2007 D5 IUFRO Forest Products and Environment: A Productive Symbiosis Taipei, Taiwan, 29 October – 2 November 2007

PROPERTIES OF KENAF BOARD BONDED WITH FORMALDEHYDE-BASED ADHESIVES

Paridah Md. Tahir, NorHafizah Abd. Wahab
Jalaluddin Harun

Institute of Tropical Forestry and Forest Products
Universiti Putra Malaysia, Serdang, Selangor, MALAYSIA

Azmi Ibrahim

Faculty of Civil Engineering,
Universiti Teknologi Mara, Shah Alam, Selangor, MALAYSIA

Nor Yuziah Mohd. Yunus

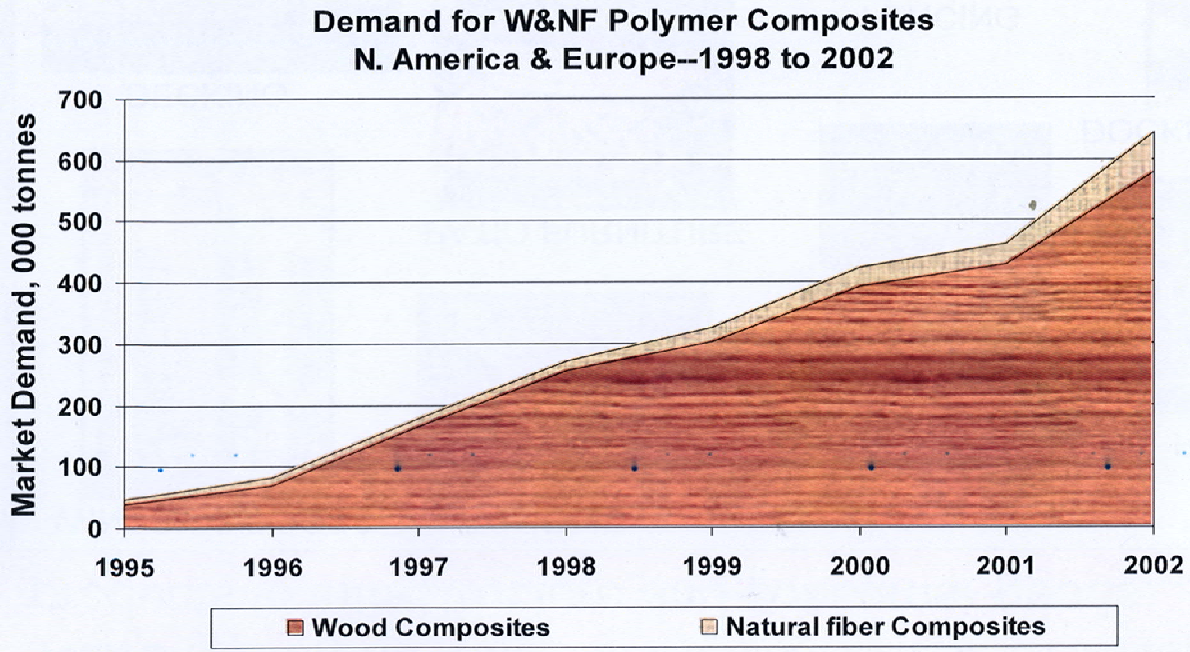
Malayan Adhesives and Chemicals, Shah Alam, Selangor, MALAYSIA

Presentation outline

- ✓ Introduction
- ✓ Kenaf utilisation in Malaysia
- ✓ Objectives of the study
- ✓ Methodology
- ✓ Results and discussion
- ✓ Conclusions

Demand for Wood and Fibre Composite Products

Composite producers have enjoyed double-digit growth in demand since the early 1990s...



Courtesy by Rowell, 2006

FUTURE SCENERIO OF THE MALAYSIAN WBP INDUSTRY

- **Decreasing supply of raw material**
- Implementation of Forest plantations initiatives
- Increase the use of readily available fibre resources
  - small sized logs
  - lesser known / UNDER utilised species
  - forest and mill residues
  - oil palm residues
- Explore new resources for WBP industries :
  - Introduce non-conventional fibre materials:
    e.g.,bamboo, kenaf

World Inventory of Biomass

Fiber Source	World (dry metric tons)
Wood	1,750,000,000
Straws	1,145,000,000
Stalks	970,000,000
Sugar cane bagasse	75,000,000
Reeds	30,000,000
Bamboo	30,000,000
Cotton staple	15,000,000
Core (jute, kenaf, hemp)	8,000,000
Papyrus	5,000,000
Bast (jute, kenaf, hemp)	2,900,000
Cotton linters	1,000,000
Esparto grass	500,000
Leaf (sisal, abaca, henequen)	480,000
Sabai grass	200,000
TOTAL	4,033,080,000

Courtesy by Rowell, 2006

Kenaf – The potential fibre

- In the early 1950s~1970s, U.S.A focused on the strategy of protecting ecological environment, and did the screening research on more than 500 kinds of non-woody materials plant.
- Kenaf was widely considered as the suitable biological resources and potential substitute for fossil fuels and wood-pulps.
- The plant: Good adaptation to environment, fast growing, strong fibres, multiuses, high production of biomass, rich in cellulose, etc.

2007 D5 IUFRO Forest Products and Environment: A Productive Symbiosis Taipei, Taiwan, 29 October – 2 November 2007

KENAF

MALAYSIA'S NEW CROP

2007 D5 IUFRO Forest Products and Environment: A Productive Symbiosis Taipei, Taiwan, 29 October – 2 November 2007

The National Kenaf Agenda

THE NATIONAL TOBACCO BOARD

Universiti Putra Malaysia
Serdang, Selangor

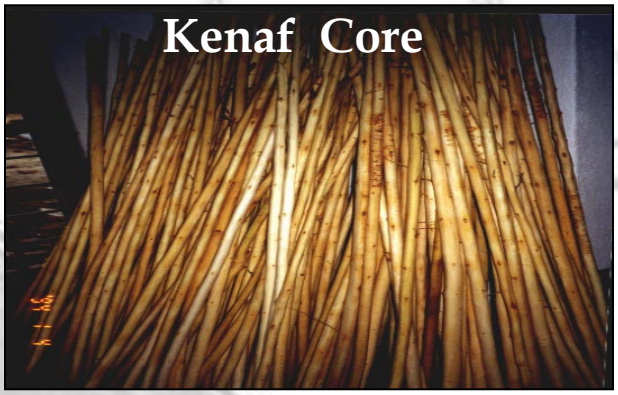
Kenaf trial plot at UPM

Improve fibre properties through Breeding programme

Hand pollination

Fibre Production: from bast and core

Bast fibre and core material of kenaf have very distinct properties



Fibre morphology	Variety KB6		Variety V36	
	Core	Bast	Core	Bast
Length (mm)	0.88	2.51	0.72	2.27
Diameter (micron)	36.78	25.74	36.10	26.59
Lumen (micron)	23.58	13.05	27.48	13.75
Cell wall thickness (micron)	6.60	6.35	4.31	6.42

Scope of the study

- This study evaluates the potential of kenaf as raw material for the production of kenaf board.
- The work comprised three main aspects:

1) Preparation of bast fibres (bast separation and retting process)
2) Evaluation of adhesion properties - buffering capacity and surface wettability
3) Board manufacture and evaluation of board performance.

The objectives of this study were:

- ✓ **To evaluate the properties of kenaf board made utilising bast fibres, core material and the combination of bast fibre and core material.**
- ✓ **To determine the effects of resin types on the properties of kenaf board.**
- ✓ **To compare the performance of kenaf board to those of rubberwood particleboard**

METHODOLOGY

1. Characteristics of Kenaf Stem Used in the Study

Characteristics	Description
Variety	Tainung-2
Soil Type	Sandy Soil (Bris)
Height	4–5 m
Age of Harvesting	4–5 months
Diameter	200–300 mm

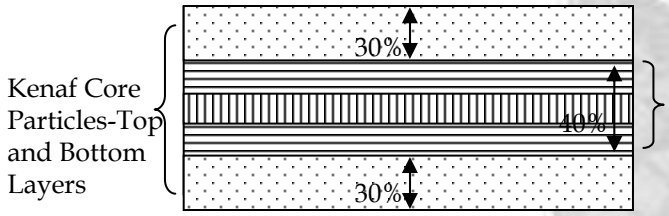
Methodology

2. Experimental Parameters

Variables	Description
Board density	**- 0.5 g/cm^3**
Resin type	**- Urea formaldehyde (UF), Melamine Urea Formaldehyde (MUF), Low molecular weight Phenol Formaldehyde (LPF)**
Bast-core proportion	**Type A 60% core: 40% bast** **Type B 70% core: 30% bast** **Type C 80% core: 20% bast** **Type D 100% kenaf core**
Control	**Type E 100% rubberwood** **Type F 100% whole kenaf (bast + core)** **Type G 30:70 whole kenaf:rubberwood**

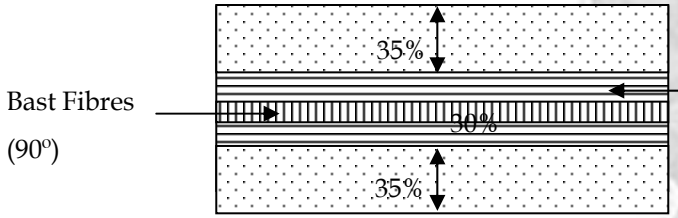
Different board structures made in the study

30% Core: 40% Bast: 30% Core



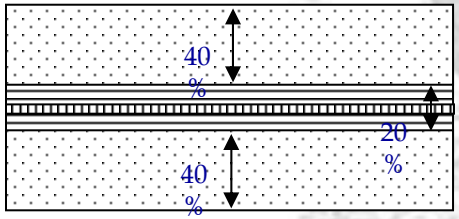
(A)

35% Core: 30% Bast: 35% Core

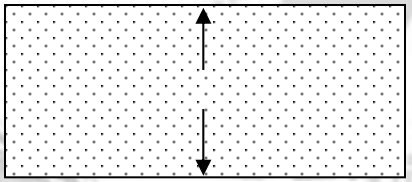


(B)

40% Core: 20% Bast: 40% Core

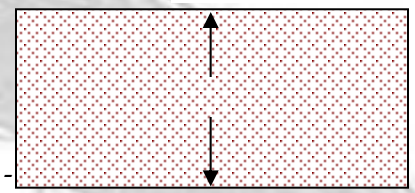


(C)



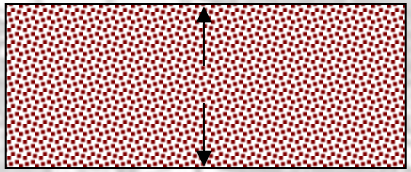
(D)

100% Kenaf core particles



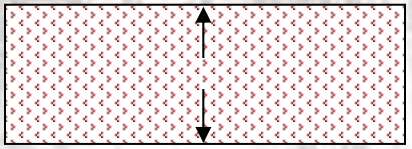
(E)

100% rubberwood particles



(F)

100% whole kenaf particles

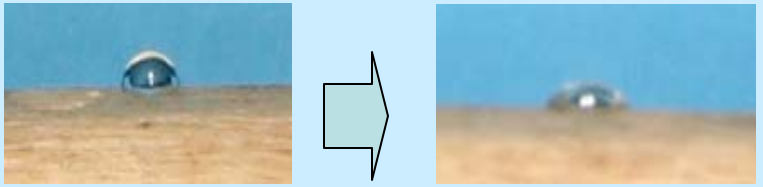
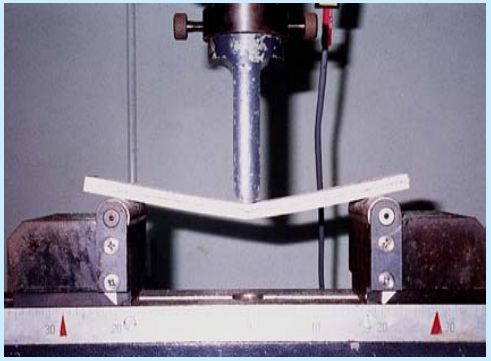


(G)

30-70 whole kenaf: rubberwood particles

Methodology

3. Evaluation of Board Performance

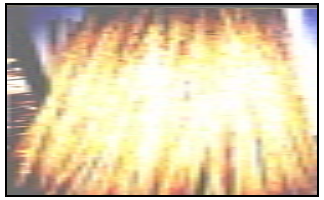
Properties	Type of Test
Adhesion	**- Surface Wettability** 
	- Buffering Capacity
Board Performance	**- Strength (MOR)** **- Stiffness (MOE)** **- Internal Bonding (IB)** **- Thickness Swelling (TS)** **- Water Absorption (WA)**
	-  

Bast fibre preparation

Kenaf Stem

Submerged in Cold Water (20° C) for 7-14 Days

Separating Bast and Core Fibre by Stripping the Bast



Bast Fibres

Core material

Drying Moisture Content 15-18%

Drying Moisture Content 15-18%

Retting

Chipping

Method 1

Immersed in water for 24 hours, drainage and added fresh water, then heated at 70° C for 6 hours. The bast fibres were soaked for 12 hours and reheated for 6 hours. This method took 3 days

Method 2

Immersed in 1% NaOH for 24 hours, drainage and added fresh water, then heated at 70° C for 6 hours. The bast fibres were soaked for 12 hours and reheated for 6 hours. This method took 3 days

Method 3

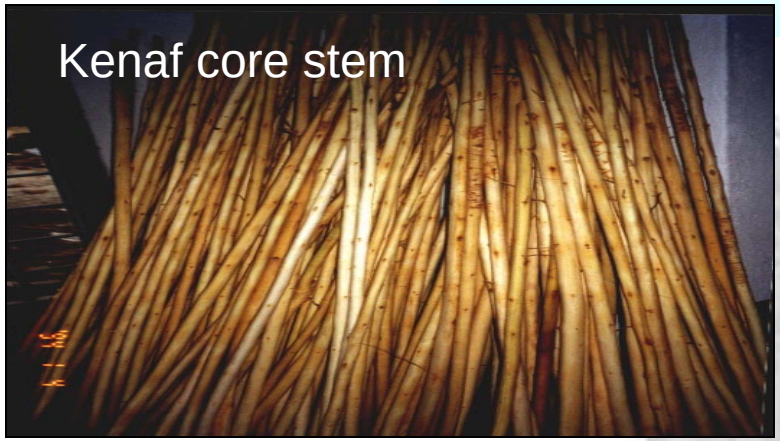
Immersed in water containing 3% NaOH for 6 hours and repeat steps in Method 1

Method 4

Immersed in water containing 5% NaOH for 6 hours and repeat steps in Method 1

Combing → Cleaning → Drying

Chipping, flaking and screening of kenaf core



Kenaf core chips

Board Fabrication

Adhesive application

Kenaf particle boards

Board forming

Hot pressing

UPM
UNIVERSITI PUTRA MALAYSIA

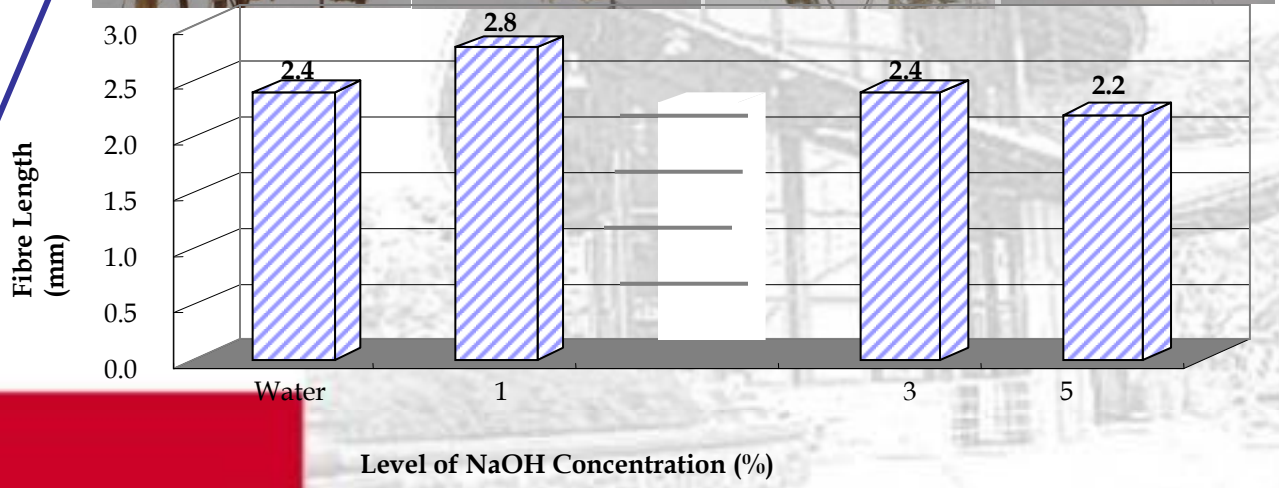
RESULTS AND DISCUSSION

Bast fibre quality

Level of Concentration, %Bast fibre	Water	1% NaOH	3% NaOH	5% NaOH
Yield After Retting, %	74.8^{bc}	78.2^{ba}	79.1^{a}	72.3^{c}

CHEMICAL RETTING

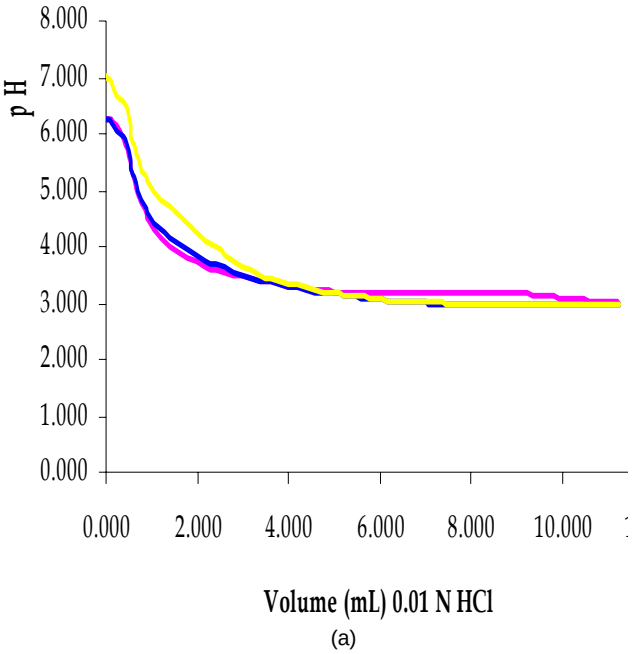
- lighter colour
- more flexible fibres
- Shorter fibres

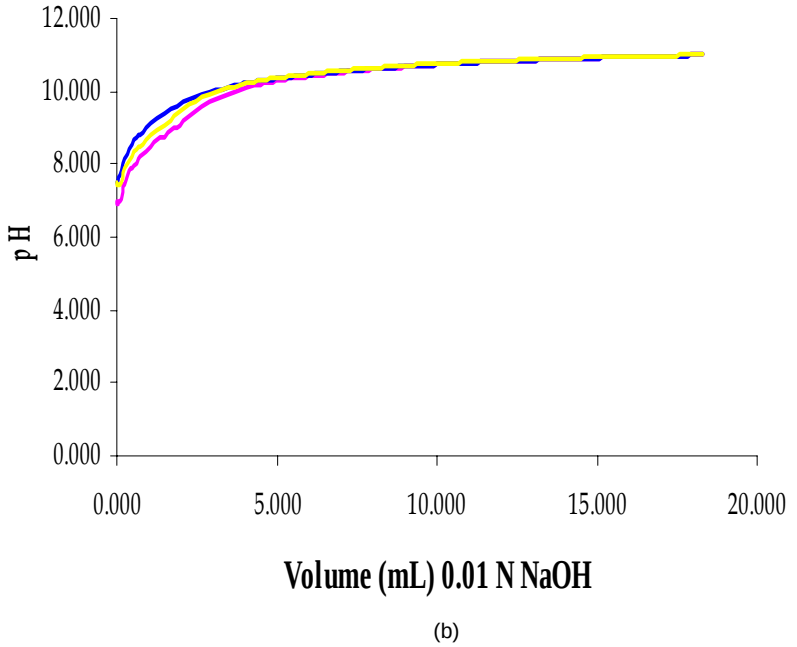


Buffering Capacity

- **Buffering Capacity is a measure of how sensitive is a material towards a change in pH**
- **Very important chriteria for composites – influence the curing of adhesives – the strength of the biocomposites**
- **Both bast and core of kenaf are relatively more sensitive towards acid**
- **Kenaf core and rubberwood exhibit similar resistance towards alkali**

Buffering Capacity





Kenaf core

Kenaf bast

Rubberwood

Comparative Stability of Kenaf Core, Bast and Rubberwood towards (a) Acid and (b) Alkali

Wettability

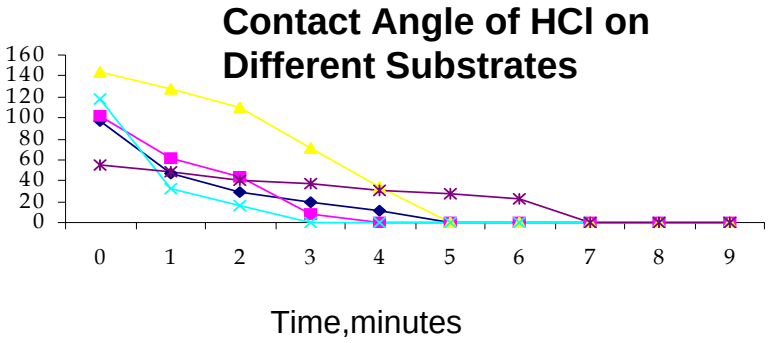
- **Wettability is a measure of ease of adhesive penetration**

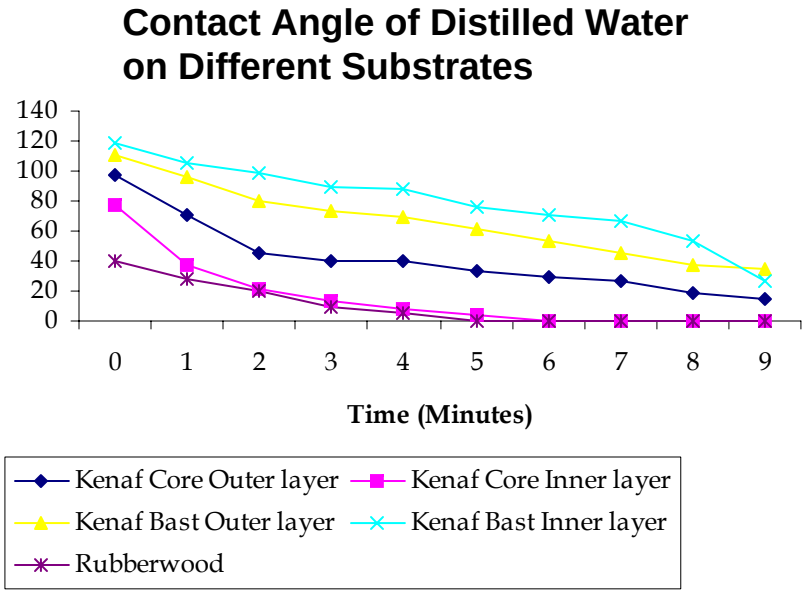
Initial

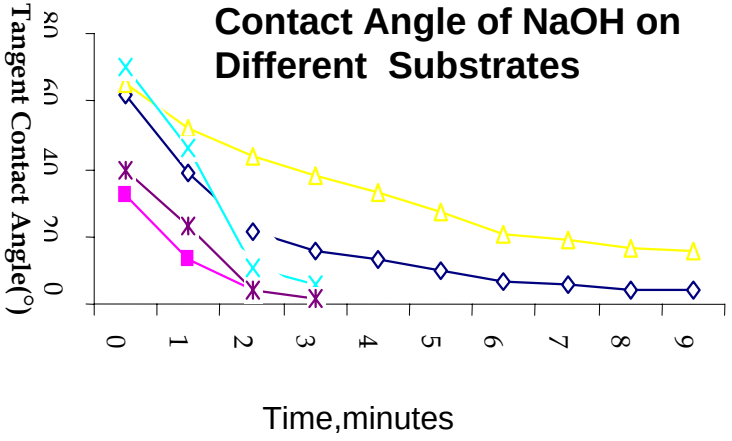
After 2-10 min.

Wettability

- ✓ Outer bast layer (yellow line) exhibits lower surface wettability in all solution
- ✓ Kenaf core and Rubberwood have similar surface wettability (pink and purple lines) except in acid solution

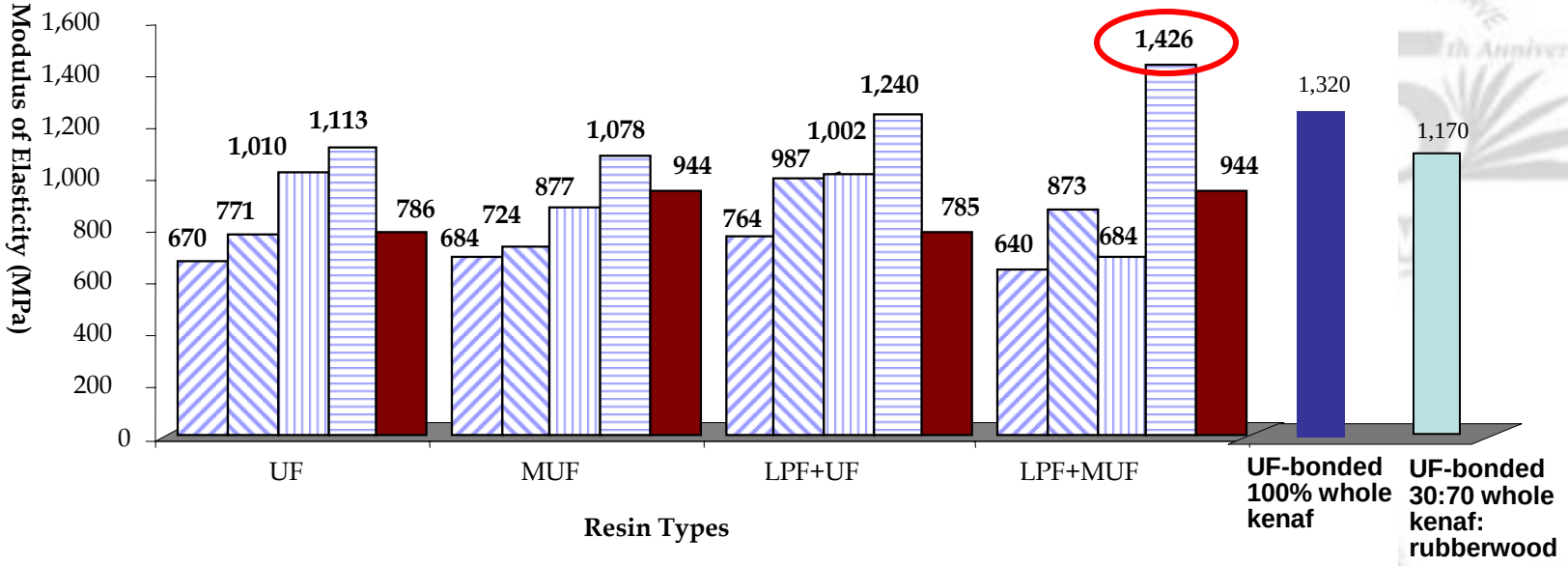






Stiffness - MOE

Board density: 500kg/m³



A (60% core: 40% bast)

B (70% core: 30% bast)

C (80% core: 20% bast)

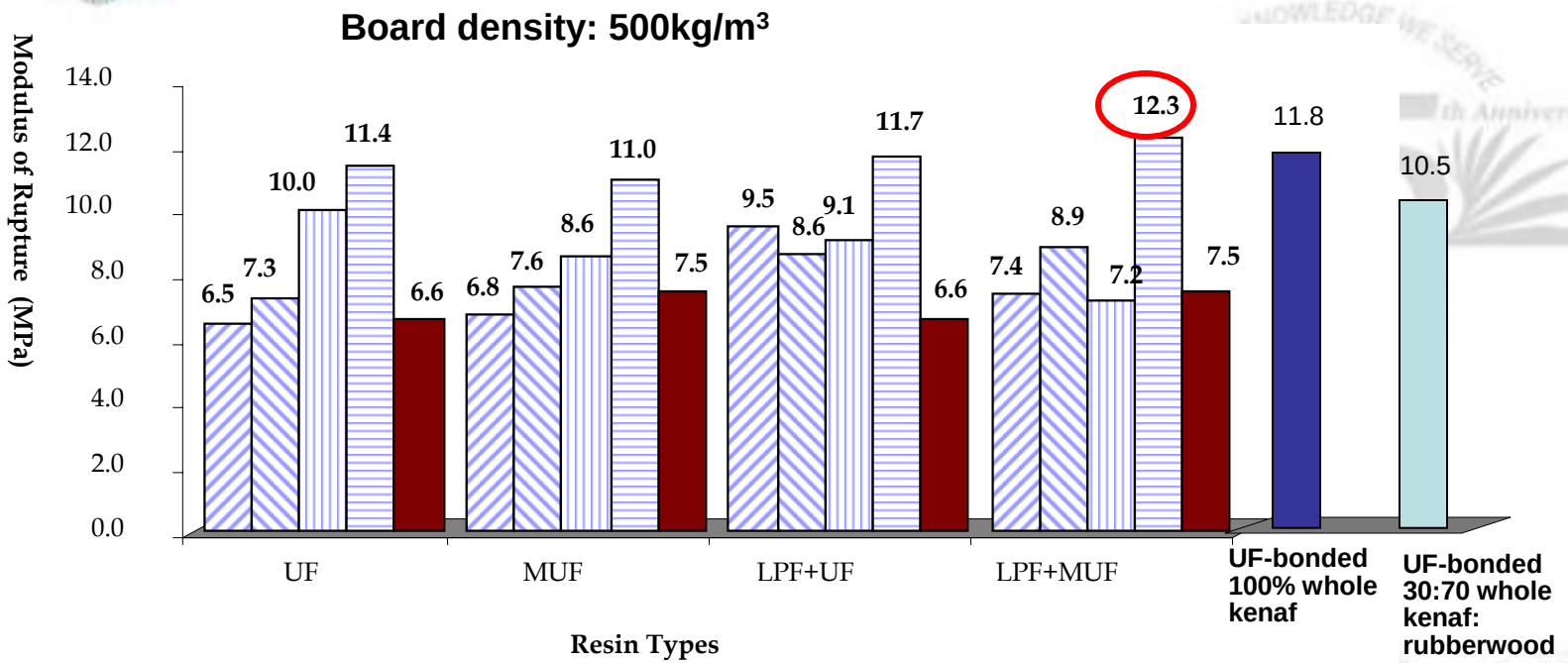
D (100% kenaf core)

E (100% rubberwood)

F (100% whole kenaf)

G (30:70 whole kenaf: rubberwood)

Strength - MOR



A (60% core: 40% bast)

B (70% core: 30% bast)

C (80% core: 20% bast)

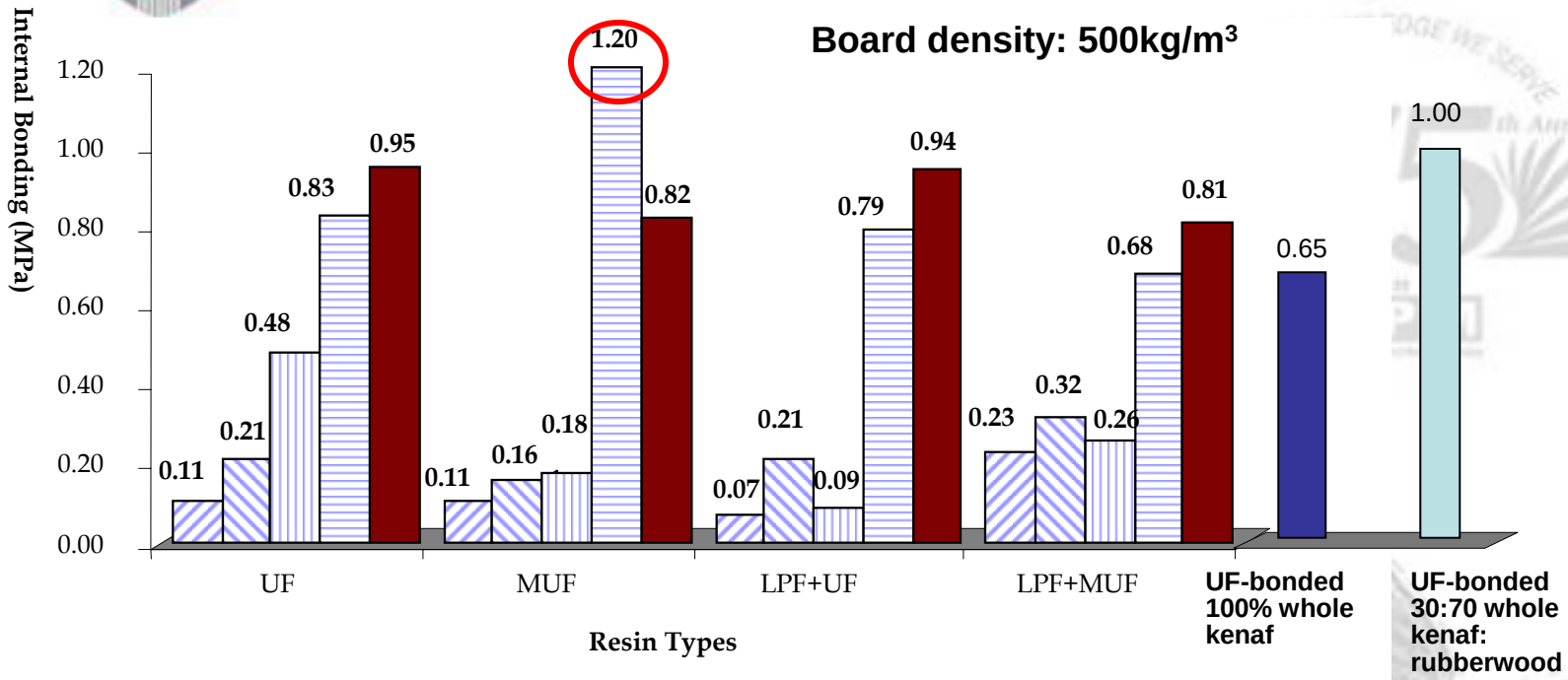
D (100% kenaf core)

E (100% rubberwood)

F (100% whole kenaf)

G (30:70 whole kenaf: rubberwood)

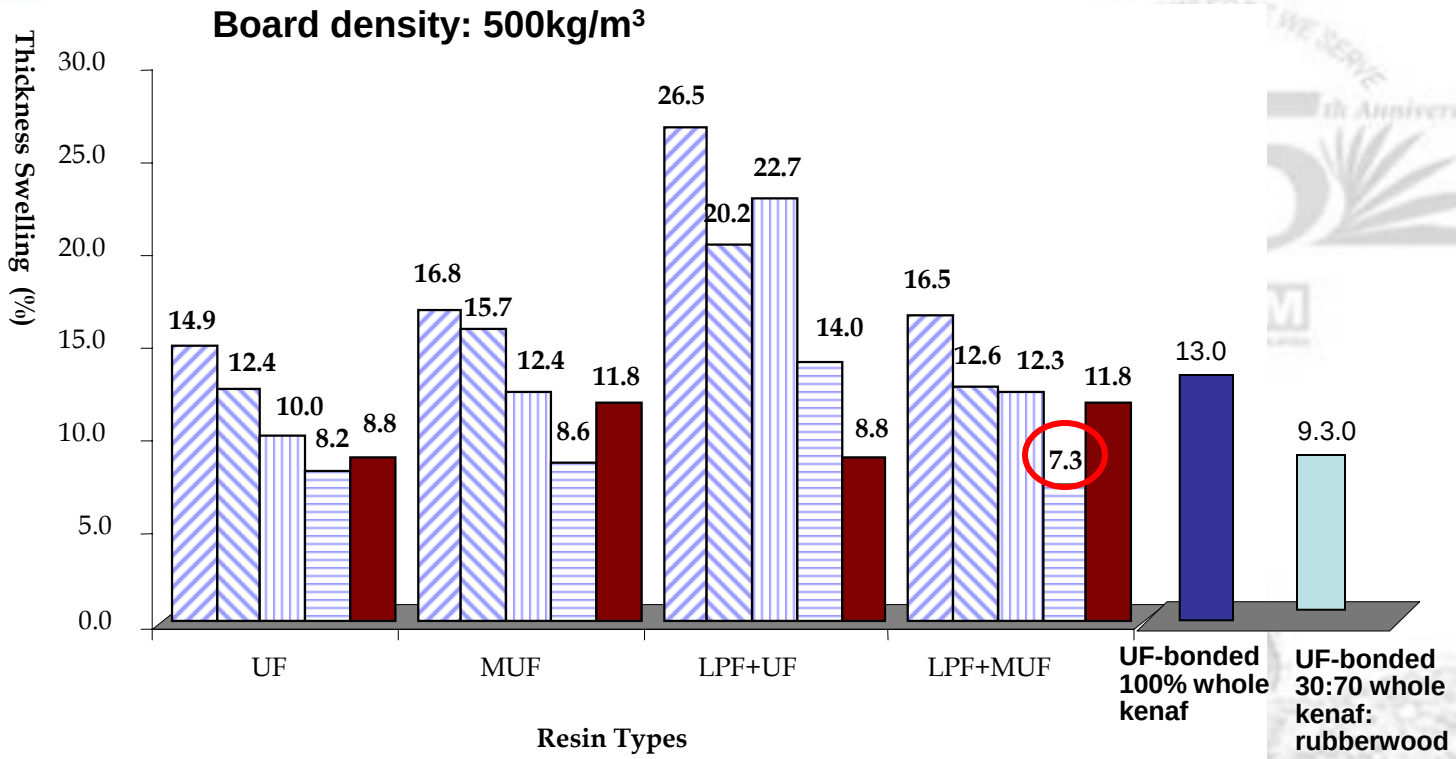
Internal Bond Strength - IB



A (60% core: 40% bast) B (70% core: 30% bast) C (80% core: 20% bast)

D (100% kenaf core) E (100% rubberwood) F (100% whole kenaf) G (30:70 whole kenaf: rubberwood)

Thickness Swelling - TS



A (60% core: 40% bast)

B (70% core: 30% bast)

C (80% core: 20% bast)

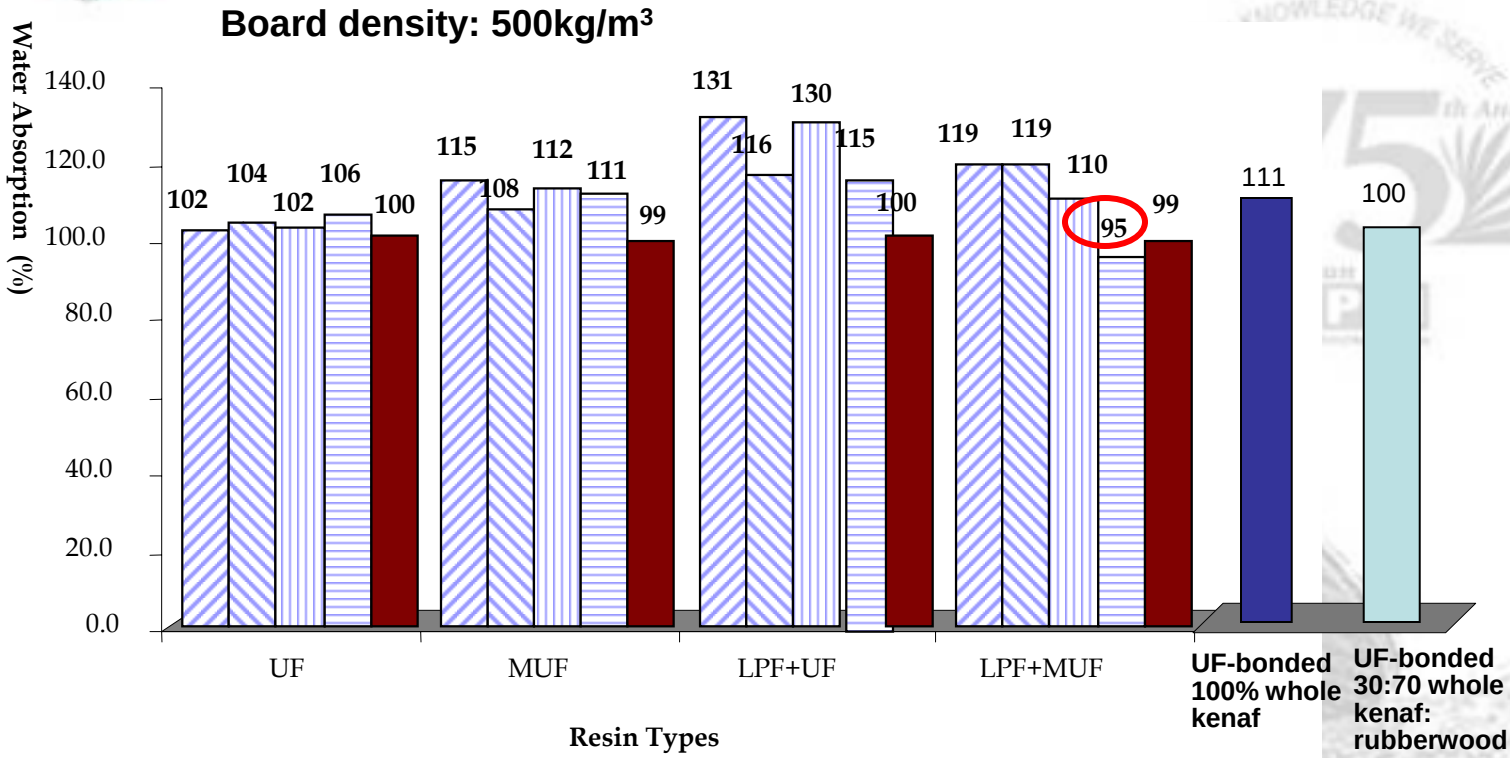
D (100% kenaf core)

E (100% rubberwood)

F (100% whole kenaf)

G (30:70 whole kenaf: rubberwood)

Water Absorption - WA



A (60% core: 40% bast)

B (70% core: 30% bast)

C (80% core: 20% bast)

D (100% kenaf core)

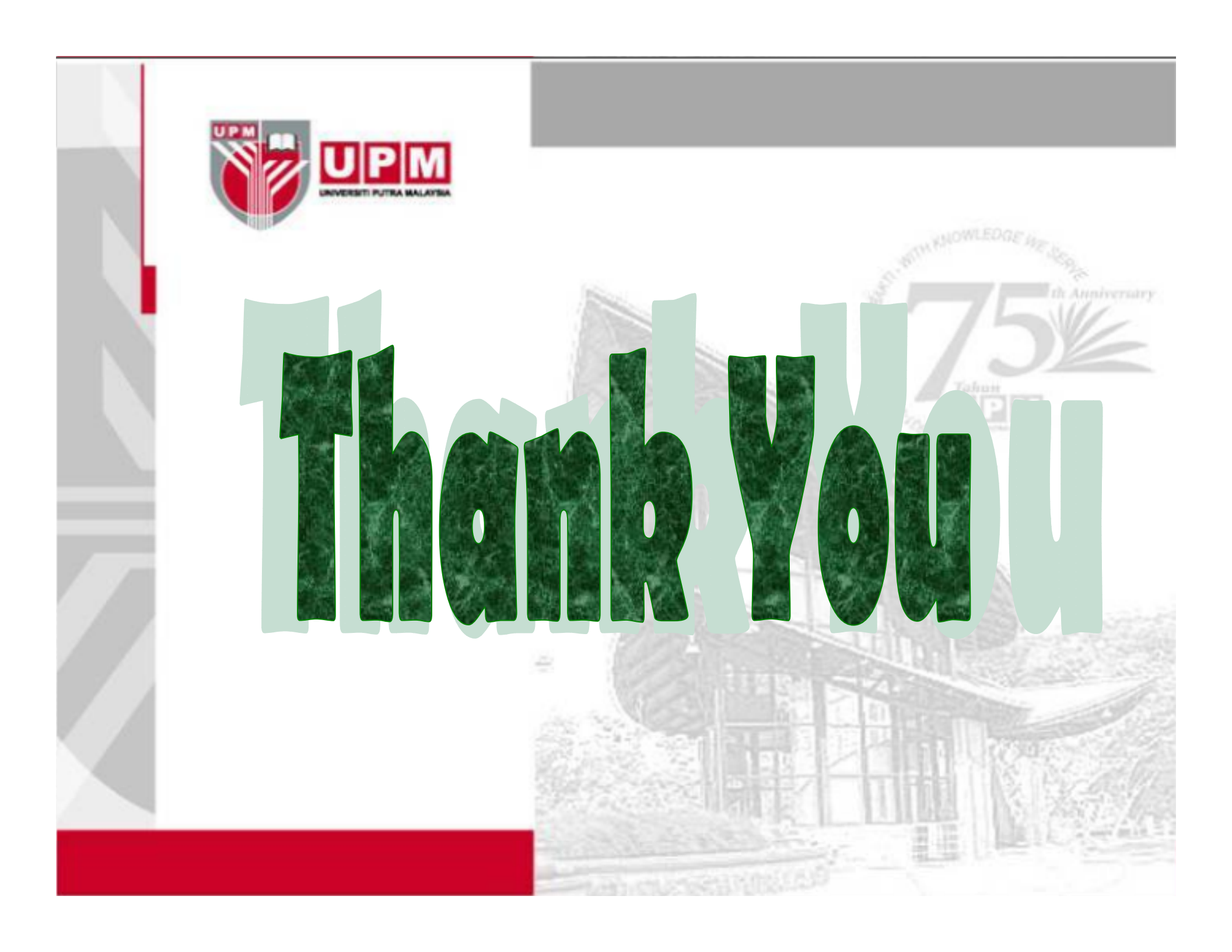
E (100% rubberwood)

F (100% whole kenaf)

G (30:70 whole kenaf: rubberwood)

CONCLUSIONS

- Both bast and core of kenaf are relatively more sensitive towards acid
- Alkali retting gives fibres of lighter colour, more flexible and shorter length
- The incorporation of Low Molecular Weight Phenol Formaldehyde (LPF) resin to impart dimensional stability in the fibres is more suitable to be used for kenaf core in combination with melamine urea formaldehyde (MUF) resin
- Kenaf board made from 100% KENAF core outperformed other boards and gave significantly superior performance than that of 100% rubberwood (control).
- Kenaf can be used to be mixed with rubberwood for the production of particleboard with acceptable overall board properties


Thank You