The bending performance of T&G joints subjected to concentrated loads

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In Part 1 of this research work, a description of the small-scale concentrated load test is presented. Unjointed and jointed (glued/unglued) particleboard samples were subjected to a mid-span concentrated load up to failure. The failure loads were compared and conclusions were drawn with regard to the influence of gluing the T&G joints on the structures' resistance to concentrated loads.

The stiffness, considered to be the slope of the linear region of the load-displacement chart, has been calculated. Linear regression lines between failure load and stiffness were sought. Relatively good correlation (R² = 0.88) was found for the unjointed samples, however, less good correlation (R² = 0.63) was found for the glued jointed samples and even worse correlation (R² = 0.53) was found for the unglued jointed ones. Generally, the stiffness can be considered as a useful indicator for the failure load and failure mode of the particleboard samples. For increased stiffness values the boards tend to fail at higher loads and in a more brittle mode, providing a sudden vertical drop in the load/displacement curves. At values over 456 N/mm 'catastrophic' failure modes (instant total failures) were observed (span size of 450 mm and thickness of the boards of 18 mm). However, at values less than 420 N/mm the failure mode was more ductile, described by 'smooth' post failure curves. By gluing the joints the stiffness of the structure increases significantly. The failure load also increases but not by the amount that is statistically significant. The failure mode of glued jointed structures seems to be more ductile when compared to unglued ones. This means that after the maximum failure load has been achieved, the boards continue to sustain the load for a longer period of time up to ultimate failure occurs.

Biegeverhalten von Nut-Feder-Verbindungen bei zentrischer Belastung

In diesem ersten Teil werden Biegeversuche an kleinen Spanplattenproben, die zentrisch belastet wurden, beschrieben. Die Bruchlast von unverbundenen und verbundenen (verleimt und unverleimt) Proben wurde bei zentrischer Belastung ermittelt. Aus dem Vergleich der Ergebnisse werden Rückschlüsse gezogen auf den Einfluß der Verleimung auf die Struktureigenschaften der Nut-Feder-Verbindungen. Die Steifigkeit wurde berechnet aus der Steilheit des linearen Bereichs der Verformungskurve. Die lineare Regression ergab gute Korrelationen für unverbundene Proben (R² = 0.88), schwache für verleimte Proben (R² = 0.63) und noch schwächer für unverleimte Verbindungen (R² = 0.53).

Allgemein erwies sich die Steifigkeit der Spanplatten als guter Indikator für die zu erwartende Bruchlast und die Art des Bruchs. Bei erhöhter Steifigkeit erfolgte der Bruch bei höherer Belastung, war zunehmend spröder und zeigte als ein plötzlicher senkrechter Abfall in der Verformungskurve. Bei Werten oberhalb 456 N/mm erfolgte ein unmittelbares totales Versagen (Katastrophenfall). Bei Werten unterhalb 420 N/mm war der Bruchverlauf zäher mit "sanfterem" Kurvenverlauf nach dem Bruch.

Glossary

Sample A  particleboard samples obtained from source A
Sample B  particleboard samples obtained from source B
T&G  tongue and groove joint
LVDT  linear variable differential transformer
FEA  finite element analysis
FEM  finite element model
SSTS  small scale test samples with overall dimensions of (450 × 500) mm
UJ  unjointed (meaning not jointed)
SSTS  under concentrated load at mid span
CE  jointed SSTS subjected to concentrated load at mid-span and positioned over the T&G joint's centre
GR  jointed SSTS subjected to concentrated load at mid-span and positioned at 23 mm from
the centre of the T&G joint, on the groove side

TG jointed SSTs subjected to concentrated load at mid span and positioned at 23 mm from the centre of the T&G joint, on the tongue side

A–UJ/(B–UJ) unjointed SSTs obtained from source A and B respectively

A–CE/(B–CE) unglued (meaning not glued) CE obtained from source A and B respectively

A–GR/(B–GR) unglued GR obtained from source A and B respectively

A–TG/(B–TG) unglued TG obtained from source A and B respectively

A–CE–GL/(B–CE–GL) glued CE obtained from source A and B respectively

A–GR–GL/(B–GR–GL) glued GR obtained from source A and B respectively

A–TG–GL/(B–TG–GL) glued TG obtained from source A and B respectively

X Axis perpendicular to the supports, i.e. parallel to the T&G joint

Y Axis parallel to the supports, i.e. perpendicular to the T&G joint

R’ stiffness [N/mm]

1 Project summary

The main aim of this study is to gain a better understanding of the bending behaviour of jointed particleboard deckings subjected to concentrated loads in the vicinity of the tongue and groove (T&G) joints. The following aspects were studied: failure load and mode – its relationship to stiffness; deformation; the influence of gluing on deformation and load carrying capacity. The research strategy employed was to design a small-scale bending experiment for which the above aspects could be established by a comparison of the unjointed boards with the jointed ones (glued/unglued).

The deflection of the unjointed and jointed (glued/unglued) boards, subjected to a mid-span concentrated load, was monitored with nine linear displacement transducers. These were placed, on the bottom surface of the boards, in fixed positions relative to the loading head and the centre of the T&G joint. The deflected shapes of the samples were interpreted in the elastic region of deformation.

Finite element models of the jointed and unjointed particleboard samples subjected to a central concentrated load were created. In the analyses, the actual material properties determined in tests were used and the T&G joints were simulated by springs. The deformation results of the FE models were compared with the real measurements from the tests and a good agreement was found. This report is presented in two parts:

- Failure loads and modes (Part 1),
- Deformation and FEA (Part 2).

2 Introduction

The primary parameters controlling the performance of a material in flooring are bending strength (modulus of rupture), bending stiffness (modulus of elasticity) and behaviour under concentrated load (TRADA 1992). Most of the failures that occur in ‘real life’, in domestic floor or flat roofing systems are due to concentrated loads. In such cases, it is the decking which fails rather than the joists (Abbott 1989). In tongue and grooved panel flooring, the critical areas, where failures usually occur, are the unsupported tongue and groove (T&G) joints perpendicular to the joists. The performance of T&G joints subjected to concentrated loads were of interest for this investigation.

When a concentrated load acts on a floor decking in the area between the joists, it produces a complex three-dimensional stress field, including shear stress and bending stress in the vicinity of the load. This is a local effect, which has been thoroughly studied for jointed particleboard decking at TRADA (Timber Research and Development Association). The ‘TRADA’ method is a small-scale pure punching shear method, in which the bending effect is minimised (Soothill 1983). Therefore, the results obtained by Soothill (1983) for jointed and unjointed boards refer only to the punching shear effect of concentrated loads. There is need for an understanding of the bending effect of concentrated loads on jointed deckings. Therefore, in this study a small-scale bending test was carried out to assess the bending performance of unjointed and jointed (glued and/or unglued) samples under concentrated loads.

3 Materials and methods

The most common board used for domestic floor and roof decking in the UK, is the moisture resistant 18 mm thick particleboard, type C4(M), (currently defined as P5 in BS EN 312-5: 1997). This material was used for investigation in this work. This grade of boards from two different industrial manufacturers (noted as source A and B), leading distributors on the European market, were purchased.

From each particleboard sheet (2400 mm × 600 mm), four test samples were cut, each with overall dimensions of 500 mm × 450 mm (Fig. 1). From these one was cut to provide an unjointed sample and the other three were cut to provide jointed samples. For the jointed specimens the particleboard sheet was cut longitudinally and the two opposite profiles, tongue and groove, were matched ‘back to back’, so as to form the middle joint of the samples. The test specimen labels reflected the sheet number, from which they were cut, and the positioning within each sheet. In this way the results of the different test cases could be compared directly, avoiding the variability in density of the replicates.

In order to maintain a constant span size and central positioning of the loading head, relative to the supports, but different placement relative to the T&G joint (Fig. 2), the groove and tongue side of the jointed samples were cut to different sizes (Fig. 3).