คานไม้ดัดในช่วงอินอีลาสติก

นายสุพจน์ วัชโรทยางกูร

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต

แผนกวิชาวิศวกรรมโยธา

บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย

พ.ศ. ๒๕๒๑

INELASTIC BENDING OF WOOD BEAM

Mr. Suphod Watcharotayangul

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering
Department of Civil Engineering
Graduate School
Chulalongkorn University
1978

Thesis Title	Inelastic Bending of Wood Beam
By	Mr. Suphod Watcharotayangul
Department	Civil Engineering
Thesis Advisor	Associate Prof. Dr. Vinit Chovichien

Accepted by the Graduate School, Chulalongkorn University in partial fulfillment of the requirements for the Master's degree.

Visid. Prachuabmoh ..... Dean of Graduate school

(Professor Visid Prachuabmoh Ph.D.)

Thesis Committee

.....Niwat. Daranandana.....Chairman

(Professor Niwat Daranandana Ph.D.)

S. Charoenphao.

.....Member

(Professor Sanan Charoenphao M.S.C.E.)

V. Thammongkol.....Member

(Associate Professor Vatana Thammongkol M.S.C.E.)

.....V. Chovichien.....Member

(Associate Professor Vinit Chovichien Ph.D.)

หัวข้อวิทยานิพนธ์	คานไม้ดัดในช่วงอินอีลาสติก
ชื่อนิสิต	นายสุพจน์ วัชโรทยางกูร
อาจารย์ที่ปรึกษา	รองศาสตราจารย์ ดร.วินิต ช่อวิเชียร
แผนกวิชา	วิศวกรรมโยธา
ปีการศึกษา	2520

บทคัดย่อ

การศึกษาได้ทดลองกระทำกับไม้แดง ไม้เคี่ยม และไม้เต็งอันเป็นสามชนิดในไม้เนื้อแข็งของประเทศไทย เพื่อจะหาพฤติกรรมทางด้านการโก่งดัดภายใต้แรงกระทำ คานหลักหกตัวขนาดหน้าตัด 7 x 21 ซม. และช่วงคานยาว 3.60 เมตร และคานขนาดเล็ก 18 ตัวถูกใช้ในการทดลอง ความเครียดทางแนวยาวของคานหลักถูกวัดโดยเครื่องวัดความเค้นทางไฟฟ้า

ผลการทดลองแสดงให้เห็นว่า แกนสะเทินของคานเลื่อนต่ำลงไปทางด้านแรงดึง เนื่องมาจากการกระจายความเครียด ผลการทดลองถูกนำมาเปรียบเทียบกับทฤษฎีที่มีอยู่ก่อนแล้ว โดยการวิเคราะห์ทางสถิติ และความน่าจะเป็นไปได้จะได้ค่าโมเมนต์ประลัยของคานไม้เนื้อแข็ง เท่ากับ 142.5 คูณความกว้าง คูณความสึกยกกำลังสอง มีหน่วยเป็น กก.-ซม.

Thesis Title	Inelastic Bending of Wood Beam
Name	Mr. Suphod Watcharotayangul
Thesis Advisor	Associate Prof. Dr. Vinit Chovichien
Department	Civil Engineering
Academic Year	1977

ABSTRACT

The experimental study were made on Dang,Kiem and Teng three of Thai hard wood to determine their flexural behavior under loading. Six main beams of 7 x 21 cm. cross section and 3.60 m. span length and 18 small beams were tested and longitudinal strains of the main beams were measured by means of electrical strain gages.

The results show that neutral axis of the beam shifted down to the tension side as a result of stress redistribution. The test results were also compared with the existing theoretical analysis. By statistical and probability analysis, the ultimate flexural moment of Thai hard wood is 142.5 bh^2 kg-cm.

ACKNOWLEDGEMENT

Sincere thanks and gratitude, are extended to the Civil Engineering Department and the Graduate School, Chulalongkorn University without which this research would have been impossible.

The writer wished to express his heartful appreciation to the kind guidance, supervision and encouragement of his advisor Associate Professor Dr. Vinit Chovichien through out this work. Thanks are also due to his Thesis Committee, Professor Dr. Niwat Daranandana, Professor Sanan Charoenphao, Associate Professor Vatana Thammongkol.

Thanks are also extended to Assistance Professor Dr. Kulthorn Silapabanleng and the Forest Product Co. for the given of the resocinal glue using in the research. Also to Dr. Chavin Iemsopana for the imported electrical strain gages.

Special thanks is due to the library of Kasetsart University for the interlibrary loan service of the literature copy from abroad without any charge, also to Miss Araya Rujisathien for language checking.

Finally specially thanks are also given to all those who participated in the experimental work.

TABLE OF CONTENTS

TITLE	PAGE
Title Page	I
Thesis Approval	II
Abstract	IV
Acknowledgement	VI
Table of Contents	VII
List of Tables	IX
List of Figures	X
Notations	XII

CHAPTER

I INTRODUCTION..... 1

1.1 Historical Introduction..... 1

1.2 Purpose and Scope..... 5

II THEORETICAL ANALYSIS..... 7

2.1 Assumption..... 7

2.2 Trapezoidal Distribution..... 7

2.3 Second Degree Parabola Distribution.....10

III BASIC PROPERTIES OF WOOD.....14

3.1 Static Bending Tests.....15

3.2 Compression Parallel to Grain Tests.....15

3.3 Tension Parallel to Grain Tests...16

3.4 Shear Parallel to Grain Tests.....17

TITLE PAGE

CHAPTER

IV FABRICATION AND ANALYSIS OF MAIN BEAM..26
4.1 Size of Main Beam.....26
4.2 Fabrication of Main Beam.....27
4.3 Analysis of Main Beam.....28
V TESTING AND RESULTS.....32
5.1 Measuring Devise.....32
5.2 Testing Procedure.....33
5.3 Test Results.....34
VI DISCUSSION OF TEST RESULTS
AND CONCLUSION.....53
6.1 Discussion of Test Results.....53
6.2 Conclusion.....60
REFERENCE.....62
APPENDIX A.....65
APPENDIX B.....72
APPENDIX C.....79
VITA.....86

LIST OF TABLES

TABLE	TITLE	PAGE
3.1	Mechanical Properties of Dang Wood	20
3.2	Mechanical Properties of Kiem Wood	21
3.3	Mechanical Properties of Teng Wood	22
3.4	Coefficient of Bending Moment of Dang Wood by the Principle of Second Degree Parabola Approximation	23
3.5	Coefficient of Bending Moment of Kiem Wood by the Principle of Second Degree Parabola Approximation	24
3.6	Coefficient of Bending Moment of Teng Wood by the Principle of Second Degree Parabola Approximation	25
4.1	Calculation of Ultimate Moment of Main Beam	30
5.1	Test Results of Main Beams	38
5.2	Strain Distribution of Main Beam Dang Wood	39
5.3	Strain Distribution of Main Beam Kiem Wood	40
5.4	Strain Distribution of Main Beam Teng Wood	41
6.1	Comparison of Test Results of Main Beams	57
6.2	Comparison of Test Results of Small Specimens	58
6.3	Statistical Distribution of Dang, Kiem and Teng Wood	59

LIST OF FIGURE

FIGURE	TITLE	PAGE
2.1	Stress diagram for trapezoidal . . ... distribution of wood beam at failure.....	8
2.2	Stress diagram for second degree parabola distribution of wood beam at failure.....	10
3.1	Position of laminated main beam.....	14
3.2	Details of tension parallel to grain and shear test specimen.....	18
3.3	Typical failure of small specimen.....	19
4.1	Position of loading on main beam.....	26
4.2	Detail sketch of fabrication set up.....	31
5.1	Detail sketch of a typical beam specimen,. ... showing relative placement of strain gages.....	32
5.2	Main beam under loading.....	36
5.2a	Main beam at failure loading.....	37
5.3	Load deflection curve of main beam DA, DB.....	42
5.4	Load deflection curve of main beam KA, KB.....	43
5.5	Load deflection curve of main beam TA, TB.....	44
5.6	Strain distribution at various loading.....	45
5.7	Strain distribution at various loading.....	46
5.8	Strain distribution at various loading.....	47
5.9	Mode of failure of main beam DA.....	48
5.10	Mode of failure of main beam DB.....	49
5.11	Mode of failure of main beam KA.....	50
5.12	Mode of failure of main beam KB.....	51

FIGURE	TITLE	PAGE
5.13	Mode of failure of main beam TA	52
5.14	Mode of failure of main beam TB	52
A 1	Load deflection curve of small specimens DA 1, DA 2, DA 3	66
B 1	Stress strain curve of tension test parallel to grain of small specimens DA 1, DA 2, DA 3	73
C 1	Stress strain curve of compression test parallel to grain of small specimens DA 1, DA 2, DA 3	80

NOTATION

A' = cross sectional area ;

A_c, A_t = compressive and tensile stress area ;

A, B, C = constants of the second-degree parabola ;

b = width of cross section ;

dA' = infinitesimal element of cross-sectional area ;

E_c, E_t = modulus of elasticity of compression and tension test parallel to grain ;

h = depth of cross section ;

I = moment of inertia of cross section ;

M_{UL} = ultimate bending moment ;

M_z = bending moment ;

m = slope of straight line equation ;

n = ratio between tensile and compressive strengths;

P = load ;

P_{UL} = ultimate load ;

q = constant of stress line equation ;

R = coefficient of ultimate bending moment of rectangular beam ;

$\overline{SD}$ = standard deviation ;

V = shear ;

$\overline{X}$ = mean value ;

y_d = distance from the infinitesimal element to neutral axis ;

ξ = downward shifting of neutral axis ;

σ_c = longitudinal ultimate compressive stress ;

σ_t = longitudinal ultimate tensile stress ;