PERENCANAAN STRUKTUR KAYU

- KEKUATAN
- KEKAKUAN
- STABILITAS

MATERIAL

(ORTOTROPIK, SIFAT FISIK, SIFAT MEKANIK)

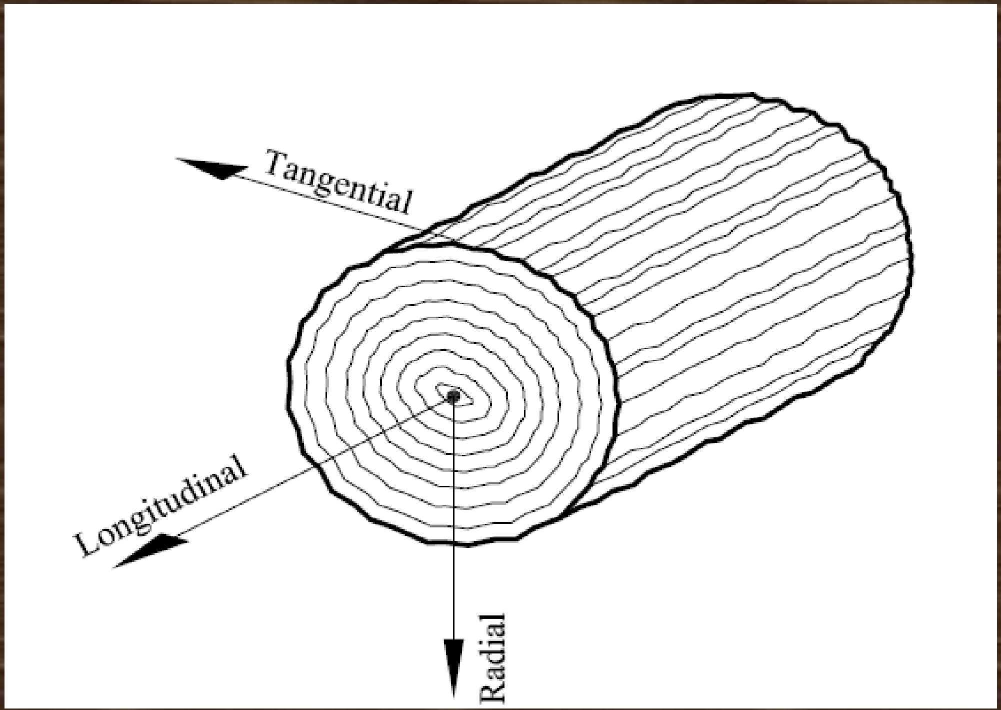
ANALISIS STRUKTUR

METODE DISAIN

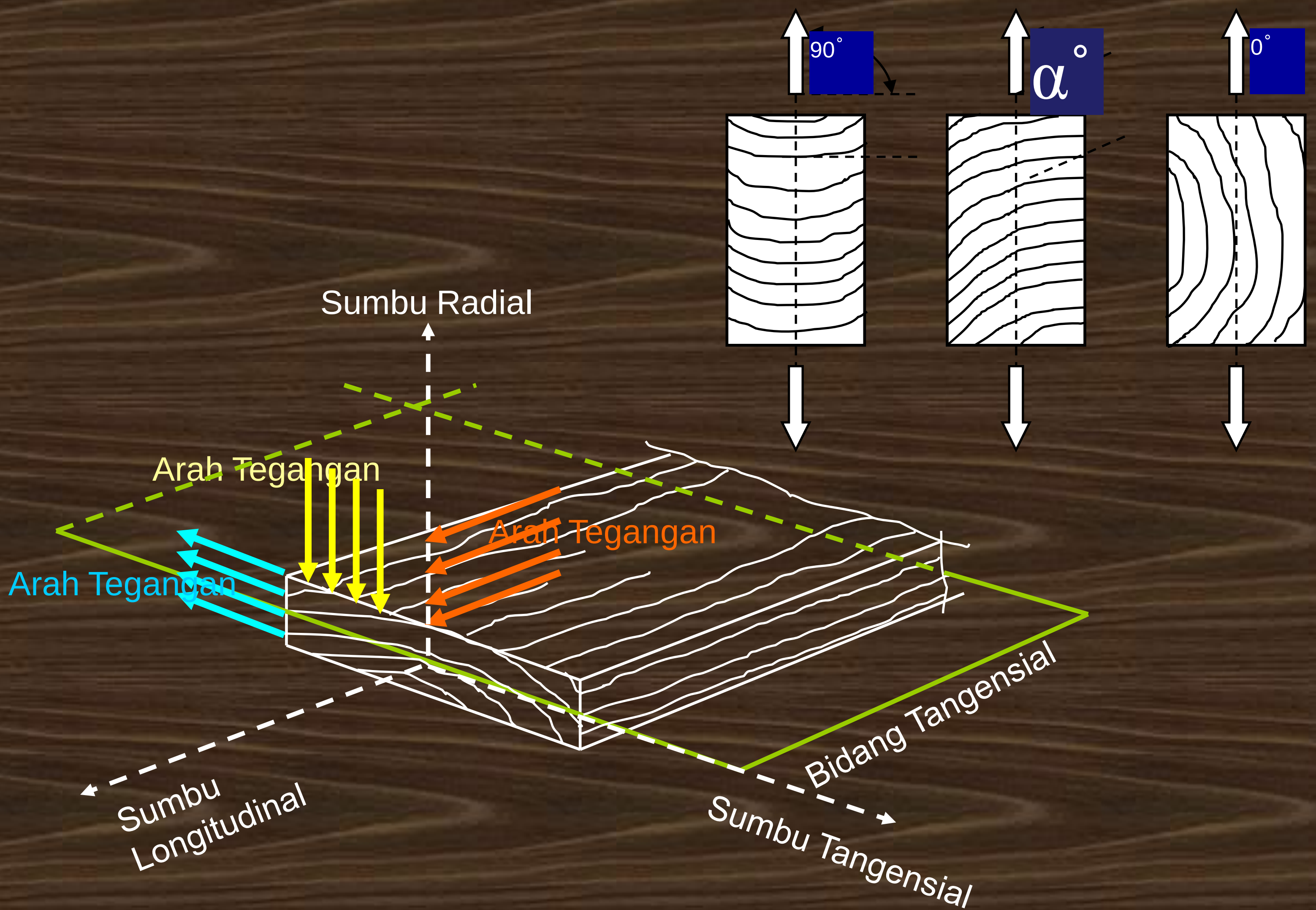
(DISAIN KOMPONEN STRUKTUR
DISAIN SAMBUNGAN)

MATERIAL ORTOTROPIK

- 3 (TIGA) SUMBU UTAMA MATERIAL YANG SALING TEGAK-LURUS L (longitudinal), R (radial) dan T (tangensial)
- SIFAT MEKANIS (KEKUATAN DAN BESARAN ELASTIS) PADA KE TIGA ARAH BERBEDA



MATERIAL ORTOTROPIK



SUDUT ANTARA GAYA/TEGANGAN DENGAN LINGKAR TUMBUH

BESARAN ELASTIS

- ISOTROPIK

E = modulus elastisitas

ν = rasio Poisson

$$G = \frac{E}{2(1+\nu)}$$

- ORTOTROPIK

E_1, E_2, E_3 = modulus elastisitas arah 1, 2, dan 3

ν_{12}, ν_{21}, ν_{13}, ν_{31}, ν_{23}, ν_{32} = rasio Poisson

G_{12}, G_{13}, G_{23} = modulus geser

HUBUNGAN TEGANGAN REGANGAN MATERIAL ISOTROPIK

$$\begin{Bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \gamma_{12} \\ \gamma_{13} \\ \gamma_{23} \end{Bmatrix} = \begin{bmatrix} \frac{1}{E} & \frac{-\nu}{E} & \frac{-\nu}{E} & 0 & 0 & 0 \\ \frac{-\nu}{E} & \frac{1}{E} & \frac{-\nu}{E} & 0 & 0 & 0 \\ \frac{-\nu}{E} & \frac{-\nu}{E} & \frac{1}{E} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{G} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{G} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G} \end{bmatrix} \begin{Bmatrix} \sigma_1 \\ \sigma_2 \\ \sigma_3 \\ \tau_{12} \\ \tau_{13} \\ \tau_{23} \end{Bmatrix}$$

HUBUNGAN TEGANGAN REGANGAN MATERIAL ORTOTROPIK

$$\begin{Bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \gamma_{12} \\ \gamma_{13} \\ \gamma_{23} \end{Bmatrix} = \begin{bmatrix} \frac{1}{E_1} & \frac{-\nu_{21}}{E_2} & \frac{-\nu_{31}}{E_3} & 0 & 0 & 0 \\ \frac{-\nu_{12}}{E_1} & \frac{1}{E_2} & \frac{-\nu_{32}}{E_3} & 0 & 0 & 0 \\ \frac{-\nu_{13}}{E_1} & \frac{-\nu_{23}}{E_2} & \frac{1}{E_3} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{G_{12}} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{G_{13}} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G_{23}} \end{bmatrix} \begin{Bmatrix} \sigma_1 \\ \sigma_2 \\ \sigma_3 \\ \tau_{12} \\ \tau_{13} \\ \tau_{23} \end{Bmatrix}$$

SIFAT FISIK

- BERAT JENIS
- KADAR AIR
- RANGKAK
- SUSUT
- TEMPERATUR

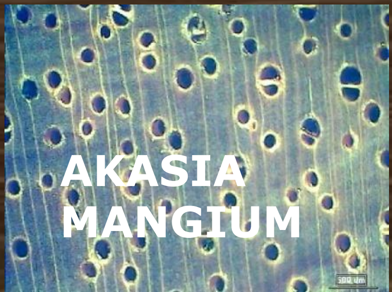
SIFAT MEKANIK dipengaruhi oleh

- BERAT JENIS (*specific gravity, SG, G*):
  SG besar → kekuatan dan E besar

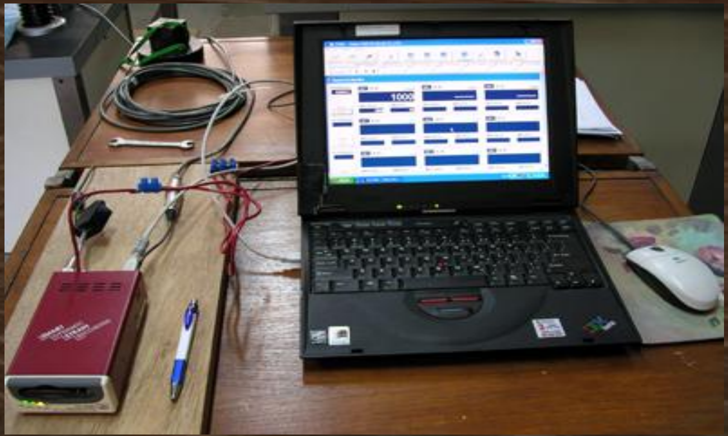
- KADAR AIR
  Basah (*green*): 30% > MC > 19%
  Kering (*air dried*): MC ≤ 19%
  MC turun → kekuatan dan E naik
  Diperhitungkan dengan C_M (*wet service factor*, faktor layan basah)

- ARAH SERAT
- CACAT/MATA KAYU

IDENTIFIKASI JENIS KAYU

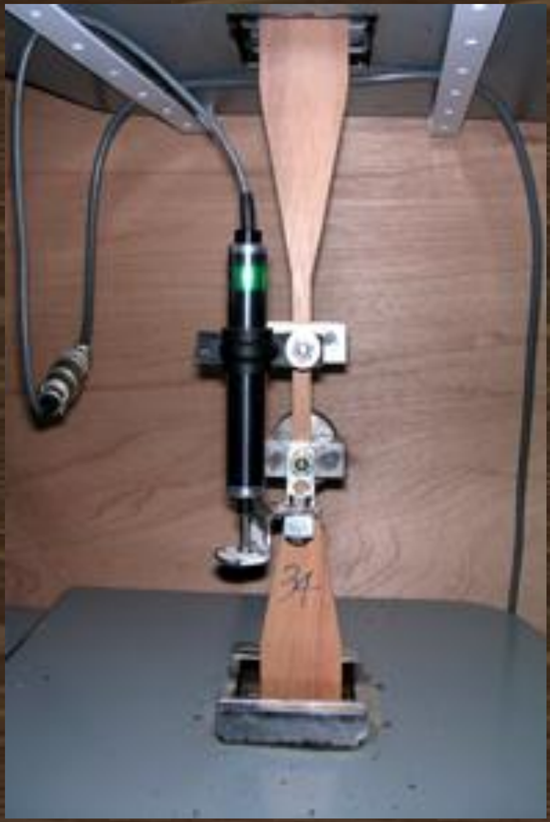


UJI SIFAT FISIK DAN MEKANIK



KUAT LENTUR

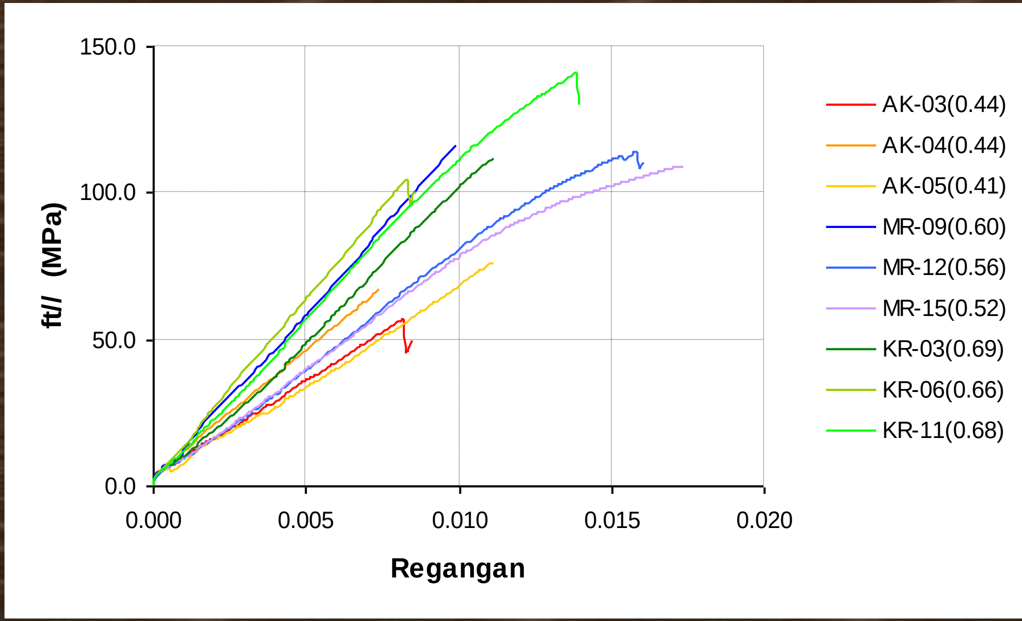
KUAT TARIK SEJAJAR SERAT



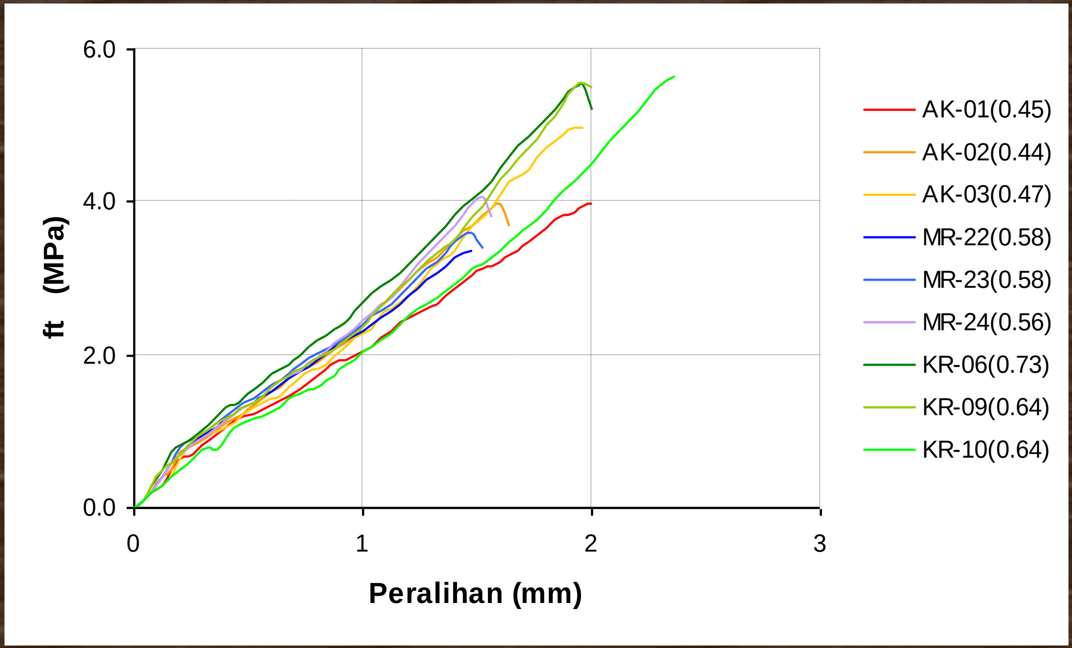
$$F_{t//} = 172.5\ SG^{1.05} \qquad (3.1)$$

$$E_{e//} = 22687\ SG^{0.98} \qquad (3.2)$$

$$\varepsilon_{u//} = \frac{7.59}{E_{e//}^{\ 0.74}} \qquad (3.3)$$



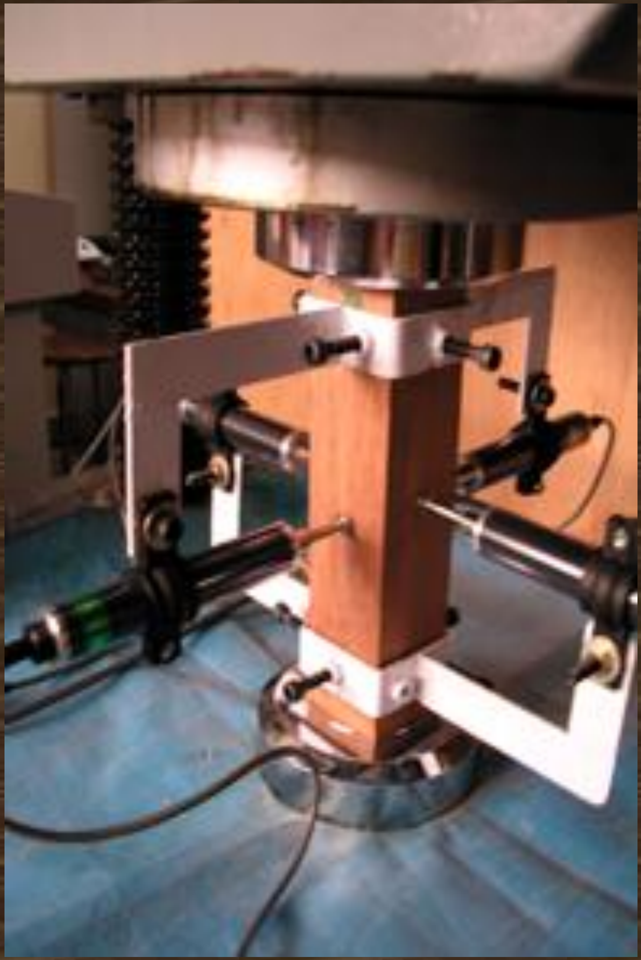
KUAT TARIK TEGAK-LURUS SERAT

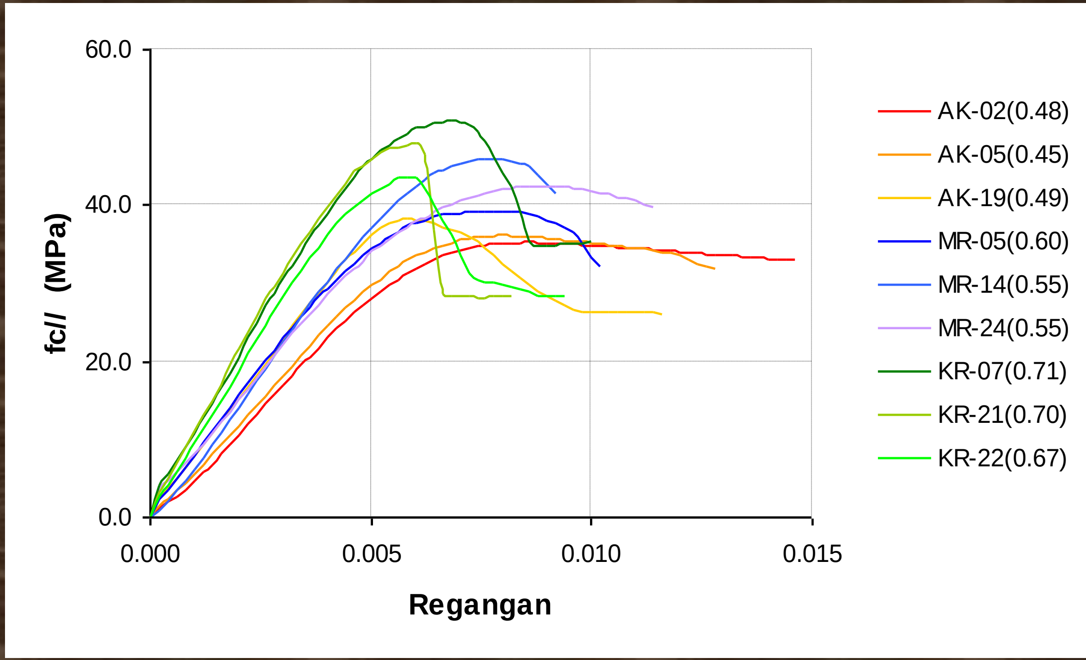


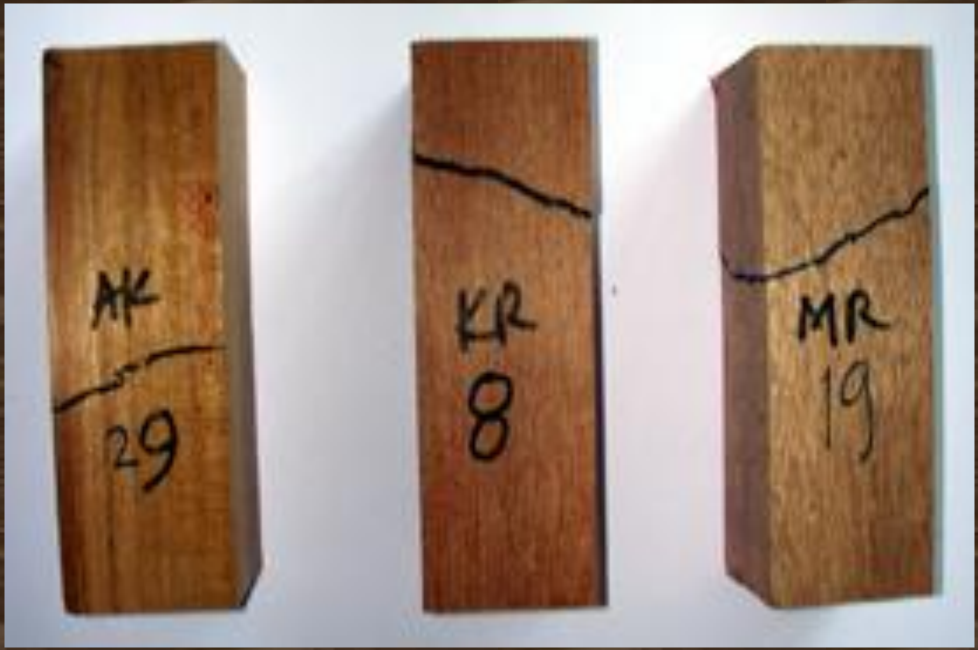
$$F_{t\perp} = 7.37\ SG^{1.04} \qquad (3.4)$$

$$F_{t\theta\perp} = 7.78\ SG^{1.11}\ \theta^{0.05} \qquad (3.5)$$

KUAT TEKAN SEJAJAR SERAT







KUAT TEKAN SEJAJAR SERAT

$F_{cu//} = 72.1\ SG^{0.95}$ (3.6)

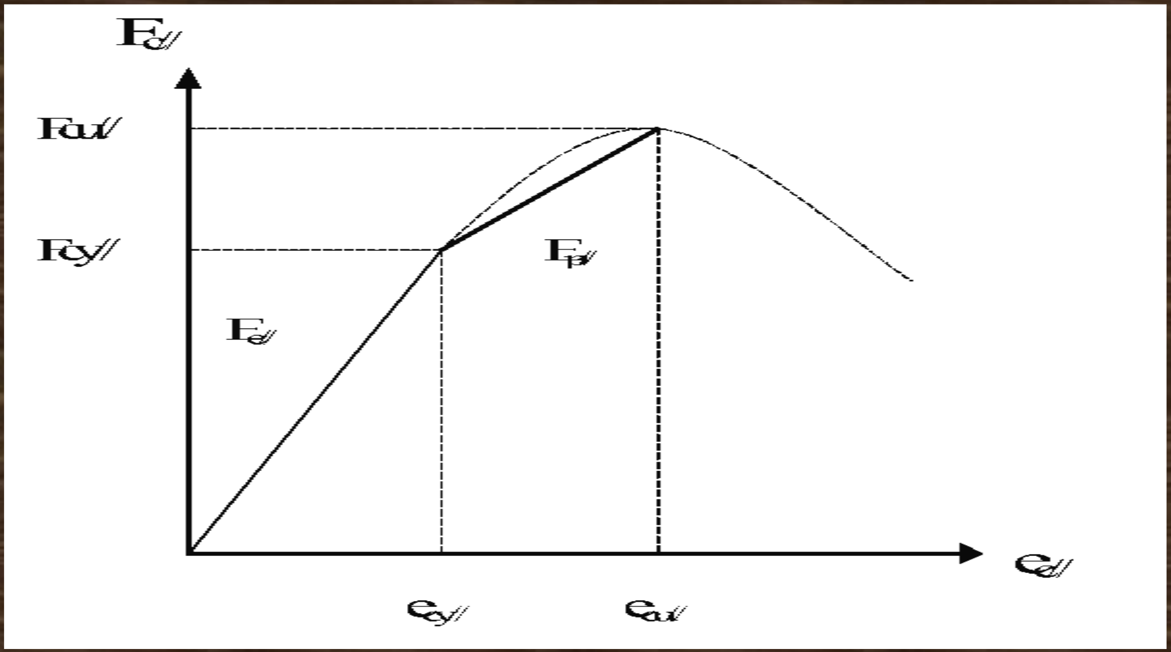
$F_{cy//} = 62.4\ SG^{1.07}$ (3.7)

$E_{e//} = 15052\ SG^{1.20}$ (3.8)

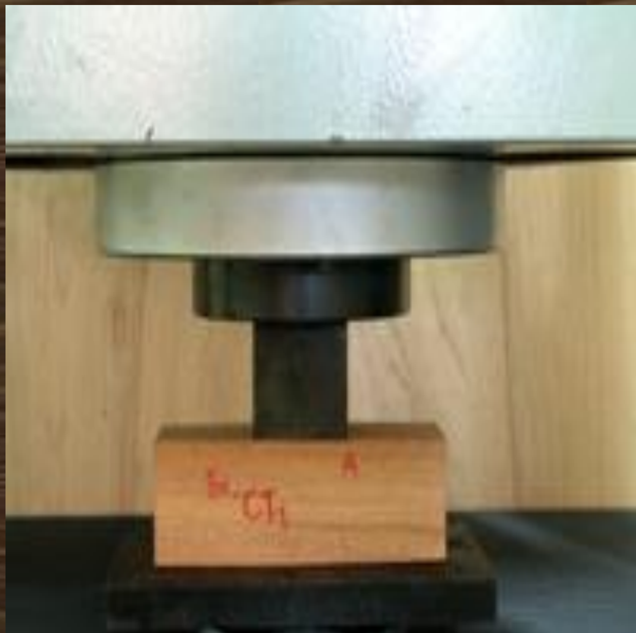
$E_{p//} = 5777\ SG^{1.16}$ (3.9)

$$\varepsilon_{cy//} = \frac{0.0042}{SG^{0.13}} \quad (3.10)$$

$$\varepsilon_{cu//} = \frac{0.0058}{SG^{0.36}} \quad (3.11)$$



KUAT TEKAN TEGAK-LURUS SERAT

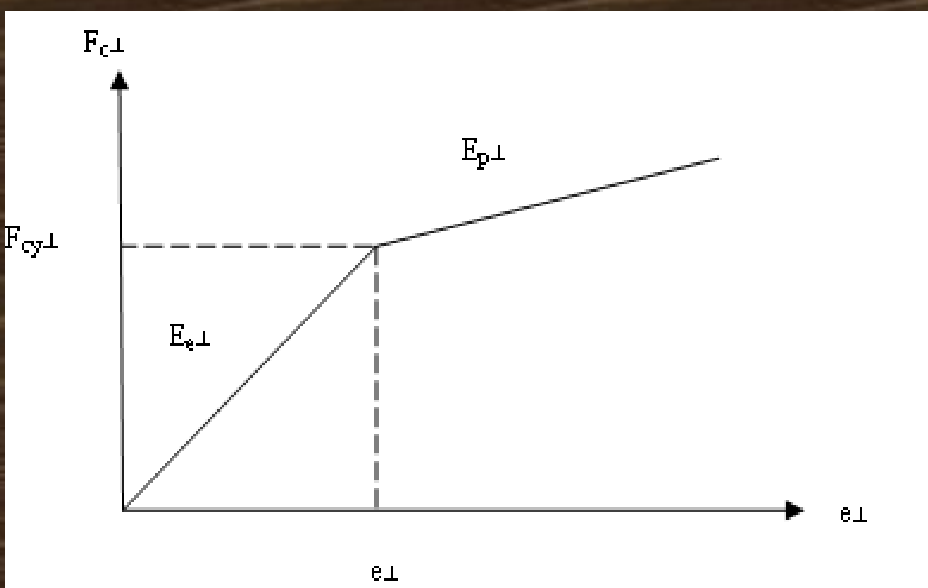


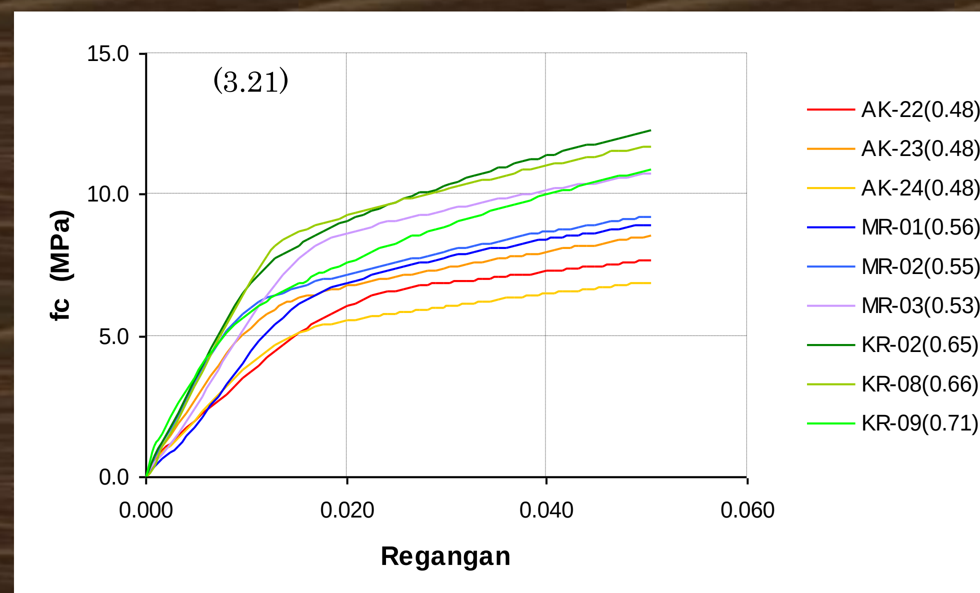
$$F_{cy\perp} = 11.48\ SG^{0.72}\ \theta^{0.10} \quad (3.12)$$

$$E_{e\perp} = 1318\ SG^{1.56}\ \theta^{0.01} \quad (3.13)$$

$$E_{p\perp} = 295\ SG^{2.61}\ \theta^{0.03} \quad (3.14)$$

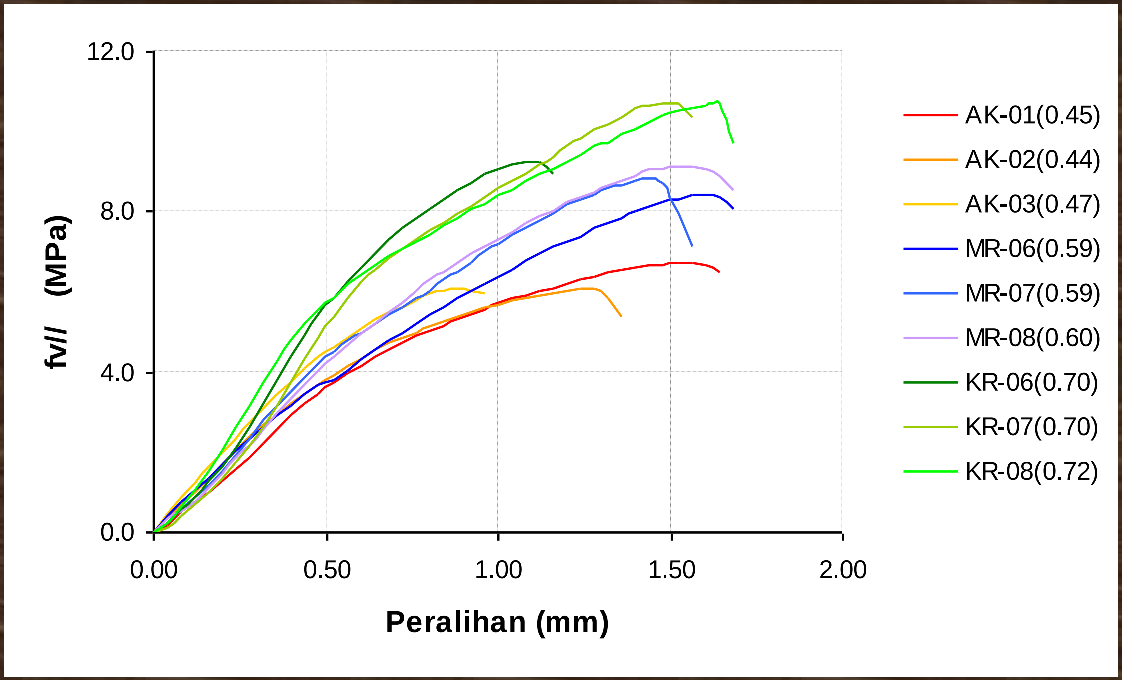
$$\varepsilon_{cy\perp} = \frac{0.0065\theta^{0.05}}{SG^{1.16}} \quad (3.15)$$





KUAT GESER SEJAJAR SERAT

$$F_{v\theta//} = \frac{15.8SG^{1.28}}{\theta^{0.02}} \quad \textbf{(3.16)}$$



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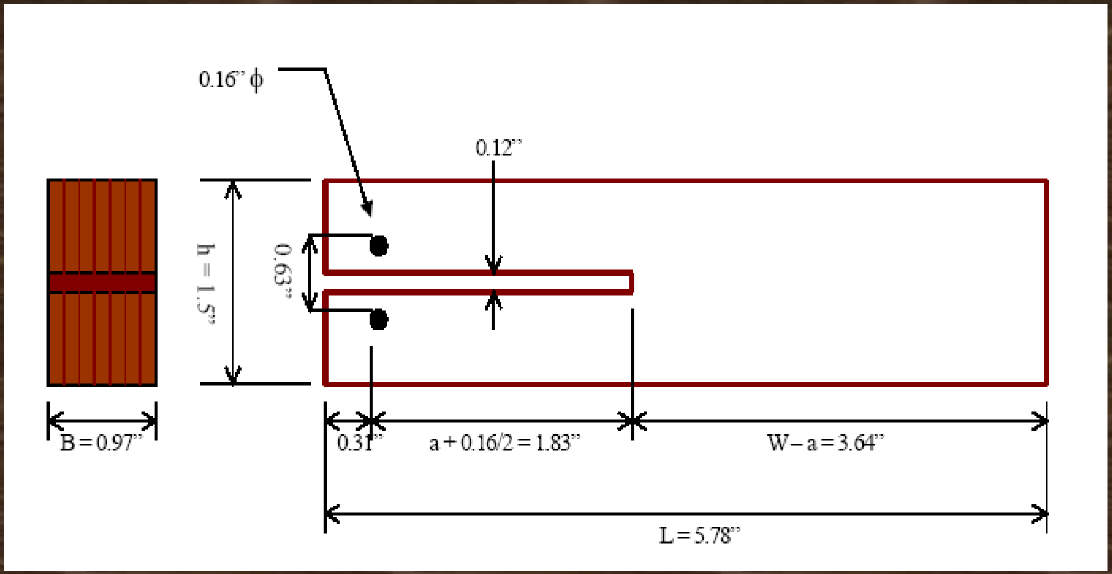
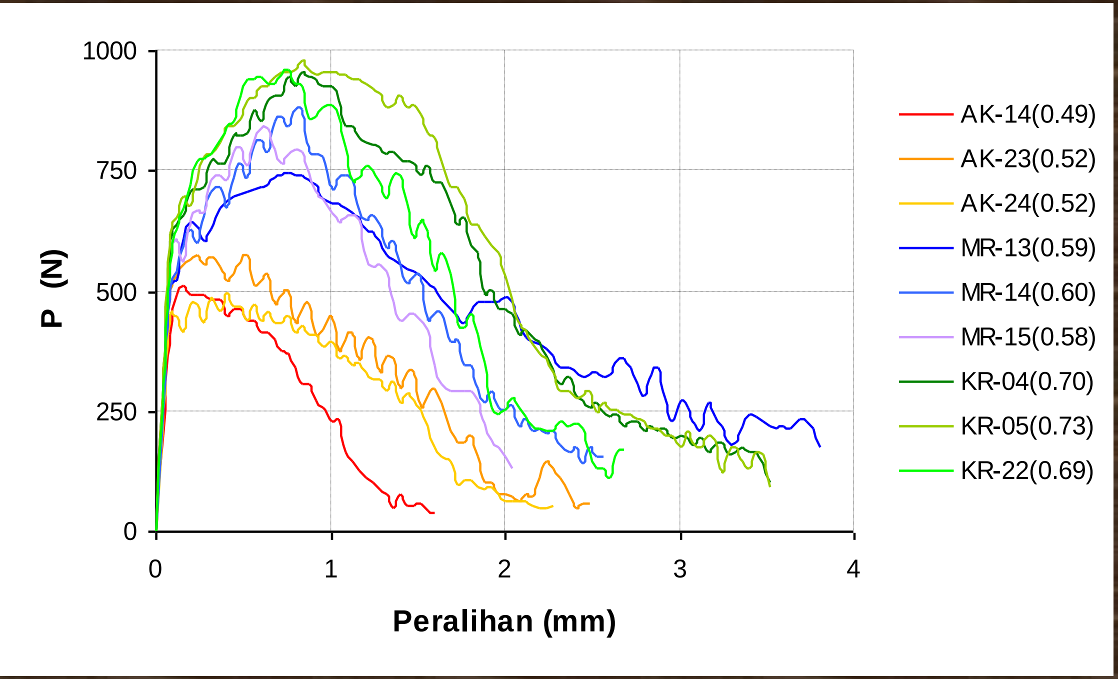
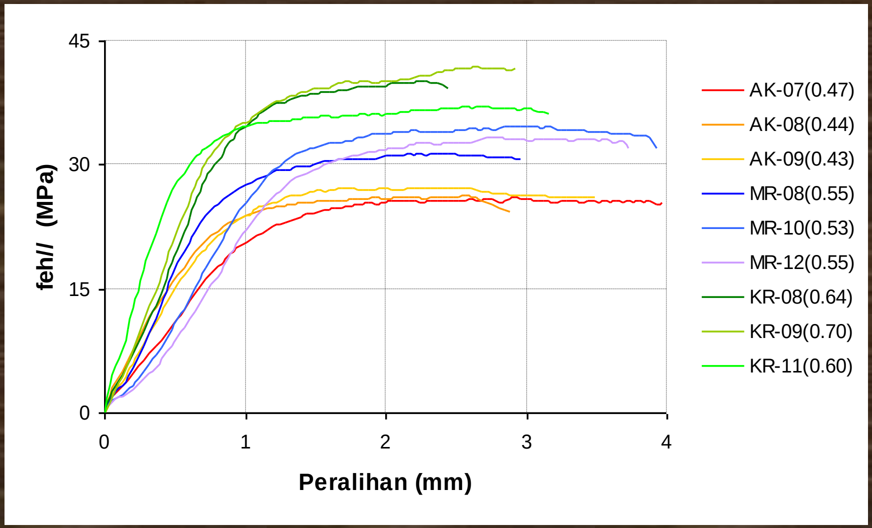


$K_I = 118.6\ SG^{1.18}$ (3.17)

$G_I = 1.42\ SG^{1.83}$ (3.18)



KUAT TUMPU BAUT SEJAJAR SERAT



$$F_{eh//} = \frac{356\,SG}{d^{0.12} mc^{0.5}} \quad (3.19)$$

$$F_{eh//\text{-}12} = \frac{103\,SG}{d^{0.12}} \quad (3.20)$$

tif.

Tabel 4.2.1 Nilai Desain dan Modulus Elastisitas Lentur Acuan (DTI)

Kode Mutu	Nilai Desain Acuan (MPa)					Modulus Elastisitas Acuan (MPa)	
	F_b	$F_{t//}$	$F_{c//}$	F_v	$F_{c\perp}$	E	E_{min}
E25	26.0	22.9	18.0	3.06	6.11	25000	12500
E24	24.4	21.5	17.4	2.87	5.74	24000	12000
E23	23.2	20.5	16.8	2.73	5.46	23000	11500
E22	22.0	19.4	16.2	2.59	5.19	22000	11000
E21	21.3	18.8	15.6	2.50	5.00	21000	10500
E20	19.7	17.4	15.0	2.31	4.63	20000	10000
E19	18.5	16.3	14.5	2.18	4.35	19000	9500
E18	17.3	15.3	13.8	2.04	4.07	18000	9000
E17	16.5	14.6	13.2	1.94	3.89	17000	8500
E16	15.0	13.2	12.6	1.76	3.52	16000	8000
E15	13.8	12.2	12.0	1.62	3.24	15000	7500
E14	12.6	11.1	11.1	1.48	2.96	14000	7000
E13	11.8	10.4	10.4	1.39	2.78	13000	6500
E12	10.6	9.4	9.4	1.25	2.50	12000	6000
E11	9.1	8.0	8.0	1.06	2.13	11000	5500
E10	7.9	6.9	6.9	0.93	1.85	10000	5000
E9	7.1	6.3	6.3	0.83	1.67	9000	4500
E8	5.5	4.9	4.9	0.65	1.30	8000	4000
E7	4.3	3.8	3.8	0.51	1.02	7000	3500
E6	3.1	2.8	2.8	0.37	0.74	6000	3000
E5	2.0	1.7	1.7	0.23	0.46	5000	2500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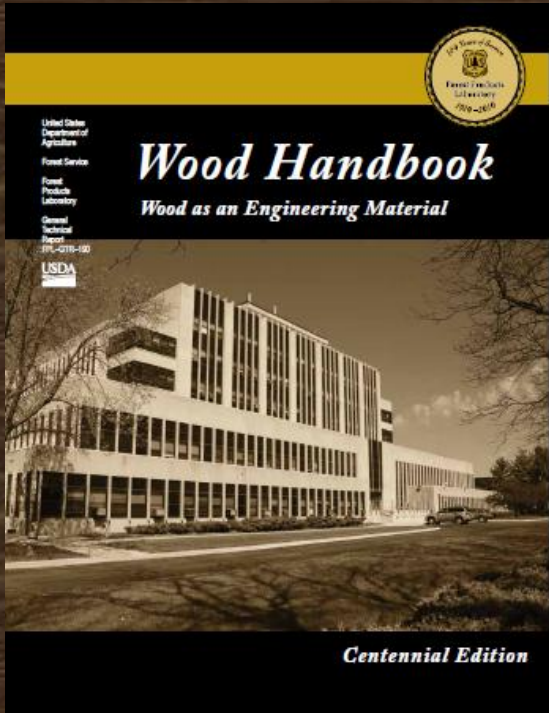
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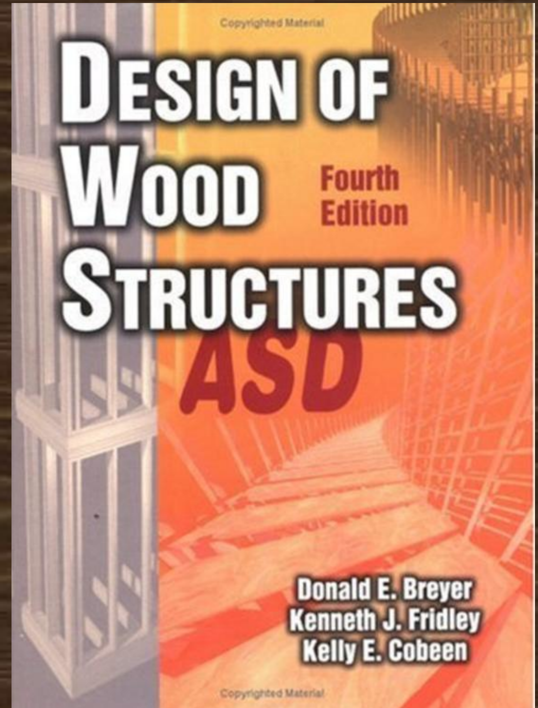
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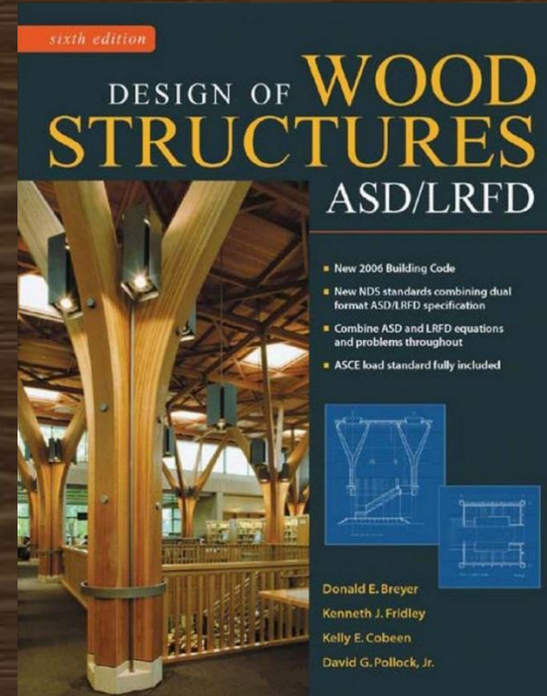
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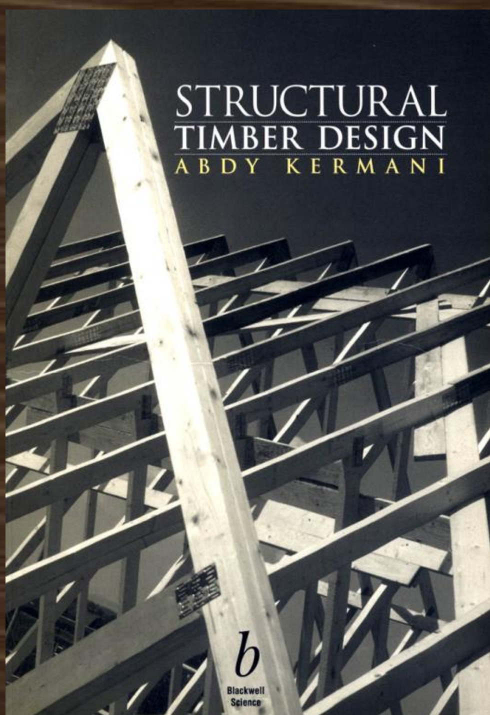
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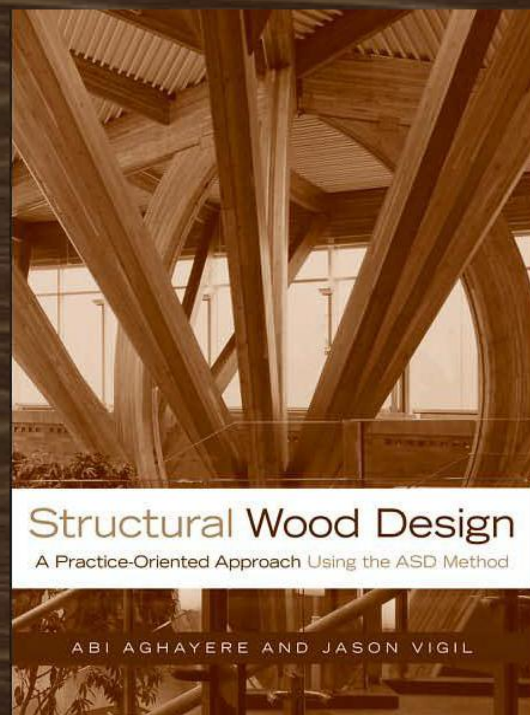
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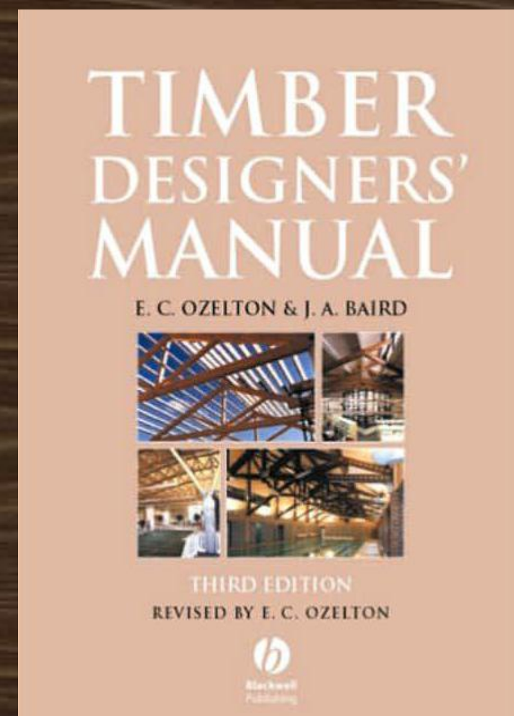
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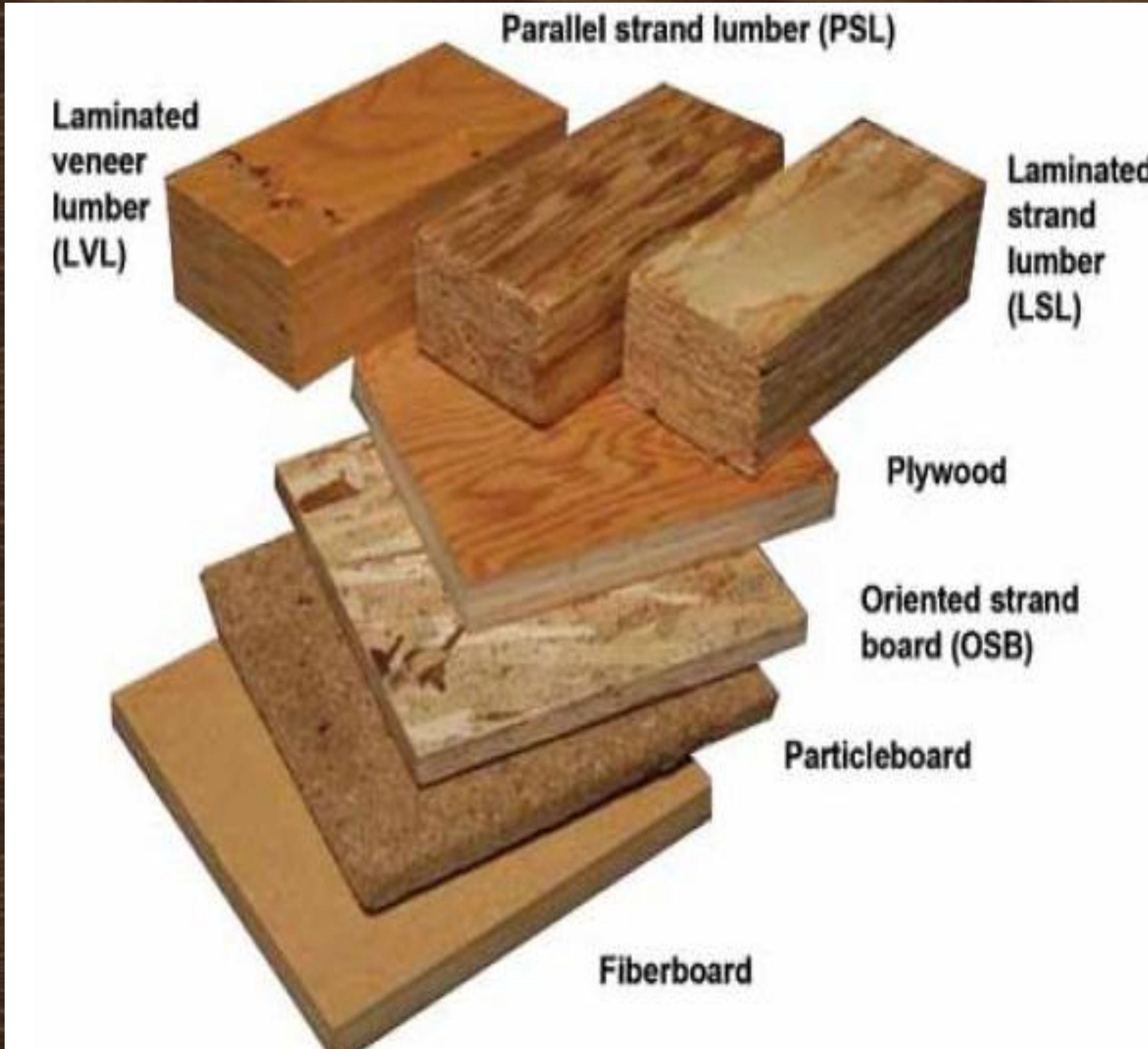
PRODUK KAYU OLAHAN STRUKTURAL

(ENGINEERED WOOD)


Parallel strand lumber (PSL)
Laminated veneer lumber (LVL)
Laminated strand lumber (LSL)
Plywood
Oriented strand board (OSB)
Particleboard
Fiberboard

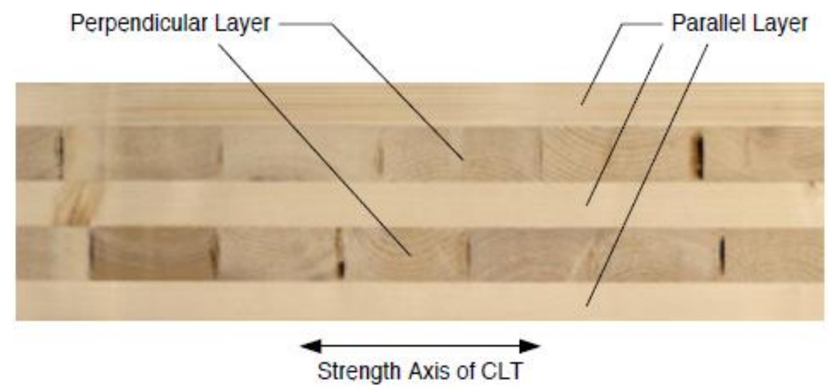
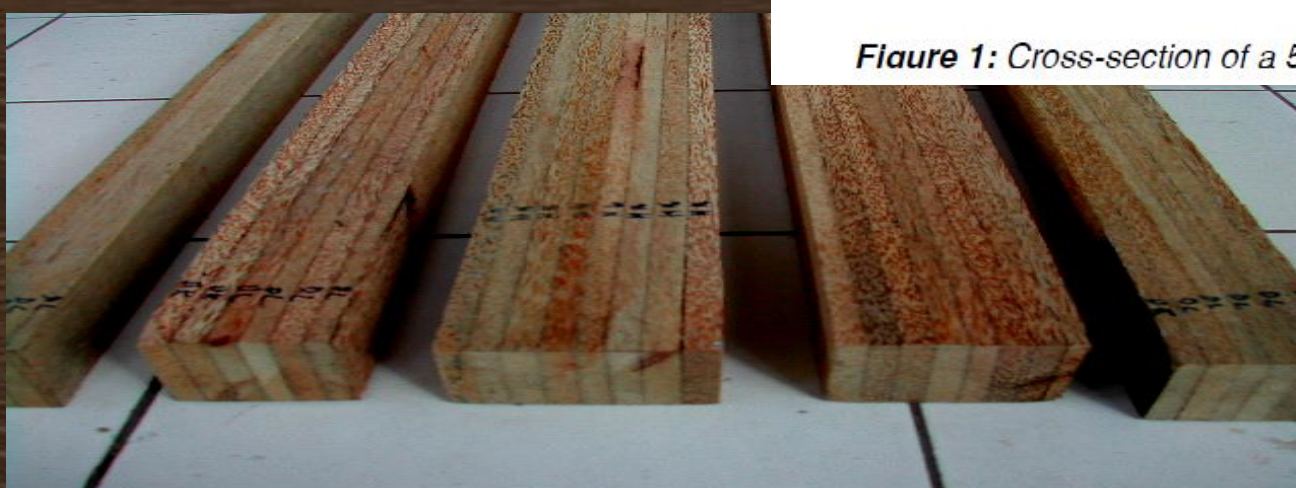


Figure 1: *Cross-section of a 5-layer CLT panel*



SISTIM STRUKTUR

SISTIM STRUKTUR

DESIGN PROCEDURE FOR LONG-SPAN POST-TENSIONED TIMBER FRAMES UNDER GRAVITY LOADING

Wouter van Beerschoten[1], Alessandro Palermo[2], David Carradine[3], Stefano Pampanin[4]

Figure 1: Construction of an unbonded post-tensioned timber frame (c/o A. Buchanan)

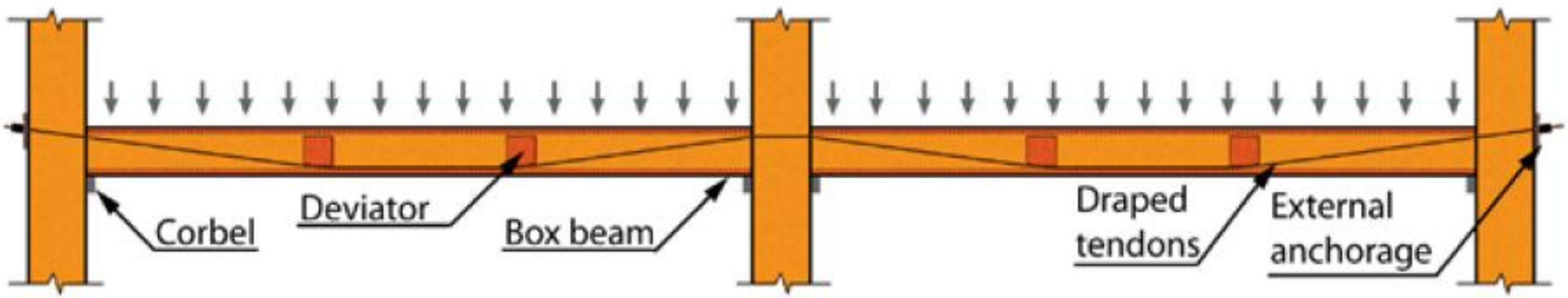


Figure 2: Layout of post-tensioned timber frame

Timber-steel-hybrid beams for multi-storey buildings

Wolfgang Winter[1], Kamyar Tavoussi[2], Tamir Pixner[3], Felipe Riola Parada[4]

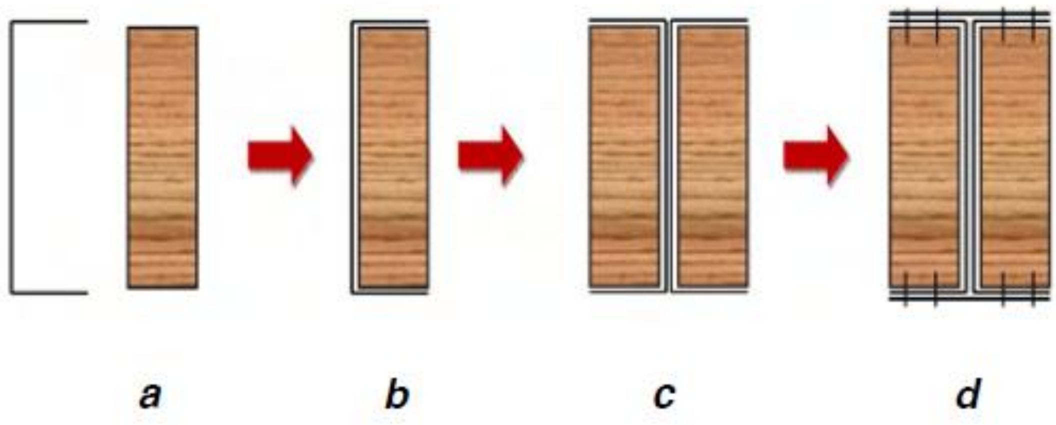


Figure 1: *Assembly process of completed timber-steel-hybrid beam*

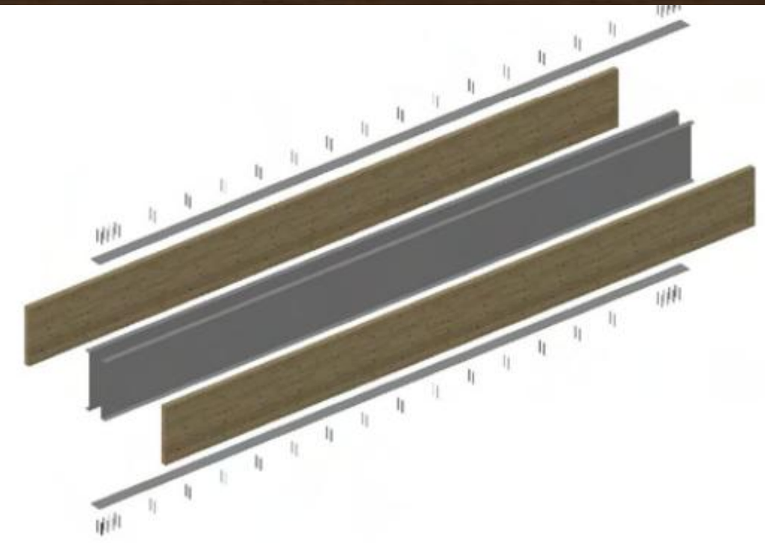
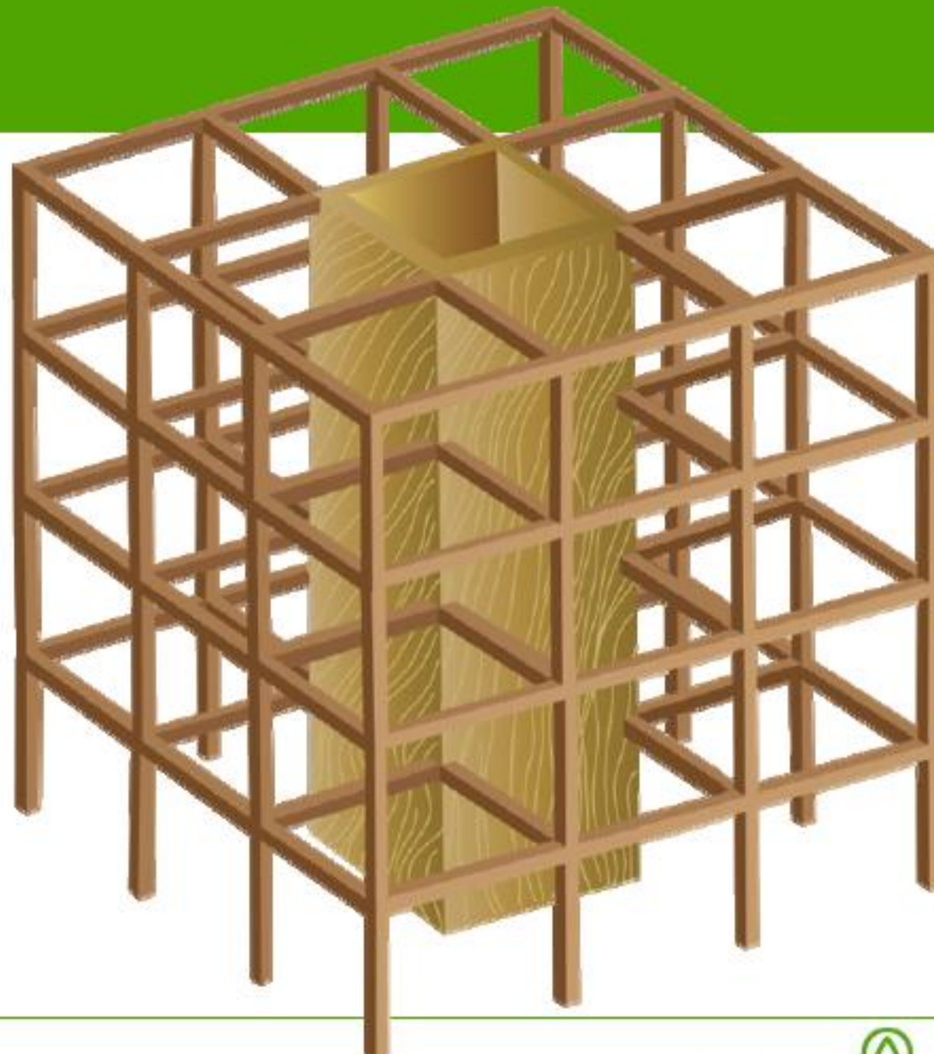


Figure 2: *Elements of the timber-steel-hybrid beam*

Replace masonry/concrete elevator shafts and stair wells with wood-based solutions



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Mid-rise Timber Buildings with Cross-Laminated timber

9-Storey building, London, UK

8-Storey buildings, Växjö, Sweden

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Cross Laminated Timber System – High Rise

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Cross Laminated Timber System – Mid Rise

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Cross Laminated Timber System – Mid Rise

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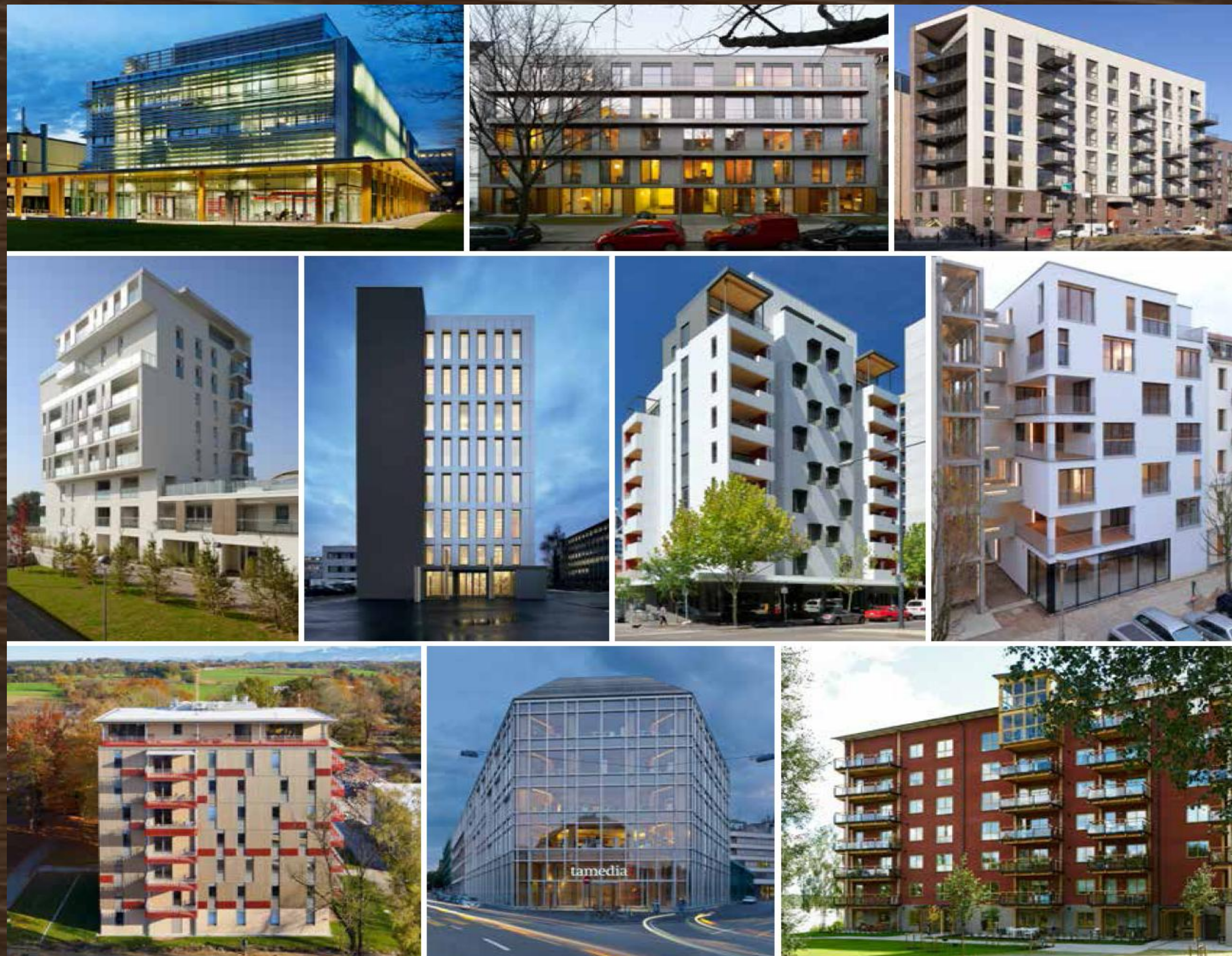
b116

b116 Erecting hollow-box floors for a timber building in panel construction



SUMMARY REPORT:
SURVEY OF INTERNATIONAL TALL WOOD BUILDINGS

MAY 2014

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Binational Softwood Lumber Council

A 30 LEVEL CROSS LAMINATED TIMBER BUILDING SYSTEM AND ANALYSIS OF THE EUROCODE DYNAMIC WIND LOADS

John Chapman[1], Thomas Reynolds[2], Richard Harris[3]

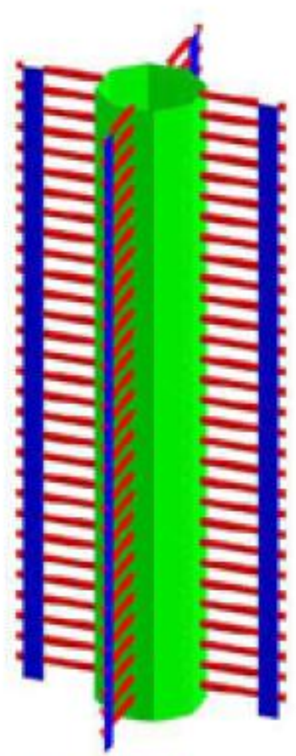


Figure 1: *Proposed structural system for 30 storey timber building with CLT circular core. 4no (of 16) frames shown for clarity.*

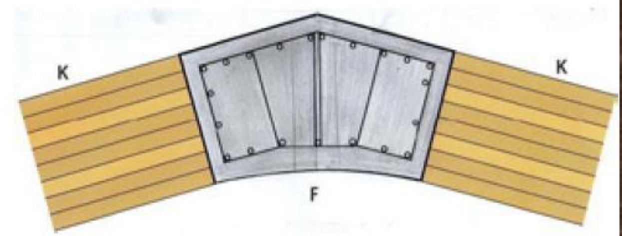


Figure 4: *Plan of reinforced concrete shear key (section A-A of Figure 3).*
F - RC shear connector, K - CLT central core panel

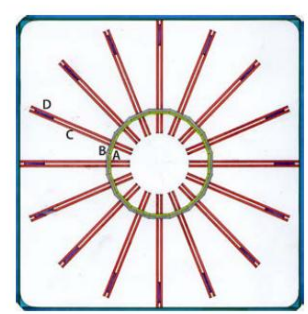


Figure 2: *Floor Structure Plan.*
A - central CLT core, B - RC 'hoop' beam,
C – floor beams, D – columns

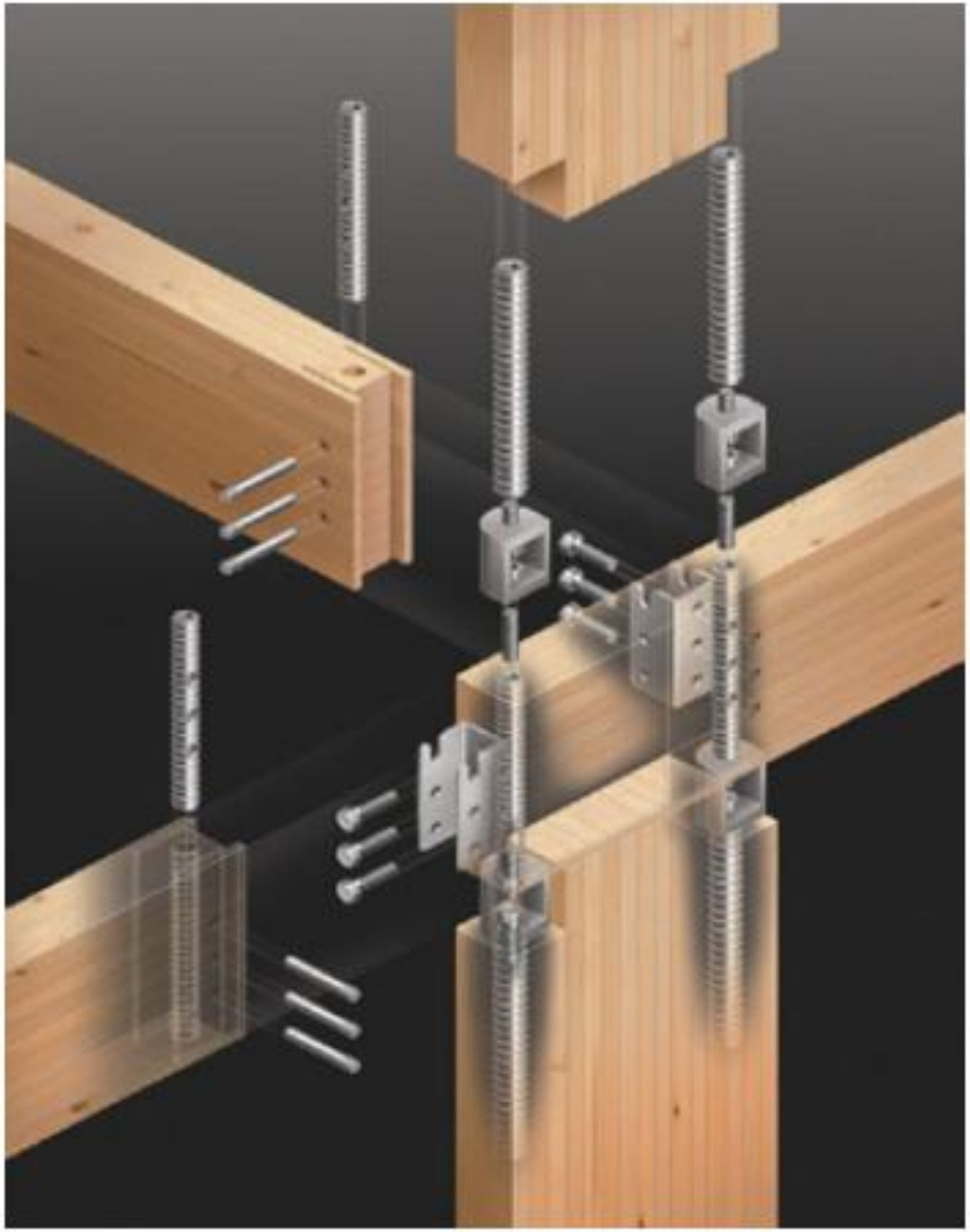


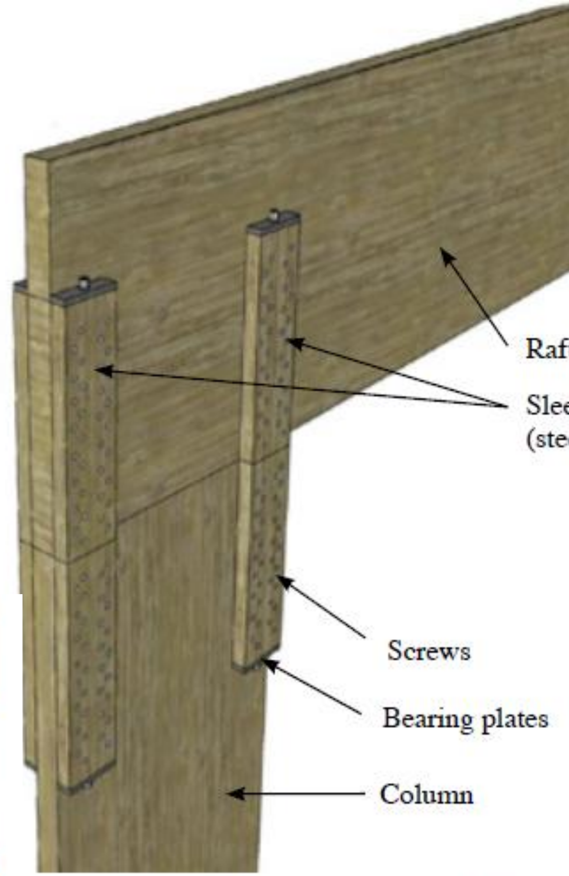
Figure 1: *Joint, BIG FRAME concept*

Figure 4: *Bearing structure*

THE QUICK CONNECT MOMENT CONNECTION FOR PORTAL FRAME BUILDINGS – AN INTRODUCTION AND CASE STUDY

Felix Scheibmair[1], Pierre Quenneville[2]

Figure 10: *Installer completing the Quick Connect joint by placing bearing plate and tightening nut on main tension rods*



ure 1: *The Quick Connect Portal Frame*
nnection

Figure 2: *Experimental timber joint*

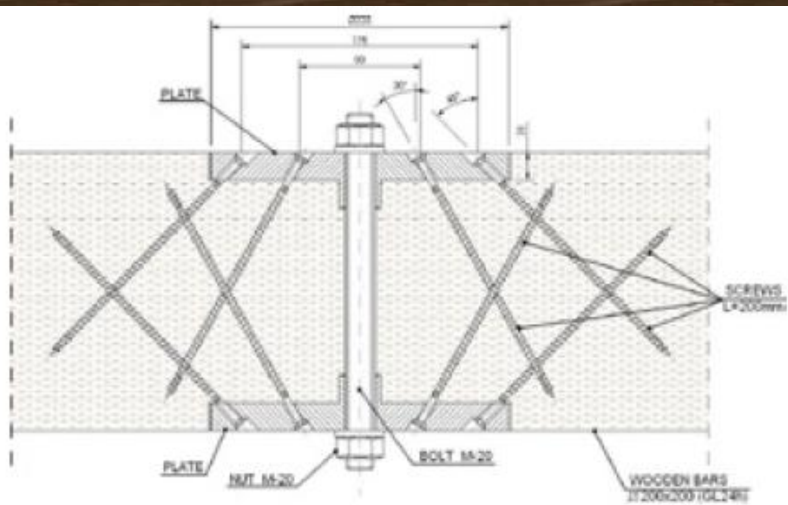


Figure 5: *Geometry of the Joint Type 2.2*

Figure 15: *Telon prototype of the structure. Scale 1:5*

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THE FLEXURAL STRENGTH OF AFRICAN WOOD FLANGE-PLYWOOD WEB I-JOIST

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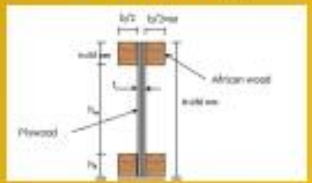
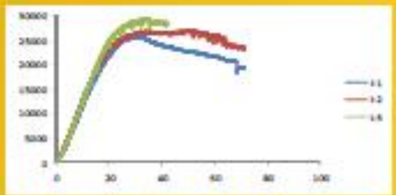
Six I-joist specimens with 2400 mm length and 250 mm height was made from fast growing wood species namely Africa as flanges and combined with plywood as web connected with strong epoxy glue. The flexural strength of the I-joist at the proportional limit and ultimate from the experimental test was compared to the allowable design load. The average ratio of load at proportional limit to the allowable design load was 2.3 and the average ratio of ultimate load to the allowable design load was 3.7. The deflections under the allowable design load was less than the requirements of 1/300 of the span length. The average displacement ductility factors at ultimate and failure was in between 2.8 and 5.5 respectively. The failure mechanism mainly was the web shear failure, no failure happened at the glue and no lateral torsional buckling was observed.

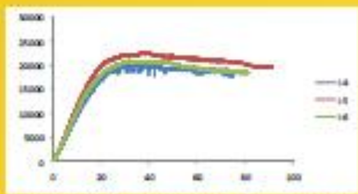


I-joist specimen cross section dimension


I joist specimen


I-joist specimen under two point loading test


The load vs displacement curve of I-1 to I-3 specimen


The load vs displacement curve of I-4 to I-6 specimen

The 3rd International Conference of European Asian Civil Engineering Forum
20-22 September 2011, Yogyakarta, Indonesia

Structural Engineering Research Center

THE FLEXURAL STRENGTH AND RIGIDITY OF COMPOSITE PLYWOOD-MERANTI STRESS SKIN PANEL

Johannes Adhijoso TJONDRO[1], Dina Rubiana WIDARDA[1], and Leonardus Eka DHARMA[2]

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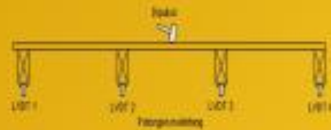
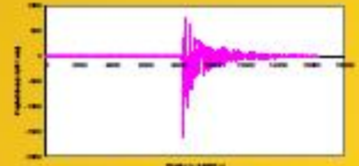
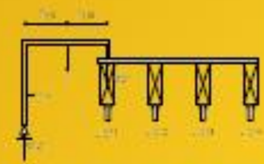
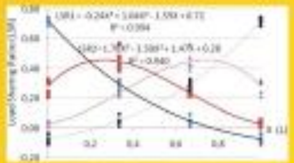
Composite action between plywood and meranti-stringer connected with strong-epoxy glue was analyzed and tested under both non-destructive and destructive test. Three stress skin panel floor specimens were tested under dynamic vibration test, static uniform and line loading. The destructive test using line load was done to observe the ultimate strength of the floor. The correlation between static and dynamic rigidity was presented. The failure mode was brittle, but the ultimate load was extremely higher than the design load prediction, which is provided a conservative safety factor. The determination of load sharing factor may be used to check the stiffness uniformity of the composite action between plywood and stringer.


Impulse loading at vibration test


Time displacement curve from dynamic test


Schematic of loading sharing test


Loading sharing ratio (LSR)

The 3rd International Conference of European Asian Civil Engineering Forum
20-22 September 2011, Yogyakarta, Indonesia

Structural Engineering Research Center

THE FLEXURAL STRENGTH AND BEHAVIOUR OF CROSS NAIL-LAMINATED TIMBER FLOOR

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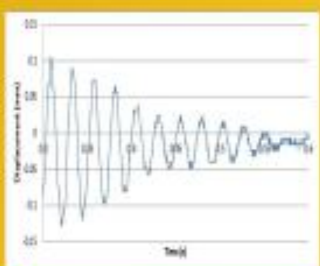
The fabricated cross nail-laminated timber floor was analysed and tested under both non-destructive vibration test and destructive static two line loading test. The six cross nail-laminated timber floor specimens was made from hardwood fast growing species, *Albizia falcata*. The thickness variation of the floor was made from three and five layers of wood plank. The vibration test was done to measure the frequency, damping ratio and dynamic rigidity of the floor. The destructive test using line loading was done to observe the rigidity and flexural strength of the floor load was suggested.

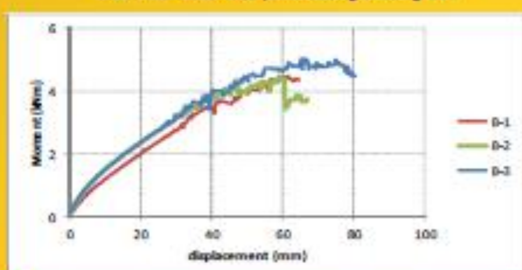
The failure mode was ductile and the ultimate load was higher than the proportional load, which is provided a conservative safety factor. Ratio of dynamic to static rigidity was presented, and prediction and suggestion of maximum service live.

CNLT floor under vibration test

CNLT floor under third point loading bending test



Displacement vs time of CNLT floor free vibration



Moment – displacement curve of 5-layer CNLT floor specimen

The 6th Civil Engineering Conference in The Asian Region
Jakarta, August 20-22, 2013.

Structural Engineering Research Center

THE BEHAVIOUR OF CROSS NAIL-LAMINATED TIMBER (CNLT) SHEARWALL UNDER CYCLIC LOADING

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Wood as a light and green material became one of the choice in civil engineering construction. Since Indonesia is in the active seismic area, the building must have the capability to resist the earthquake loading. The cross laminated timber (CLT) shearwall is the one of the recent development in timber engineering, this CLT is using adhesive to construct the sheet. In this experimental study three lamina of albasia wood plank was constructed as cross nail-laminated timber (CNLT) shearwall. The CNLT was framing and connected with glue adhesive. Three specimen of CNLT shearwall was tested under a cyclic loading, and the parameters in the hysteresis rule such as yield force, ultimate force, unloading-reloading parameters and ductility factors was observed.

The parameters of the hysteresis curve were similar with the Stewart hysteresis model. The stiffness and the ductility of the CNLT shearwall was sufficient for drift control and ductility limit in the timber shearwall earthquake design requirements. The failure mode and strength of this CNLT shearwall was depend on the number of lamina forming CNLT sheet, hold-down plate or angle and framing connections.

Test setting of CNLT shearwall

Hysteresis curve

Cross nail laminated timber sheet, 9 nails per 180x180 mm² area

Hold down angle

Hold down plate

The 2nd International Conference on Earthquake Engineering and Disaster Mitigation, 19-20 July 2011, Surabaya, Indonesia


INDONESIA, NOVEMBER 07 - 08 2012
02/11/2007


11/08/2012


THE 4th INTERNATIONAL SYMPOSIUM OF
INDONESIAN WOOD RESEARCH SOCIETY (IWoR
02/11/2007

- SNI-7973:2013
- Spesifikasi desain untuk konstruksi kayu

- METODE DISAIN DAN ANALISIS PADA KOMPONEN STRUKTUR DAN SAMBUNGAN

METODE DISAIN

- Desain dengan Tegangan Ijin (ALLOWABLE STRESS DESIGN)
- Desain dengan Faktor Beban dan Faktor Tahanan (LOAD AND RESISTANT FACTOR DESIGN)

3.3 Komponen Struktur Lentur – Lentur

3.3.1 Kekuatan Lentur

Momen atau tegangan lentur aktual tidak boleh melebihi nilai desain lentur terkoreksi.

3.3.2 Persamaan Desain Lentur

3.3.2.1 Tegangan lentur aktual akibat momen lentur, M, dihitung sebagai berikut:

$$fb = \frac{M.c}{I} = \frac{M}{S} \qquad (3.3\text{-}1)$$

Untuk komponen struktur lentur persegi panjang dengan lebar, b, dan tinggi, d, persamaan di atas menjadi:

$$fb = \frac{M}{S} = \frac{6M}{bd^2} \qquad (3.3\text{-}2)$$

3.3.2.2 Untuk komponen struktur persegi panjang masif dengan sumbu netral tegak lurus tinggi penampang:

$I = \frac{bd^3}{12}$ = momen inersia, mm^4 (3.3-3)

$S = \frac{I}{c} = \frac{bd^2}{6}$ = modulus penampang, mm^3 (3.3-4)

US CODE – SNI

- NDS 1986 (ASD)
- NDS 1991 (ASD)
- AWS 1995 (LRFD)
- NDS 1996 (LRFD)
- NDS 2001 (ASD)
- NDS 2005 (ASD/LRFD)
- NDS 2012 (ASD/LRFD)

- PKKI 1961 (ASD)…1980….SNI 03-XXXX-2002 (ASD/LRFD)
- SNI 7973:2013

Contoh kombinasi pembebanan pada ASD :

D

D + L

D + (La atau H)

D + 0,75L + 0.75(La atau H)

D + (0,6W atau 0,7E)

D + 0,75L + 0.75(0,6W) + 0.75(La atau H)

D + 0,75L + 0.75(0,7E)

0,6D + 0,6W

0,6D + 0,7E

Dan kombinasi pembebanan pada LRFD :

1,4D
1,2D + 1,6L + 0,5(La atau H)
1,2D + 1,6(La atau H) + (L atau 0,5W)
1,2D + 1,0W + L + 0,5(La atau H)
1,2D + 1,0E + L
0,9D + 1,0W
0,9D + 1,0E

KOMBINASI BEBAN - LRFD

- 1.4D
- 1.2D + 1.6L + 0.5(L_a atau H)
- 1.2D + 1.6(L_a atau H) + (0.5L atau 0.8W)
- 1.2D + 1.3W + 0.5L + 0.5(L_a atau H)
- 1.2D $\pm$ 1.0E + 0.5L
- 0.9D $\pm$ (1.3W atau 1.0E)

D = beban mati
L = beban hidup
La = beban hidup di atap
H = beban hujan
W = beban angin
E = beban gempa

FAKTOR WAKTU λ
PADA KOMBINASI PEMBEBANAN

Kombinasi beban	λ
1.4D	0.6
1.2D + 1.6L + 0.5(L_a atau H)	(*)
1.2D + 1.6(L_a atau H) + (0.5L atau 0.8W)	0.8
1.2D + 1.3W + 0.5L + 0.5(L_a atau H)	1.0
1.2D ± 1.0E + 0.5L	1.0
0.9D ± (1.3W atau 1.0E)	1.0

(*) 0.7 (L=gudang), 0.8 (L=ruangan umum, 1.25 (L=kejut)

Kuat Acuan dalam PKKI 1961

Tabel 1. Tegangan-Tegangan Ijin (NI-5, PKKI 1961)

Kelas Kuat Kayu	$\overline{\sigma}_{lt}$ (kg/cm^2)	$\overline{\sigma}_{tr\,//}$ (kg/cm^2)	$\overline{\sigma}_{tk\,//}$ (kg/cm^2)	$\overline{\sigma}_{tk\perp}$ (kg/cm^2)	$\overline{\tau}_{//}$ (kg/cm^2)
I	150	130	130	40	20
II	100	85	85	25	12
III	75	60	60	15	8
IV	50	45	45	10	5

Wood Handbook, 2010

	Specific gravity–strength relationship			
	Green wood		Wood at 12% moisture content	
Property[a]	Softwoods	Hardwoods	Softwoods	Hardwoods
Static bending				
MOR (kPa)	109,600 $G^{1.01}$	118,700 $G^{1.16}$	170,700 $G^{1.01}$	171,300 $G^{1.13}$
MOE (MPa)	16,100 $G^{0.76}$	13,900 $G^{0.72}$	20,500 $G^{0.84}$	16,500 $G^{0.7}$
WML (kJ/m^3)	147 $G^{1.21}$	229 $G^{1.52}$	179 $G^{1.34}$	219 $G^{1.54}$
Impact bending (N)	353 $G^{1.35}$	422 $G^{1.39}$	346 $G^{1.39}$	423 $G^{1.65}$
Compression parallel (kPa)	49,700 $G^{0.94}$	49,000 $G^{1.11}$	93,700 $G^{0.97}$	76,000 $G^{0.89}$
Compression perpendicular (kPa)	8,800 $G^{1.53}$	18,500 $G^{2.48}$	16,500 $G^{1.57}$	21,600 $G^{2.09}$
Shear parallel (kPa)	11,000 $G^{0.73}$	17,800 $G^{1.24}$	16,600 $G^{0.85}$	21,900 $G^{1.13}$
Tension perpendicular (kPa)	3,800 $G^{0.78}$	10,500 $G^{1.37}$	6,000 $G^{1.11}$	10,100 $G^{1.3}$
Side hardness (N)	6,230 $G^{1.41}$	16,550 $G^{2.31}$	85,900 $G^{1.5}$	15,300 $G^{2.09}$

[a]Compression parallel to grain is maximum crushing strength; compression perpendicular to grain is fiber stress at proportional limit. MOR is modulus of rupture; MOE, modulus of elasticity; and WML, work to maximum load. For green wood, use specific gravity based on ovendry weight and green volume; for dry wood, use specific gravity based on ovendry weight and volume at 12% moisture content.

Tabel 2. Kuat Acuan (MPa) berdasarkan modulus elastis, SNI 03-xxxx-2002

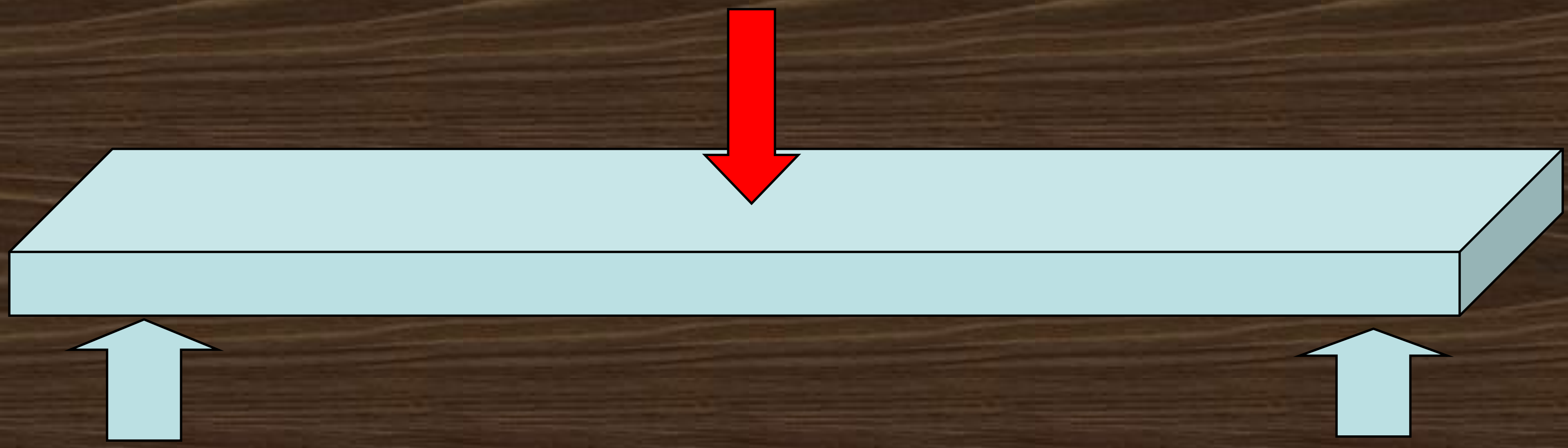
Tabel 2. Kuat Acuan (MPa) berdasarkan modulus elastis, SNI 03-xxxx-2000

Kode mutu	Modulus Elastisitas Lentur E_w	Kuat Lentur F_b	Kuat tarik sejajar serat F_t	Kuat tekan sejajar serat F_c	Kuat Geser F_v	Kuat tekan Tegak lurus Serat $F_{c\perp}$
E26	25000	66	60	46	6,6	24
E25	24000	62	58	45	6,5	23
E24	23000	59	56	45	6,4	22
E23	22000	56	53	43	6,2	21
E22	21000	54	50	41	6,1	20
E21	20000	50	47	40	5,9	19
E20	19000	47	44	39	5,8	18
E19	18000	44	42	37	5,6	17
E18	17000	42	39	35	5,4	16
E17	16000	38	36	34	5,4	15
E16	15000	35	33	33	5,2	14
E15	14000	32	31	31	5,1	13
E14	13000	30	28	30	4,9	12
E13	12000	27	25	28	4,8	11
E12	11000	23	22	27	4,6	11
E11	10000	20	19	25	4,5	10
E10	9000	18	17	24	4,3	9

PEMILAHAN KAYU (GRADING)

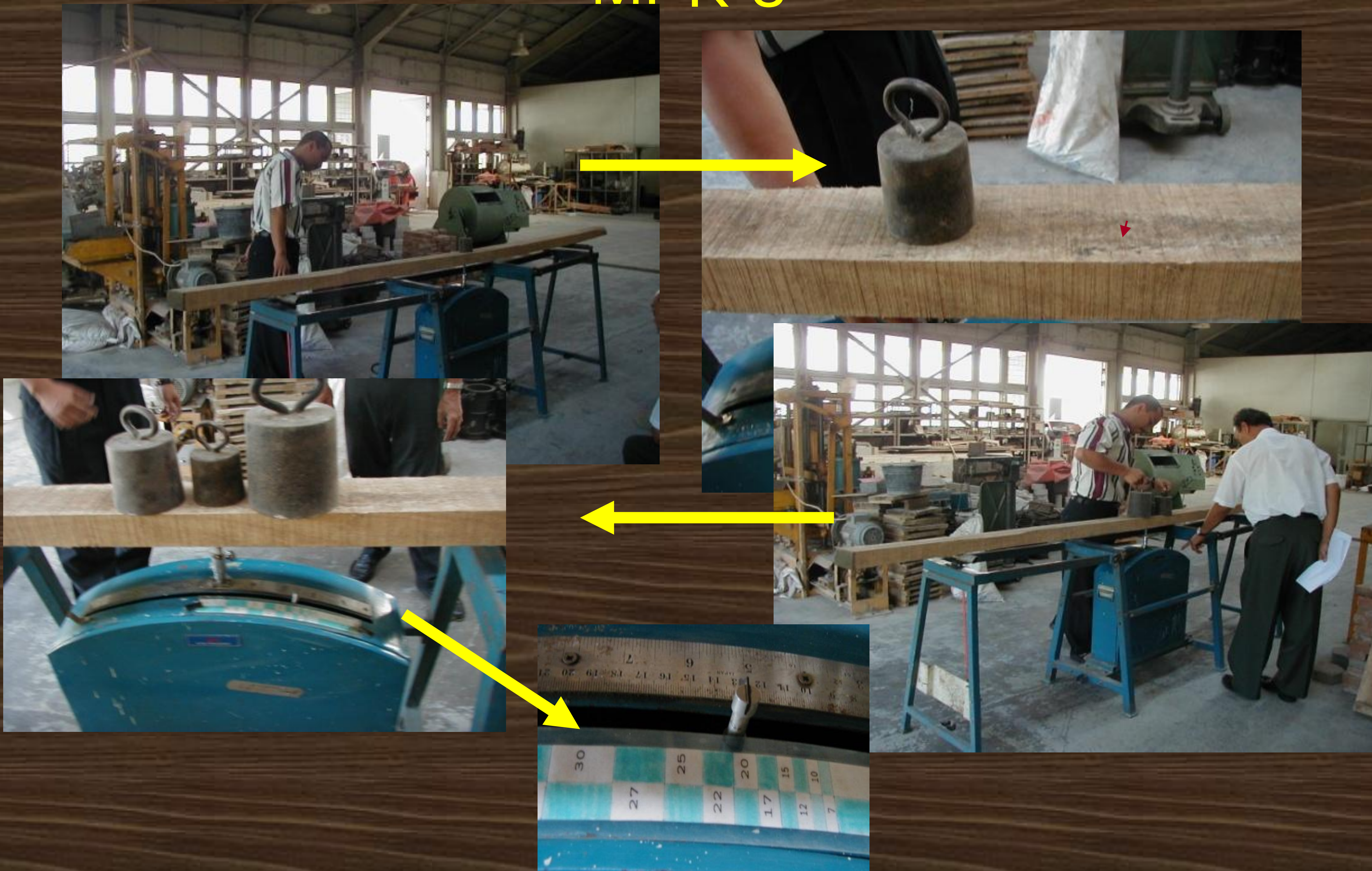
- Mekanis (*mechanical grading*):

- *E* dicari dengan *static bending test, flatwise*)



- Besaran mekanis lain diprediksi berdasarkan *E* yang telah diperoleh (SNI Tabel 4.2.1)

PEMILAHAN MASINAL DENGAN PANTER MPK-3



tif.

Tabel 4.2.1 Nilai Desain dan Modulus Elastisitas Lentur Acuan (DTI)

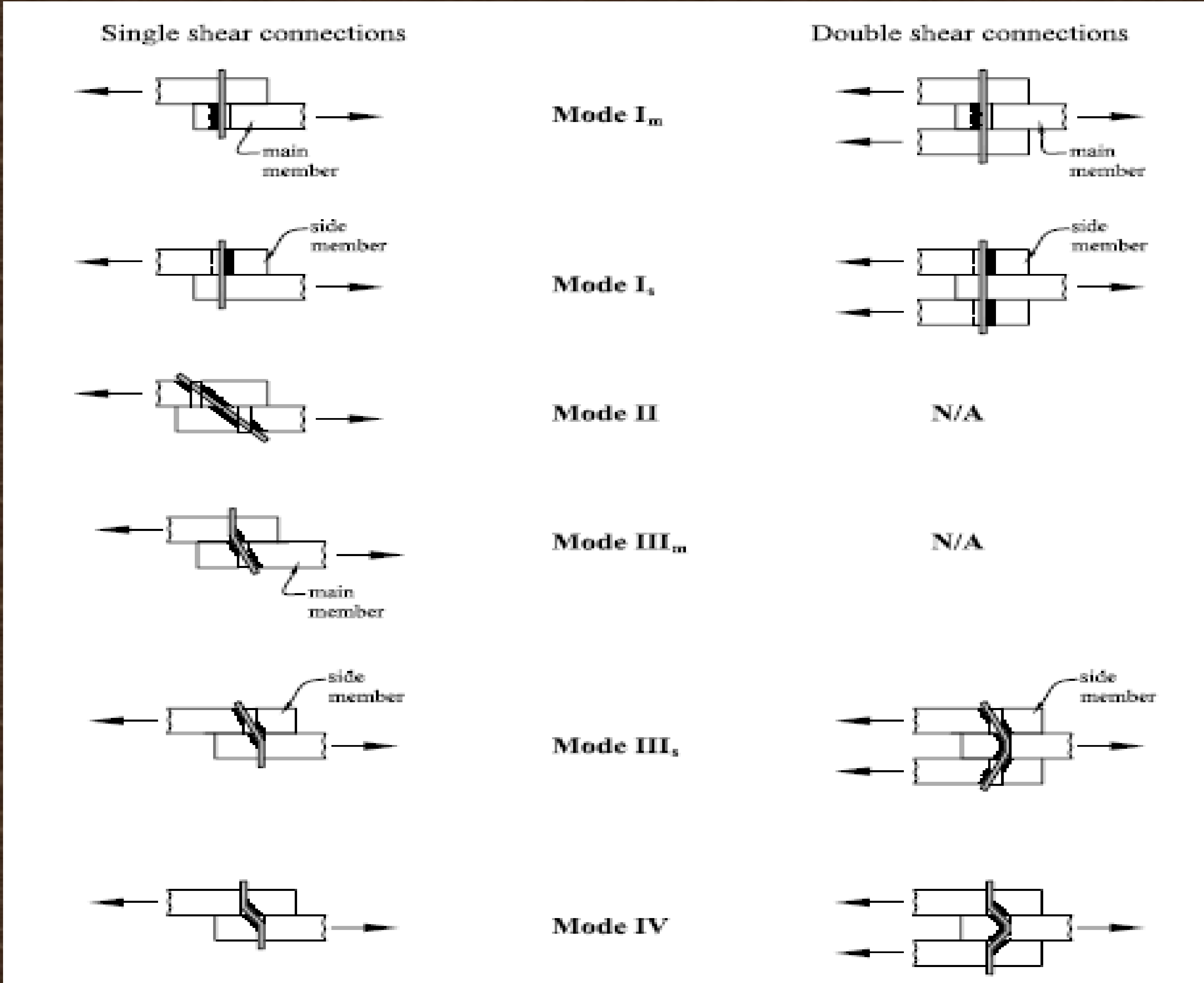
Kode Mutu	Nilai Desain Acuan (MPa)					Modulus Elastisitas Acuan (MPa)	
	F_b	$F_{t//}$	$F_{c//}$	F_v	$F_{c\perp}$	E	E_{min}
E25	26.0	22.9	18.0	3.06	6.11	25000	12500
E24	24.4	21.5	17.4	2.87	5.74	24000	12000
E23	23.2	20.5	16.8	2.73	5.46	23000	11500
E22	22.0	19.4	16.2	2.59	5.19	22000	11000
E21	21.3	18.8	15.6	2.50	5.00	21000	10500
E20	19.7	17.4	15.0	2.31	4.63	20000	10000
E19	18.5	16.3	14.5	2.18	4.35	19000	9500
E18	17.3	15.3	13.8	2.04	4.07	18000	9000
E17	16.5	14.6	13.2	1.94	3.89	17000	8500
E16	15.0	13.2	12.6	1.76	3.52	16000	8000
E15	13.8	12.2	12.0	1.62	3.24	15000	7500
E14	12.6	11.1	11.1	1.48	2.96	14000	7000
E13	11.8	10.4	10.4	1.39	2.78	13000	6500
E12	10.6	9.4	9.4	1.25	2.50	12000	6000
E11	9.1	8.0	8.0	1.06	2.13	11000	5500
E10	7.9	6.9	6.9	0.93	1.85	10000	5000
E9	7.1	6.3	6.3	0.83	1.67	9000	4500
E8	5.5	4.9	4.9	0.65	1.30	8000	4000
E7	4.3	3.8	3.8	0.51	1.02	7000	3500
E6	3.1	2.8	2.8	0.37	0.74	6000	3000
E5	2.0	1.7	1.7	0.23	0.46	5000	2500

FAKTOR TAHANAN ϕ

Jenis	ϕ
Tekan	$\phi_c = 0.90$
Lentur	$\phi_b = 0.85$
Stabilitas	$\phi_s = 0.85$
Tarik	$\phi_t = 0.80$
Geser/puntir	$\phi_v = 0.75$
Sambungan	$\phi_z = 0.65$

Tabel 4.3 . keberlakuan faktor-faktor koreksi untuk kayu gergajian

		Hanya DTI	DTI dan DFBK										Hanya DFBK		
		Faktor Durasi Beban	Faktor Layan Basah	Faktor Temperatur	Faktor Stabilitas Balok	Faktor Ukuran	Faktor Penggunaan rebah	Faktor Tusukan	Faktor Komponen struktur Berulang	Faktor Stabilitas Kolom	Faktor Kekakuan Tekuk	Faktor Luas Tumpu	Faktor Koversi Format	Faktor Ketahanan	Faktor Efek Waktu
$F_b' = F_b$	x	C_D	C_M	C_t	C_L	C_F	C_{fu}	C_i	C_r	-	-	-	2,54	0,85	λ
$F_t' = F_t$	x	C_D	C_M	C_t	-	C_F	-	C_i	-	-	-	-	2,70	0,80	λ
$F_v' = F_v$	x	C_D	C_M	C_t	-	-	-	C_i	-	-	-	-	2,88	0,75	λ
$F_{c\perp} = F_{c\perp}$	x	-	C_M	C_t	-	-	-	C_i	-	-	-	C_b	1,67	0,90	-
$F_c' = F_c$	x	C_D	C_M	C_t	-	C_F	-	C_i	-	C_P	-	-	2,40	0,90	λ
$E' = E$	x	-	C_M	C_t	-	-	-	C_i	-	-	-	-	-	-	-
$E_{min}' = E_{min}$	x	-	C_M	C_t	-	-	-	C_i	-	-	C_T	-	1,76	0,85	-


Single shear connections
Double shear connections
main member
Mode I_m
side member
Mode I_s
Mode II
N/A
Mode III_m
N/A
Mode III_s
Mode IV

Tabel 11.3.1A Persamaan Batas Leleh

Mode Kelelehan	Geser Tunggal		Geser Ganda	
I_m	$Z = \dfrac{D\,\ell_m\,F_{em}}{R_d}$	(11.3-1)	$Z = \dfrac{D\,\ell_m\,F_{em}}{R_d}$	(11.3-7)
I_s	$Z = \dfrac{D\,\ell_s\,F_{es}}{R_d}$	(11.3-2)	$Z = \dfrac{2D\,\ell_s\,F_{es}}{R_d}$	(11.3-8)
II	$Z = \dfrac{k_1\,D\,\ell_s\,F_{es}}{R_d}$	(11.3-3)		
III_m	$Z = \dfrac{k_2\,D\,\ell_s\,F_{em}}{(1+2R_e)R_d}$	(11.3-4)		
III_s	$Z = \dfrac{k_3\,D\,\ell_s\,F_{em}}{(2+R_e)R_d}$	(11.3-5)	$Z = \dfrac{2k_3\,D\,\ell_s\,F_{em}}{(2+R_e)R_d}$	(11.3-9)
IV	$Z = \dfrac{D^2}{Rd}\sqrt{\dfrac{2\,\text{Fem Fyb}}{3(1+\text{Re})}}$	(11.3-6)	$Z = \dfrac{2D^2}{Rd}\sqrt{\dfrac{2\,\text{Fem Fyb}}{3(1+\text{Re})}}$	(11.3-10)

Catatan:

$$k_1 = \frac{\sqrt{Re + 2Re^2(1 + Rt + Rt^2) + Rt^2Re^3} - R_e(1+R_t)}{(1+R_e)}$$

$$k_2 = -1 + \sqrt{2(1 + Re) + \frac{2Fyb(1+2Re)D^2}{3Fem\ \ell m^2}}$$

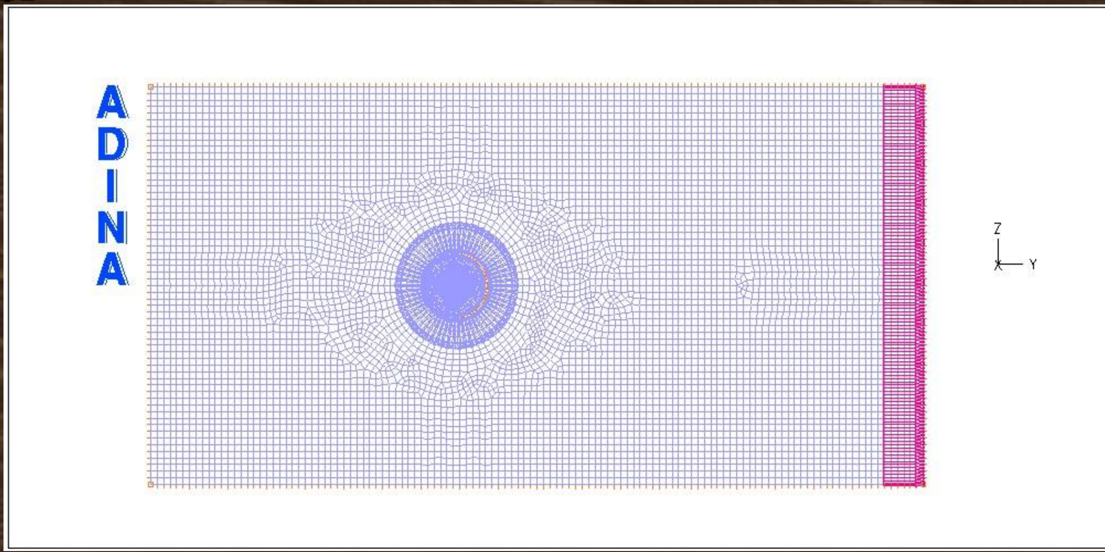
$$k_3 = -1 + \sqrt{\frac{2(1+Re)}{Re} + \frac{2Fyb(2+Re)D^2}{3Fem\ \ell s^2}}$$

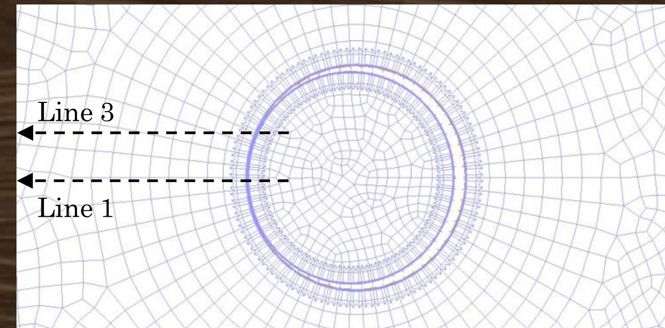
Tabel 11.3.3.A
Berat Jenis Beberapa Kayu Indonesia

Tabel 11.3.3.A
Berat Jenis Beberapa Kayu Indonesia

No.	Nama perdagangan	Nama botanis	Berat Jenis Kayu
1.	Akasia	Acacia mangium	0.52 (0.47-0.58)
2.	Bungur	Lagerstroemia speciosa	0.69 (0.58-0.81)
3.	Damar	Agathis alba	0.48 (0.43-0.54)
4.	Durian	Durio zibethinus	0.57 (0.42-0.69)
5.	Jabon	Anthocephalus cadamba	0.42 (0.29-0.56)
6.	Jati	Tectona grandis	0.67 (0.62-0.75)
7.	Karet	Hevea brasiliensis	0.59 (0.47-0.73)
8.	Kayu afrika	Maesopsis eminii	0.41 (0.34-0.48)
9.	Kayu manis	Cinnamomum purrectum	0.63 (0.40-0.86)
10.	Laban	Vitex pubescens	0.81 (0.72-0.87)
11.	Mahoni	Swietenia macrophylla	0.61 (0.53-0.67)
12.	Matoa	Pometia pinnata	0.77 (0.50-0.99)
13.	Meranti	Shorea sp	0.63 (0.47-0.83)
14.	Mindi	Melia excelsa	0.53 (0.48-0.57)
15.	Pasang	Quercus lineata	0.96 (0.90-1.10)
16.	Balobo	Diplodiscus sp	0.73 (0.67-0.73)
17.	Puspa	Schima wallichii	0.62 (0.45-0.72)
18.	Rasamala	Altingia excelsa	0.81 (0.61-0.90)
19.	Saninten	Catanopsis argentea	0.73 (0.55-0.85)
20.	Sengon	Paraserianthes falcataria	0.33 (0.24-0.49)
21.	Sengon buto	Enterolobium cyclocarpum	0.49 (0.39-0.57)
22.	Sonokeling	Dalbergia latifolia	0.83 (0.77-0.86)
23.	Sonokembang	Pterocarpus indicus	0.65 (0.49-0.84)
24.	Sukun	Artocarpus altilis	0.33 (0.24-0.54)
25.	Sungkai	Peronema canescens	0.63 (0.52-0.73)
26.	Suren	Toona sureni	0.39 (0.27-0.67)
27.	Tusam	Pinus merkusii	0.55 (0.40-0.75)
28.	Waru	Hibiscus tiliaceus	0.54 (0.36-0.64)
29.	Waru gunung	Hibiscus macrophyllus	0.40 (0.36-0.56)
30.	Nyamplung	Calophyllum inophyllum	0.69 (0.56-0.79)

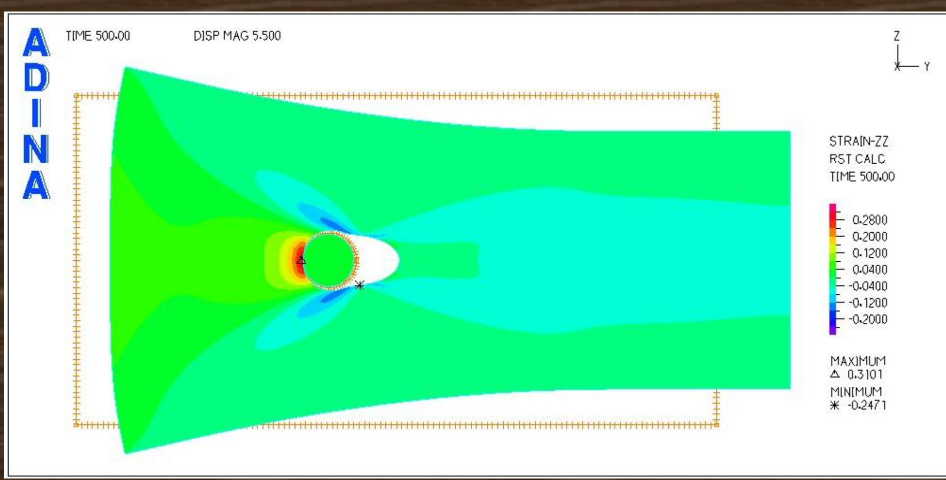
ANALISIS TEGANGAN DENGAN METODE ELEMEN HINGGA

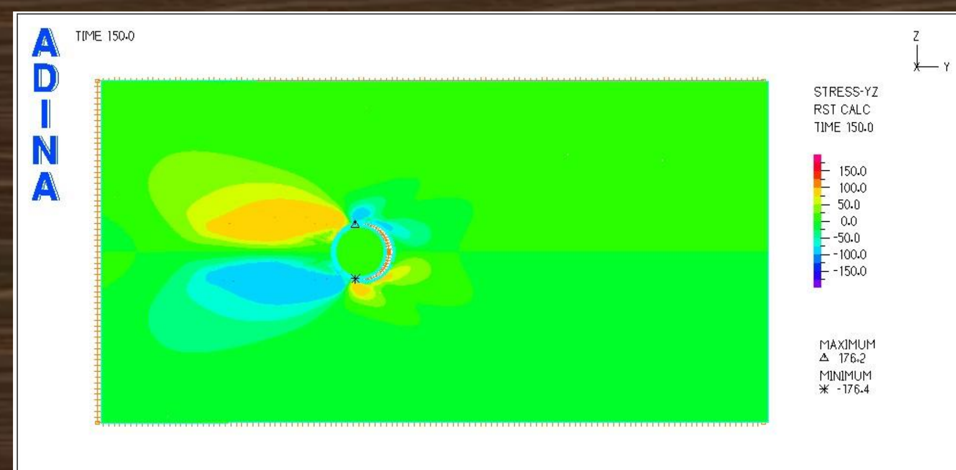




Daerah kontak antara elemen kayu dan baut

Model sambungan kayu dengan baut tunggal dengan elemen hingga





Kontur regangan arah sumbu – Z

Kontur tegangan geser bidang YZ

Figure 1

Walls must be strong enough to resist the wind forces that push against the home.

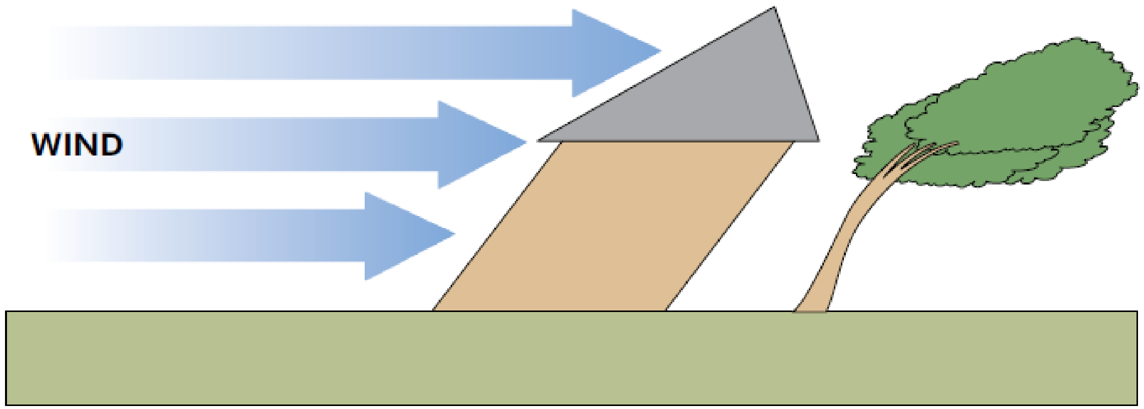


Figure 2

In an earthquake, the seismic ground motion acts on the foundation, while inertia attempts to keep the roof from moving with the foundation, causing forces on the walls.

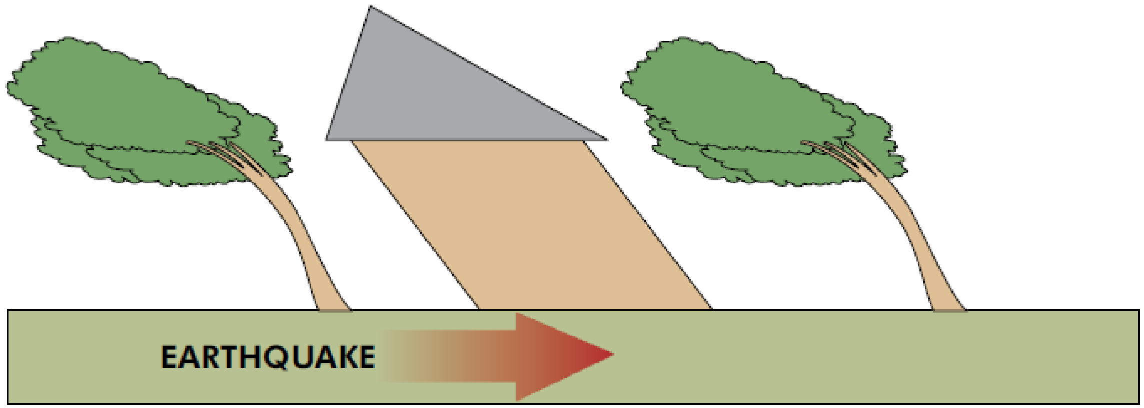
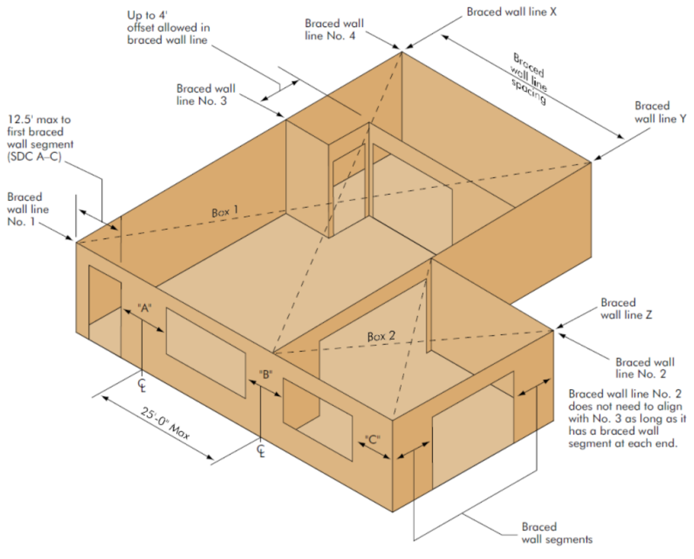
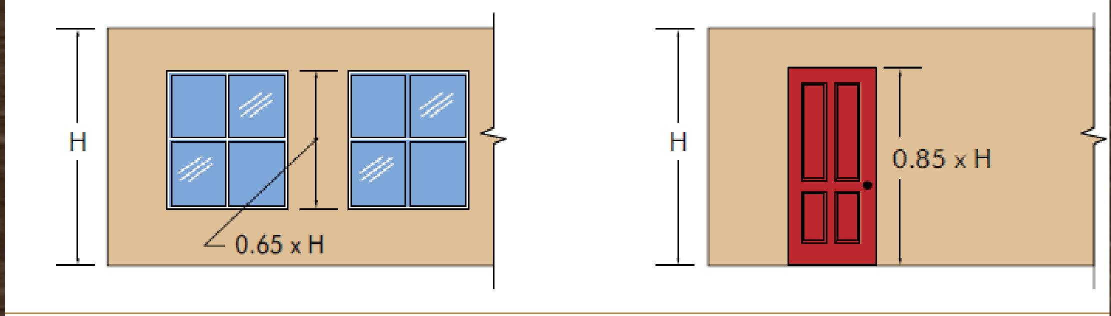
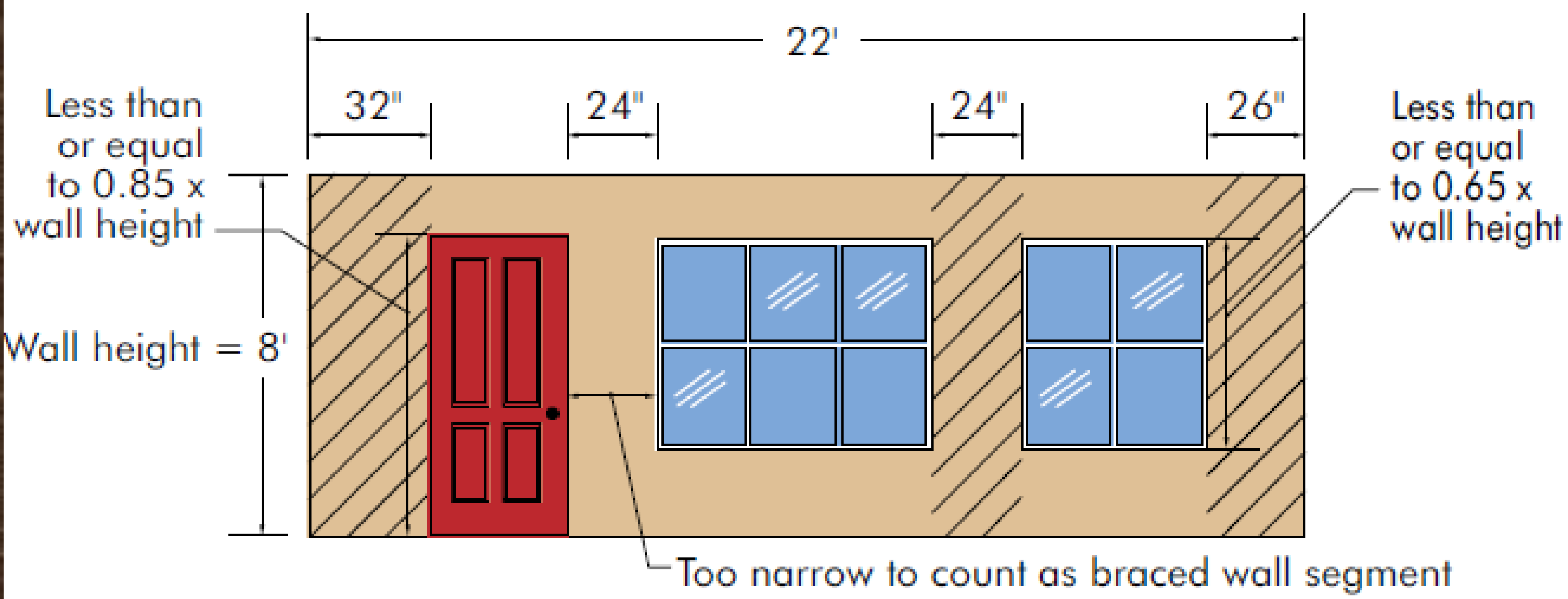


Figure 17

This diagram of a home shows wall bracing requirements from the 2006 IRC.







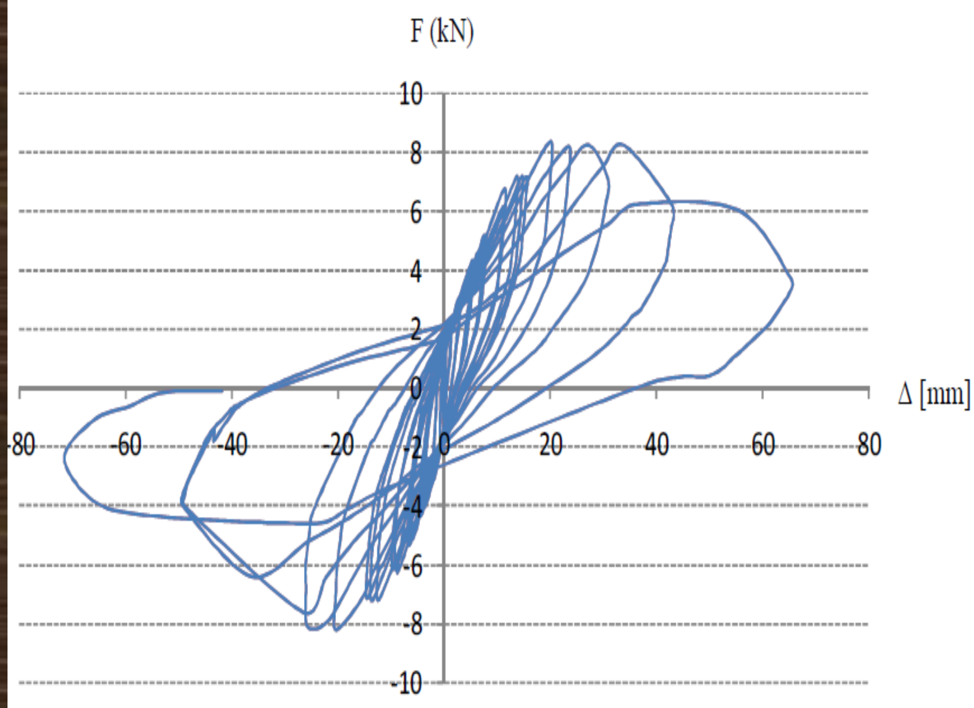


Figure 8. Hysteresis curve of WP-SW2 specimen

Table 1. Data in the trilinier curve and intercept point

Specimen	dir	F_y (kN)	Δ_y (mm)	F_u (kN)	Δ_u (mm)	F_{max} (kN)	Δ_{max} (mm)	F_i (kN)
WP-SW1	+	**3.90**	6.10	**5.89**	19.50	**6.21**	41.90	0.20
	-	4.00	4.00	6.05	9.55	7.51	**91.50**	0.80
WP-SW2	+	5.05	7.50	7.05	14.90	8.05	33.10	1.50
	-	5.05	6.58	7.00	13.90	8.00	**24.90**	1.75
WP-SW3	+	4.05	5.02	6.95	14.90	8.05	37.50	1.40
	-	**5.05**	4.02	**7.10**	20.02	**8.10**	31.90	1.40

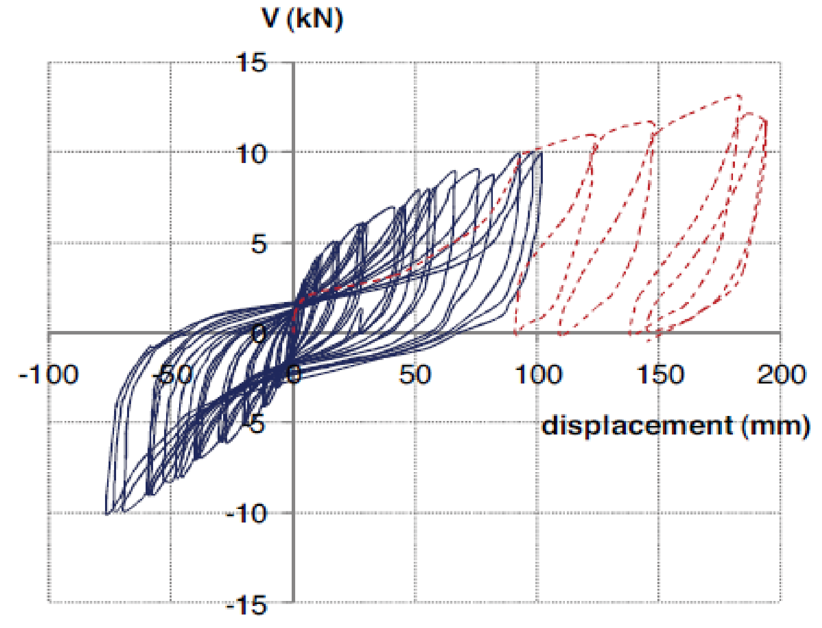


***Figure 12:** Hysteresis curve of WPO-3 with door and window openings*

***Table 3:** Shear force and displacement at tri-linier curve of WPO-shearwall with opening*

Specimen	dir	V_y (kN)	Δ_y (mm)	V_u (kN)	Δ_u (mm)	V_{max} (kN)	Δ_{max} (mm)	V_i (kN)
WP-O1	+	3.85	11.20	5.95	36.00	10.00	135.00	1.80
	-	3.00	7.50	6.00	46.00	7.70	88.00	1.20
WP-O2	+	3.80	12.50	7.99	63.00	13.00	190.00	1.10
	-	4.00	12.50	6.10	33.00	8.10	64.00	1.25
WP-O3	+	4.00	10.00	7.00	40.00	13.00	182.00	1.80
	-	4.00	10.00	6.15	28.00	10.00	78.00	1.80

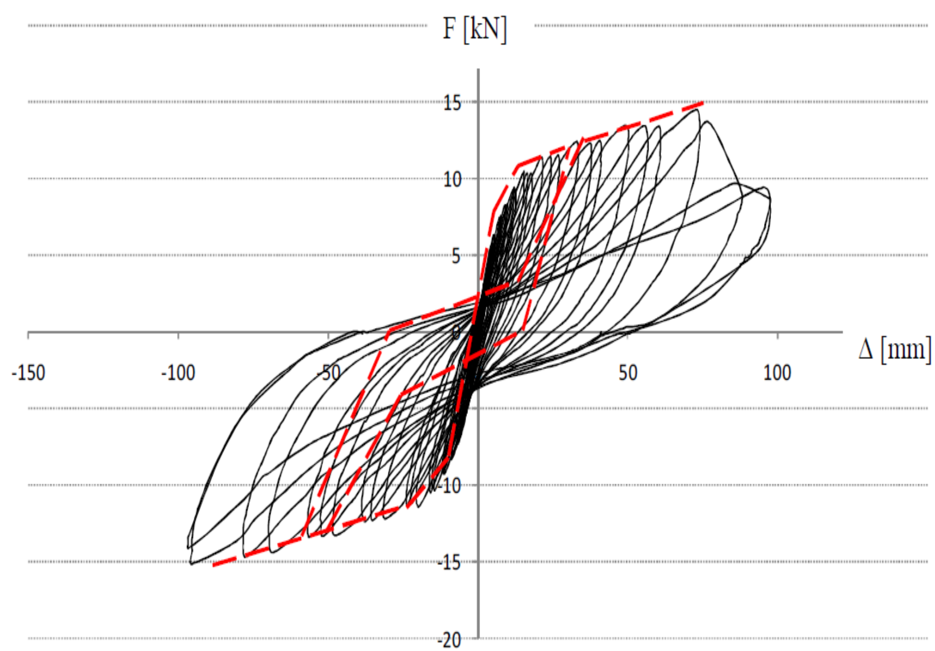
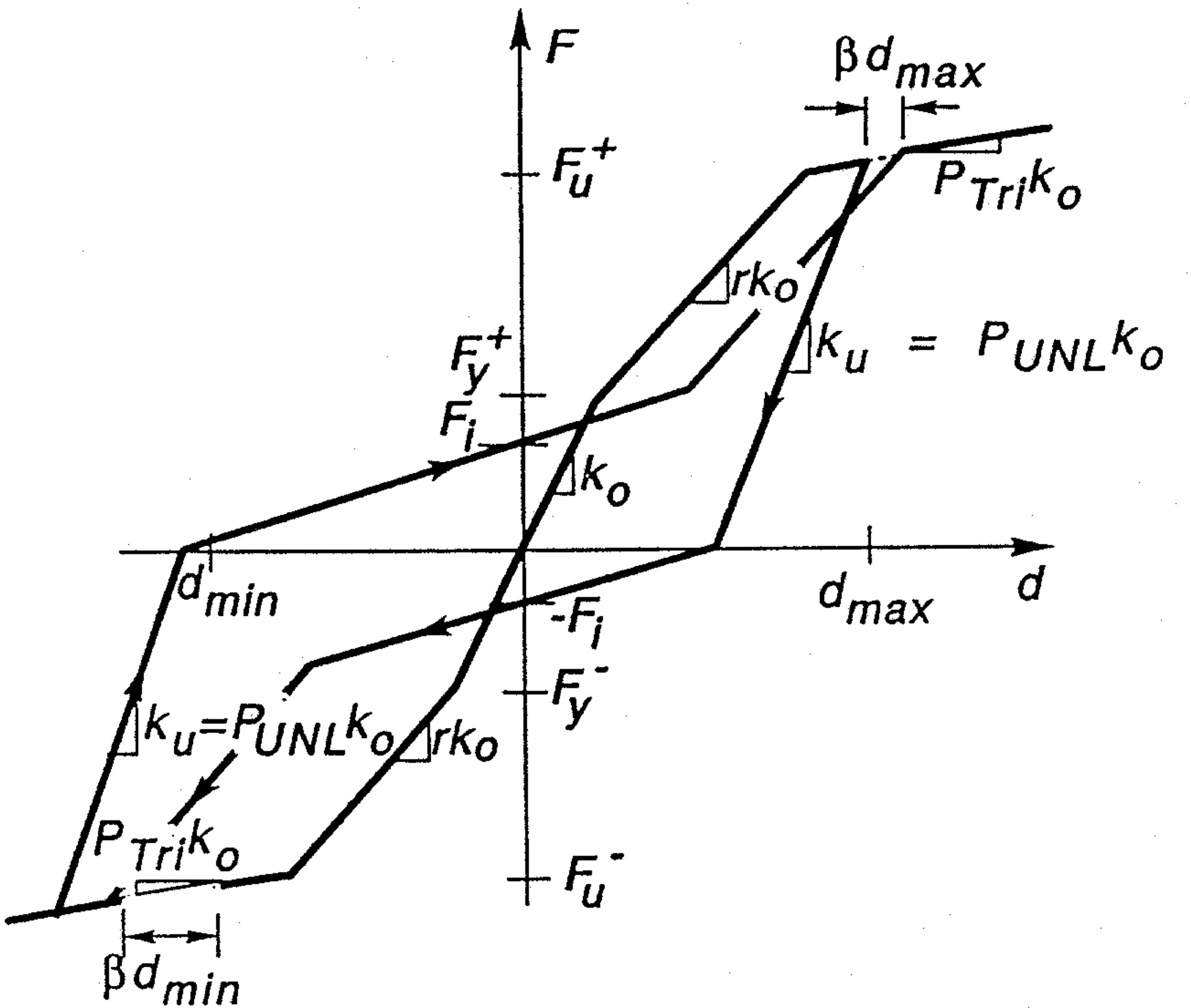


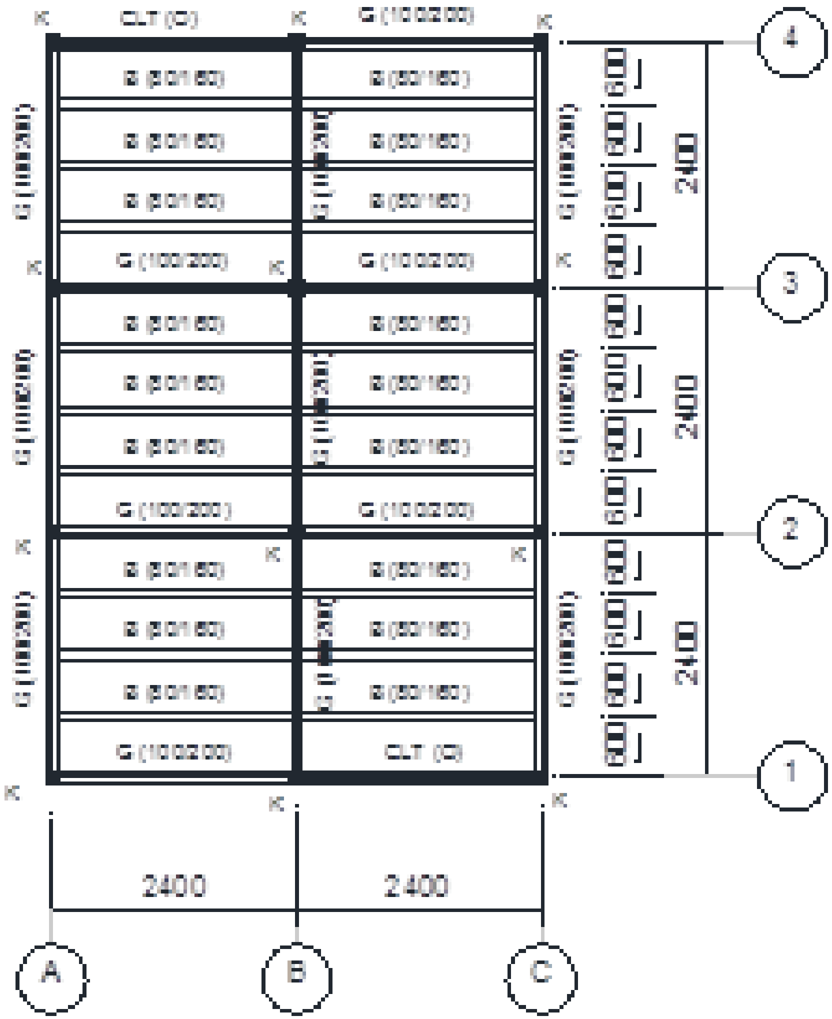
Figure 12. Hysteresis curve of CNLT-SW3

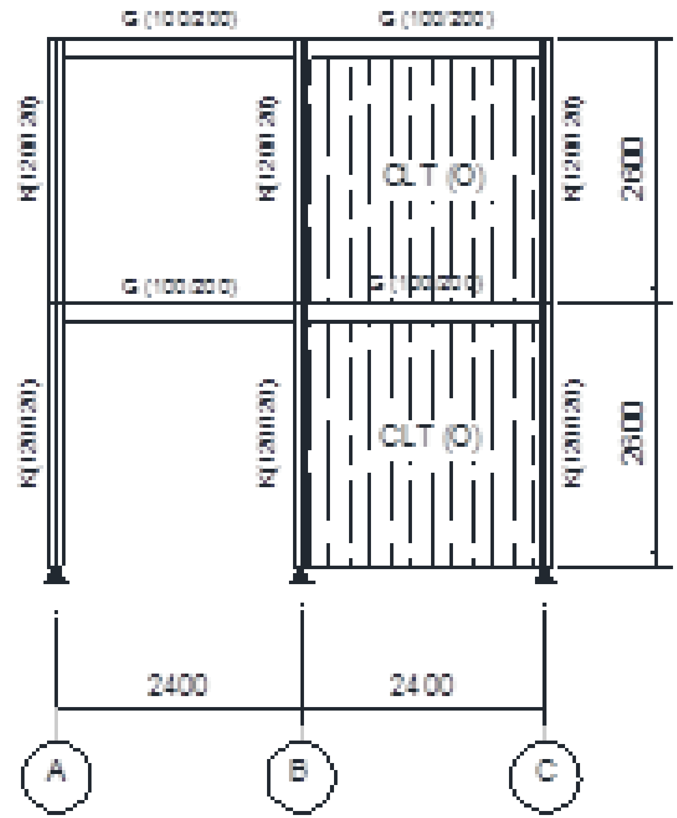
Table 1. Data in the trilinier curve and intercept point

Specimen	dir	F_y (kN)	Δ_y (mm)	F_u (kN)	Δ_u (mm)	F_{max} (kN)	Δ_{max} (mm)	F_i (kN)
CNLT-	+	**9.45**	10.50	**12.09**	22.10	14.22	**49.89**	3.85
SW1	-	8.45	7.85	**10.20**	20.19	**13.26**	55.79	2.80
CNLT-	+	8.30	9.05	11.20	22.30	**17.70**	**160.00**	2.40
SW2	-	8.30	7.30	10.95	22.00	14.15	70.10	3.15
CNLT-	+	**8.25**	8.50	11.20	21.00	14.35	73.00	2.00
SW3	-	9.15	9.00	11.20	20.05	15.10	95.40	2.40

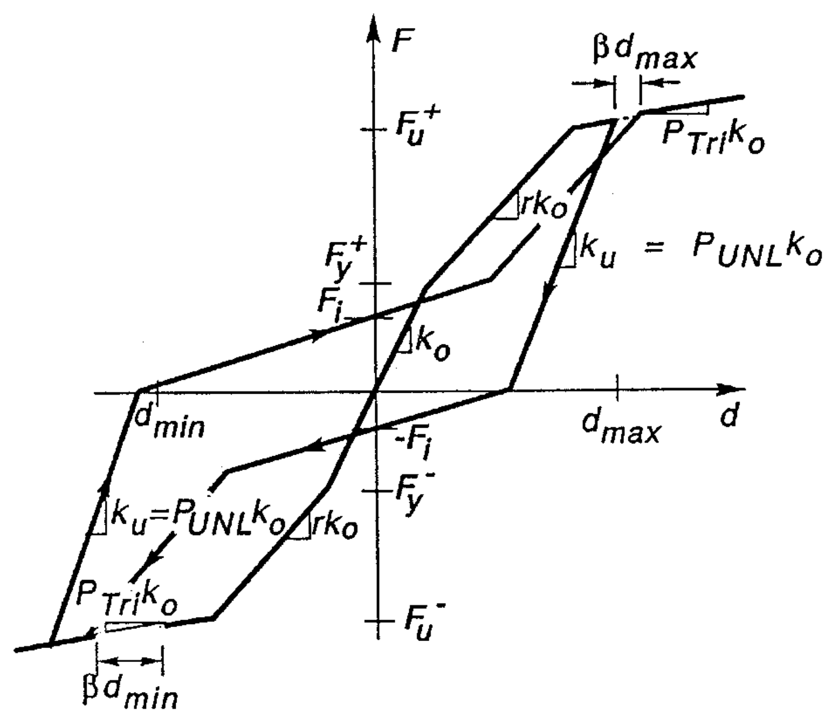


F
βd_max
F_u^+
P_Tri k_o
rk_o
k_u = P_UNL k_o
F_y^+
F_i
k_o
d_min
d_max
d
-F_i
F_y^-
k_u=P_UNL k_o
rk_o
P_Tri k_o
F_u^-
βd_min

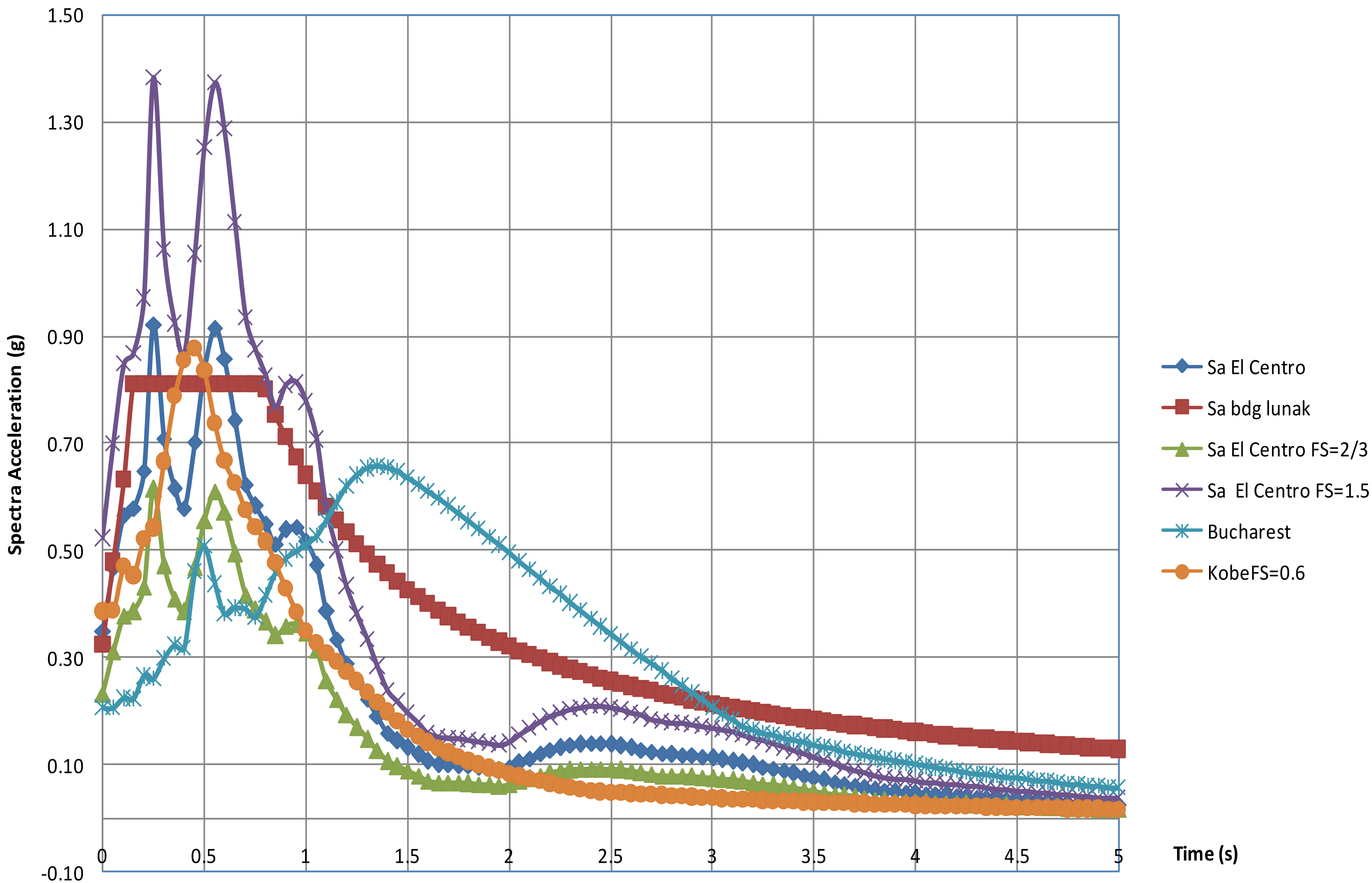

CLT (O)
G (100/200)
2400
2400
2400
2400
2400
1
2
3
4
A
B
C

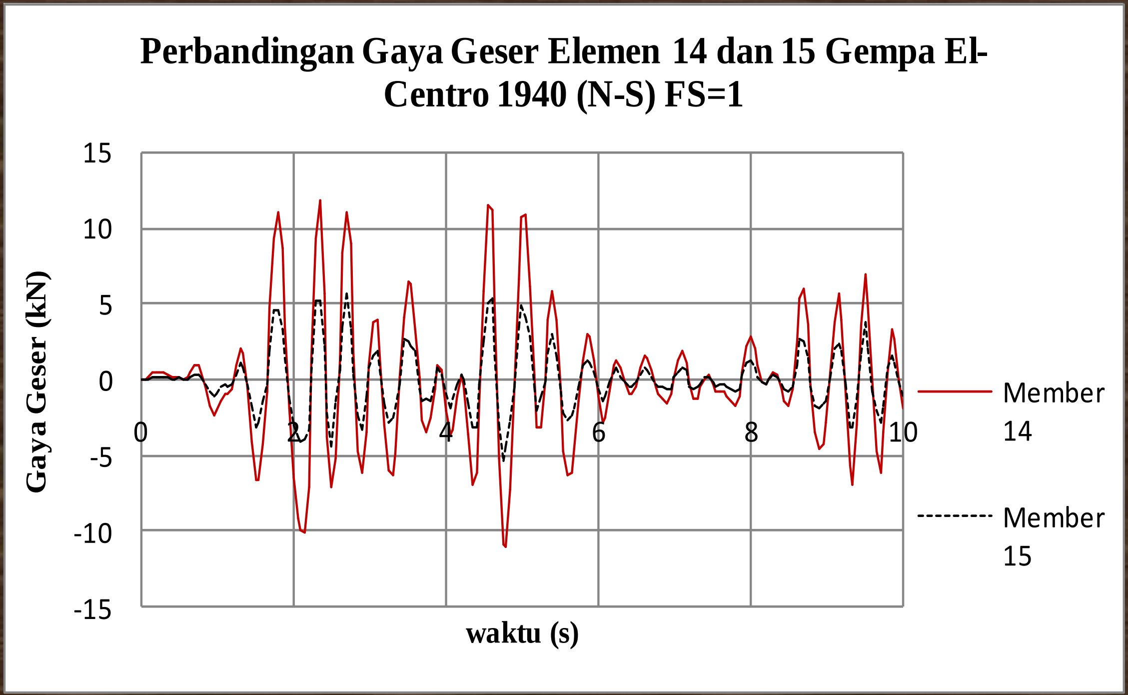

G (100/200)
CLT (O)
CLT (O)
2600
2600
2400
2400
A
B
C


G (100/200)
CLT (0)
K(120/120)
2600
2600
2400
2400
A
B
C

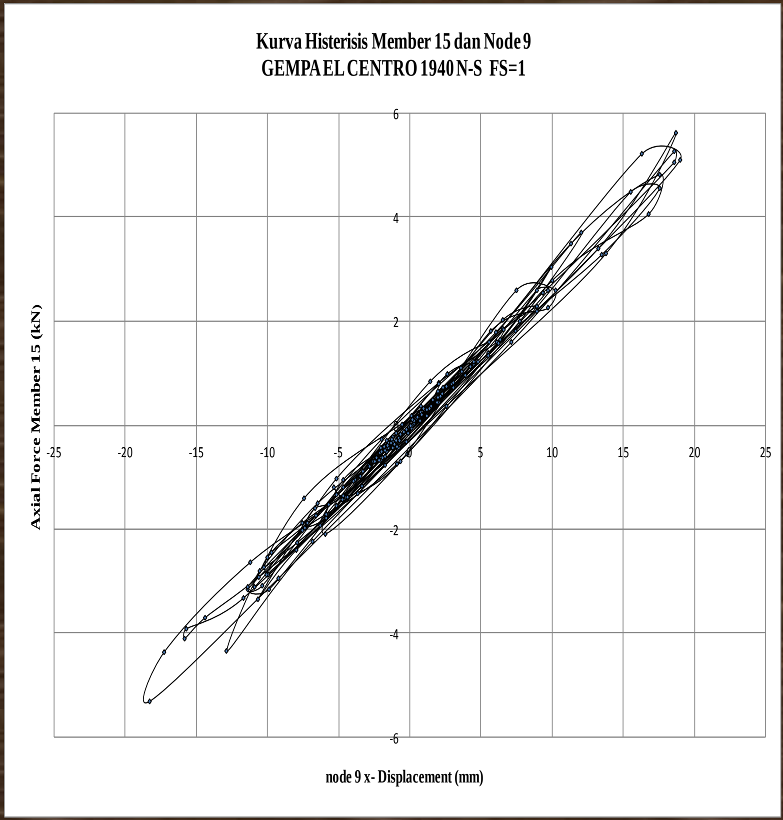

F
βd_max
F_u^+
P_Tri k_o
rk_o
k_u = P_UNL k_o
F_y^+
F_i
k_o
d_min
d_max
d
-F_i
F_y^-
k_u=P_UNL k_o
rk_o
P_Tri k_o
F_u^-
βd_min

Perbandingan Spectra Acceleration Gempa El Centro NS, Gempa Bucharest NS , Gempa Kobe NS dan Respons Spectra Wilayah Bandung Tanah Lunak

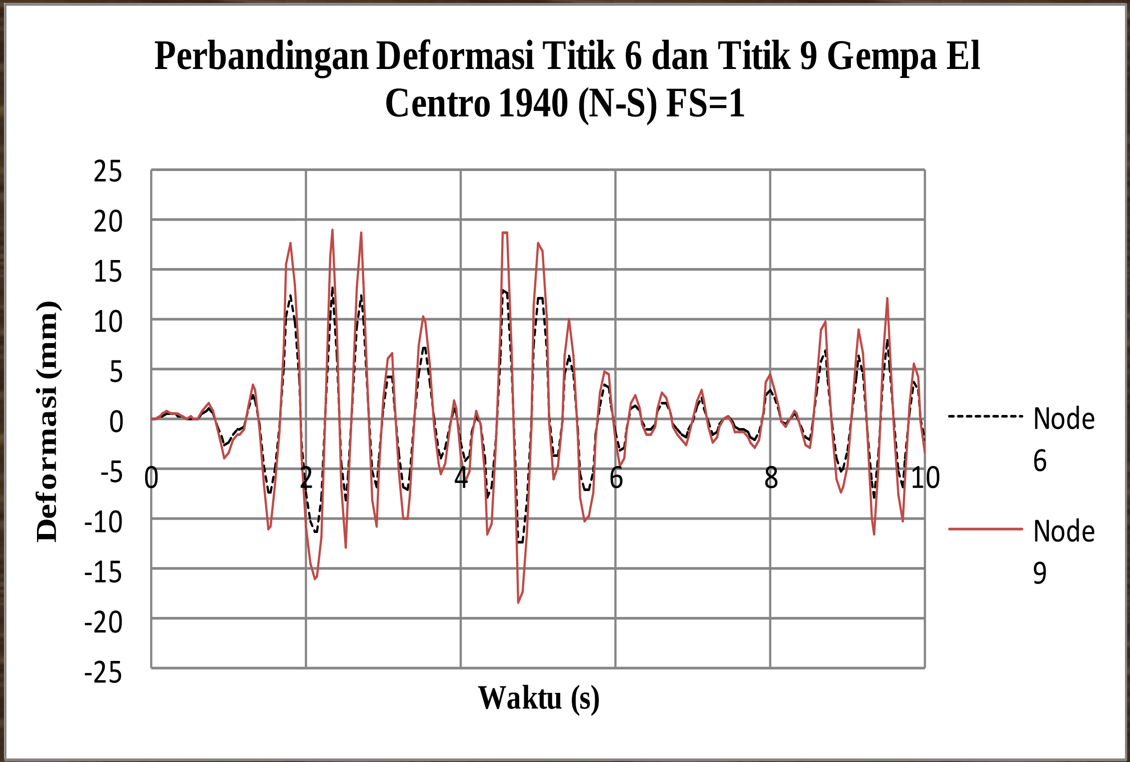




Perbandingan Gaya Geser Elemen 14 dan 15 Gempa El-Centro 1940 (N-S) FS=1
15
10
5
0
-5
-10
-15
0
2
4
6
8
10
Gaya Geser (kN)
waktu (s)
Member 14
Member 15



Kurva Histerisis Member 15 dan Node 9
GEMPA EL CENTRO 1940 N-S FS=1
6
4
2
-2
-4
-6
-25
-20
-15
-10
-5
0
5
10
15
20
25
Axial Force Member 15 (kN)
node 9 x- Displacement (mm)



Perbandingan Deformasi Titik 6 dan Titik 9 Gempa El Centro 1940 (N-S) FS=1
25
20
15
10
5
0
-5
-10
-15
-20
-25
0
2
4
6
8
10
Deformasi (mm)
Waktu (s)
Node 6
Node 9

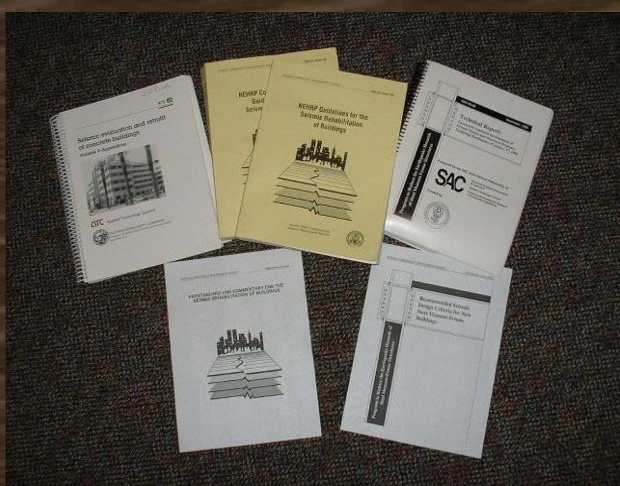
Perbandingan Gaya Geser dan Deformasi Lateral akibat Berbagai Record Gempa

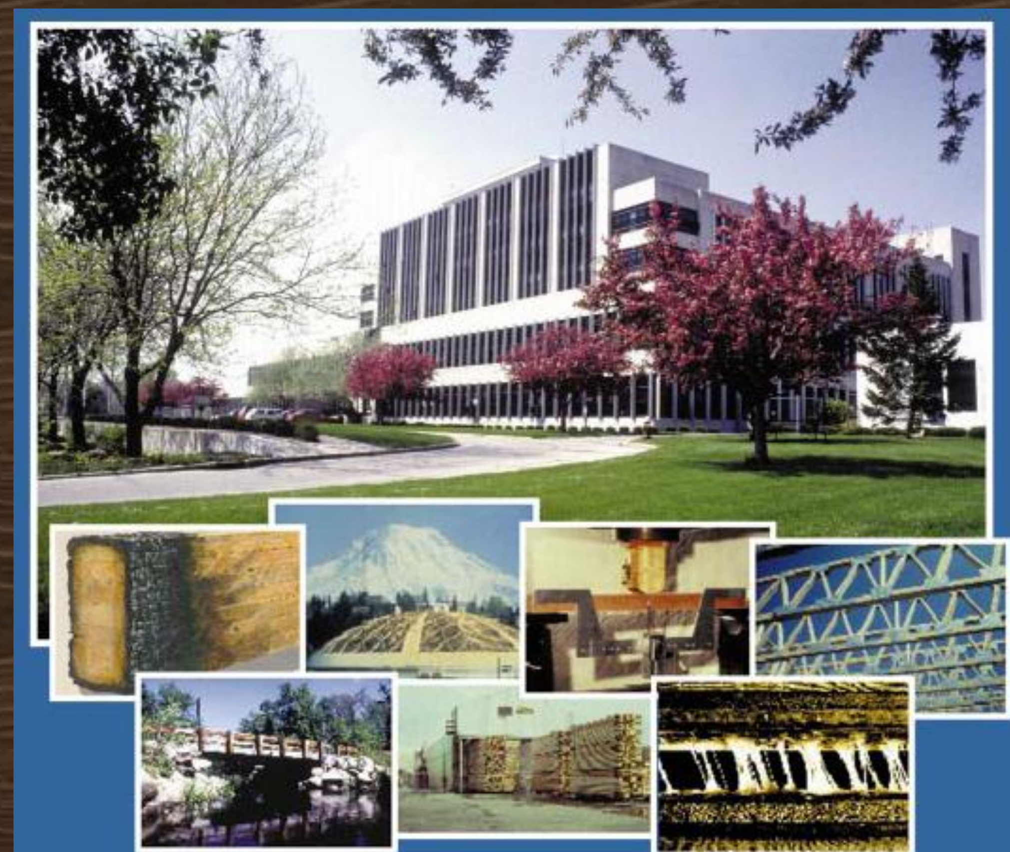
Record Gempa	El/Node	El Centro 1940 NS			Bucharest NS	Kobe 1995 NS FS=0.6
		FS=0.67	FS=1	FS=1.5		
Periode (s)		0.389	0.389	0.389	0.389	0.389
Gaya geser (N)	14	8086	12140	18120	8131	17570
	15	3489	5789	8657	3348	8059
Deformasi Lateral (mm)	6	9.051	13.58	20.28	9.101	19.650
	9	13.36	20.06	29.96	12.94	28.84

GOOD BUILDING CODES

≠

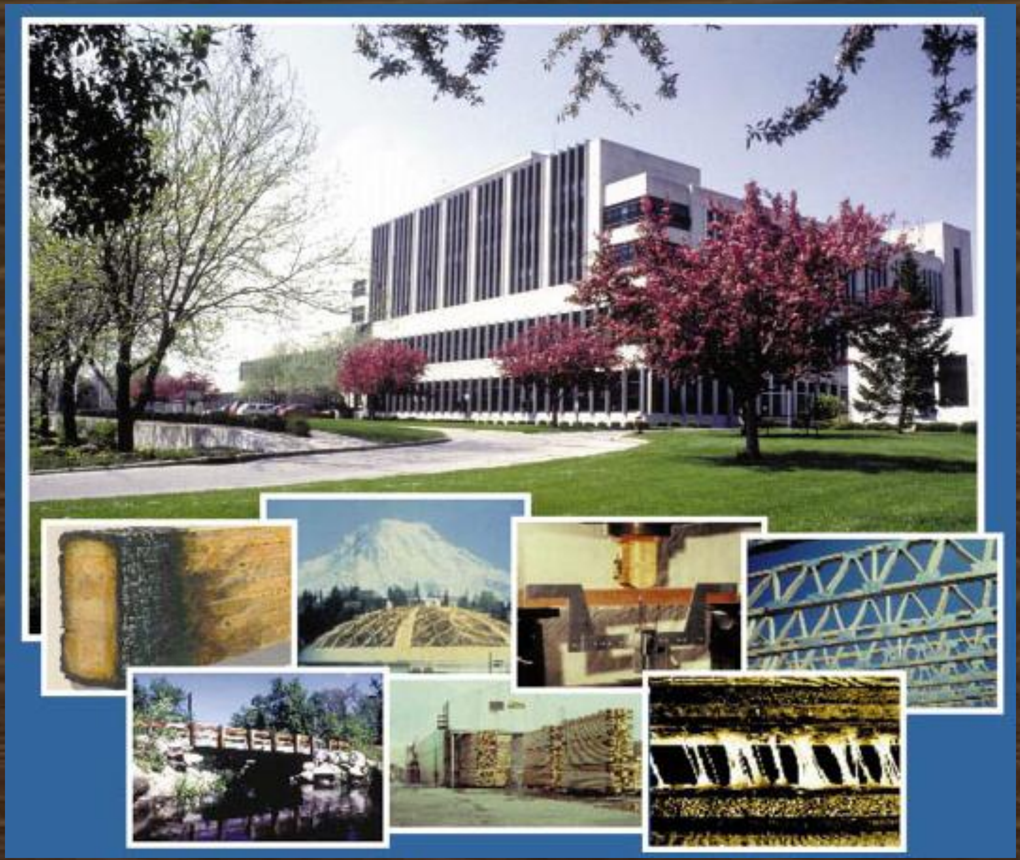
GOOD STRUCTURES





The Challenge

GOOD STRUCTURES = GOOD BUILDING CODES + GOOD DESIGN + GOOD MATERIALS + GOOD CONSTRUCTION



THANK YOU

THE END