Carlo F. Christensen A/S Sepatec Fire Tests

Date : 01/07/2016

Version: : 1

Project number : RE31376-001

Prepared by : BVJ

DBI – Danish Institute of Fire and Security Technology

Jernholmen 12, 2650 Hvidovre · Tel.: +45 36 34 90 00 · Fax: +45 36 34 90 01 · Email: dbi@dbi-net.dk ·

Table of contents

1 Introduction

1.1 General

At the request of Carlo F. Christensen AS, DBI – Danish Institute of Fire and Security Technology – has prepared this report on fire tests performed with the Sepatec fire protection system used in thatch roofing.

This report is based on fire tests conducted at DBI on Monday, 20 June 2016 and the fourth edition of Sepatec's installation instructions of 28 April 2014.

The results given in this report apply solely to detached buildings such as single-family houses, holiday cottages, cabins and related small buildings at a distance of at least 5.0 metres to the boundary line.

1.2 Object

This report concerns fire safety in thatch roofs on buildings erected in compliance with the fire safety requirements of the Danish Building Regulations.

Pursuant to the Danish 'Collection of Examples for Fire Protection of Buildings', second edition 2016, the following applies:

The distance to the boundary line may be reduced to at least 5 m for detached, single-family houses, holiday cottages, cabins and related small buildings if the thatched roof is fireproofed in the following manner. The thatched roof is made of traditional reed and thatched directly, without underlying cavities, on an underlying class EI 30 building element [building element 30] made of a class D-s2,d2 material [class B material]. Thatch roofing must be fixed to the underlying building element using a non-combustible material.

The aim of the conducted fire test was to investigate whether similar guidelines may be established for boundary distance requirements for thatch roofing with a cavity of up to 60 mm between an underlying class EI 30 building element [building element 30] made of a class D-s2,d2 material [class B material] and thatch roofing installed with Sepatec fire protection.

2 Test description

2.1 Test method

The conducted fire test was subjected to a comparative analysis. Test results from a roof structure built according to the Danish Collection of Examples for Fire Protection of Buildings (no cavities between thatched roof and underlying building element) were compared with a thatched roof structure using the Sepatec fire protection system with underlying cavity.

The test method applied is identical to the test method used to document the solution proposal described in the Collection of Examples for Fire Protection of Buildings (second edition, 2016) according to which a boundary distance of at least 5 metres is allowable provided that the thatched roof is made of traditional reed and thatched directly, without underlying cavities, on an underlying class EI 30 building element [building element 30] made of a class D-s2,d2 material [class B material].

A total of three thatched roof designs were investigated in the fire tests:

- Roof model 1: Thatch roof without an underlying cavity facing the underlying building element
- Roof model 2: Thatch roof with Sepatec and a 30 mm cavity facing the underlying building element
- Roof model 3: Thatch roof with Sepatec and a 60 mm cavity facing the underlying building element

The acceptance criterion for roof designs using the Sepatec fire protection system with underlying cavity is that fire test results should be similar to or better than data for a roof design without an underlying cavity.

2.2 Test setup

In fire tests, the roof models are exposed to fire based on DS/EN 13501-5 Fire classification of construction products and building elements. Part 5: Classification using data from external fire exposure to roofs tests, applicable to roof coverings in class B_{ROOF} (t2).

- The roof models are exposed to a fire of the size described in DS/EN 13501-5.
- The roof models are exposed to fire for 15 minutes after which the fire is extinguished and damage evaluated.
- During the fire tests, the roof models are exposed to air flow of 4 m/s (perpendicular to and 1 metre from the source of the fire).

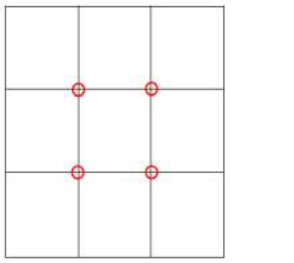
As in the case of 'standard' classification tests, a setup comprising a total of 40 grams of small wooden sticks is used as the fire source and ignited with a Bunsen burner.

All roof models (three in all) are constructed as a section of a roof surface, bordered by panels to create a convincing representation.

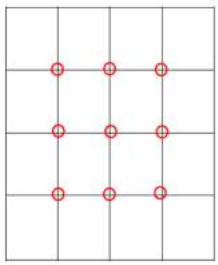
The fire source (40 grams of small wooden sticks) is ignited away from the roof structure and then moved to the thatched roof once it is fully ignited.

The following factors apply to all roof models:

- Size: 122 cm x 244 cm
- Roof pitch: 45 degrees
- Thatched with traditional reed
- Thatched using rustproof wire tied around steel rods. Thatching screws are used
- Thatch thickness is approximately 30 cm
- The model is completed with a structure such as a class EI 30 building element made of material of at least class D-s2,d2 (two layers of 18 mm plywood are used in fire tests)
- Fitting of panel layers on the sides of the model (height equivalent to the level of thatch)
- A total of 13 thermocouples are fitted on the rear of the roof model and between the thatching straw and the underlay. The thermocouples are placed at the intersections of the lines dividing the models into three sections (both horizontally and vertically) on the rear (four pcs.) and at the intersections of the lines dividing the model into four sections (both horizontally and vertically) between the thatching straw and the underlay (nine pcs.). The location of the thermocouples is illustrated in the diagrams below:



Three sections - rear



Four sections - Btw. thatching straw and underlay

The following factors apply to roof models with Sepatec (fire tests 2 and 3) :

- Construction of batten layers, equivalent to a cavity of 30 mm and 60 mm, respectively
- A Sepatec membrane is laid on the battens
- One layer of 45 mm rock wool mats is laid on top of the battens and on top of the membrane over the first 60 cm of the model. The same edge insulation – with a width of 15 cm – is used at the top of the roof model. No edge insulation is used on the sides of the model
- Air access at the top of the model is narrowed to a gap of no more than 30 mm.

Photo 1: Underlying class EI 30 building element of a material of at least class D-s2,d2 (two layers of 18 mm plywood).

Photo 2: Construction of batten layers (roof models 2 and 3) with cavity facing the underlying class EI 30 building element.

Photo 3: Laying of Sepatec and edge insulation on batten layers (roof models 2 and 3).

Photo 4: Finished roof model.

Test setup in which the roof model is exposed to air flow is shown in the photo below. The centre of the roof model is exposed to air flow of 4 m/s. The distance between the front of the roof model and the wind turbine is 1 metre.

Photo 5: Test setup of roof model and wind turbine.

2.3 Description of test runs

The fire tests are used as a basis for evaluating the course of events after a thatch roof is ignited. The fire tests examine the spread of the fire in the roof from the time at which the roof is exposed to an ignition source until 15 minutes after ignition when the fire test ends and the fire in the thatched roof is extinguished.

Three fire tests were performed in total. All fire tests were performed with exposure to wind and using identical test setups.

The acceptance criterion for roof designs using Sepatec with an underlying cavity is that fire test results should be similar to or better than data for a roof design without an underlying cavity.

3 Results of fire tests

3.1 Measuring parameters

The results of the fire tests are evaluated based on visual observations of the spread of fire damage in each roof model and measurement of the roof model's temperature.

For the evaluation, the results of the roof model using Sepatec and a cavity between thatch and underlying class EI 30 building element are compared with roof model 1, which has no cavity.

3.2 Fire development

The series of photos below illustrate the development of the fire in fire test 2 (roof model 2). The development of the fire in the other roof models is comparable.

Photo 6: Immediately after exposure to the ignition source.

Photo 7: After approximately 5 minutes of fire development.

Photo 8: After approximately 10 minutes of fire development.

Photo 9: After approximately 15 minutes of fire development.

3.3 Visual observations of fire spread

In all three fire tests, an identical fire pattern was observed on the surface (however, the spread was smallest in roof model 3 with a cavity of 60 mm). The fire pattern indicates a fire that spreads from the location of the test fire. After the test fire had burnt out, this burning area grew larger and larger. The flames from the burning area ignited the thatched roof above the fire. After the fire had developed for some minutes, the area under the fire source was also ignited by the heat of the flames or by heat transfer in the upper layer of the thatched roof and, thus, constant heat, resulting in ignition of the surface once the temperature was sufficiently high (gas evolution from the thatch).

Evaluation of the damage after the tests clearly indicated a burn in the thatched roof at the location of the ignition source and at the centre of the wind exposure. After the fire had developed for 15 minutes, there was a local burn, approximately 20 cm deep, in the thatched roof.

Burn-in was also evident from the centre of the ignition source and outwards, towards the sides of the roof model. The area with deep burns in the thatch is circular with a diameter of approximately 50 cm. The centre is the location of the ignition/fire source, which is also the centre of the wind exposure (also a circular cross section).

In none of the three fire tests did burns reach the underlay of panels (plywood) which could cause ignition of the underlay.

Beyond the areas of the roof models with burns in the roof (thatch), the only visible damage is in the roof's surface.

Photo 10: Roof model 1 (no cavity).

Photo 11: Roof model 2 (30 mm cavity and Sepatec).

Photo 12: Roof model 3 (60 mm cavity and Sepatec).

Photos 10 to 12 show the roof models after completion of the fire tests, when the fire has been extinguished.

The depth of the burn in the thatched roof is shown in photo 13. In all three fire tests, the degree of local burn-in around the ignition source is comparable and the roof did not burn through in any of the tests.

3.4 Temperature measurements

The temperatures of the roof models were measured during the fire tests. In all roof models, four thermocouples were fitted on the rear of the class EI 30 building element and nine thermocouples were fitted between the thatch roof and the underlay (EI 30 building element).

The (four) thermocouples on the rear of the roof models showed no increases in temperature in any of the tests and, therefore, the results are not given here.

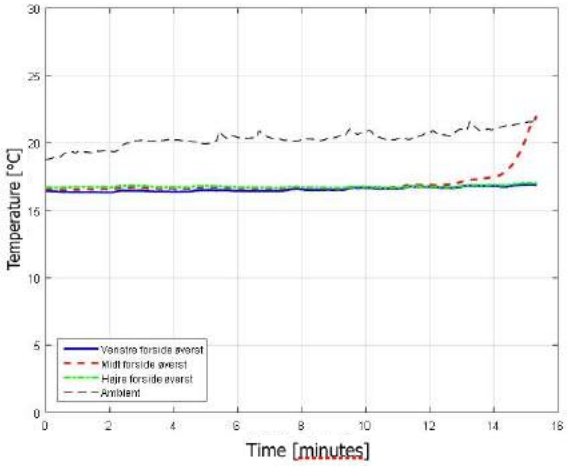
In general, temperatures over 80 degrees are not recorded and the highest temperature was noted at the roof model's centre line (red curve), where the ignition source is located.

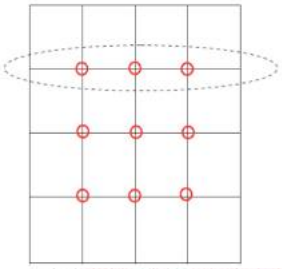
It should be noted that the fire in roof model 2 was allowed to develop for 17 minutes whereas fire development in the other two roof models lasted 15 minutes. Only 15 minutes are included in the analysis of results.

The temperature of the roof model without a cavity was only measured at the centre line, where it is clearest in the centre and lower section. This tallies with observations of fire spread on the front.

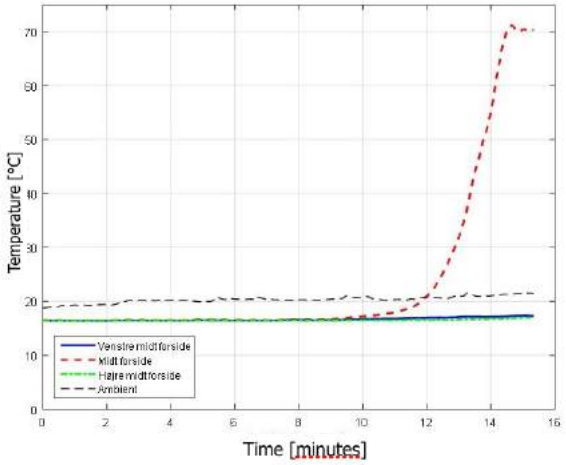
Temperature measurements of roof models with a cavity indicate general heat transfer across the cavity and an increase in temperature within the cavity. The temperature increase is greatest at the top of the cavity (in contrast to the roof model without a cavity in which the temperature increase is greatest in the lower section). However, the maximum temperature increase and temperature increase rate for both roof models 2 and 3 are either comparable or less than for roof model 1 without a cavity.

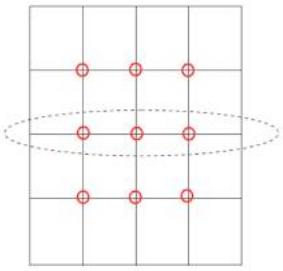
Temperature measurements for roof model 1 (no cavity):



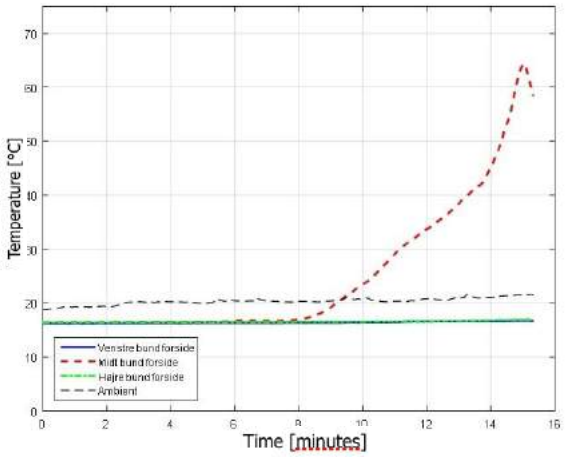


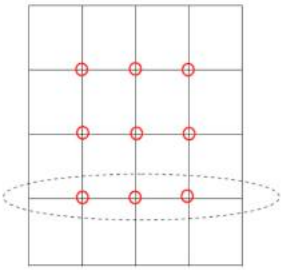
Location of thermocouples





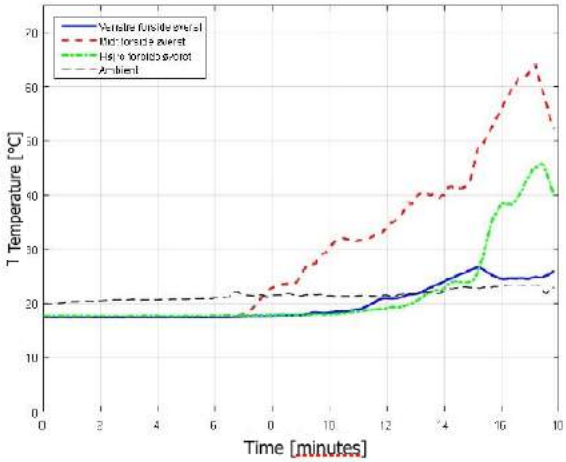
Location of thermocouples

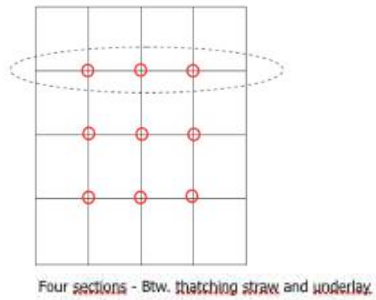




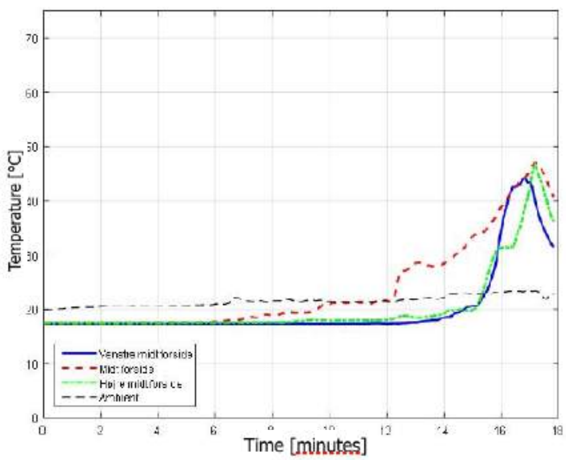
Location of thermocouples

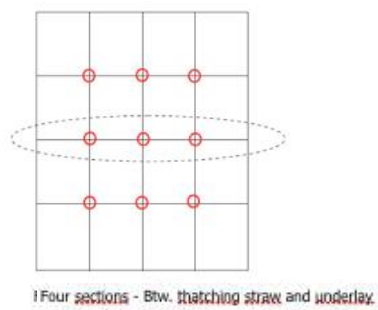
Temperature measurements for roof model 2 (30 mm cavity):



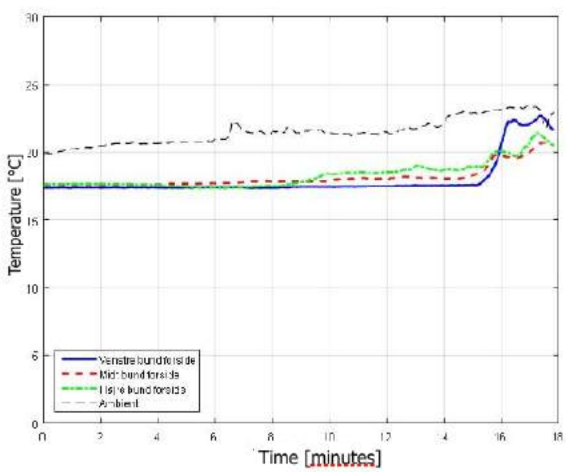


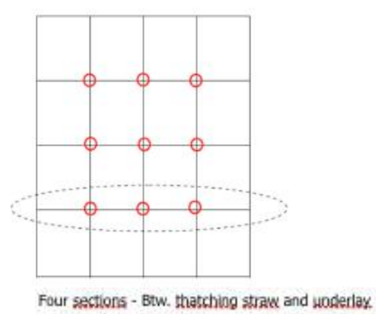
Location of thermocouples





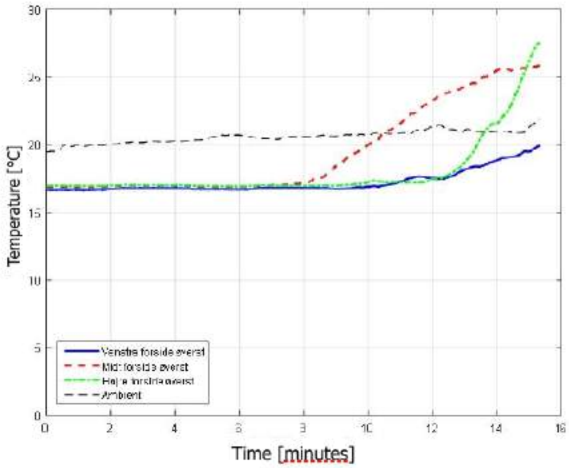
Location of thermocouples

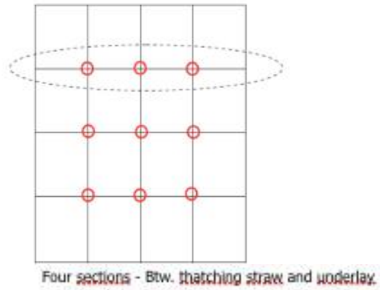




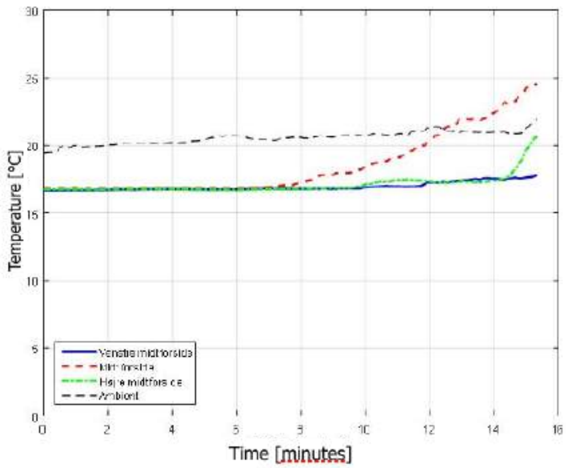
Location of thermocouples

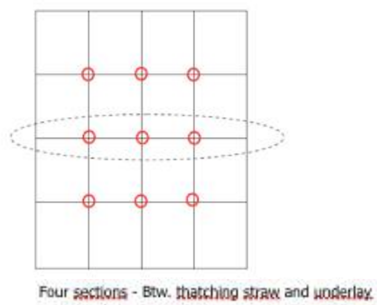
Temperature measurements for roof model 3 (60 mm cavity):



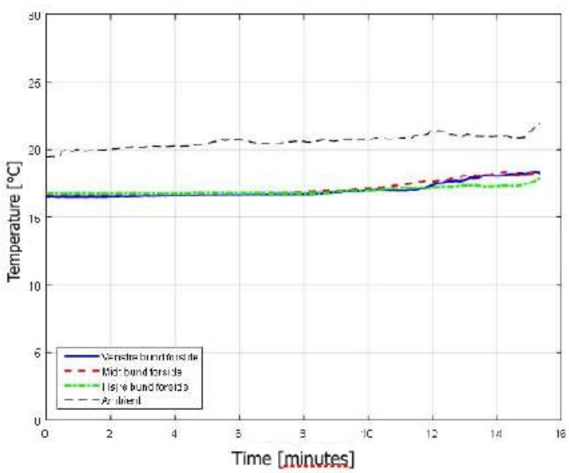


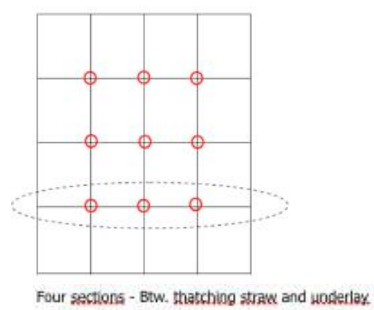
Location of thermocouples





Location of thermocouples





Location of thermocouples

4 Conclusion

In DBI's opinion, based on the fire tests performed and their results, a thatch roof with an underlying, ventilated cavity of no more than 60 mm constructed with the Sepatec fire protection system has at least the same fire resistance as a thatch roof thatched directly, without underlying cavities, on an underlying class EI 30 building element [building element 30] made of a material of at least class D-s2,d2 [class B material].

Thus, it is assessed that a roof structure with batten layers with an underlying cavity of no more than 60 mm, constructed with the Sepatec fire protection system (fibreglass membrane and edge insulation) and thatched with traditional reed could be erected at a distance of at least 5 metres to the boundary line.

Batten layers must always be constructed on a class EI 30 building element [building element 30] made of a material of at least class D-s2,d2 [class B material]. Thatch roofing must be secured with non-combustible material.

The supplier's instructions must be followed when installing the Sepatec fire protection system. A layer of 45 mm rock wool panels must be used for edge insulation: 60 cm wide along the edges of the thatched roof and 75 cm wide from the ridge and downwards.

The test method and test setup used for comparative analyses are identical to the test method and test setup used to document the solution proposal given in the Collection of Examples for Fire Protection of Buildings, second edition, 2016, for examples of thatched roofs at a distance of at least 5 metres to the boundary line.