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Wood Composites and Chemistry

Session 3 " Compound Materials and Glued Products"

19th – 20th September 2002
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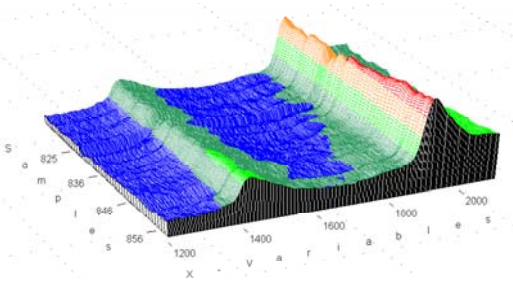
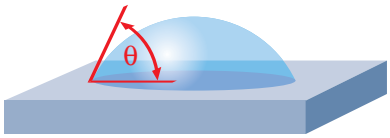
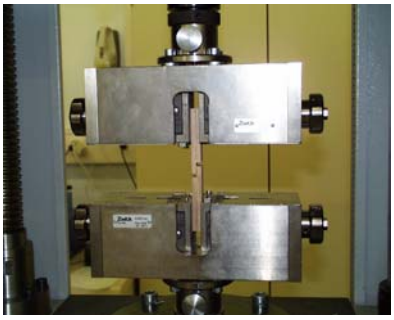


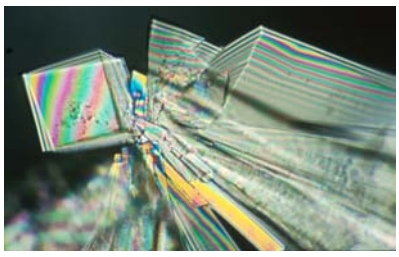
Wood Modification and Processing



Adhesives and Glueing



Compound Materials and Glued Products



Wood Chemistry and Biotechnology

Post Conference Edition of the Proceedings of the International Symposium „Wood Based Materials"

organized by COST Action E13 „Wood Adhesion and Glued Products" and „Wood Kplus"

The issue covers the post conference edition of the proceedings of the symposium „Wood Based Materials – Wood Composites and Chemistry", which was organized by the Competence Centre for Wood Composites and Wood Chemistry „Wood K plus" in cooperation with the COST Action E13 – Wood Adhesion and Glued Products" in Vienna, Sept. 2002. The proceedings comprize 5 key-note lectures and 27 oral presentations, a summary of the Cost Action E13, a presentation of the Austrian Competence Center „Wood Kplus" as well as 30 Posters with following topics:

- Wood modification and processing
- Adhesives and glueing
- Compound materials and glued products
- Wood chemistry and biotechnology

Abstracts and Summaries

Development of a suitable adhesive for the gluing of prestressed artificial fibres to glulam beams

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Summary

Delamination is a major problem when glulam beams are to be strengthened by attaching prestressed, high-strength fibres on the tension side. There are theoretical reasons to believe that delamination could be reduced by using "soft" adhesives which - unlike the usual "stiff" adhesives on the market - could spread the prestressing force over a larger area at the ends of the beam where the prestressed fibre is attached. The test results are a valuable start. Much more work will need to be done in this vast field before a reliable "soft" glue can be developed. In the meantime, there is hope that the positive experience gained with concrete beams using a gradiented attachment of the prestressing force may prove to be applicable to timber as well.

Interaction between resins and wood

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Summary

The sorption of melamine resins was studied using a partially and fully methylated melamine resins. The results show, that up to 35% the resin is deposited in the cell walls. The adsorption of the resins in the cell walls are combined with the swelling of the test pieces. The crosslinking of the resins reduced the WPG, because during crosslinking volatile compounds were released. Since the volume did not change to a big extent, the density decreased. The impregnation of wood using melamine resins results in a strong distribution of the resin. The maximum level was reached after a impregnation time of 23 h.

The stability of aqueous resin solution depend strong on the pH-value. In acidic milieu one observed the cleavage of the ether bond (methyl ether) and the crosslinked curing of the resin. At pH 8 and 9 the OCH_3 content did not change significantly. The resin was stable during the reaction time of 210 minutes at 100°C.

Wood as acidic material is supposed to diminish the crosslinking temperature of a wood-melamine resin system. Using dynamic mechanical analysis (DMA) and differential scanning calorimetry (DSC) one can show that the wood content and resin structure exert a strong influence on the crosslinking temperature. A dependence of the crosslinking temperature on the wood content and components of wood (cellulose, hemicellulose, lignin) was found. Hemicellulose (xylan) showed the strongest effect on the lowering of the crosslinking temperature. The fully methylated resins are much more stable in the presence of wood than partially methylated resins.

The impregnation of wood with melamine resins increase the compressive strength of the test pieces. The compressive strength depended only on the resin content and not on the molecular structure of the resin. Nevertheless, the type of resin use a strong influence on the moisture uptake by under water storage of the test pieces. The impregnation of wood with fully methylated resins yielded in a significant lower moisture uptake than the impregnation using the partially methylated resins.

Glued-in Rods:
Local Bond Line Fracture Properties and a Strength Design Equation

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Abstract

The shear stress versus the shear slip across the bond layer in glued-in rod joints was tested by use of small specimens. The glued length of the rods tested was 8 mm and the rod diameter was 16 mm. The entire load-deformation curve, including the descending branch of the curve showing the gradual damage of the bond during increase of the displacement was recorded. Three adhesives, two rod materials and various rod-to-grain orientations were tested. The shear stress-slip performance, the shear strength and the gradual fracture degradation rate are reported.

The part of a recent European research project on glued-in rods discussed in this paper also included development of a design equation proposal for the basic pullout strength of glued-in rods. A strive in this development was to find an equation both simple and general, and with a rational theoretical basis. The equation proposed is based on quasi-non-linear fracture mechanics and reads

$$\bar{\tau} = \tau_f \frac{\tanh \omega}{\omega}$$

where $\bar{\tau}$ is the mean shear stress along the rod at joint failure and τ_f the local bond line shear strength. The parameter ω is determined by the geometry of the joint and by the stiffness of the adherend materials and the strength and fracture energy of the bond layer. Experimental calibration and verification was made by means of a large number of ramp loading pullout tests.

GIROD - Glued-in rods for timber structures

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Conclusions

- A calculation model based on a combination of Volkersen theory and fracture mechanics gives good prediction of the pull-out strength for adhesives that bond to the rod such as PUR and EP. The pull-out strength is controlled by two material property parameters that can be easily determined in full-scaled pull-compression tests.
- Fatigue is a significant factor in the performance of glued-in rods and needs to be considered in applications like for instance bridges. Failure can occur in the rod, in the adhesive bond line, in the wood substrate and in the interface between wood and adhesive.
- The effect of rod spacing and edge distances has been clearly demonstrated and proposals to be used in design have been made.
- Storage without mechanical loading in variable outdoor climates had a strength reducing effect mainly on PUR-bonded rods. After storage in 85% RH the PRF-bonded rods were most affected.
- Glued-in rods have a duration-of-load behaviour that can differ quite considerably from that of timber and other timber connections. In 85% RH EP-bonded rods showeda behaviour in accordance with the Madison curve for timber while PRF and PUR had much shorter time to failure. At 50°C the PRF behaved in a better way than PUR and EP.
- The method developed for evaluation of the durability of adhesives for glued-in rods is suitable for intended purpose. It is cabable of ranking the adhesives. EP shows the highest strength values after the different treatments. PRF, which is known to give very durable wood-to-wood bonding, obtains extremely low strength values after testing in wet conditions. The method punishes adhesives that do not bond to the rod.
- The creep-rupture test method also manages to rank the adhesives. At normal room temperature the EP adhesive seems to be superiour to the other adhesives. There is also a certain correlation between the creep rupture test on small specimens and the full sixed duration of load test.
- A simple production control test method based on proof-loading has been developed. It is able of detecting a number of serious production errors.

Screening of Wood - Glue Combinations: Findings of the European Plywood Project

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Abstract

Plywood products represent a valuable market within Europe, and their manufacture often depends on the raw materials available per country of origin. Thus there is considerable variation in material types. To better understand the materials and the properties of these various types of plywood, the European Commission have funded a project (PLYWOOD, G6RD-2000-00273) where among other things, the current market within Europe and the screening of wood type and glue is being evaluated.

This paper will consist of two sections. The first will be concerned with the current market trends for plywood in Europe, which will take into account the available raw materials. An important directive within the project is to evaluate the current situation in NAS-countries, and to this end, a survey of the Baltic states and Poland is also included, along with an example of a representative company.

The second section of the paper will consider the screening of the plywood produced, with emphasis on the type of wood and adhesive used in the manufacture. These will represent different groupings where the generic form of the wood (for example its colour) will be contrasted to the glue type used (including such systems as UF, MUF, PVAc, PF). Based on these findings, evaluations of different materials will be made, and from these findings, physical product evaluations will be made (see article by Burkhard Plinke - Automatic determination of wood fibre failure percentage of plywood shear samples). By combining all findings it is hoped to establish protocols for a revised version of the European standard for the evaluation of the plywood glue bond performance (EN 314).

Quality monitoring for smart processing of fibre boards through on line spectroscopy

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Abstract

Wet processed fibre boards made from wood can be used in many industries. Besides the production of furniture, tailor made interior parts for the automotive industry is a main target for production. Although the use of a great variety of different raw materials and many special processing steps offer the option to produce tailor made boards, the full potential has not yet been exploited.

Therefore several different on-line spectrometer (UV/VIS/NIR) have been developed for a knowledge based feed back and feed forward controlled production of fibre boards with varying raw materials of different wood species. The sensors measure the kind of wood (mainly miscellaneous wood mixtures of spruce, beech and bark) directly on a conveyor belt as well as the severity of the thermal steam treatment and activation of the lignin directly in the blow pipe. With this information it is possible to produce boards with a specific mechanical and chemical performance and it is possible to guarantee and maintain a high level quality standard.

Creep testing at elevated temperatures - suggested test methods for adhesives other than phenolic or aminoplastic

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Summary

SP has compared two methods for creep rupture testing of adhesives at elevated temperatures, European 3535 and European 4680. The two methods are based on the American standards ASTM D 3535 - 92 and ASTM D 4680-92 respectively. The suitability of the two methods to determine creep properties of structural wood adhesives is evaluated as part of the work within the standardisation group CEN/TC193/SC1/WG4.

The study has primarily been based on experimental comparison of the two accelerated creep test methods. FE simulations of stress patterns in the test samples have been made. A reference test method based on tensile shear tests at 20 °C / 65 % RH has been developed.

The two methods have shown to be able to separate adhesives with different creep properties. Both methods have shown to have advantages and disadvantages.

The European 3535 method is a creep rupture method using six relatively complex test samples with 12 gluline surfaces each tested in compression shear. The test sample is subject to a load corresponding to 3 N/mm^2 shear stress and stored two weeks in each of three climates in sequence: 80 °C / dry followed by 20 °C / 85 % RH and 50 °C / 75 % RH. The result of tests according to the European 3535 method is a pass/fail answer.

The European 4680 method is based on an established principle for determining creep properties of structural materials. The method is based on 50 test samples containing one gluline each. The test is done in two constant climates 50 °C / 75 % RH and 80 °C / dry. Groups of ten test samples are subject to loads corresponding to a range of shear stress levels and median time to failure is determined for each load level. The median time to failure at each load level is used to predict the shear stress at 50 °C / 75 % RH corresponding to 10 000 h time to failure. The result of tests according to European 4680 is a prediction of the shear stress corresponding to a specific time to failure in 50 °C / 75 % RH in combination with the median time to failure at 3 N/mm^2 shear stress for samples tested at 80 °C.

Both methods have shown to be sensitive to variations in sample geometry. Both methods apply the force to the gluline by coil springs, causing uncontrolled variations in stress patterns due to the load not being centred in the gluline. Suggested test requirements have been determined theoretically. Correlated tests with accelerated creep tests and long term tests of full size specimens have not been made.

The main advantage of the 3535 method is a relatively simple test procedure and short test period. The main disadvantages are the difficulty to set requirements as comparative tests are missing in combination with the pass/fail answer.

The main advantage of the 4680 method is the numerical test result produced according to established principles. The result both makes it possible to compare relatively similar adhesives and makes it relatively easy to re-evaluate older data if requirements are to be altered in the future. The main disadvantages are a longer test period and problems to handle adhesives with insignificant creep tendency.

The results of the study indicate that the European 4680 method presently can be implemented as a test procedure to determine creep properties of PU adhesives. The results of the study indicate that the European 4680 method is in need of further studies in order to set requirements.

Automatic determination of wood fibre failure percentage of plywood shear samples

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Abstract

Various wood species and glue types are used in plywood production all over Europe: The range comprises apparently light species such as Nordic birch as well as medium-coloured beech or dark exotic species and light glue types such as urea as well as dark phenolic. One of the main parameters of glue bond performance beside the shear strength is the percentage of wood fibre failure in shear strength samples. The EN 314 standard requires this wood fibre failure percentage to be estimated visually. A joint European research project (PLYWOOD G6RD-2000-00273) will improve the use of these standards and propose procedures for calibration and testing. A training image database with various types of shear samples for the training of operators and databases to support internal and external factory controls and production monitoring according to EN 326 will be supplied.

One task is the automatic visual evaluation of scanned images of the fracture surfaces. A shear sample set (10 pieces) is mounted into a plastic sample holder. Digitized images of the sample set are created using a standard office scanner and processed using a computer program in a PC. Different image processing procedures such as thresholding, gradient filtering, smoothing, and a combination thereof, have to be applied, depending on glue type and wood species, and are included as options in the program. The image of each piece is converted into a binary image where wood and glue area are segmented and area sizes can be measured. This can be output in table form with the estimated wood fibre failure percentages for all pieces of the sample. The computer program and procedures for implementation and operation are currently under development and will be ready for use in the plywood industry within the next months.

Development in wood fiber composites

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Summary

Composites are made of distinct elements with the target to produce materials which have better properties than the individual elements. The following presentation refers to composites made of wood particles and plastics. Different plastic materials can be used as the matrix for such kind of composites, and the ratio of wood can vary within a wide band ranging from 10 to 90%. Wood particles are being used as filler or reinforcing element. Depending on the planned application of the composite, wood can be added as powder, sawdust, chips or fibres. Historically, first thermosets were used as a suitable basis for wood composites.

Such products are still produced in big amounts and could defend their position in the market. The use of thermoplastics for the creation of composites led to a new generation of materials. Most frequently used thermoplastics are polypropylen (PP), polyethylen (PE), polyvinylchlorid (PVC) but as well as polystyrene (PS), PET or ABS. Besides this, interesting developments using starch as matrix for wood composites started recently in Austria resulting in biodegradable materials. Woodfiber/plastics composites are processed mainly with technologies as used in the plastic processing industry: extrusion, injection molding, thermoforming, pressing and calendring.

More Information:

www.boku.ac.at/holzforschung

www.kplus-wood.at

www.cost.cordis.lu