribution.

Slide 45 – Lime Stabilised Daub Production

Craftsmanship skill and experience is needed to judge the optimum plastering consistency. Trial and error and experience is part of the process of achieving the best results. It was found that a good quality mix of the correct consistency can be easily discharged from a standard drum mixer.

Slide 46 – Applying the Lime Stabilised Daub Ceiling Plaster

The daub plaster was applied to riven ceiling laths below the thatch in a similar way to normal lime plaster but with a thicker first coat. It is important that the daub is applied as stiff (dry) as possible to reduce shrinkage. The quicklime took approximately 15 to 20 minutes before its reaction with the clay was sufficiently marked to make the mix too stiff to work. By preparing the mix in one small batch at a time and using it immediately, there was just time to complete the plastering operation before the material became too stiff to work.

<u>Slide 47 – Partially Completed Ceiling Repairs</u>

The new plaster daub was matched into the existing on new and repaired riven laths.

Slide 48 – A View of the Completed Building from the South-East

The majority of first floor infill panels are wattle and daub which have been retained. A consistent finish of limewash on lime render was given to all rendered panels and the sound existing lime plaster and wattle and daub panels were conserved.

If There is Sufficient Time a Note on Suspended Floors and Field Kilns

(Also with slides not shown here)

Slide 49 – Baggrave Hall, Leicestershire

This 17th century timber framed house has an attic floor composed of a light-weight lime ash aggregate which is the residue of fuel and under-burnt material found at the bottom of kilns after lime burning or similar operations. Light-weight floor screeds on upper floor joists were regularly used in England from at least the 16th century and probably well before this date. Gypsum was the normal binder which provided a quick set to the floor slab which was in the order of 3" thick.

Slide 50 – Detail of Lime Ash Floor Slab Supported on Reeds Spanning Between Floor Joists

The support was either lath or reed spanning between floor joists.

Slide 51 – Light-Weight Aggregates, England

A view of the underside of a lime ash floor exposed to view following loss of boarding. The boarding appears to have been used as a permanent shutter and some of this has rotted away exposing the ash combined with under-burnt fuel, mostly coke and coal, used as a light-weight aggregate.

Slide 52 – Suspended Floor, Zanzibar

A view of to the underside of an upper floor in Zanzibar, damaged by water seepage (over 30 years) from a bathroom above. The light-weight aggregate in this case is coral ragstone bedded in a lime stabilised lateritic mortar supported on boriti (mangrove) poles and then lime plastered on the underside.

Slide 53 – Coral Ragstone Floor Construction

A view to the underside of a traditional suspended floor under construction in Zanzibar. This shows the coral ragstone in place supported by boriti poles before plastering.

Slide 54 – Completed Ceiling, Zanzibar

A typical upper floor and lime plastered ceiling found throughout the Stone Town.

Slide 55 – First Floor Surface Finish, Zanzibar

Lime is excellent as a binder but it is not in itself a tough hard-wearing finish The way this has been overcome for floors in the past is to incorporate durable materials in the surface. These can be incorporated as part of the aggregate, or included randomly close to the surface, or they can be individually placed giving the opportunity to enhance the floor with decorative patterns. Typical materials for adding into the surface are small pieces of broken brick or marble which are suitable for grinding down to a smooth finish. Alternatively, laying in shaped pieces to the surface by hand is possible. Elaborate mosaics, some of which have survived from the Roman period and earlier, are good examples of the level of decoration that can be achieved. "Waste not want not" is an adage that springs to mind when describing this type of floor. The residue from kilns and unspent fuel is not wasted but incorporated as an aggregate. In this example of a floor finish in Zanzibar broken crockery has not been wasted either but turned into an attractive mosaic floor pattern and hard-wearing finish.

Slide 56 – The Good, The Bad and The Ugly

Since 1992 the Building Limes Forum has been holding annual gatherings for its members. Prior to these gatherings volunteers, from Burning Interest Group have constructed various field kilns. The principal purpose of these is to demonstrate small-scale lime burning, the fact that there is often a local source of limestone, the diversity of building limes and their attributes, and that it is possible to construct field kilns from local materials.

The Good – a field kiln constructed of marl compacted within wattle formwork supported on a stone base with marl mortar and lime render. Approximately 1 ton of limestone was burnt from the local quarry near Cirencester using forestry thinnings as wood fuel supplied by the local agricultural college.

Slide 57

The Bad – a field kiln constructed of Purbeck marble to burn limestone for field trials at Corfe Castle, Dorset for the National Trust. The Purbeck marble was not wasted. Due to the use of lime mortar in the kiln construction it was possible to dismantle it following the trials. The lime mortar was easily cleaned off the Purbeck marble which was returned to store for reuse.

Slide 58

The Ugly – In 1994, following a Building Limes Forum gathering, a demonstration field kiln was built of waste limestone at Tout Quarry, Somerset. This was constructed to examine the feasibility of reintroducing blue lias building lime to Britain. Subsequently, a series of larger and more advanced kilns have been built and the quarry is now producing up to 5 tons of lime a day. Another modern kiln is now planned which is expected to produce up to 25 tons per day.

STAFFORD HOLMES Dip.Arch., ARIBA

Developed a keen interest in the conservation of historic buildings and the use of traditional building materials after qualifying as an architect in 1966. Became a Partner of Rodney Melville & Partners in 1988. Member of the British Standards Institute Committee for Building Limes, on behalf of The Building Limes Forum and Director of the Scottish Lime Centre Trust. Architect for a range of work specialising in the conservation of historic buildings including churches, castles, mills and country houses. Consultancy advice given in the U.K. and abroad for the research, development and use of traditional building materials including on-site training and demonstration courses. Author, with others, of ‘Lime and Other Alternative Cements’, and with Michael Wingate ‘Building with Lime’ published in 1997.