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Fire Safe Use Of Bio-Based Building Products

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State-of-the-art about how real fires may be influenced by structure

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Following summary gives an overview of fire tests, research studies and fire incidents where bio based building materials (BBBM) have been involved with respect to observations and results about the potential contribution of bio based building materials to the fire scenario.

This documentation aims to help in understanding the influence of BBBM in each stage of the fire and to an overall fire safety.

This knowledge is needed to quantify the risk in using BBBM and in order to add or develop passive and/or active measures to guarantee fire safe buildings.

The potential influences can be summarised as follows and are derived from the table below:

- the presence of BBBM increase the smoke production rate and most dominant in under-ventilated scenarios or smouldering fires the production of toxic gases, in particularly in the early stage of fire,
- combustible linings can lower the time to flash over,
- the presence of combustible linings can increase the fire severity and heat release, but does not necessarily lead to increased peak temperatures in fully developed fires, the influence is less pronounced if only the ceiling or a single wall is unprotected,
- the contribution of combustible linings can postpone the decay of fire, however self-extinguishment may also possible even combustible linings are present
- multiple flash overs may cause if delamination of unprotected CLT or falling down of a protection lining occur,
- intense flaming combustion outside the windows may occur in ventilation controlled compartment fires
- a thread for rapid fire spread and large fire incidents within the erecting phase of building exist, in particular for light timber frame structure when protective lining is not in place

However, several projects in recent years have shown, that considering these potential influences adequate within the design process fire safety will be reached even if bio based building products are used. A further detailed description about measures to exclude and compensate these potential influences will be part of further publications within the COST action FP1404..

Country (Date)	References	Type of fire (real/ fire test)	Real Fire		Full Scale fire test		Potential contribution of BBBM to fire behaviour
			Building	Compartment	Building	Compartment	
SE	Karlsson et al. (1992)	Analysis of 24 fire tests with different lining materials				✓	• for combustible linings compartment temperatures under the ceiling in pre flash over fires can be determined by multiply following equation by factor 2 $\Delta T = 6.85\left(\frac{\dot{Q}^2}{A_v\sqrt{H_v}h_k A_T}\right)^{1/3}$
USA	Tewarson (2002)	ASTM E2058 fire propagation apparatus tests with respect of combustion efficiency and toxic hazard of materials					• under ventilated combustion (equivalence ration >1) result in excessive production of toxic gases e.g. CO
UK (1995)	Lennon et al. (2000) Bullock et al. “TF2000 project”	Fire test of a 6-storey residential building			✓	✓	• fire and smoke spread via egress route, • timber structure of the stair and shaft contributed to the fire event (insignificant)
A(< 1999)	Dowling et al. (1999) Wade (2001)	ISO 9705 and room / corridor tests with different lining materials				✓	• plywood lining reduced time to flash over and increased heat release and smoke production • ISO 9705 room: wall + ceiling (125s), wall only (163s), ceiling only (400s)
CH (1999)	Maag et al. (2000) Frangi (2005)	Timber frame compartment fire tests			✓	✓	pre flashover: • no contribution of combustible linings in sprinklered compartment

	“wooden modular hotels”	with different linings (pre- and post-flashover)					post flashover: • rapid flashover, combustible lings increased fire plume outside the window, no significant temp. differences • rear ventilated caps in combustible façade will contribute to an increased fire spread
JPN (2000)	Kagiya et al. (2002)	Fire of a large glulam gymnasium	✓				• Flashover in a large enclosure
FI (2002)	Hakkarainen (2002)	Four compartment fire tests with different linings				✓	• no increase in compartment temperature • release of additional pyrolysis gases and increased fire plume (heat flux) in front the façade • extension of the phase of the fully developed fire (delay of the decay phase)
GER (2004)	Hegemann (2004)	Full scale test to evaluate the influence of combustible linings			✓		• extended fire duration and larger fire plume outside the window within the compartment with combustible linings
UK (2006)	Schneider et al. (2007) Bregulla et al. (2010) “Colindale fire“	Fire in Beaufort Park building site of a large timber frame building	✓				• fire protection lining and separating elements only partly finished - allowed a rapid fire spread, size of the fire uncontrollable for fire service
JPN (2006)	Frangi et al. (2008)	Full scale fire tests of compartment fires		✓		✓	• Excessive burning outside window after lining failed

GER (2006)	Winter et al. (2009)	Full scale fire tests to evaluate flame spread mechanism in timber buildings		✓	✓	• continuous gaps and voids in contact with combustible materials promoted the spread of fire
AT (2010)	Feuerwehr Salzburg (2010) "Brand Stabauergasse Salzburg“	Fire in 3 storey timber frame apartment building	✓			• fire spread via eave within an unseparated roof structure • Smoldering fires within void cavities
CAN (2011)	Sherlock et al. (2011)	Fire in the “Remy” housing project in Richmond Canada, timber frame structure with 81 units under construction	✓			• rapid fire spread, buildings were fully engulfed by flames when fire service arrived • wood contributed to the severity of the fire (citation chief of fire & rescue service)
JPN (2011-2013)	Hasemi et al. (2014) Suzuki et al. (2016)	Fire tests of a 3-storey wooden school building (3 tests)		✓	✓	• rapid fire spread by ejected flame • severe heating to structural timber elements • charring rate of timber column in natural fire
JPN (2011-)	Watanabe et al. (2015) Naruse et al, (2015)	Full scale fire tests of compartment fires			✓	• • floor area, opening, location and surface area of wood

AUS (2011)	England et al. (2011)	Literature review, risk assessment and fire tests				✓	• no difference in the fire tests between compartments with lined steel and timber studs found • estimations about a maximum increase in the fire load due to the light timber frame between 4 – 20%
SE (2013)	Östman and Stehn, SP Rapport 2014:07	Fires in a residential timber building	✓				• fire growth via cavity of walls after initial fire
CAN (2012)	McGregor (2013)	Fire tests in protected and unprotected CLT compartments			✓		• initially unprotected CLT or when protective lining failed - panels contributed to the fire intensity (heat release) and duration • increased fire growth rates, with reduced time to flash over for unprotected CLT compartment tests • extended fire duration, delay of decay and “second flash over” if delamination of layers occurred
UK (2014)	BBC (2015)	Fire in a university building site	✓				• large timber frame building unprotected, under construction
Literature review (Multi-Contries)	Brandon and Östman, (2016)	Summary of several full scale fire tests of compartment fires		✓		✓	• opening, fire source and types of interior linings

References

BBC: (2015), "University of Nottingham laboratory fire caused by electrical fault, says report"

http://www.bbc.com/news/uk-england-nottinghamshire-30751431

Brandon D., Östman B.: (2016), "Fire Safety Challenges of Tall Wood Buildings – Phase 2: Task 1 - Literature Review - The contribution of CLT to compartment fires", Report number: FRPF-2016-22 of the Fire Protection Research Foundation, USA

Bregulla J., Mackay S., Matthews S.: (2010), "Fire safety on timber frame sites during construction", 11th World Conference on Timber Engineering (WCTE), Riva del Garda, Italy

Bullock M, Lennon T, Enjily V.: "TF2000 Stair Fire Test Summary Report", University Manchester

http://www.mace.manchester.ac.uk/project/research/structures/strucfire /CaseStudy/Timber/stair.htm

Bullock M, Lennon T, Enjily V.: "The Fire Resistance of Medium-Rise Timber Frame Buildings Summary Report", University Manchester

http://www.mace.manchester.ac.uk/project/research/structures/strucfire /CaseStudy/Timber/default.htm

Dowling V., McArthur N.A., Webb A.K., Leonard J.E., Blackmore, J.: (1999), "Large Scale Fire Tests on Three Building Materials", Proceedings 3rd International Conference on Fire Research and Engineering, Chicago, 4-8 October, Society of Fire Protection Engineers, Bethesda, Maryland, USA, pp 217-227

England P., Matthew E.: (2011), "Extension of the Concession which allows timber frame construction in class 2 buildings to include class 3 buildings", Forest & Wood Products Australia, Melbourne, Australia

Karlsson B.: (1992), "Modeling Fire Growth on Combustible Lining Materials in Enclosures," Department of Fire Safety Engineering, Lund University, Sweden, Report TVBB-1009

Lennon T., Bullock M., Enjily V.: (2000), "The fire resistance of timber frame building", BRE Report No 79485-1, BRE, UK.

Li X., Zhang X., Hadjisophocleus G., McGregor C.: (2014) "Experimental study of combustible and non-combustible construction in a natural fire", Fire Technology, 2014

Fire service Salzburg: (2010), "report of fire incident in wooden residential building Stabauergasse Salzburg"

http://www.ffb122.at/wordpress/news/einsatz/brand-eines-wohnhauses-in-der-stabauergasse/

Frangi A., & Fontana M.: (2005), "Fire Performance of Timber Structures under Natural Fire Conditions", Fire Safety Science Symposium 8: 279-290. IAFSS, Beijing, China.

Frangi A., Bochicchio G., Ceccotti A. & Lauriola M.P.: (2008), "Natural Full-Scale Fire Test on a 3 Storey XLam Timber Building", World Conference on Timber Engineering (WCTE), Miyazaki, Japan

Hakkarainen T.: (2002), "Post-flashover fire in light and heavy timber construction compartments", Journal of Fire Sciences, 20 (2002): 133-175.

Hasemi Y., Noboru Y., Itagaki N., Izumi J., Osaka T., Kaku T., Naruse T., Hagiwara I., Kagiya K., Suzuki J. & Kato K.: (2014), Full-scale fire tests of 3-storey wooden school building, World Conference on Timber Engineering (WCTE), Quebec, Canada

Hegemann K.: (2004), "Raumbrandversuche mit unterschiedlicher Belegung der Oberflächen“, MFPA Leipzig (internal confidential report)

Kagiya K., Hasemi Y., Nam D., Hokugo A., Masuda H., Harada T., Miyatake A. & Hiramatsu Y.: (2002), Investigation of a Large Wooden Gymnasium Fire - Its documentation, estimation of the fire scenario by experiments and evaluation of the structural properties of surviving timber elements, Proceedings of 7th International Symposium on Fire Safety Science

Maag T., & Fontana M.: (2000), "Brandversuche an Modulhotels in Holzbauweise", ETH Zürich, Institut für Baustatik und Konstruktion

McGregor C.J.: (2013) "Contribution of cross-laminated timber panels to room fires". Master thesis at Department of Civil and Environmental Engineering Carleton University - Ottawa-Carleton Institute of Civil and Environmental Engineering, Ottawa, Ontario, Canada

Naruse T., Kagiya K., Suzuki J., Yasui N. & Hasemi Y., (2015), Experimental Study of Time to Onset of Flashover in Classroom Size Compartment, Proceedings of Asia-Oceania Symposium of Fire Science and Technology (AOSFST), Tsukuba, Japan

Östman B. & Stehn L., (2014) Brand i flerbostadshus - Analys, rekommendationer och FoU-behov (Fires in Residential Timber Buildings - Analysis, Recommendations and R&D Needs), SP Rapport 2014:07, ISSN 0284-5172, SP Technical Research Institute of Sweden

Sherlock T., Kane L.: (2011), VANCOUVER SUN

http://www.megabuilding.com/pdf/richmond-fire2.pdf

Suzuki J., Naruse T., Kagiya K., Kaku C., Yasui N., Itagaki N., Izumi J., Seki M., Kaku T. & Hasemi Y.: (2016), Charring Behavior of Structural Timber Elements in Full Scale Fire Tests of 3 Storey Timber School Buidling, Proceedings of World Conference on Timber Engineering (WCTE), Vienna, Austria

Schneider U., Oswald M.: (2007) „Brandschutztechnische Studie Aufbereitung des Colindale Fire", Institut für Hochbau und Technologie Zentrum für Baustoffforschung, Werkstofftechnik und Brandschutz, TU Wien

Tewarson A.: (2002), "Generation of Heat and Chemical Compounds in Fires ", in SFPE Handbook of Fire Protection Engineering, 3rd edition, Section three, Chapter 4, National Fire Protection Association, Massachusetts, USA

Wade C.A.: (2001), "Building Fire Safety and Hazard Assessment Methods for Combustible Surface Finishes", Conference Paper No. 85 at the CIB World Building Congress, Building research Association of New Zealand (BRANZ), Wellington

Watanabe M., Hasemi Y. & Yasui N., (2015), Effects of Interior Finish Designing for Fire Safety to Fires and Behavior of Ejected Flames in School Buildings, Proceedings of Asia-Oceania Symposium of Fire Science and Technology (AOSFST), Tsukuba, Japan

Winter, S.; Stein, R.: (2009); Abschlussbericht zum Teilprojekt 11 „Mechanismen der Brandweiterleitung bei Gebäuden in Holzbauweise - Erstellung eines Konstruktionskataloges für Holzhäuser mit erhöhter Brandsicherheit" des Forschungsverbundes "Holzbau der Zukunft" im Rahmen der Hightech-Initiative Bayern vom Bayrischen Staatsministerium für Wissenschaft, Forschung und Kunst