Building and Environment 81 (2014) 404–409

Contents lists available at ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

An innovative test method for evaluating the critical moisture level for mould growth on building materials

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A R T I C L E   I N F O

Article history:
Received 7 February 2014
Received in revised form
30 June 2014
Accepted 2 July 2014
Available online 24 July 2014

Keywords:
Mould
Relative humidity
Temperature
Building materials
Laboratory test

A B S T R A C T

The critical moisture level (RH_{crit}) for mould growth, that is the lowest relative humidity (RH) at which mould can grow, varies between different materials. The factors that most affect mould growth, RH and temperature, also vary in different parts of a building. One way of preventing the growth of mould in buildings is therefore to choose building materials that can withstand the expected conditions, materials that have a higher critical moisture level than the highest expected RH. It is thus crucial that data are available to allow the correct choice of materials to be made. In this paper an innovative laboratory test method for determining the RH_{crit} of a material is described and discussed. The results from testing of a material according to the method gives information to make the correct choices. The method is developed based on the results of a variety of laboratory studies and has been validated by field studies.

1. Introduction

Mould growth on building materials is the consequence of an interaction between environmental factors (temperature and humidity), material properties and the characteristics of the mould fungi. In general, the availability of water in the material is regarded as the crucial element for growth to occur. It is then the surface of the material that is of interest, since the mould fungi are growing at the surface of solid material. At equilibrium, the moisture at the surface is the same as in the surrounding air. Generally, the higher the moisture availability, the higher is the risk for mould growth. However, building materials differ in their mould resistance; some materials can withstand high moisture conditions better than others. Also, while some materials are susceptible to mould growth at low levels of humidity, down to 75% RH, others can tolerate high moisture levels, above 95% RH, without mould growing on them [8,12,15,16]. There is a theoretical level of RH for each material, above which mould growth is possible, the critical moisture level for mould growth. This is dependent on the temperature; the lower the temperature, the higher is the critical moisture level [12].

Traditionally, mould resistance is evaluated by exposing test specimens of the material to spores of mould fungi and then incubating the specimens at a relative humidity and temperature that are favourable to mould growth. The principle behind the test is that most fungi grow well at high RH and if the material is such as to allow mould growth, then it should also grow on the test pieces in the laboratory. Several standardised test methods are available; some are presented in Ref. [2] and in Table 1 of this paper. While being able to discriminate between materials in a general way, these test methods do not provide any information on how a material will perform in a building where the moisture conditions are not that high. It may, therefore, be possible to use materials that have been subject to mould growth in the tests in constructions where the moisture load is lower.

In this paper, a test method [18] is discussed. The Critical Moisture Level method, for evaluating the critical moisture level of a material. The method is presented in Ref. [10]. Instead of completely excluding the use of certain materials that have failed existing mould resistance tests, the CML method can differentiate mould susceptibility at several different moisture levels. With the introduction of this newly developed and validated method, the field for testing materials' susceptibility to mould has widened. It also makes possible a practical application for use in situations with known lower RH. This in turn provides the basis for material choice in designs where moisture and temperature conditions are known.

The CML method is a result of a range of tests conducted in the laboratory over several years. These tests have been based on routines from several of the existing testing methods; with some

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http://dx.doi.org/10.1016/j.buildenv.2014.07.002
0360-1323/

Table 1
Comparison of some variables for the CML method for testing critical moisture level and five methods for estimating mould resistance.

		The CMLmethod SP Met 4927	ASTM C1338	BS_1982: Part 3: 1990	ASTM G 21-09	ISO 846:1997	MIL-STD 810 G***
Material		Building materials	Insulation materials and their facings	Panel products, made of or containing materials of organic origin	Synthetic polymeric materials	Plastics	A variety of materials commonly used in the construction of military materiel
Purpose of the test		Critical moisture level	Mould resistance	Mould resistance	Mould resistance	Mould resistance	Mould resistance
Specimen	Size	50 × 100 mm	Surface area not defined	40 × 40 mm	50 × 50 mm/dia. 50 mm/length 76 cm (rods)	Not defined	Not defined
	Number of test specimens	7	3	Minimum 3	3	5	Not defined
Inoculum	Number of species	6	5	7	5	5	5
	Spore solution	Yes	Yes	Yes	Yes	Yes	Yes
	Concentration of spores	10^6 spores/ml	$10^6 \pm$ 200,000 spores/ml	Not specified	$10^6 \pm$ 200 000 spores/ml	10^6 spores/ml	$10^6 \pm 2\%$ spores/ml
	Inoculation methodology	Spraying	Spraying	Spraying	Spraying	Spraying or pipetting	Spraying
	Amount of solution	0.4 ml	0.5 ml	0.5 ml	Until surface is moistened	0.1	Not specified
	Number of spores/cm^2	8000	*(a)*	*(b)*	*(c)*	*(a)*	*(a) and (c)*
Incubation	Temperature	22 ± 1 °C	30 ± 2 °C	24 ± 1 °C	28–30 °C	24 ± 1 °C or 29 ± 1 °C	30 ± 1 °C
	RH	80 ± 2.5% 85 ± 2.5% 90 ± 2.5% 95 ± 2.5%	95 ± 4%	Not specified	>95%*	>95%*	At least 90% but less than 100%
	Incubation environment control	Recording of temperature and relative humidity every 10 min	No	No	Automatic recording of wet and dry-bulb temperature recommended	No	Record chamber temperature and humidity versus time
	Incubation time	12 weeks	Min 28 days	4 weeks	28 days	4 weeks or longer	28 days or up to 84 days
	Storage of suspension	Must be used the same day	28 days at 6 ± 4 °C**	Must be used the same day	Not more than 4 days at 3–10 °C	6 h	6 ± 4 °C for not more than 14 days
Analysis	Method	40× magnification	40× magnification with low angle light	Hand lens 10× or microscope 10×–50×	Microscope used only to confirm growth less than 10%	Visible effect, microscope (×50) if necessary	Visible effects
	Assessment	5-point rating scale	No rating scale	6-point rating scale based on percentage coverage	6-point rating scale based on percentage coverage	5-point rating scale based on % of surface with growth	5-point rating scale and analysis of species
Interpretation of results		Critical moisture level reached in when there is established growth on at least two test specimens	Growth compared to reference material; if bigger on test specimen, considered to have failed. If no growth is criterion, any growth on any test piece considered a failure	Calculate the notional mean ratings. No pass or fail criterion	No pass or fail criterion	Depending on rating of growth, material is classed as fungistatic, containing small amounts of nutrients or is not resistant to fungal attack	No guidance

(a) Cannot be calculated since the area of test specimen is unknown, (b) Cannot be calculated since the concentration of spores in the suspension is unknown, (c) Cannot be calculated since the volume of spore suspension is unknown, *specimens are placed on solidified nutrient salt agar and RH is according to ISO 846 > 95%, ** or until the viability test indicates poor growth or until growth appears in the sealed storage bottle, *** although this method is not specified for testing building materials, it is useful and often used for this purpose.