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STRENGTH AND STIFFNESS OF JOINTS IN RATTAN FURNITURE

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By

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This thesis is dedicated to the author’s beloved wife;

Khamsaton Sayuti

and their energetic children;

Wan Watari
Wan Amanina

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LIST OF ABBREVIATIONS

N	Nailed Rattan Joint
S	Screwed Rattan Joint
N+B	Nailed and Bound Rattan Joint
S+B	Screwed and Bound Rattan Joint
SG	Specific Gravity
MC	Moisture Content
$\varnothing$	Diameter of Rattan
P-X	Load-Displacement Curve
P-θ	Load-Rotation Curve
Puw	Ultimate Withdrawal Load
UWS	Ultimate Withdrawal Strength
Sw	Withdrawal Stiffness
S1	Initial Slope of Lateral P-X Curve
S2	Secondary Slope of Lateral P-X Curve
PA	First Lateral Load Peak
PB	Second Lateral Load Peak
P0.05	Bending Load at 0.05 rad Joint Rotation Angle (Similarly applied to P0.02, P0.10 & P0.15)
ANOVA	Analysis of Variance
ns	Not Significant at 95% Probability Level
*	Significant at 95% Probability Level
**	Significant at 99% Probability Level

Sb	Bending Rotational Stiffness
L	Moment Arm
Ssb	Side Bending Rotational Stiffness
E	Modulus of Elasticity
I	Moment of Inertia
W_0	Distributed Load
θ	Rotation Angle in radian
J1	A Joint Constructed from the Rattan Pole Numbered as 1 (Similarly applied to J2, J3,..., J74 & J75)

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Chairman: Ir. Dr. Shahnor Basri

Faculty: Engineering

A study was conducted with the objective of gathering information on the strength and stiffness properties and behaviour of joints in rattan furniture subjected to various kinds of load. Four types of joint commonly found in rattan furniture making industry, *i.e.*, nailed (N), nailed and bound with rattan rope (N+B), screwed (S), and screwed and bound (S+B) were tested in withdrawal, lateral and bending loads. The results showed that in general screwed joints were stronger and stiffer than nailed joints. Furthermore, although bindings have increased the joint strength, the bindings have not improved the joint stiffness against the all types of load, except the side bending load. Regression analyses showed that the rattan specific gravity has significantly influenced

the withdrawal and lateral strength. The results of the analyses have also provided some insights especially on how the nails, screws or bindings were contributing to the strength and stiffness properties of the joints. Through this knowledge, theoretical models were developed for predicting the bending and side bending rotational stiffnesses of the joints. In the first model, the bending stiffness was proportional to the withdrawal stiffness of joint. The second model showed that the side bending stiffness was much determined by the bending properties (EI) of the embedded fasteners. Beside its predictive functions, the theoretical models were envisaged to be a basis for future efforts to develop better rattan jointing methods.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi syarat ijazah Sarjana Sains.

KEKUATAN DAN KEKAKUAN PENYAMBUNGAN DI DALAM PERABOT ROTAN

Oleh

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Satu kajian telah dijalankan bertujuan mendapatkan maklumat mengenai ciri-ciri kekuatan dan kekakuan serta perlakuan penyambungan-penyambungan di dalam perabut rotan terhadap pelbagai jenis beban. Empat kaedah penyambungan yang biasa didapati di dalam industri pembikinan perabut rotan, iaitu berpaku (N), berpaku serta diikat dengan tali rotan (N+B), berskru (S), dan berskru serta diikat (S+B) telah diuji dengan beban-beban tarikan, sisian dan lenturan. Hasil ujian menunjukkan bahawa pada amnya penyambungan berskru lebih kuat dan kaku berbanding penyambungan berpaku. Seterusnya, walaupun ikatan tali rotan telah didapati dapat meningkatkan kekuatan penyambungan, terutama yang berpaku terhadap beberapa jenis beban, ikatan tersebut tidak menambahkan kekakuan penyambungan

terhadap semua jenis beban kecuali beban lenturan tepi. Analisis regresi menunjukkan bahawa graviti tentu rotan sangat mempengaruhi kekuatan tarikan dan sisian penyambungan. Keputusan analisis ini juga telah memberikan beberapa pemahaman terutamanya bagaimana paku, skru atau tali ikatan menyumbang ke atas ciri-ciri kekuatan dan kekakuan penyambungan. Menerusi pengetahuan tersebut, model-model teoretikal telah dibangunkan bagi meramal ciri-ciri kekakuan penyambungan rotan terhadap beban lenturan dan lenturan tepi. Di dalam model pertama, kekakuan lenturan telah didapati berkadar terus dengan nilai kekakuan tarikan penyambungan. Manakala model kedua telah menunjukkan bahawa kekakuan lenturan tepi sangat ditentukan oleh ciri-ciri kekakuan lenturan (EI) yang dimiliki oleh paku atau skru. Selain daripada fungsi ramalannya, model-model teoretikal ini diharap dapat dijadikan asas kepada usaha-usaha seterusnya untuk membangunkan kaedah penyambungan rotan yang lebih baik.

CHAPTER I

INTRODUCTION

It has been conventionally agreed that the overall performance of any engineering structure such as a bridge, a roof truss or even a furniture frame, is very much dependent on the behaviours of its joints or connections. Many studies have been conducted to investigate the behaviour of steel, concrete and timber structures. However, virtually none is done on structures made from rattan. Rattans are connected and made into structures mainly for making furniture frame. By understanding the behaviour of its joints, a rattan furniture design could be engineered for optimum performance.

Rattan, a word derived from a Malay term 'rotan' (Whitmore, 1973) is referred to spiny climbing plants belonging to a large subfamily of palms known as the Calamoideae (Uhl and Dransfield, 1987). There are about 600 rattan species arranged in 13 genera (Dransfield, 1992). However, only a small portion of the entire species are commercially used. For instance, there are 104 species of rattan in Peninsular Malaysia, but only 20 species are being utilized (Choo and Daljeet, 1985).

Rattan enters world of commerce as whole poles and in split forms as cores and skins. Being cylindrical and uniform in shape, light in weight but strong, pliable and durable, they are excellent materials for various end-products. The large-diameter (>18 mm) rattan poles are used mainly for making furniture frames (Plate 1) while the small-diameter (<18 mm) poles are woven into baskets and utility boxes (Plate 2). The split rattans such as skins and cores, beside being used for the wrapping of rattan furniture joints, are also used in wicker works and for making handicraft items (Choo and Daljeet 1985; Win and Jumogot, 1991; IDRC, 1992; Basu, 1992).

The rattan furniture manufacturing industry in Malaysia has grown significantly in the past decade. The export values of rattan furniture has increased from a mere RM 2.8 million in 1980 to RM 90.4 million in 1993 (MPI Malaysia, 1994). However, despite these delighting figures, the quality of the furniture produced is still considered lower than those manufactured in the Philippines, Hong Kong and Singapore. Many aspects of the local manufacturing industry need to be improved in order to obtain better quality rattan furniture. The strength and stiffness of rattan furniture is one aspect to look into.

Plate 1. A Rattan Dining Chair

It has been a common practice among the rattan furniture manufacturers in Malaysia to build rattan furniture according to aesthetic value with little attention given to the furniture strength characteristics. The designs are imitated from those found in international magazines and sometimes altered to meet the taste of local consumers. Even if a design has been proven to survive tremendous load and misuses (because it is overdesigned), the lack of knowledge often leads the manufacturers to use rattan and fasteners of incorrect properties. As a result, the furniture would not perform as expected and furniture of a same design would not behave similarly, from the engineering point of view.

Plate 2. Rattan Baskets and Utility Box