THATCH GUIDE:

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A GUIDE
TO GOOD THATCHING PRACTICE

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1. INTRODUCTION

Thatch has been used as a roof cladding material for many centuries. It creates an aesthetically pleasing end result, well adapted to the natural environment, and its popularity has not diminished over time. Thatching is a craft traditionally handed down from father to son; consequently relatively little documented information exists. It is to this end that this guide is presented in an endeavour to report concisely on the present status of technology related to good thatching practice.

Scope

This guide describes the basic techniques employed in roof thatching. It identifies certain problems that are commonly encountered in both design and construction and offers guidelines for good thatching practice. The most significant drawback of a thatched roof is its vulnerability in the event of fire. Practical fire-safety design principles, developed after years of research, are consequently briefly reported on in this document. Guidelines for a typical thatch roof specification are included in Appendix A.

The construction of thatched lapas has also become an area of major concern, not only for most local authorities, but also for insurance brokers. Since no guidelines are given for the construction of thatched structures in SABS 0400:1990 *(Code of practice for the application of the National Building Regulations)*, guidance will also be given in this regard. Guidelines for the fire-safe design of thatched lapas are provided in Appendix B.

2. MATERIALS

Thatching makes use of materials that are naturally obtainable, i.e. grass or reed. In South Africa, only certain indigenous grasses are normally used. Detailed information with regard to all the grass species can be found in Frits van Oudtshoorn's book, Gids tot Grasse van Suid Afrika (1991).

12.1 Common thatching grass

The most commonly used South African grasses with their main geographical locations are listed below:

- *Hyparrhenia hirta* (generally known as common thatching grass) - Natal Berg area, in abundance;
- *Hyperphilia dissoluta* (commonly known as yellow thatching grass) - Northern Province, Mpumalanga, northern KwaZulu-Natal and Swaziland;
- *Thamnochortus insignis* (or Cape thatching reed, commonly known as "dekriet",) - Albertinia and Riversdale districts of the Cape;
- *Hyparrhenia dregeana* - Natal midlands and Berg area;
- *Hyparrhenia filipendula* (commonly known as fine thatching grass) - KwaZulu-Natal, Zululand coastal regions;
- *Thamnochortus erectus* and *Thamnochortus specigerus* (dekriet or thatch reed) - Cape coastal regions;
- *Chondropetalum tectorum* - Cape area, widespread; and
- *Phragmites australis* (Norfolk reed or swamp grass, known locally as Umhlanga grass) - widespread in South Africa.

Although commonly used in Britain, Norfolk reed has not been widely used for thatching in this country, in spite of its general availability. The type of grass known as Tambookie grass *(Tamboekie)* is often used in the rural areas for thatching, but there are coarse varieties, with stalks thicker than 4 mm, that are not considered suitable for thatching.

Natal thatching grass has a finer texture, when laid, than the grass found in Mpumalanga and the Northern Province, and is often preferred for this reason.

The stalks of thatching grass are normally hollow and about 3 mm thick. Cape dekriet stalks, however, are solid and about 3 to 4 mm thick. The quality of the material improves with cultivation and regular cutting. A question often asked is whether the quality of the thatch is dependent on the way in which the grass is harvested (cut), since some thatchers consider the quality of material cut by hand (with a sickle) to be superior to that cut with a machine. The answer is no. The quality of the thatch produced is the same; however, hand-cutting will produce only about 50 to 100 bundles a day, whereas a mechanical cutter and binder will process about 6 000 bundles a day.

Thatching grass is usually cut from mid-winter to August, after growth has stopped and the first hard frost has killed the leaves. In areas where no frost occurs, the only measure for determining whether the grass is ripe and ready for cutting is whether the grass plumes still contain any seeds. Should this not be taken into account (still lots of seeds) and the grass be cut too early, this will impact not only on the quality, but also the grass yield for the following seasons. At the end of the cutting season the remaining stubble and undergrowth must be removed, either by grazing or by burning.

2.2 Cape thatching reed

Cape thatching reed is a species of the *Restionaceae* (reed) family, which is widely distributed in the Albertinia and Riversdale regions. This species, known as *Thamnochortus insignis* is unisexual, incorporating female as well as male plants. The clumps of reed have a diameter of 300 mm and more, and grow to a height of 2.5 m. This is most commonly used in the Cape regions because of availability but is also used throughout South Africa.

The sandy area, or dunes, stretching between the Gouritz River east of Albertinia and the Duivenhoks River west of Riversdale, from the coast in the south to the sweet dunes near the N2 national road that links Mossel Bay and Cape Town, is thatching reed territory *par excellence*. The thatching reed that grows mainly in the sand dunes is consequently less abundant, and is found in an area of about 2 000 km^2. The lushest reeds, however, grow in the sweet dunes that lie below the chalk ridges as well as in the white sand in front of the dunes.

Various species of the Proteaceae family that grow mainly on the chalky ridges and sandy soil are also found in this area and include *Protea obtusifolia*, *P. susannae* and *P. repens*, the genera *Leucospermum muirii* and *L. cuneioforme*, as well as different species of leucadendrons, and the well-known heath, *Erica bauera*.

As soon as the thatching reed has formed seed, ripened and been dispersed, it is cut with sickles or reed-cutting machines and spread out to dry, transforming in colour to a rich gold.

Soon after the first rains, the tufts start growing again and recover to such an extent that they can be re-harvested after three years.

3. PREPARATION

3.1 Cleaning and bundling

After the grass has been cut and loosely bundled, each bundle is shaken vigorously to dislodge all loose material. The bundles are then cleaned by passing a sickle through them, working from top to bottom. This removes the remaining leaf growth from the lower two-thirds of the stalks.

The grass is then regrouped into bundles about one to 1.5 m long and between 75 and 100 mm in diameter (see Photograph 1). These bundles are each tied with a thong of twisted grass or with twine and packed in heaps (pyramid shape) about 2 m high and 2.5 to 3 m in diameter at the base.

3.2 Combing

When the thatch or thatching reed is to be used for the "spray layer" (or what is commonly referred to as the *spreilaag*), immediately above the thatching battens, where the underside will often be exposed in a room, the material should be combed to ensure that the stalks are perfectly clean. A comb is made by driving a few 75 x 3.5 mm-diameter round wire nails into a horizontal pole about 300 mm long. The nails are spaced about 12 mm apart, in a straight line.

The bundles of grass are placed across the top of the comb and pressed down so that the stalks are separated by the nails. The bundle is then pulled through the comb from the top to the bottom end.

3.3 Storing

After combing, the bundles should be stacked clear of the ground and under cover. Poor thatch storage is portrayed in Photograph 2. Bundles are normally baled for transport, in batches of 10 to 20 bundles for manual handling and 500 bundles for mechanical handling.

4. THE THATCHER'S TOOLS

A thatcher in South Africa normally uses five tools:

4.1 A sickle

This is used for hand cutting as well as for cleaning the cut bundles.

4.2 The thatching spade or "*dekspaan*"

This tool is known as a leggatt in Europe. (See Photograph 3). This is usually a home-made implement consisting of a board about 150 x 200 x 30 mm thick, with a handle on one flat side, rather like a plasterer's (wooden) float. Several metal blades are secured to the other flat side. These blades run across the 150 mm width and are set at an angle of about 45° to the bottom surface of the board, projecting about 10 mm from it. This tool is used to dress and shape the thatch in position.

4.3 A straight needle

When an assistant works on the underside of the thatch, a straight needle, about 300 mm long, is used to "stitch" the thatch to the roof battens with thatching twine (treated sisal rope).

4.4 A curved needle

This is about 600 mm long and is used to stitch the thatch to the roof battens, when the thatcher works alone from the top of the roof.

4.5 Climbing hooks

S-shaped climbing hooks are used to provide the thatcher with a foothold when working on the roof slope. The top hook, which is smaller than the others, is hooked over the roofing battens and the lower hook is then used as a stirrup.

An alternative method of providing a foothold is to use poles, 100 mm in diameter. These may be supported on two climbing hooks, or they may be wired to the roof timbers with 4 mm diameter galvanised steel wire, as seen in Photographs 4 and 5. At the apex of the roof, a 100 mm diameter ridge pole is fixed and another pole of the same diameter is nailed on top of it.

5. WORKMANSHIP

5.1 The thatching team

Normally, a thatching team consists of four men: one to pass material from ground to roof level, two thatchers working on the external roof surface, and one working under the roof to assist those working on the outside (Photograph 5). Such a team can be expected to lay about 10 m^2 of thatch in a working day.

5.2 Thatching

Before each bundle is passed to the thatcher on the roof, it is "butted" against a butting board, or on level ground (Photograph 1), to ensure that the butt end is even and that any sharp ends are blunted. The bundles are normally thrown up to the thatcher. If the bundles are less than 75 mm in diameter, it will be difficult to throw them up to the roof because they will be too light. This problem can be overcome by tying two bundles together before they are passed to the thatcher. However, this creates extra work for the thatcher, who will usually prefer the bundles to be about 100 to 125 mm in diameter, with a circumference of about 300 - 400 mm.

Thatching is then started at one verge (footlog level). The grass is used in bundles, as it was cut, and laid on the roof with the butt end at the lowest end. As each bundle is laid on the roof, the thatcher cuts through the twisted grass or twine that secures it. He places the first bundle on the corner, at an angle of at least 45°, thus exposing the butt end at the eaves and starting at the verge (barge). As he works the course towards the opposite corner, the bundles are laid parallel to the rafters. Each bundle in the first course, at the eaves level, is secured to the second batten with tar-treated sisal twine (thatching twine) at 75 mm intervals. Subsequent courses are secured by *sways* (compaction rods) being laid on top of the bundles and secured to the roof batten below with thatching twine at 75 mm intervals. As an alternative to the traditional method, some thatchers prefer to stitch each bundle direct onto the thatching battens, not using any sways. This method of fixing, however, creates an undulating uneven surface that may adversely affect the density, performance and the durability of the thatch as a roof covering.

The thatch is placed two bundles thick to achieve a minimum thickness of 175 to 200 mm, depending on the diameter of the thatch bundles. Each successive layer conceals the sways that secure the previous layer. The compaction of the thatch and the possible sliding down of the thatch layer over the roof structure are very dependent on the tension of the twine stitching. A roof with good compaction will not only be more durable but will also slow down the propagation and spread of fire should the roof be ignited.

Good compaction of the thatch layer is also a requirement for the effective fire protection of any roof prior to the application of an approved fire retardant.

5.3 Sways

In this document the sways or compaction rods recommended for use refer to non-conductive sways (either *poplar* or *willow* sticks, imported cane or a group of four to five thatching reeds bundled together). Wire or metal rods (conductive sways) are most commonly used by thatchers in Southern Africa; however, this practice is not recommended owing to the associated lightning risk.

Poplar and willow sticks are commonly used but Spanish reed *(Arundo donax)* [or] or basket willow *(Salax viminalis)* might also be suitable. Some thatching contractors use four to five strands of dekriet for sways, while others use imported cane.

It should be noted, however, that the effect of lightning must never be underestimated in the construction of thatch roofs. The prerequisite for the use of wire *(conductive sways)* for the compaction of any thatch roof is the installation of a certified lightning protection system that conforms to the requirements stipulated in SABS 03:1985 *(Code of Practice for protection of structures against lightning)*.

5.4 Spray layer

Before thatching proceeds, a layer of selected reed, cleaned thatching stems or Cape thatching reed, known as the *spray layer* (spreilaag), is spread evenly on the roof battens to a thickness of about 5 to 8 mm (enough to conceal the top layer). This imparts an aesthetic appearance to the inside of the roof covering.

A loose spray layer, cut to fit between the timber laths on the inside of the roof at ridge level, is used to finish off the ridge from the inside.

If no spray layer of selected reed is used, it is recommended that ordinary clean thatching grass be used as a bottom layer to create a neat surface on the inside of the roof.

5.5 Chimney stacks

Special care is required where elements such as chimney stacks and vent pipes penetrate the roof plane. Such features should be dressed/lined with a sheet metal or fibreglass-reinforced polyester flashing under, between and over the top surface of the thatch. The width of the flashing should be at least 250 to 300 mm. In case of chimney stacks a secret gutter is then formed against the upper face of the chimney and flashed against it. The higher end of the sheet metal or fibreglass gutter is dressed up under the thatch to about 300 mm in width. (See Figure 1.)

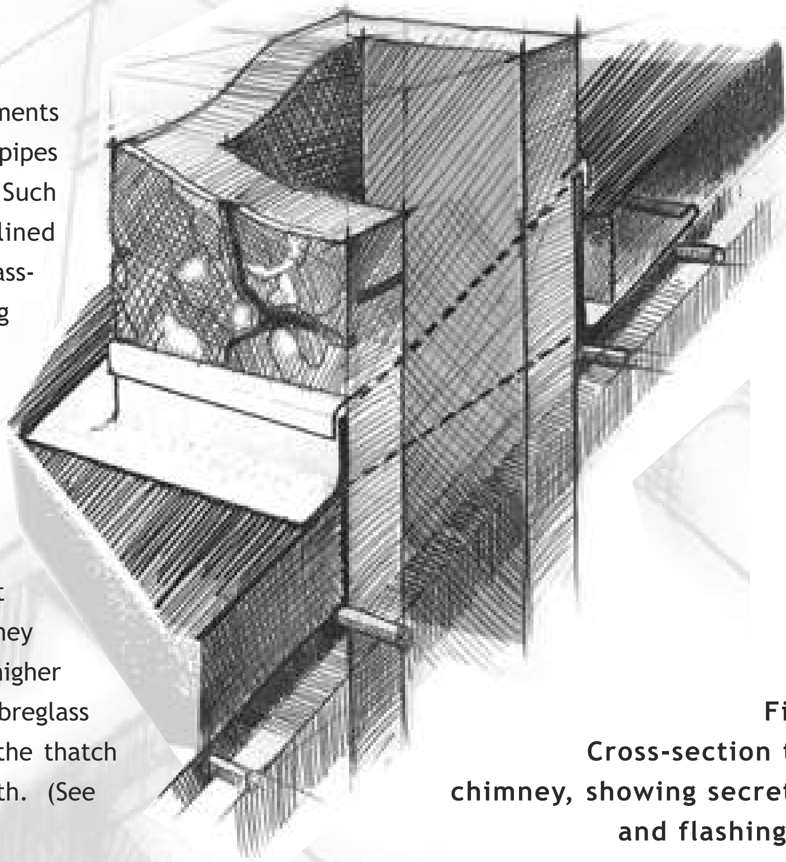


Figure 1: Cross-section through chimney, showing secret gutter and flashing details

The side flashing (both sides of the chimney) will connect the upper flashing (under the thatch layer) with the bottom flashing (above the thatch layer), to allow the water to drain over the thatch surface (see Figure 1). To prevent the thatch above and below the side flashing from sliding down, the thatch should be laid at an angle to secure the thatch to the laths adjacent to the flashing and at the same time also cover the side flashing (see Figure 2). The thatch layer should never be in contact with the top and the two sides of the chimney so as to allow water from the upper flashing to flow down. The thatch should be fixed around the chimney (the top and the two sides) to form a channel of at least 50 mm between the thatch and chimney.

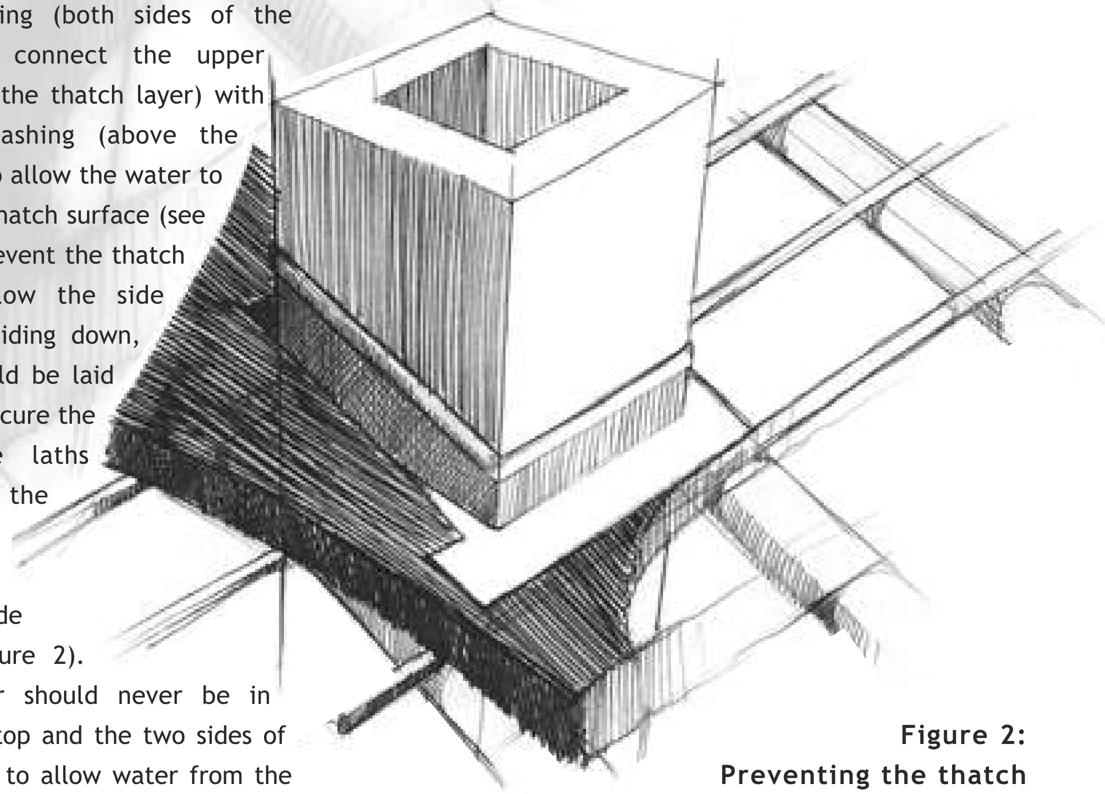


Figure 2: Preventing the thatch from sliding down

Alternatively, to prevent any possible leak normally associated with chimneys, the buildings and/or roof should be such that the chimney stack always penetrates the roof at ridge level. Should this not be possible, the stack can be twisted by 45°, and not constructed parallel with the roof structure, thus eliminating the problem of creating concealed gutters and complicated flashings, etc, to allow water to run off without spilling over the flashings. (See Figure 3.)

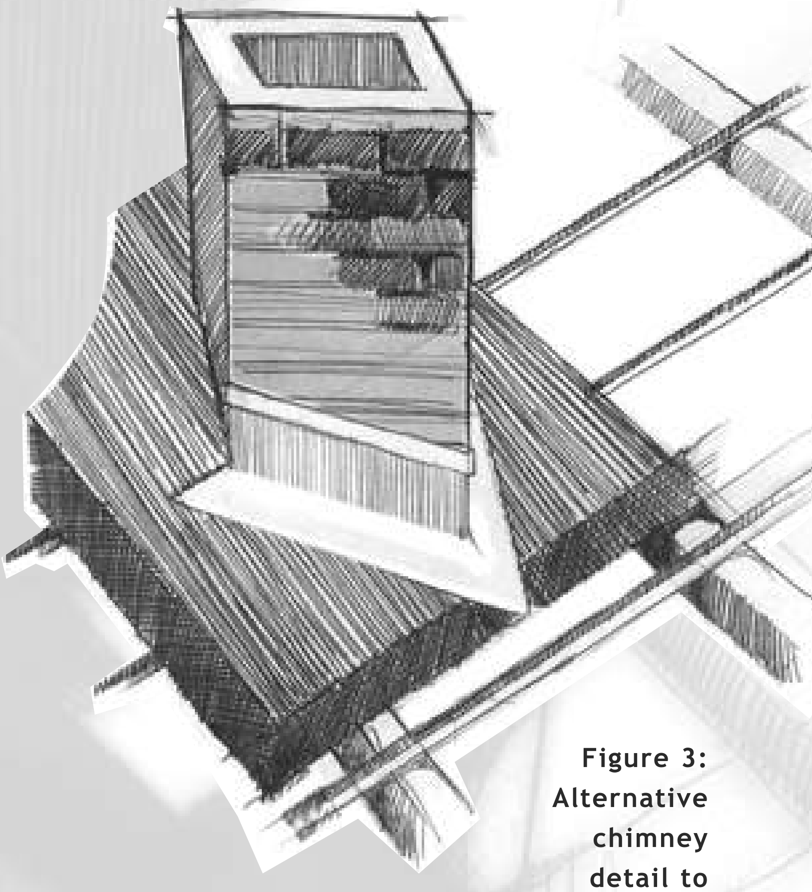


Figure 3: Alternative chimney detail to minimise water leakage

5.6 Hips

Care should be taken when thatching roof hips to ensure that the grass bundles at the end of a hip plane run parallel to the hip rafter. On each side of the hip, as the course proceeds away from it, the bundles are gradually orientated until they are aligned perpendicularly to the battens. Care should also be taken to ensure that the full thickness of the thatch is maintained as it progresses around the bend of the hip (see Figure 4). The density of the thatch layer on the hips tends to be lower than over the flat sections and additional thatch may be required. The thatch at the hips may require more regular maintenance because of accelerated weathering normally associated with low density. The use of two hip beams, one at each side of the corner, will provide an acceptable alternative to the problems caused by the 90° angle. (See Figure 5.)

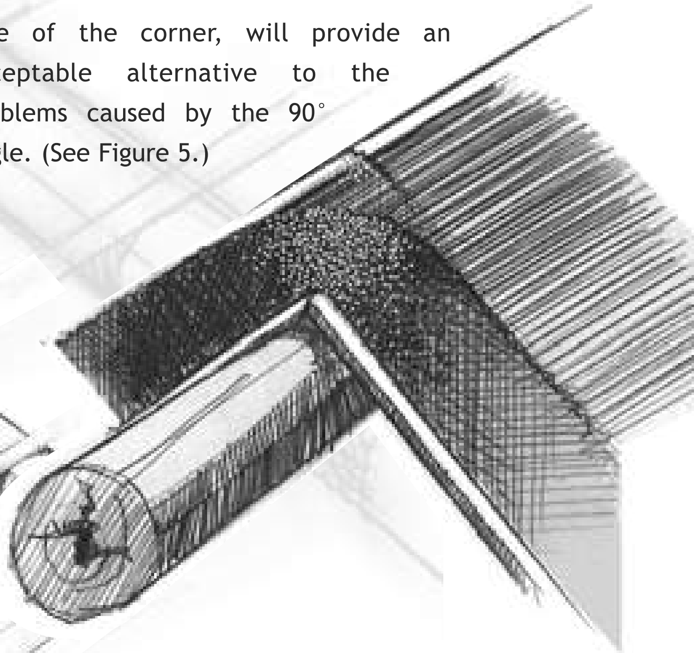


Figure 4: Section through hip showing a single pole and the thinner thatch layer over the corner

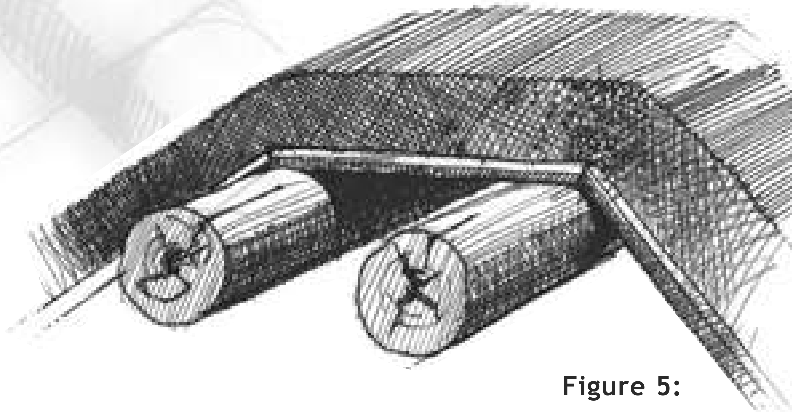


Figure 5: Section through hip showing a double pole construction with a thicker and denser thatch layer over a 135° corner

5.7 Valleys

These are formed by gradually orientating the thatching bundles in each layer from the normal vertical alignment direction to one parallel to the valley. Additional material must be laid in the valley to provide extra thickness to prevent water penetration into the thatch layer and to provide a gradual sweep, rather than a sharp bend. (See Figure 6.)

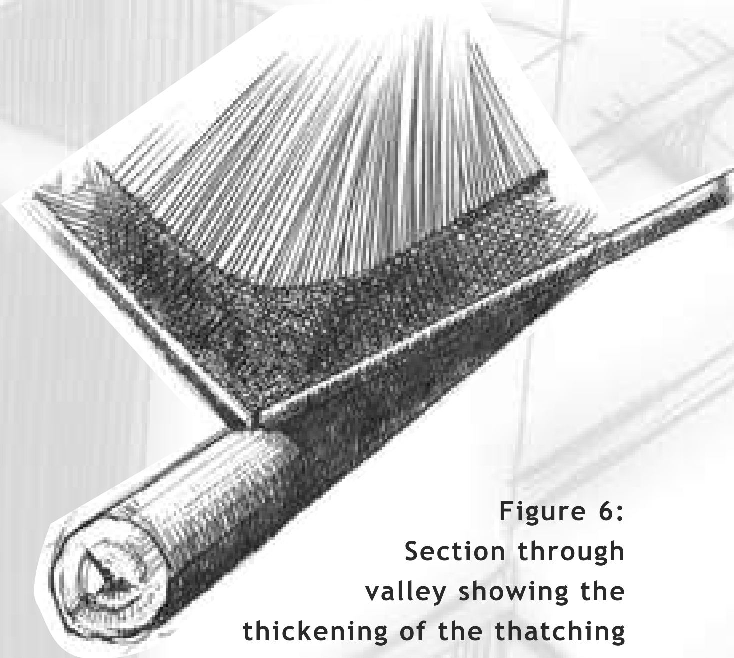


Figure 6:
Section through valley showing the thickening of the thatching layer over the valley

5.8 Verges

The angle at which the bundles are laid, where eaves and verge join, should be maintained for the full sweep of the roof, up to ridge level.

5.9 Ridges

A variety of ridge types is used in the construction of thatch roofs, although the most common materials are grass, fibreglass and mesh-reinforced plaster. The latter two may be regarded as alien materials.

This guideline does not recommend the use of glass-reinforced plastic (GRP) ridge cappings as not only is the material combustible, but a concealed space is also created under the GRP capping, which may allow the lateral spread of fire along the ridge, the most vulnerable part of the structure.

5.9.1 Grass ridges (natural material)

The grass that is used to form the ridge capping is thinner, softer and more pliable than that used for the main roof. The bundles of ridging grass are bent over the ridge and anchored down onto the two topmost battens with sways and thatching twine. In the case of grass ridges, the twine stitching is used only to form the ridge before thin wire stitching is used to secure the completed ridge. The use of exposed twine is not recommended, unless it is covered by a ridge capping, flashing or some other detail. The lower edges of the ridge capping may be trimmed to a decorative profile with chevrons or scallops. Some thatchers maintain, however, that such features weaken the ridge and shorten its life.

5.9.2 Fibreglass and cement mortar ridges (alien materials)

The use of alien material for ridge capping is not considered to be ideal since it detracts from the natural, aesthetic impression of the thatch. Nevertheless, alternatives to grass are often used, the most common being preformed fibreglass or cement mortar (see Figure 7 and Photograph 7). The provision of a steel wire mesh in the mortar ridge-capping layer would normally be adequate to limit shrinkage-induced crack development in the ridge.

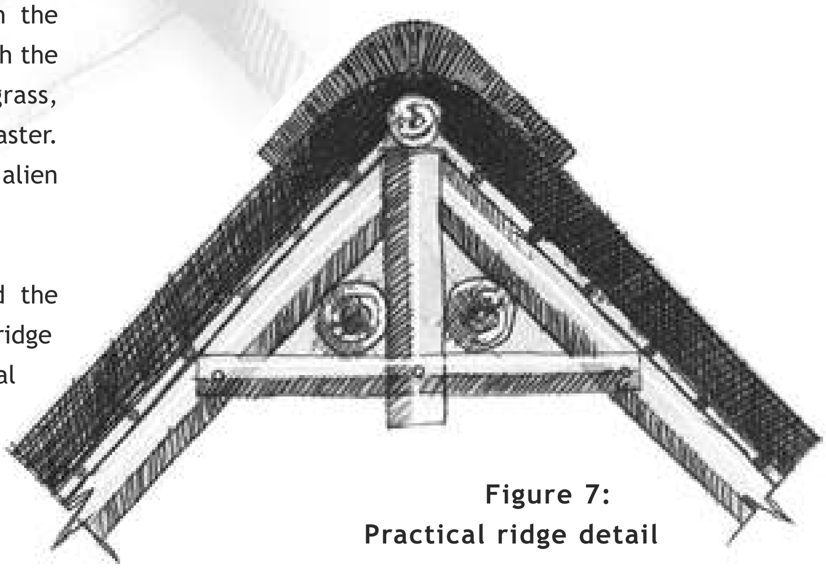


Figure 7:
Practical ridge detail

Most thatchers are very negative towards the use of sand/cement mortar ridge cappings, the main reason being the size of the ridge and the resulting weight of the capping. Other aspects such as maintenance, cracking and construction are also often mentioned. Many, if not all, of these perceived problems can be related to either bad design or poor construction. Most of the problems associated with a thatch roof are in fact attributable to these factors.

The advantages of a sand/cement mortar ridge capping are that the material is non-combustible, the formation of a concealed space at the ridge level is avoided, and the weight of the capping provides additional compaction, preventing the thatch from sliding out at the ridge.

The grass bundles at the ridge are either cut to fit close to the uppermost ridge pole, or the bundles are bent back under themselves to form a knuckle against the ridge pole. Even though this, or any other ridge detail, is done very neatly, it will always look incomplete on the inside. The use of a *spreilaag* over the two ridge poles creates an aesthetically pleasing detail when viewed from the inside of the building (see Photographs 8 and 11).

The following aspects should be considered in the construction of an acceptable and aesthetic mortar ridge capping:

- a proper roof design and roof structure;
- additional laths at the top of the roof;
- an additional layer of thatch at ridge level (continuation of the flat, dressed surface as high as possible);
- flatness of the roof at ridge level;
- detailed ridge drawings; and
- good thatch compaction (stitching and tension of the twine).

The ridge is the most vulnerable part of a thatch roof, as regards both water penetration and fire. Particular care is necessary to ensure that this feature of the roof is *absolutely watertight*. Cement ridges should always be used in conjunction with a waterproofing membrane, to prevent leaking in case of cracking of the ridge. Some thatchers employ special techniques to seal the cement ridge capping with a waterproof membrane, or use a waterproofing membrane under the cement capping to permit them to grant a guarantee.

Concerns with regard to fire safety will be discussed later, under a separate heading (see Section 12).

5.10 Use of conductors

The presence of steel or any type of conductor in the roof structure presents a lightning conduction hazard if the roof is not protected (as already mentioned). It is therefore essential that the guidance given in SABS 03:1985 be followed rigorously to prevent any damage from lightning. Under no circumstances should steel pipes, cables or electric wiring be in direct contact with the thatch. Electrical and other services (telephone and TV) should always enter a building at ground level and never be closer than one metre to the thatch.

6. CHARACTERISTICS OF THATCH

The characteristics of thatch are described under the headings of "advantages" and "disadvantages".

6.1 Advantages

Local materials harmonise well with the landscape surrounding their place of origin. Thatch, as a natural material, will always blend well with any environment, especially rural developments, creating a pleasing architectural impression. After one season's exposure, however, the thatch will lose its fresh straw colour and take on a dusty, grey appearance.

An ecological advantage to be gained from using thatch is that it is produced by natural processes that do not consume scarce and expensive energy resources. The thatching process is a labour-intensive activity and, therefore, of practical economic value where unemployment among the lower income groups is common.

A thatch roof functions as both an insulated roof and a ceiling. The roof will ensure that the building is cool in summer and warm in winter, since thatch has a high insulation value. In technical terms the thermal transmittance, or U-value, for thatch 150 mm thick is 0.65 $W/m^2/^\circ C$ for downward heat flow (i.e. from external sources), and 0.67 $W/m^2/^\circ C$ for upward heat flow (i.e. from internal sources). The corresponding figures for 200 mm-thick thatch are 0.50 $W/m^2/^\circ C$ and

0.52 W/m^2/°C. Comparative figures for a galvanised sheet-steel roof with a 6 mm-thick gypsum plasterboard ceiling, insulated with 38 mm-thick mineral wool are 0.68 W/m^2/°C and 0.73 W/m^2/°C.

6.2 Disadvantages

Thatched houses are more vulnerable to *fire risk* than those covered with other materials, and it is therefore imperative that precautions be taken to reduce this risk. This aspect is not covered adequately in Part T of SABS 0400:1990.

Being an organic material, thatch is susceptible to *decay and decomposition*, and three main precautions must be taken to minimise this process.

- First, the grass must be mature when laid; this implies that it should be cut after the first frost has killed the leaves in the case of Natal and Mpumalanga grasses, and at the end of the growing season (March to August) in the case of Cape thatching reed - which may be green when delivered but will gradually take on a light brown appearance. When stored, the bundles of grass should be stacked clear of the ground in well-ventilated mounds, to prevent rotting.
- Second, leaves falling from nearby trees must not be allowed to accumulate on a thatched roof surface.
- Third, the pitch of the roof must not be less than 45°, to facilitate the rapid runoff of water. In general terms, the steeper the pitch angle of the roof, the greater the potential durability of the thatch covering. Vegetative growth on the roof can seriously inhibit water runoff, and should be prevented at all costs.

Thatch can harbour *vermin*, but such infestation does not usually reach significant proportions. The thatch may, if desired, be sprayed with any of a variety of commercially available toxicants.

7. RAINWATER DISPOSAL

Thatch roofs are generally constructed with dripping eaves and rainwater gutters. Downpipes are not normally provided. It is therefore essential that eave overhangs should extend at least 600 mm beyond the wall and provision should be made at ground level to limit *erosion* caused by water discharge. This may be achieved by providing either a one-metre concrete apron slab or paving, or a strip of gravel around the building.

8. THATCH DECAY

Thatching grass lasts best if it is kept dry and out of the sun. This is true both for grass in storage and thatch on a roof. Research indicates that thatch deteriorates through the combined processes of *physical erosion* and *biological decay*. The thatching technique is designed to keep to a minimum that portion of each grass stem on the roof surface that is exposed to the environment and to the effects of weathering.

Decay starts when the stem surface is physically damaged. This may be caused by wind, rain and hail, as well as by swelling and shrinking through temperature change, or a combination of these factors. (See Photograph 9.)

Exposure to sunlight accelerates decay. Ultraviolet light affects the *lignin* of the surface cells (epidermis), and causes the grass stems to split, exposing the less strongly bonded internal cells (parenchyma). It has been found that fungal attack then causes the most significant damage to the stem structure, and that favourable conditions for fungal activity are when the moisture content exceeds 20% and temperatures range between 20 and 30 °C. In other words, the structure of the grass is destroyed by warm, wet weather conditions. For these reasons thatched buildings should not be erected under and/or shaded by trees.

The thatcher's task is therefore to lay the grass stems so that only a minimum amount of thatch stem is exposed to the elements. The stems should slope steeply and be tightly packed, so that water runs from tip to tip, over the surface, rather than penetrate into the thatch. If this can be consistently achieved through careful workmanship, over the entire roof surface, decay will occur only on the outer surface of the roof.

9. MAINTENANCE

With proper maintenance and re-thatching at required intervals, a well-constructed thatch roof should have a long lifespan. The original design of the roof structure needs to be adequate to take the additional load after re-thatching. Apart from keeping the surface of the thatch clear of creepers and other vegetation, maintenance has to be done on the thatch itself. Deterioration is usually evident from the untidy appearance of the covering.

The lifespan of the thatch will be prolonged by regular inspections which will indicate when "brushing" with a thatching spade (leggatt) is required. Re-dressing of the thatch cover (adding of a new thatch layer) becomes necessary when decay has reached the stage when the fixings become exposed on the surface. Once the fixings are exposed, rainwater can be channelled down through the thatch by running down the stitching twine into the thatch layer and into the building. Exposure of the fixings will result not only in the weathering of the twine stitching, but also in the deterioration of the entire roof cover when the compaction of the stitching is lost.

Because thatch is a natural material, it will deteriorate at a given rate, depending on the environmental conditions for that area. Inspections of the roof, in particular of areas such as valleys, the areas under trees, and areas with slopes of less than 45°, should be carried out regularly to determine the condition of the thatch layer. In general, the rate of loss in thickness may be assumed to be in the order of 20 mm to 25 mm in cover over seven to nine years. For a 175 mm-thick thatch layer, the thatching twine will generally be located in the middle of the layer (about 80-100 mm below the top surface) as the twine could eventually become exposed after 20 years or so.

Re-dressing maintenance intervals are reflected in Table 1, which assumes an initial thatch covering thickness of 175 mm and a re-thatching thickness of at least 100 mm. The maximum thickness of the covering attained in the assumed 50-year lifecycle is estimated at 255 mm. This thickness should be used by designers in the analysis of the roof's structural stability.

All rotted thatching material should be completely stripped out during maintenance and replaced with new, tightly packed, mature material. The entire roof should then be dressed by brushing prior to the application of any new thatch layer.

Table 1: Typical thatch re-dressing maintenance intervals

Time (years)	Thatch in situ (mm)	Add thatch (mm)	Total thatch (mm)
0	175	0	175
7	155	0	155
14	135	0	135
21	115	0	115
28	95	100	195
35	175	0	175
42	155	100	255
49	235	0	235

10. DESIGN

A thatch roof should have a minimum pitch of 45°. The steep slope is needed so that water will run off from the roof surface with minimum penetration into the body of the thatch coat. At a pitch of less than 45° the thatch will decay rapidly. Advantage may be taken of this steep pitch to utilise the roof space for an extra room.

Dormer windows, set into the roof slope, and "eyebrow" windows at eave level should, for maximum thatch durability, be avoided. They invariably have a shallower pitch than the rest of the roof, so that the thatch above them decays at a more rapid rate. However, since they can be an appealing design feature, they are often included, especially when the otherwise superfluous attic space would be unused. The roof timber around these windows must be designed to accommodate the thickness of thatch (see Photograph 10), and should slope as steeply as possible, and never less than 40°. For dormer windows, the bottom of the sill must be set a minimum of 450 mm above the structural roof level to accommodate the thatch thickness and a suitable flashing.

As a general guide, the configuration of a thatch roof should be as simple as possible. The inherent ability of thatch to adapt to freeform curved roof shapes allows designers to develop less formal layouts than they would for conventional roof structures.

Flashings frequently result in waterproofing problem areas. Features that intrude in the roof plane should consequently be avoided as far as possible. Chimney stacks should be designed to penetrate the roof plane at the ridge (see Photograph 7), thus avoiding the need for secret gutters. Soil vent pipes are best located on external walls, so that they penetrate the thatch covering only near the eaves line. However, modern plumbing systems do have special vent valves, which eliminate the need for soil vent pipes to penetrate a roof.

In the design of multiple-level thatch roof structures it is important to consider rainwater discharge from these roofs. It is essential to prevent a concentration of rainwater discharging from a high-level roof onto a thatch roof at a lower level.

10.1 Roof structure

Thatch should be placed to a thickness of between 175 and 200 mm, resulting in an approximate mass of 35 to 50 kg/m^2. The roof structure normally consists of eucalyptus poles that have been chemically treated. Preservatives such as *Pentachlorophenol*, *CCA*, *borax* or *Tributyltin oxide* are suitable for such treatment. The use of fire-retardant treated timber for the roof structure will enhance the fire safety of the roof.

The thatching battens are usually treated *eucalyptus* poles (battens or laths) with a minimum diameter of 25 to 32 mm. Given the maximum thatch covering thickness of 255 mm (see Table 1) attained during the lifecycle of the roof, battens should be spaced a maximum of 250 mm apart, except at the eaves where the spacing between the first three battens is 150 mm, and at the ridge where the spacing between the last two battens is also 150 mm. Batten spacings in excess of these proposed may result in sagging of both the thatch grass and the battens in the long term.

To limit batten sagging, rafter poles should be spaced between 750 and 900 mm apart. The roof-framing element sizes are dependent on many factors such as roof span, loading (including wind), truss configuration and support conditions. It is however proposed, from a fire safety point of view, that poles with a diameter of less than 100 mm be avoided, unless the design is done by a structural engineer. All the roof-timber joints of structural importance must be securely bolted together.

To prevent the thatch sliding down at eaves level and to increase the tension of the stitching, it is recommended that a larger diameter bottom lath (tilting lath) be used to lift the thatch (see Figure 8).

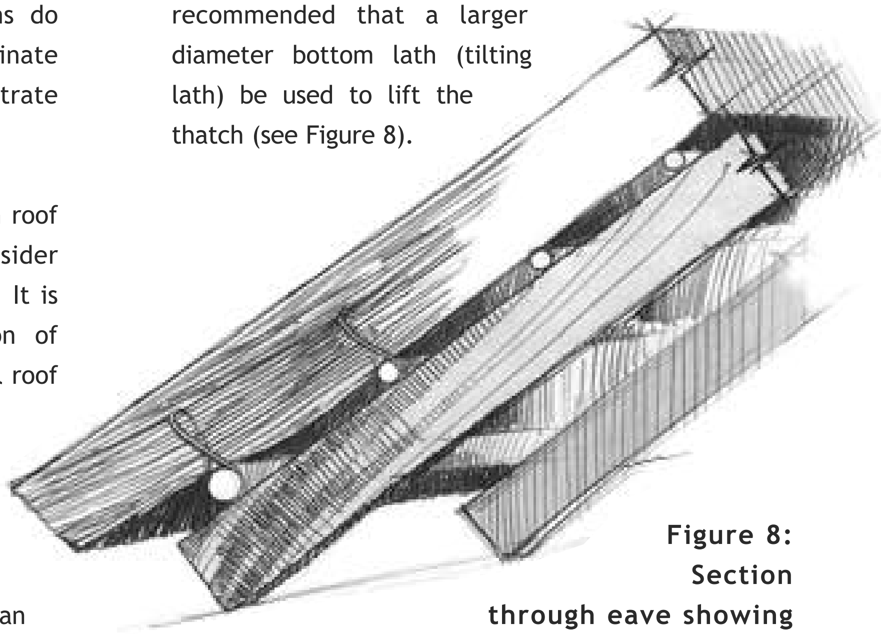
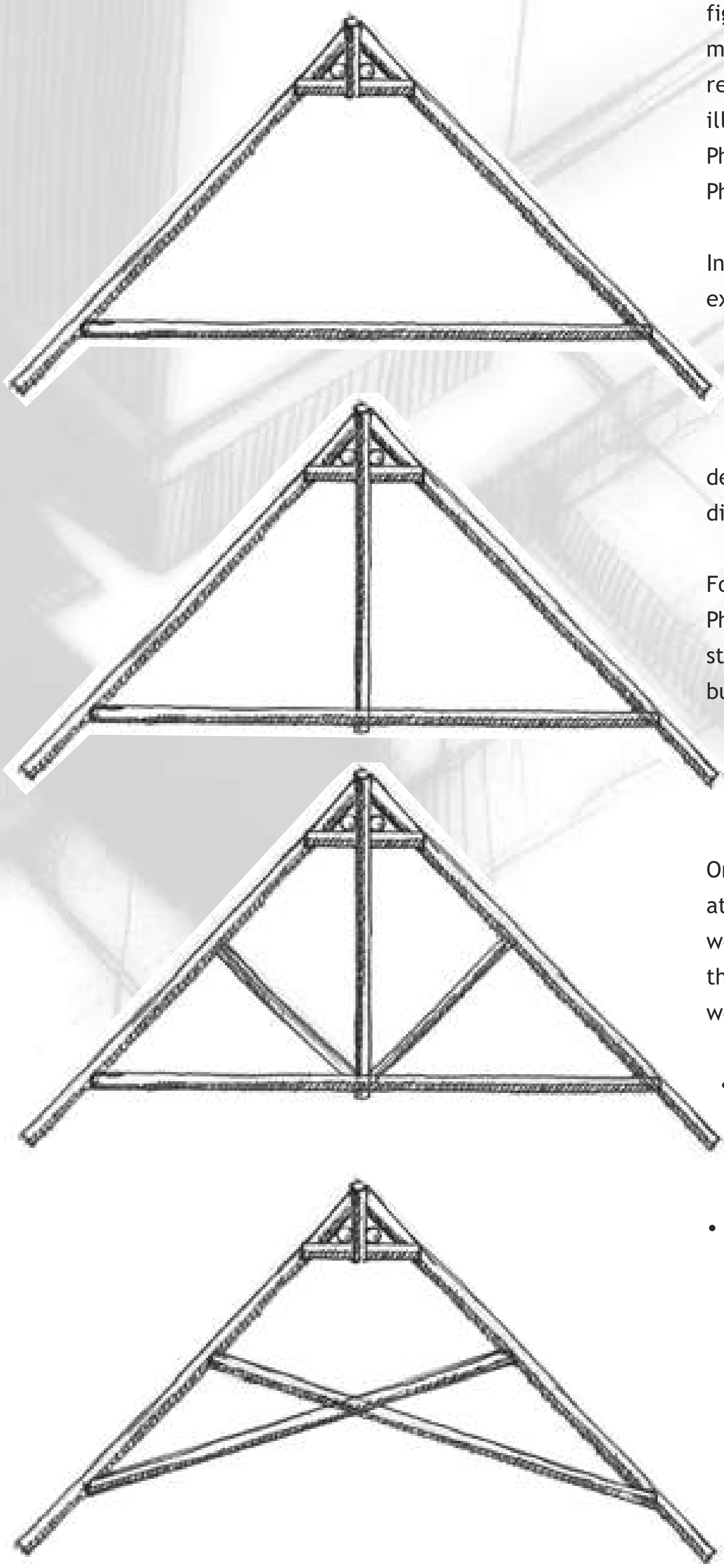


Figure 8: Section through eave showing the tilting lath

Some popular truss configurations are illustrated in Figure 9 and Photographs 11 and 12.

Figure 9:
Some popular truss configurations



A great variety of ridge details exist in practice. The ridge of a thatch roof is the most critical feature in the case of fire as it represents the highest point in the roof, to which the heat rises rapidly. Loss of the integrity of the ridge construction inevitably results in partial collapse of the roof structure, making fire-fighting impossible from the inside of the building. The most practical ridge detail, with regard to fire resistance as well as ease of construction, is illustrated in Figure 7 (see Section 5.9.2) and Photograph 8. A typical hip detail is portrayed in Photograph 13.

In an attempt to quantify the lateral restraint by an external wall element on in-plane rafter forces, an experiment was conducted at Boutek's materials and structural laboratory. Uncertainty about the typical lateral restraint offered by external double-leaf brickwork walls makes the designer's decision as to the most appropriate truss configuration difficult.

Four double-leaf wall components, as portrayed in Photograph 14, constructed from standard imperial stock bricks with 100 mm-diameter eucalyptus poles built in at 45°, were subjected to pull-out forces in the plane of the rafter elements. The wall components were restrained at the top and bottom in the assumption of complete wall stability.

Only two of the four wall components were cured for at least 10 days and two (one cured and one uncured) were provided with a 4 mm-diameter wire anchor to the depth of seven courses. The following conclusions were drawn from the results of the experiment:

- Wire anchors contribute to the ultimate strength of the assembly and result in a more ductile mode of failure. Sudden, brittle failure occurred in the wall components without wire anchors.
- The well-cured brickwork wall components performed better than those not cured at all. Given the wall stability assumed in the experiment, the ultimate resistance to rafter forces (in the plane of the rafter beams, tested at 45°) was greater than 20 kN. An appropriate factor of safety should be added to obtain a permissible design load. Varying degrees of slip took place before shear failure in the walls occurred.

It may consequently be concluded that the lateral restraint on rafter forces will generally be controlled by the lateral restraint generated by the overall wall stability and configuration.

10.2 Timber foundation supports

Due to the decomposition of the internal structure ("pipe rotting") of timber poles in contact with the ground (including treated poles), it is recommended that poles be founded and connected according to the engineer's details.

It is good engineering practice not to have any structural timber in direct contact with the ground or cast into concrete. The use of concrete footings with special steel connecting plates or sleeves is recommended at all times.

As an alternative to concrete footings, an approved protective sleeve around the lower end of the pole may be used for timber poles in contact with the ground. This method should be used only for minor structures and not for major structural components requiring a life expectancy exceeding 30 years.

10.3 Effects of wind on thatch roofing

It is Boutek's opinion that, in general, thatch roofs respond fairly well to extreme wind conditions. This opinion is based on experience gained in several site inspections of areas devastated by wind.

This can largely be attributed to the overall form of thatch roofs, in particular

- rounded-off edges and corners - as opposed to being well defined (sharp) as in other roofing systems;
- typical geometry which can be approximated to the principle of "hipped roofs". Various research has shown that local extreme wind pressures of hipped roofs are significantly lower than those corresponding to the mono- or duo-pitched roofs; and
- a roof slope of 45° (which minimises the risk of uplift).

Photograph 15 depicts a luxury house with a thatch roof, which was in the path of an F2 (on the Fujita scale) tornado that struck the Midrand area on 21 April 1994. As can be seen, only minor roof-damage occurred. As an indication of the severity of the storm, all the water in a swimming pool located some twenty metres from this house was sucked out .

11. LIGHTNING PROTECTION

SABS 03:1985 (*Code of Practice for the protection of structures against lightning*) sets out the principles of lightning protection, and covers the installation of a lightning protection system. The requirements for air-terminal systems such as aerials, down-conductors, earthing and materials are also given in this code.

The basic principles of lightning protection require that the following be provided:

- air terminals at strategic locations, so that the installation is capable of intercepting and withstanding a lightning strike while effectively shielding adjacent objects that require protection;
- low-impedance paths, termed "down-conductors", which can effectively conduct a lightning discharge current from any air terminal to the earth; and
- a low-impedance connection between the down-conductor and the body of the earth, in the form of an effective earth electrode, for dissipating the lightning-discharge current.

The need for lightning protection is an assessment of risk based on the following factors:

- the effective height of the structure, which is related to the elevation of the highest point on the structure compared to the elevation of the surrounding area;
- an estimate of the local ground flash density (average number of ground flashes per square

kilometre of ground per year at a given location);

- the expected number of flashes striking the structure per 100 years, which relates to the capture area of the structure in respect of lightning strikes; and
- the hazard category of the structure. Consequential damage to a structure or its contents, or injury to its occupants, depends upon the nature of the contents, or of the occupancy, or both.

An air terminal - comprising one or more masts that cover the thatched-roof structure or area to be protected - which has the appropriate shielding angle will, with the possible exception of a few weak lightning strikes, successfully intercept lightning strikes, and provide the highest degree of protection. As a result of the lightning discharge-current path being kept from too close proximity to the structure, a mast reduces the risk of induced voltages in, and consequent sparking between, conducting parts of the structure.

A safe clearance between a mast (or a catenary conductor strung between masts) and the structure to be protected by the mast (or the catenary conductor) depends upon the following:

- the earth resistance of the earth electrode of the mast, if it is not part of a common earth electrode for the masts and the structure;
- whether the structure is provided with an electrode, which may be the foundations; and
- whether the structure is connected to a remote earth electrode, intentionally or accidentally, through services which may enter the structure either above or below ground.

12. FIRE SAFETY OF THATCH ROOFS

Numerous thatched dwellings have been lost in Southern Africa because of the rapid spread of fire through the roof. In most cases, the loss could have been avoided or reduced if certain precautionary measures had been adopted. The extent of potential destruction in thatch-roof fires is portrayed in Photographs 16 and 17.

The fire safety of a thatched building is dependent upon a number of factors, including the design and construction of the thatch structure, the provision of additional fire-safety measures and good housekeeping and maintenance. Fire-safety design is particularly critical for a thatch structure, as its fire resistance is dependent upon the quality of the thatch and the stability of the structure. This is the essence of good thatching practice.

The fire resistance of a thatch structure can, however, be enhanced by the application of fire retardants which retard the spread of flame, thus "buying time" for escape and fire control measures.

The design of any building must comply with the National Building Regulations. However, these regulations were drawn up with certain common types of building in mind and in the case of thatch structures the code does not provide sufficient fire-safety design guidelines.

It is the purpose of this section to address the shortcomings of the code, to provide clear guidelines for fire-safety design and good thatching practice, and to create general awareness among homeowners of fire-safety measures for thatch roof construction.

12.1 Design and construction

The fire resistance of a thatched structure is dependent upon the quality of the thatch and the stability of the structure. These critical aspects are often either underestimated or misunderstood by architects and engineers, despite the fact that their designs have complied with the requirements of the National Building Regulations. This is because there is often a problem with the interpretation of the code with respect to thatched structures and the code is deficient concerning the fire-safe design of thatched structures.

12.1.1 Good thatching practice

The quality of the thatch and the stability of the structure determine the fire resistance of a thatched building. The following guidelines should be incorporated in the design and construction of a thatch roof, to maximise the structure's ability to resist fire:

- The thatch density should be at least 35 to 50 kg/m^2 for a thickness of 175 to 200 mm. The density of the thatch is a very important factor in the rate at which it burns. Densely compacted thatch will burn slowly because it reduces air flow and leads to oxygen starvation.
- Sisal binding twine should be used in preference to the polypropylene variety as the latter is liable to melt in the event of a fire.
- Lattice work must be of good quality and soundly constructed.
- The structure as a whole must be well designed, so as to be stable in the event of a fire. (See Section 10.)
- In the case of large thatch roofs in areas where lightning could pose a problem, no wire must be used in the roof construction and a lightning conductor as specified in SABS 03:1985 must be provided. (See Section 11.)

12.1.2 Additional fire-safety measures for the thatch owner

The introduction of safety measures over and above the minimum requirements of the regulations is necessary to protect the dwelling itself from fire. It is in the thatch owner's interest to be well informed of such fire-safety measures for the protection of life and property. Subsections 12.1.2 to 12.1.2.9 highlight some of the additional safety measures detailed in the guidelines for a typical thatch roof specification contained in Annexure A.

12.1.2.1 Lightning conductors

A lightning ground flash density chart has been compiled for South Africa and Namibia, as shown in Figure 1 of SABS 03:1985. Average values for specific locations are given in Table 1 of this code (with the lowest and the highest ground flash densities being 0.2 at Hermanus and Grabouw and 11.8 at Piet Retief, respectively). Full protection is always recommended for those areas at the upper levels of the scale. Limited or no protection may be necessary for the low-intensity areas, provided the roofs have been constructed correctly and the thatch is treated with an approved fire retardant that will effectively slow down the rate of combustion should a fire start on the roof.

Lightning conductors should be installed to protect thatched buildings or structures in accordance with the recommendations contained in SABS 03:1985. Furthermore, the installation of lightning protection should be undertaken only by contractors competent and qualified to do so.

It should be noted that this document does not favour the use of wire or any other conductor for the securing of thatch (although it is commonly used in South Africa). Rather, it is recommended that a suitable natural material be used for sways and the binding of the thatch.

12.1.2.2 Chimneys

Chimney stacks should be constructed in such a way that the outer faces in contact with the thatch do not become hot. A full brick thickness (220 mm) is necessary to satisfy this requirement. All mortar joints in the stack must be properly filled. The top of the stack must extend to at least a one-metre radius from the highest point of the stack (closest to the covering) and the roof covering (see Figure 10). A spark-arrestor, fitted not less than 700 mm from the top of the stack, should be provided. The spark-arrestor typically comprises a 10 x 10 x 1 mm (minimum) section of stainless steel wire mesh, across the full width of the flue and securely built into the flue around the edges (see Figure 11), or supported on mild steel dowels. It is essential that chimney flues be cleaned regularly to avoid an accumulation of soot, which may ignite and generate sparks.

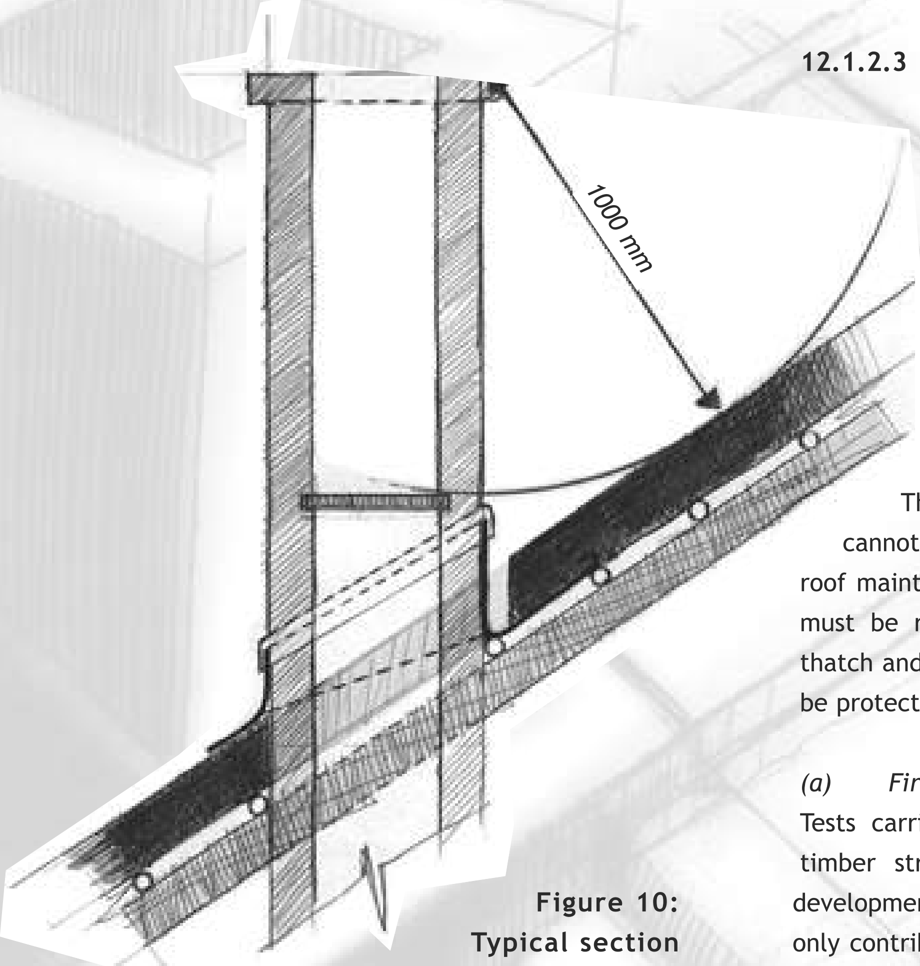


Figure 10: Typical section through chimney showing the minimum height above the thatch layer

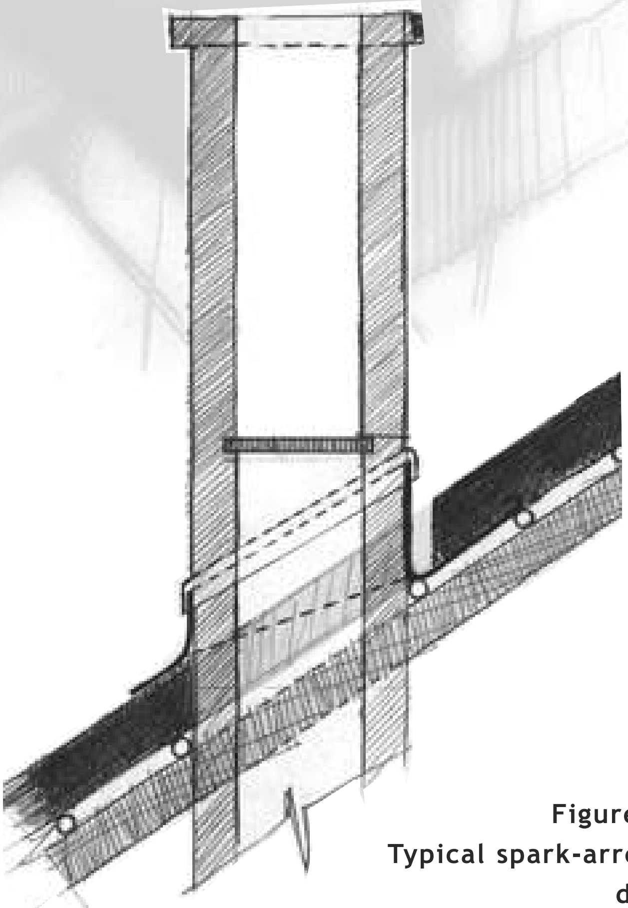


Figure 11: Typical spark-arrestor detail

12.1.2.3 Services

Electrical power supply and telephone cables should enter the building by means of underground ducts/conduits, and all electrical wiring in the roof space should be run in plastic conduiting, with all junction boxes properly sealed.

12.1.2.4 Fire protection

The advantages of good thatching practice cannot be overstressed both in terms of reduced roof maintainence as well as fire safety. However, it must be recognised that the two basic materials, thatch and timber, are both combustible and need to be protected by different methods.

(a) Fire protection of timber

Tests carried out by Boutek have shown that the timber structure plays an important part in the development of a thatched-roof fire. The timber not only contributes to the fire load in the roof, but also to the rapid spread of the fire in its early stages. The thin battens that support the thatch burn through, loosening the burning thatch. Once a portion of the thatch has collapsed it creates an opening, allowing free oxygen access to the seat of the fire: this leads to vigorous burning. All of the timber used in the roof should be treated with *approved* fire retardants to inhibit ignition in accordance with the procedures stipulated in Paragraph A3.1.2 in Appendix A.

(b) Fire protection of the thatch

The fire safety of a thatch roof is dependent upon the structural stability of the roof under fire conditions. The fire stability of the roof structure can be increased substantially by using fire retarded timber and thatch. It is recommended that the thatch be treated on both sides with an *approved* fire retardant in accordance with Section A4 of Appendix A.

12.1.2.5 The use of fire-protective membranes to restrict the flow of air

The rate of fire development in a thatch roof can be greatly reduced by restricting the free flow of oxygen to the fire. This can best be attained by means of providing a non-combustible layer beneath the thatch. If, for aesthetic reasons, a thatch finish is required on the underside of the roof, the barrier layer should be placed on a layer of thatch not more than 6 mm thick.

In the case of a fire starting inside a house, the protective layer will delay the burn-through of the thatch. Because only a thin layer of thatch will be directly exposed to fire on the inside of the building (provided that the roof timbers are fire-retarded) the fire in the roof will be of a low intensity. The protective layer will also delay the burning thatch falling into the building.

Such layers must cover the total roof area, including the eaves and ridges, if maximum protection is to be obtained. Special care must be taken to ensure that adequate overlaps are provided, along both horizontal and vertical joints in the material used.

The use of impervious protective layers, however, has certain disadvantages. Air flow through the thatch is restricted and, if the thatch becomes damp from rain or condensation, high humidity levels may develop which, in warm conditions, can permit the growth of destructive fungi and bacteria.

12.1.2.6 Fire-fighting facilities

A hosepipe of sufficient length to reach every part of the roof and house, and permanently attached to a garden outlet, should always be available to assist fire-fighting.

An extendable ladder, of sufficient length to provide access to every part of the roof, should be available at all times. In addition, a long-handled metal rake should be provided (in an easily accessible place) for pulling down smouldering thatch from the roof. The handle may be fitted with a suitable clip to which the nozzle of the hosepipe can be attached, thus improving the reach of the water jet.

12.1.2.7 Good housekeeping

In addition to the requirements described in Section 12.1.1, combustible material should not be allowed to accumulate near the building. A number of thatched roofs have, in the past, been set alight as a result of the burning of garden refuse in the vicinity of the roof overhang.

12.1.2.8 General maintenance and "do's" and "don'ts" for the thatch owner

The inherent danger of fire risks associated with thatch roofs are sometimes exacerbated by the following features:

- When thatch is old, it is often covered with loose fibers which can easily ignite.
- It is possible that, when thatch is damp, flammable gases may be generated.
- The incorrect use of conductors that may penetrate the roof (do-it-yourself installations) greatly increases the fire risk.
- The installation of a metal coping on the roof and metal water or gas pipes in contact with the thatch can increase the risk of fire associated with lightning.
- Electric wiring (conductors) mounted in close contact or just under the roof could also increase the risk of fire. An example would be the overheating of conductors caused by a lightning strike, or short-circuiting in wiring due to faulty electrical appliances or incorrect electrical installations.

Apart from the protection of thatch roofs against lightning by the installation of a mast terminal system, consideration needs to be given to the following additional good housekeeping features:

- Do not install antennas directly on a thatch roof.
- Introduce electrical and telephone-cable services at the ground level of the structure.
- Ensure there is adequate clearance between the thatch and metal objects under it. Where metals used in the construction of the roof are not bonded and earthed, maintain a minimum clearance of one metre between metals in the roof and water pipes, vent pipes, tanks, gas

pipes, antennas, telephone and bell wires, burglar alarms and electrical wiring and conduiting.

12.1.2.9 General

Even when all these precautions have been taken, the occupant of a thatched building must always exercise caution when handling open fires in or near the building (e.g. when preparing for a barbecue, burning garden refuse or discharging fireworks in the vicinity).

12.2 Fire protection for thatched structures

Fire protection measures generally fall into two categories; those that prevent fires from starting in the thatch, and those that reduce the ignitability of the thatch and the roof structure.

The prevention of fires in thatch relates to the fire-safety design of the thatched structure. This includes a number of fire-safety measures as well as the good thatching practice already described in Section 12.1.1.

Fire can reach the thatch from either the inside of the building or from an external source. The latter is the cause of most thatch fires. Fire-protection measures that reduce the ignitability of thatch include the use of fire retardants.

This section highlights the factors that influence the effectiveness of thatch treatments and discusses the criteria for the evaluation of fire retardants.

12.2.1 The use of fire retardants to treat thatch

Recent developments in fire-retardant technology have produced a number of products suitable for several distinct applications. These include

- fire prevention;
- preservation and maintenance;
- internal fire protection only; and
- fire retardation, preservation and maintenance (exterior and interior).

Any of the products referred to above should have been the subject of evaluation by either Boutek or the SABS, in which case a report detailing the results of any such testing will be available. Such reports may be used for advertising purposes only with the express permission of the testing organisation.

Furthermore, it is important that the scale of the test evaluation be taken into account when considering a product for use on thatch, and in this regard a comprehensive large-scale test is usually beneficial.

Thatched lapas fire-retarded with effective treatments can be erected closer to boundaries than would normally be permissible. The exact difference in fire-safety distances is a factor of the efficacy of the treatment being considered, such efficacy usually being the subject of suitable fire tests on the products.

12.2.2 Factors that will influence the effectiveness of thatch treatment

(a) As with most treatments, the efficacy of the treatment is directly related to the quality and condition of the thatch and to the stability of the structure as a whole. New thatch roofs can be treated without any pre-treatment, whereas weathered roofs must be combed to remove loose and weathered thatch. It is desirable to treat thatch roofs as soon as possible after construction.

(b) Any treatment should be applied to both the interior and exterior surfaces, and should penetrate the exterior thatch to a depth of at least 65 to 75 mm. Sisal twine used to bind the thatch is effectively protected by means of the interior application, and twine so treated will delay the dislodgement of the thatch during a fire. During application it is necessary to monitor the weather conditions. Depending on the temperature and humidity, a treated roof can be adversely affected should a heavy shower occur within four to six hours of application. Roofs affected by rain should always be evaluated to determine whether re-application is required.

(c) Quality control, both with respect to the product itself and its application, is of prime importance. In this regard, the quantity of material applied per square metre must be strictly controlled to ensure adequate fire protection. To this end, a certificate detailing the batch number of the product used and the quantity applied to the roof should be supplied by the application contractor. This certificate also serves as a guarantee and will indicate a period for which the guarantee is valid. Copies of such certificates are lodged with the local fire station and with the organisation that evaluated the product. This ensures that both the local authority and the house owner are fully informed.

(d) Responsibility for the maintenance of the treated roof rests with the building owner (Clauses A14 and A15 of the National Building Regulations). On expiry of the guarantee referred to in (c) above, the structure becomes illegal in terms of the building regulations and the owner can be forced by the relevant authority to remove it, or re-treat it, to extend the guarantee. The certificate referred to in (c) above is transferable in the event of the sale of the property.

(e) It is critical that any thatch roof is constructed according to good thatching practice (see Section 12.1.1).

12.2.3 Criteria for the evaluation of a fire-retardant thatch treatment

All fire-retardant products envisaged for the fire-retardation of any building component need to be evaluated in terms of suitable criteria for the evaluation of such fire properties. Such an evaluation report is required in terms of SABS 0400:1990, (Regulation A13 and deemed-to-satisfy rule TT5), for final approval by the relevant authorities.

The report should also contain specific information regarding the requirements for the acceptability of the roof and the structure prior to the application of the product and any limitations and precautions with regard to its application. The evaluation of the effectiveness of the fire-retardant product for the protection of thatch roofs should not only consider the properties of the product, but should also include an evaluation of the product applied to a test roof, and the control over the manufacturing and the application.

The following aspects should be considered by the relevant authority:

(a) Physical properties of the product
- Composition (environment-friendly)
- Specific gravity (SG)
- Chemical stability of product (shelf life)
- Manufacturing (quality-control system)
- Fire properties (small-scale)
- Durability (effect on weathering of the thatch)
- Appearance (before and after ageing)
- Leaching-out properties
- Long-term exposure tests

(b) Application of the product
- Preparation
- Application
- Control of application
- Product retention (run-off during application)
- Health and safety precautions

(c) Tests for the evaluation of treated roofs (fire safety only)

In the absence of suitable local test criteria for the evaluation of treated roofs, international test criteria have been adopted for this purpose. However, some minor changes were necessary to the following test protocols to customise Boutek's procedures.

- Small-scale evaluation (fire only)
  DIN 4102, Part 7 (Germany)
- Large-scale evaluation (fire and weathering).
  ASTM E108 (USA)

12.2.4 General

The evaluation of a product to improve the fire safety of thatch roofs should always look both at the entire system and at the product alone. The application and the control over the application are of major importance when certification is required in terms of SABS 0400:1990. Unless these are documented properly, the system will not be acceptable for approval by any local authority.

It is also necessary that the information required, in terms of approval by the local authority, be shown on the documentation submitted for approval as this forms part of the information considered for approval in terms of SABS 0400:1990.

In terms of the National Building Regulations, Part A, Administration, A4(9), it is possible to cover all of the above requirements and conditions in a valid certificate issued by the Agrément Board of South Africa. Once a product is approved and covered by such a certificate, the product is deemed to satisfy all the relevant fire-safety requirements in terms of the National Building Regulations.

12.3 The regulatory environment
The National Building Regulations (SABS 0400:1990), Part T

The National Building Regulations (SABS 0400:1990), Part T, are applied by most local authorities for the approval of thatch roof construction. The regulations recognise the high fire risk associated with thatch roofs and are enforced in an endeavour to prevent the spread of fire between adjacent buildings. Two options are offered by the regulations; the thatched structure should either comply with the deemed-to-satisfy rules reflected in Part T of Section 3, or the structure should be the subject of an acceptable rational design prepared by a professional engineer or other approved competent person.

12.3.1 SABS 0400:1990, Part T, Section 3

Sufficient distance must be allowed between buildings to prevent fire spreading to the thatched building from adjacent buildings, and *vice versa*. The National Building Regulations (SABS 0400:1990 Part T, rule TT2) prescribe minimum requirements in this regard. Safety distances should be considered not only for boundaries between buildings on separate properties, but also between buildings/structures on the same property.

12.3.1.1 Discussion of SABS 0400:1990, Part T

Problems have been experienced with respect to the absence of reasonable fire safety guidelines for thatched structures that comply with SABS 0400:1990 (Clauses TT2 and TT12). Inconsistencies within Part T of the code have resulted in different interpretations of required safety distances, boundary distances, fire-division elements and protection of openings.

No structural guidance is offered by the code with respect to rafter and lath spacing and timber dimensions, despite the fact that the timber's structural design is fundamental to the effective fire performance of the building. In the absence of any clear guidelines, specifiers often resort to relying on the experience of the thatching contractor and specify on their plans "thatch roof design in accordance with thatching contractor details". This clearly is an undesirable situation in many instances.

12.3.2 Rational fire safety design principles

The fire code was drawn up with certain common types of building in mind and it recommends that the designer should resort to the basic principles of fire-safety design for "non-standard" types of buildings. In addition, it is advisable to use a rational fire design approach for thatch roofs as this is building-specific and relates to the entire fire-safety performance of the building and its installations.

In any rational fire design the following points must be taken into account when the fire safety of any thatched construction is being considered:

(a) From a fire-safety point of view, the thatched structure is a habitable dwelling or a non-habitable building (lapa). Essentially, the fire hazard for humans in a non-habitable building is limited: it really only affects humans if a burning lapa has an effect on an adjoining structure - in most cases the dwelling.

(b) The size of the thatched building has a bearing on its effect, when burning, on adjacent structures. The larger the building, the larger the fuel source and, in consequence, the greater the risk of conflagration.

(c) A distinction is made between buildings that have a roof-plan area of less than 20 m^2 and those larger.

(d) Boundary distances are determined in relation to the intensity of the radiation released from such a structure at the boundary position.

12.3.4 Guidelines for a typical thatch roof specification

Based upon the above rational fire-design principles and due to the shortcomings of the code as already discussed, Boutek, in collaboration with the SABS, has developed guidelines for specifications for thatch roof construction. These guidelines are contained in Annexure A, "Guidelines for a typical thatch roof specification", and Annexure B, "Rational fire-safety design proposals for thatched lapas".

These proposals make provision for both new and existing structures. They also contain information on the various options, the responsibility of the owner, and the requirements of local authorities.

Boutek is of the opinion that the above guidelines should be considered in the assessment of the fire risk associated with thatched structures. The aim of these guidelines is to provide a basis for a rational design in order to ensure fire-safe design.

12.3.5 Existing thatch roof constructions

The procedures for the fire protection of existing thatch roofs are similar to the requirements for new roofs, with the exception that the safety distances stipulated in SABS 0400:1990 Part T, Clause TT12.2, in many instances cannot be met.

These guidelines are concerned mainly with the protection of new thatch roofs and do not cover existing roofs. Measures to reduce the fire risk for existing roofs that do not conform to the safety distance requirements require special attention. The only way to implement fire safety for these buildings is either to remove the thatch roof, or portions of it, or to change the fire properties of such a roof by protecting it with an approved fire-retardant product, to bring the risk down to an acceptable level. It should be noted, however, that while the thatch layer may be effectively fire-retarded, the timber can be treated only on the surface with an *approved* fire-retardant coating, which offers limited protection.

A distinction has to be made between residential and non-residential buildings as the ultimate allowable safety distances are different. A non-residential building (lapa) is permitted *within one metre* of the site boundary if it is protected, provided the roof does not extend beyond the inside face of the boundary wall. Residential buildings, on the other hand, have to comply with the regulations as closely as possible, with certain limited relaxations. The minimum distance between boundary and the residential building is three metres, provided that

- the thatch elevation facing the boundary is completely shielded by a fire-separating wall with adequate fire resistance, to the extent that radiation from the burning thatch will not impact on an adjacent building in a similar position; and
- the thatch roof or roofs of the building have been protected with an *approved* fire-retardant to prevent the spread of fire, as contemplated

in Regulation T1 (a), (b) and (c) of SABS 0400:1990.

13. ACKNOWLEDGEMENTS

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- SABS: Timber Division
- SABS: Fire Division
- The SA Thatchers' Association
- The Division of Building Technology, CSIR
- Technical information by Phillip de Vos, Kobus Strydom and Chris Morris.

Illustrations: ARTINE cc

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SABS 457:1994, Parts 1, 2 and 3. S*tandard specification for wooden poles, droppers, guardrails posts and spacer blocks*. Pretoria : South African Bureau of Standards.

SABS 673:1987. *Standard specification for mixtures of copper-chromium-arsenic compounds for timber preservation*. Pretoria : South African Bureau of Standards.

SABS 753:1994. *Standard specification for pine poles, cross-arms and spacers for power distribution, telephone systems and street lighting*. Pretoria : South African Bureau of Standards.

SABS 754:1994. *Standard specification for Eucalyptus poles, cross-arms and spacers for power distribution and telephone systems*. Pretoria : South African Bureau of Standards.

SABS 871:1967(1997). *Standard specification for boron timber preservatives*. Pretoria : South African Bureau of Standards.

SABS 1288:1994. *Standard specification for preservative-treated timber*. Pretoria : South African Bureau of Standards.

SABS 1783:1997. *Standard specification for swan softwood timber*. Pretoria : South African Bureau of Standards.

APPENDIX A

GUIDELINES FOR A TYPICAL THATCH ROOF SPECIFICATION

This specification includes fire-safety control requirements for the construction of typical thatch roofs on individual buildings. All thatch roof construction must comply with good thatching practice, as described in this document.

This rational design approach has been adopted by the Division of Building Technology (Boutek) in order to overcome some of the deficiencies in the SABS 1400:1990 code and to provide the construction industry with a set of guidelines for the sound construction of thatch roofs.

A1. ROOF STRUCTURE

A1.1 General

All trusses, beams, rafters, timber posts, bracing and roofing members, etc, should be supplied and fixed in accordance with the engineer's design and details.

Generally the soffit of roof rafters and thatching is not to project lower than 2 125 mm above the finished floor level (FFL), unless specifically indicated.

Rafters and trusses should be evenly and equally set out, on the centre line of the building, as far as possible.

No roof timbers should penetrate the chimney brickwork.

A1.2 Construction

All roof carpentry should be executed neatly and be of a high standard.

The pitch of the roof should be 45°.

Rafters should be spaced at 750 to 900 mm centres.

The minimum roof overhang should be 600 mm, measured to the wall.

Working drawings (construction details) of the roof should be approved by the engineer.

A1.3 Structural timber or poles

All structural timber should comply with SABS 1783:1997, Part 2 and Part 4.

All poles should be of the eucalyptus species.

Roof construction poles should be at least 100 mm in diameter at the thin ends, unless otherwise specified and designed by the engineer.

Poles for columns or ring beams should have a minimum thin-end diameter of 175 mm, or as indicated by the engineer.

Other structural timber (bracing) should be in accordance with the engineer's design details.

Structural poles should comply with SABS 457:1994 in terms of SABS 0163-2:1994, Code of practice for the structural use of timber, Part 2, Allowable stress design, Table 5: Grade stresses for round poles. Timber poles for use in the construction of roofs are limited to the species stipulated in SABS 753:1994 and SABS 754:1994.

All structural timber to be treated in accordance with SABS 457:1994.

Exposed pole ends should be finished with nail plates (minimum penetration depth 15 mm) to prevent cracking, as stipulated in SABS 457:1994, Paragraph 4.2. Should it be necessary to cut the timber, involving removing the existing end-plates, new end-plates must be secured as soon as possible. The use of the new, round end-plates is recommended.

A1.4 Structural fixings

Securely wrap 4 mm diameter (No 8 gauge) wire anchors around rafters and nail the ends of the wire down. These roof anchor wires should be built into the brickwork at rafter-bearing centres, to a minimum depth of seven brickwork courses, or as specified by the engineer.

All joints of structural importance in rafters and trusses should be bolted down according to the engineer's details.

A1.5 Laths

Battens (laths) should be a minimum of 25 to 32 mm in diameter, spanning over at least two spans (at least 1 500 to 1 800 mm in length), and nailed to rafters with at least 75 mm-long wire nails.

The bottom and top three laths at the eaves and ridge should be fixed at 150 mm centres.

The remaining laths should be spaced at centres no more than 250 mm apart up to the ridge of the roof, depending on the length of the thatching grass.

A1.6 Timber foundation supports

Timber supports to be founded as per engineer's detail.

A2. RIDGES

All ridge cappings should be formed with sand/cement mortar that is trowelled smooth. Lay a single layer of 250 µm polyethylene sheeting over the thatch at the ridge. Over the sheeting lay one layer of 1 000 mm wide 12 mm x 12 mm galvanised mesh on non-metallic spacers, to elevate the mesh off the sheeting. Place a second layer of mesh in the upper part of the ridge capping, 15 - 20 mm from the top, to prevent shrinkage induced cracking.

Form the ridge capping with a minimum thickness of 75 mm, with a mortar mixture of three parts sifted river sand to one part Ordinary Portland Cement (OPC). Generally, but dependent on the roof size, the overall dimension of the ridge capping should be 1 000 mm wide. The width of the capping is dependent upon the condition and shape of the roof at ridge level. It is therefore recommended that an additional thatch layer be secured at the top, to extend the smooth, dressed surface as high as possible, leaving only a small flat surface to be covered by the ridge capping.

All ridge cappings should be sealed. Clean surface thoroughly with a soft brush and dress the entire surface with an approved sealant, applying it according to the manufacturer's specifications and details.

A3. POLES AND STRUCTURAL TIMBER

A3.1 Treatment of timber detail

A3.1.1 Preservative treatment

All preservative treatment of timber must comply with the SABS specifications listed below:

- SABS 1288:1994. *Standard specification for preservative treated timber (sawn structural timber and laths).*
- SABS 457:1994. *Standard specification for wooden poles, droppers, guardrails, posts and spacer blocks.*
- SABS 05:1994. *Code of practice for preservative treatment of timber.*

The preservative treatment products have to comply with the following product specifications:

- SABS 673:1987. *Mixtures of CCA compounds for timber preservation.*
- SABS 871:1967 (1997). *Boron timber preservatives.*

(a) <u>CCA (copper-chrome-arsenic)</u>

- CCA treatment is also known as *celcure* or *tanalith*.
- CCA-treated timber is suitable for use in ground contact for non-structural timber.
- All poles should be of the eucalyptus species.
- All timber poles should be vacuum-pressure-impregnated with 6 to 12 kg approved CCA per cubic metre of timber for H2 (no ground contact) and H4 (ground contact) poles respectively.

(b) Boron

- All structural timber (poles, laths, etc) not in contact with the ground (H2) should be vacuum-pressure-impregnated with an approved boron product to 5 kg BAE (boric acid equivalent) per cubic metre of timber.

A3.1.2 Fire-retardant treatment

- All preservative-treated timber to be treated with an approved fire retardant in accordance with the manufacturer's specification.
- Alternatively, all untreated timber to be treated with an approved preservative and fire-retardant combination product in accordance with the manufacturer's specification.

A3.1.2.1 Quality control procedures for fire retarded timber

Delivery schedules should include dates and batch numbers.

The treatment contractor must keep records indicating date, time at start-up, time at close, volume of product added, batch number, and specific gravity of mixture before treatment.

Records of timber sampling should include date, log number, and period immersed.

The frequency and method of sampling should be agreed with the engineer.

A4. Finishing of poles

Staining of the poles and painting of the nail plates as per finishing specification schedule as per building contract.

All external boron-treated timber to be sealed with an approved timber sealant.

A5. Thatch

A5.1 Thatching grass

Thatching grass should be of the *Hyperhenia filipendula* species, harvested after the summer rain season and beige/yellow in colour.

The grass should have a maximum body moisture of 10 to 15% by mass.

Only straight pieces of grass should be used, cut above the first notch.

All grass should be well combed and cleaned of all loose leaves.

The grass should be 760 to 1 020 mm in length, with ends ranging from 1.5 to 2.5 mm in diameter.

A5.2 Spray layer

Spray thatch of *Cape thatching reed (Thamnochortus insignis)* or other cleaned grass should be installed at all exposed interiors, to enhance the aesthetic appearance of the thatch grass.

Only straight pieces of grass should be used, cut above the first notch.

All grass should be well combed and cleaned of all loose leaves.

Reeds should be 1 000 mm to 1 500 mm in length, with ends ranging from 2 to 5 mm in diameter.

A5.3 Laying of thatch

Thatch should be thoroughly and evenly compacted to a density of ± 35 to 50 kg per square metre (i.e. 40 bundles of grass and nine bundles of Cape reed per square metre of thatch, measured on the slope).

The minimum thickness of thatching, evenly laid with consistent thickness, should be 175 mm.

Cape thatching reed should be laid as the first layer to a thickness of 5 to 8 mm, and compacted thoroughly.

Ensure that the thatch is well compacted by adequately tensioning the twine, in order to prolong the durability of the covering.

A5.4 Fixing

Thatching grass must be attached to the laths (on the inside) with a treated sisal binding twine and sways, as discussed previously.

A6. FIRE-RETARDANT THATCH TREATMENT

A6.1 Fire-retardant coating

An approved fire-retardant coating should be applied to all thatch surfaces, internally and externally, including the underside of roof eaves and roof voids concealed by suspended ceilings.

The fire-retardant treatment must be applied according to the manufacturer's specifications and re-applied at intervals, according to the manufacturer's specifications or as conditions require.

A6.1.1 Quality-control procedures

The fire-retardant treatment must be undertaken using an applicator approved by the engineer.

The fire-retardant treatment must be applied according to the manufacturer's specifications and in accordance with the manufacturer's quality-control procedures. The manufacturer shall issue a certificate of compliance on completion of the project.

A6.1.2 Pre-application checklist

Before proceeding with the application of the fire-retardant treatment, the engineer is to check and confirm the following:

- the specified quality of the thatch grass: he must ensure that no repairs are necessary and that the outer surface does not require combing;
- the compaction of the thatch layer is adequate and that the sisal binding twine is adequately tensioned;
- the thatch is not less than 175 mm in thickness;
- the rafter spacing is not more than 900 mm apart;
- the lath spacing is not more than 250 mm apart;
- the roof structure is of sound construction without defects and within deflection limitations (excessive movement of the roof structure may impact on the effectiveness of the fire-retardant treatment of the thatch layer over time); and
- the ridge cap is according to specification, and aesthetically acceptable.

A7. CHIMNEYS

The design and construction of chimneys to be in accordance with SABS 0400:1990 Part V.

The brickwork must be of sound construction with no openings, and the mortar joints properly filled. No timber is to penetrate the chimney.

The top of the stack must extend for a radius of at least one metre (measured from the top of the stack, closest to the roof covering) above the thatch covering of the roof.

Securely build into the flue around the edges, or support on mild steel dowels, a spark-arrester consisting of a piece of 10 x 10 x 1 mm (minimum) stainless steel wire mesh, fitted 700 mm from the top, covering the full width of the flue.

A8. SERVICES

All electrical wiring is to be inside plastic conduits and must be fitted onto timber poles or laths, and should not penetrate the thatch layer.

Ensure light-fitting beams are not focused directly on the thatch surface.

All services must enter the building from below ground level.

APPENDIX B

RATIONAL FIRE DESIGN PROPOSALS FOR THATCHED LAPAS

B1. GENERAL

The problems experienced with respect to the fire safety of thatched lapas constructed in accordance with SABS 0400:1990, Clauses TT2 and TT12 have been discussed in Section 12.3. Boutek has therefore developed the following guidelines aimed at addressing this risk.

The following points must be taken into account when the fire safety of any thatched lapa is being considered:

(a) A thatched lapa is a non-habitable structure and must be considered in this light. Essentially, the fire hazard for humans is limited; it affects humans, however, if a burning lapa has an effect on an adjoining structure - in most cases the dwelling.

(b) The size of a burning lapa has a bearing on its effect on adjacent structures. The larger the lapa, the larger the fuel source and, in consequence, the greater the risk of conflagration.

(c) A distinction is made between lapas that have a roof-plan area of less than 20 m^2 and those larger.

(d) Boundary distances are determined in relation to the radiation intensity (heat release per unit area) of a burning roof measured at the boundary.

B2. THATCH ROOFS COVERING A ROOF-PLAN AREA OF LESS THAN 20 m^2

According to the National Building Regulations, Part T, Clause TT 12.3, thatched lapas with a roof plan area of less than 20 m^2 are regarded as non-combustible and, as such, will not have an effect on the determination of boundary distances. However, exceptions can occur and actual safety distances may need to be calculated.

A small thatched lapa (less than 20 m^2 roof plan area) can therefore be built within one metre of the boundary, provided the following conditions are met:

(a) The lapa must be a non-habitable structure.

(b) The lapa must be free-standing and not be attached to any other structure, either on the same premises or on adjacent premises.

(c) Should any lapa be constructed within the minimum safety/boundary distance from any existing structure on the same premises, the minimum safety/boundary distance from such a structure would be equal to that of the pre-existing structure.

(d) If a lapa is erected against an existing building, the fire-safety effect of the lapa on the existing structure must be taken into account.
For example: If the lapa extends over the only exit or facing a large aperture (window), other safety measures may need to be applied.

(e) The threat of fire emanating from neighbouring premises cannot be disregarded, even though this may not form part of any legal requirement. The risk is carried by the owner of the lapa, even though the lapa may be erected according to the requirements of fire safety or any other applicable regulation.

(f) Where thatched lapas border on vacant lots, agricultural or park lands, it would be in the owner's interest to undertake the following or similar preventive measures:

- Allow greater safety/boundary distances.
- Reduce the potential fire hazard by protecting the structure's roof from fire (e.g. with the use of approved fire-retardant treatments).
- Provide for adequate fire-fighting facilities (e.g. provide an adequate water supply).

(g) Good thatching practice must be complied with (see Section 12.1.1)

(h) In all cases where a lapa is built close to a boundary, it is advisable to construct a boundary wall, the top of which should extend at least 300 mm higher than the bottom line (footlog) of the lapa's roof. This wall should also extend at least one metre on each side of such a lapa. A lapa should preferably not be constructed closer than one metre to any boundary, this being the minimum distance detailed in Table 2 of SABS 0400:1990, Part T, Clause TT2.

(i) The foregoing is based on the assumption that the lapa has a single roof surface parallel to the boundary and a roof pitch not exceeding 45°. Any other roof configuration obviously impacts on the surface area exposed to the boundary. Such situations must conform with further evaluations (rational design from a fire safety point of view) in accordance with the National Building Regulations, Part T, Regulation T1(2)(a).

B3. THATCH ROOFS COVERING A ROOF-PLAN AREA OF MORE THAN 20 m^2

Thatch roofs covering a lapa roof-plan area in excess of 20 m^2 are considered to pose the same fire hazard as any other roof constructed of combustible materials, the major difference being that lapas are non-habitable.

To ensure a fire-safe structure, one of two building regulations should be applied, namely:

(a) SABS 0400:1990, Part T, Clause TT12; or

(b) Regulation T1 subparagraph (2) of the National Building Regulations, which includes the possibility of rational design.

B3.1 SABS 0400:1990, Part T

This regulation simply stipulates that any thatch roof covering a roof-plan area greater than 20 m^2 must be constructed at least 4.5 m from any boundary. This distance has been determined with respect to the intensity of radiation emanating from a burning roof and its ability to ignite neighbouring structures. It therefore follows that the same distance is required between two or more buildings on the same stand. If a thatched lapa has been erected within the safety distance of 4.5 m, then - in common with smaller lapas - further steps must be taken to ensure adequate fire safety.

B3.2 National Building Regulations, Regulation T1, subparagraph (2)

If a thatched lapa with a roof plan area in excess of 20 m^2 is erected within 4.5m of any boundary or where the safety distance between the lapa and an existing house is insufficient, then such cases should form the subject of rational design.

B3.3 Rational design criteria

B3.3.1 *If the lapa is within 4.5 m of a boundary*

In this case Table 2 of SABS 0400:1990, Part T, Clause TT2 should be consulted to calculate a realistic fire-safety distance. Both local and foreign regulations have been examined and, in conjunction with SABS 0400:1990, the following procedure has been adopted:

(a) Determine the elevation (vertical) area of the roof which is visible from the boundary or neighbouring structure on the same stand, assuming that there is a boundary wall of a height at least that of the bottom edge of the thatch roof. In the absence of a wall, the elevation must be calculated from ground level to the roof ridge.
Note: It is sound practice to erect a wall on the boundary nearest the lapa which should extend to at least one metre either side of the lapa. Such a wall also serves as a heat shield at ground level in the event of fire.

(b) Using the vertical elevation area of the roof, determine the safety distance for a moderate fire load (i.e. 25 to 50 kg/m^2 timber equivalent - the usual range in which a thatch roof falls).

(c) Now determine the centre point of the roof slope (i.e. the centre between the roof ridge and the roof's bottom edge on the side closest to the boundary).

(d) The safety distance determined in (b) above should describe the required distance from the boundary to the centre of the roof slope (measured in (c)).

B3.3.2 *A dwelling with a lapa on the same stand*

Refer to rules TT2.10 of SABS 0400:1990.

In this case, the safety distance is calculated as the sum of the safety distances described in Table 2 of SABS 0400:1990, part T, as determined in (d) above.

Notwithstanding the above, the minimum safety distance from any point of the roof of a lapa to the boundary must not be less than 1.0 m.

B3.3.3 *Reduce the potential fire intensity of the lapa*

This can be achieved in two ways:

- pull down the existing lapa and erect it again to comply with fire-safety requirements; or
- treat the lapa with approved fire retardants to minimise the intensity of any resultant fire.

Photograph 1
Typical thatch bundle

Photograph 2
Poor thatch storage

Photograph 3
Thatching spade or leggatt
("dekspaan")

Photograph 4
Eucalyptus poles on climbing hooks

Photograph 5
Typical two-man thatching team with helper (one team member on the inside)

Photograph 6
Completing the thatching at the ridge of the roof

Photograph 7
Chimney (with flashings)
at ridge of roof

Photograph 8
Inside view of ridge

Photograph 9
Typical thatch decay in
need of maintenance

Photograph 10
Typical thatched-roof dormer window under construction

Photograph 11
Typical scissor-type truss configuration

Photograph 12
Typical lattice truss configuration

Photograph 13
Typical thatched-roof hip detail

Photograph 14
Experimental test set-up to determine rafter pull-out force from walls

Photograph 15
A thatched-roof house struck by the Midrand tornado, April 1994

Photograph 16
Total destruction, following a thatch roof fire

Photograph 17
Severe warping of structural steel, an indication of extreme heat