ABSTRACT

FUNDAMENTALS AND DESIGN MODEL FOR VERIFICATION OF TIMBER COMPONENTS WITH HIGH PERFORMANCE FIRE RESISTANCE COATINGS

The use of timber in constructions is limited in Germany because the building codes require minimum requirements for the flammability of building materials. The model building code (MBO) allows timber constructions up to "Class IV" with five storey buildings. In this case the load bearing and stiffening components have to be encapsulated by a non-flammable cladding to prevent their ignition when a fire occurs. The cladding causes an increase in the dimensions of building components and the natural and aesthetic character of wood is lost.

A relatively new approach to avoid the ignition in case of a fire is the use of High Performance Fire Resistance Coatings (HPFRC) which are applied on timber components such as ordinary opaque or transparent paints. Under exposure to high temperatures it forms into a voluminous foam which insulates the wood and prevents ignition or at least delays it for some time. According to the state-of-the-art in science and research the ignition protection can be effective for more than 30 minutes under standard (ISO) fire exposure. In this work it is shown that HPFRC can reach the same fire safety objectives as non-flammable claddings although the coating itself is, strictly speaking, a flammable material.

The designing engineer needs a tool to quantify the protective effect of the coating both in terms of preventing ignition as well as the load bearing capacity of timber members during the fire process. For this reason, a deterministic design model was developed which is supplemented by a probabilistic safety concept to ensure the generally accepted safety levels in a quantitative manner. The developed model has been calibrated with various fire tests and simulations.

For the thermal analysis of coated cross sections the temperature-dependent thermal properties of the foam had to be determined and transferred to a mathematical model. The thermal properties are the bulk density, specific heat and thermal conductivity. On the basis of the design model, extensive parameter studies were performed. They have shown that load bearing capacity of beams and columns can be significantly improved for a standard (ISO) fire of 30 minutes. Slender columns that cannot reach a fire resistance rating of 30 minutes without any cladding or coating can be improved to European class R 30 rating using a transparent HPFRC which prevents ignition for less than 30 minutes. However it is not satisfactory to use a HFRPC with ignition protection of 30 minutes to strengthen timber members of European class R 30 up to R 60. This is because after ignition the burning rate of timber is very high as a result of preheating, so that the bearing capacity decreases quickly. Complementary to the development of the design model, the results of fire tests and simulations were used to derive construction rules for timber members with HFRPC. These partly differ extensively from the known rules for timber components with claddings.