Honeymoon MUF adhesives for exterior grade glulam

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An exclusively MUF- (melamine-urea-formaldehyde) based honeycomb adhesive for glulam and fingerjoints is presented in which one component is composed of a high performance MUF resin, while the second separate application component is based on just slightly acid water thickened to the same viscosity of the first component by the addition of 1.5% carboxymethyl cellulose (CMC).

MUF-based, honeycomb-type, fast-setting, separate application adhesive systems, which do not need any resorcinol, are shown here to be capable of performing as adhesives for structural exterior-grade joints and glulam and to satisfy all the requirements of the relevant adhesive specifications for such an application. The parameters which are shown to be determining are mainly the performance of the MUF resin, if and once an excellent resin formulation is available, both the ratio of melamine to urea and the molar ratio having a lesser effect. The performance only starts to drop lower than the requirements of relevant standards from M:U weight ratios well below 20:80 and of the order of 10:90. Addition of resorcinol at these failing levels while improving slightly the performance do not solve the problem, and resorcinol addition does not allow satisfaction regarding specification requirements. At the higher M:U ratios such as M:U = 47:53, but even lower, addition of resorcinol does not improve at all the results, its addition again revealing itself superfluous. The reasons for such a behaviour are presented and explained. The MUF honeymoons present all the other usual advantages associated with honeycomb adhesives, namely high curing rate, long pot-life, tolerance to higher moisture content of the substrate, and tolerance to even quite severe imbalances in viscosity and proportions between the two components.

MUF-Kleber vom Typ ‘Honeymoon’ für Glulam zur Außenverwendung


1 Introduction

Honeymoon fast-set adhesives for exterior-grade structural glulam and fingerjoints have now been used industrially for about twenty years (Pizzi 1983, 1989, 1994). From the original concept of the honeycomb fast-set system and the initial systems which were eventually industrialized (Pizzi 1989, Pizzi and Cameron 1984, Pizzi et al. 1980), and are still extensively used commercially, several relevant variations were derived over the years. Thus, to the original PRF/PRF systems were added fairly soon afterwards the PRF/Tannin systems, both being fast adhesives of structural marine grade capability able of setting and curing at elevated rates but at ambient and even lower winter temperatures, and even at higher moisture contents of the timber (Pizzi 1989, 1994, Pizzi and Cameron 1984). Variations of the two same types but more apt to automatic fingerjoints equipment and capable of pot-lives of 48 hours or longer, while maintaining the same curing rate (Pizzi 1989, 1994) were then added. Variations based on TRF/TRF systems (Stephanou and

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Pizzi 1994, Pizzi et al. 1980), were also commercialized earlier, and all of these variations are now in industrial use in a few countries, and have been so for a long time. All these systems have been aimed at the decrease of the expensive resorcinol content on total resin solids while conserving the structural, exterior bonding performance well over the requirements of the standards.

Some other variation on the same theme have been presented in the literature, although some of them might not as yet be extensively commercial, such as for instance (i) substituting one inexpensive component (for instance tannin) with another inexpensive component (for instance soya protein hydrolysates) with, however, the need to use heating (Steele et al. 1998) to achieve performance and thus partly denying the advantages of a separate application fast set adhesive system; (ii) the use of “pre-branched” resins to produce fast-set adhesive systems of extremely low resorcinol content (Scopelitis and Pizzi 1993, Pizzi 1994), and capable of bonding very high moisture content timber, and (iii) the use of a melamine resin and a resorcinol separate components system (Greeneweld, US patent 5,674,338 – 1997), the alleged greater tolerance of which to the bonding of higher moisture content timber being in reality on par with most of the other systems already listed above. However, for all the improvements apportioned to the commercial resin of this type and all the different variations on the honey-moon-type fast-set adhesives, all these systems are still based on some resorcinol or resorcinol-aided component.

Systems (ii) and (iii) above are the two possibly using the lowest amount of resorcinol. System (iii) using as one component a melamine-urea-formaldehyde (MUF) resins of high melamine content and resorcinol as a second component is just unusual in its use of a MUF rather than a PRF resin, a very acceptable resin concept, except for the fact that it is coupled with a phenol such as resorcinol. The coupling of an acid-setting MUF adhesive and of resorcinol might well present no advantages or even some potentially serious disadvantages. It has been shown, for example, that thermostetting PMUF resins do not present a better performance than equivalent MUF resins and that often, depending on their sequence of manufacture, they present instead a much worse performance. There are very well defined technical and chemical reasons for this (Higuchi et al. 1994, Cremonini et al. 1996) that boil down to the relevant differences in reactivity of the two materials, namely the phenol (here resorcinol) and melamine. The reactivity of melamine and even urea at the acid setting pHs they need is much greater than that of any phenol, even resorcinol, as this pH range is the one of lowest reactivity of any phenol. Thus, even resorcinol runs the risk to be very little linked to the MUF matrix, especially in a fast setting system, such as a honeycomb, and at best it will remain as a by-passed pendant side group not able to fulfill the function for which it has been added.

There have also been, in the past, equally valid trade reasons for their use, their introduction having been originally prompted by the then perceived need to upgrade the exterior performance of MUF wood adhesives. The idea that the addition of small percentages of phenol to a MUF resin yields resins of better exterior durability is an incorrect myth today traditionally perpetuated in the wood panels industry. Newer formulations of MUF resins always outperform the corresponding PMUF. PMUFs are not bad resins, they are simply resins in which one of the materials, phenol or resorcinol, is often wasted for no purpose. This is not too important for the relatively inexpensive phenol, but it is rather grave in the case of the expensive resorcinol. The idea that resorcinol under the conditions of operation of a MUF resin can be used to upgrade its performance, or at least to accelerate its rate of curing can indeed be challenged.

This paper then deals with the development of a new type of exterior-grade, structural honey-wood-type fast-set MUF resins for glulam/fingerjointing of excellent performance, without the need to use any resorcinol, equally bonding higher moisture content timber, of totally clear/transparent colour of the hardened glue-line, and on achieving the lowest possible melamine content at parity of performance by simply upgrading MUF resin formulation.

2 Experimental

2.1 Resin preparation

MUF resins of urea to melamine weight ratios of 47:53, 40:60, 30:70, 20:80 and 10:90, and of (M + U):F molar ratios of 1:2, 1:1.9, 1:1.7 and 1:1.5 were prepared according to a resin formulation already reported (Pizzi 1994). The MUF resins were prepared to a degree of advancement as defined by a water tolerance of 150%, while some resins of much lesser advancement and of water tolerance of 300% were also prepared. These are indicated in the text and in the relevant figure legends. Solid contents and viscosity of the resins were maintained in the range 6070% and 2000–2500 mPa.s, unless otherwise indicated. Gel permeation chromatography (GPC) was carried out on a Waters GPC equipped of both UV and refractometer detectors, in dimethylformamide as the mobile phase.

2.2 Glue-mix preparation and testing

The two components of the separate application honey-wood adhesive were composed as follows:

Component A: the MUF resin at a pH of approximately 10, solids content of 72%–73%, and viscosity of 200–2500 mPa.s. No fillers were added.

Component B: 1.01 parts by weight carboxymethyl cellulose is dissolved in 55 parts water and the solution is left to hydrate well for 24 hours. 27 parts by weight of formic acid solution is then added.

The two components were then each spread on the surface of separate beech (Fagus sylvatica) strips of dimensions 120 × 25 × 3 mm, and these were then assembled to have a bonded overlap of 25 × 25 mm, then clamped and left in the clamp for 16 hours and then aged for 7 days, all at 20 °C. The bonded specimens so prepared were then tested for tensile strength dry (10 specimens), after 24 hours cold water soak (10 specimens), and after 2 hours boil (10...