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# *Preliminary* Duration of Load and Creep Factors for Cross Laminated Timber

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# Creep and Load Duration

## ➤ Creep

- Time-dependent deformation of a material under constant load.

## ➤ Load Duration

- Duration of continuing application of a load or a series of periods of intermittent applications of the same load type. Creep rupture is attributed to the load duration effect.

### **Main Factors Affecting Creep of Wood:**

- Magnitude, type and duration of load
- Moisture content (service conditions)
- Type of product (grain orientation, etc.)

# Adjustment Factors in CSA O86-09

(Canadian Standard on Engineering Design in Wood)

## ➤ Load Duration Factor ( $K_D$ )

### ➤ **Standard term**

Examples: snow load, occupancy load

→ No increase/reduction of specified strength

### ➤ **Short term**

Examples: seismic loads, wind loads

Less than 7 days continuous/cumulative loading

→ 15% increase of specified strength

### ➤ **Long term**

Examples: dead load

Continuous loading

→ 35% reduction of specified strength

**Load Duration Factor,  $K_D$**   
**Table 4.3.2.2, CSA O86-09**

Duration of load	$K_D$
Short term	1.15
Standard term	1.00
Long term	0.65

# Adjustment Factors in CSA O86-09

(Canadian Standard on Engineering Design in Wood)

## ➤ Service Condition Factor ( $K_s$ )

➤ DRY Condition (average EMC  $\leq$  15% & MC  $<$  19%)

➤ WET Condition  $\rightarrow$  reduction of specified strength

*Note:  $K_s$  is product specific & tabulated for different loading types.*

**Service Condition Factors Glulam, Table 6.4.2, CSA O86-09**

$K_s$	For specified strength in	GLULAM	
		Dry	Wet
$K_{Sb}$	Bending at extreme fibre	1.00	0.80
$K_{Sv}$	Longitudinal shear	1.00	0.87
$K_{Sc}$	Compression parallel to grain	1.00	0.75
$K_{Scp}$	Compression perpendicular to grain	1.00	0.67
$K_{St}$	Tension parallel to grain	1.00	0.75
$K_{Stp}$	Tension perpendicular to grain	1.00	0.85
$K_{SE}$	Modulus of elasticity	1.00	0.90

# Modification Factors in EN 1995-1-1

## (Eurocode 5 Design of Timber Structures)

### ➤ Strength Modification Factor ( $k_{mod}$ )

➤ Interaction – Load duration class & Service class

*Note:  $k_{mod}$  is product specific.*

**Strength Modification Factor, Table 3.1, EN 1995-1-1**

Load Duration Class	SC 1	SC 2	SC 3
<b><math>k_{mod}</math> for GLULAM / PLYWOOD</b>			
Permanent	0.60	0.60	0.50
Long term	0.70	0.70	0.55
Medium term	0.80	0.80	0.65
Short term	0.90	0.90	0.70
Instantaneous	1.10	1.10	0.90

Load Duration Class	Accidental	Service Class	Climatic Condition
Permanent	> 1 year	SC 1	Lumber MC<12%; Panels MC<8%
Long term	6 months	SC 2	Lumber MC<20%; Panels MC<15%
Medium term	1 year	SC 3	Lumber MC>20%; Panels MC>15%
Short term	< 1 week		
Instantaneous	N/A		

# Modification Factors in EN 1995-1-1

## (Eurocode 5 Design of Timber Structures)

### ➤ Deformation Modification Factor ( $k_{def}$ )

➤ Accounts for creep deformation

*Note:  $k_{def}$  is product specific.*

**Deformation Modification Factor, Table 3.2, EN 1995-1-1**

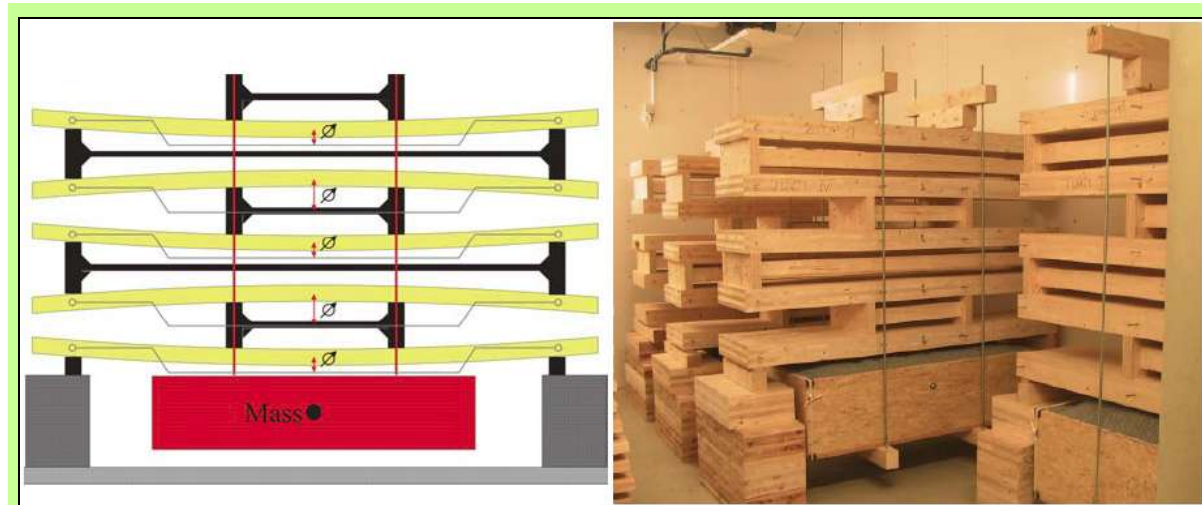
$k_{def}$	SC 1	SC 2	SC 3
LUMBER (EN 14081-1)	0.60	0.80	2.00
GLULAM (EN 14080)	0.60	0.80	2.00
PLYWOOD (EN 636)	0.80	1.00	2.50

Service Class	Climatic Condition
SC 1	Lumber MC<12%; Panels MC<8%
SC 2	Lumber MC<20%; Panels MC<15%
SC 3	Lumber MC>20%; Panels MC>15%

# Research at Graz University of Technology, Austria

- Creep Tests -- CLT vs. Glulam
  - 1-yr constant load @ 9% / 25% Ultimate Load & SC1 / SC2
  - **30-40% higher creep for CLT compared to glulam**

CLT  
more likely to  
behave like  
plywood than  
glulam



Source: Jöbstl, R.A. and Schickhofer, G. 2007. Comparative examination of creep of glulam and CLT slabs in bending. CIB-W19/40-12-3. Bled, Slovenia.

Proposed Deformation Modification Factor, $k_{def}$	SC 1	SC 2	SC 3
CLT (less than 7-layer)	0.90	1.10	N/A
CLT (more than 9-layer)	0.80	1.00	N/A

# Why larger creep in CLT vs. Glulam?

- Orthogonal orientation of adjacent layers in CLT
  - Bending → Cross plies in shear perpendicular to the grain
  - Wood = low rolling shear → Significant deformations



# Options Considered

## Option I (CSA O86-09)

- Load Duration Factor:  $K_D$  (Table 4.3.2.2)
- Service Condition Factor:  $K_S$  (Table 4.3.2.3)
- “Creep Factor (for total load) & Use Factor (for long-term load) **compared to glulam**”

Duration of load	$K_D$
Short term	1.15
Standard term	1.00
Long term	0.65

$K_S$	For	Load Duration Class	SC 1	SC 2	SC 3
<b><math>k_{mod}</math> for GLULAM / PLYWOOD</b>					
		Permanent	0.60	0.60	N/A
$K_{Sb}$	Bending	Long term	0.70	0.70	N/A
$K_{Sv}$	Long term	Medium term	0.80	0.80	N/A
$K_{Sc}$	Compression	Short term	0.90	0.90	N/A
$K_{Scp}$	Compression	Instantaneous	1.10	1.10	N/A
$K_{St}$	Tension parallel to grain			1.00	0.75
$K_{Stp}$	Tension perpendicular to grain			1.00	0.85
$K_{SE}$	Modulus of elasticity			1.00	0.90

## Option II (EN 1995-1-1)

- Strength Modification Factor:  $k_{mod}$
- Deformation Modification Factor:  $k_{def}$

Proposed Deformation Modification Factor, $k_{def}$	SC 1	SC 2	SC 3
CLT (less than 7 layers)	0.90	1.10	N/A
CLT (more than 9 layers)	0.80	1.00	N/A



# Recommended Approach

## ➤ Ultimate Limit State

**$K_D$**  (Table/Equation Clause 4.3.2, CSA O86-09)

**$K_S$  Glulam** ( $K_{S \text{ Glulam Dry SC}} = 1.0$ , Table 6.4.2, CSA O86-09)

## ➤ Serviceability Limit State

### ➤ Deflection

Calculate elastic deflection due to total load using **0.75  $G_{90}$**

**Limit:** Elastic deflection  $< L/180$  (Clause 4.5.2, CSA O86-09)

Calculate permanent deformation due to long-term load using **0.50  $G_{90}$**

**Limit:** Permanent deformation  $< L/360$  (Clause 4.5.3, CSA O86-09)

### ➤ Vibration

Chapter 7: Design method for controlling vibrations in CLT floors

# Road Ahead

## ➤ Short-term

- Evaluate creep behavior of CLT products manufactured in Canada
- Verify and fine tune the recommended approach
- Update Chapter 6 of CLT Handbook

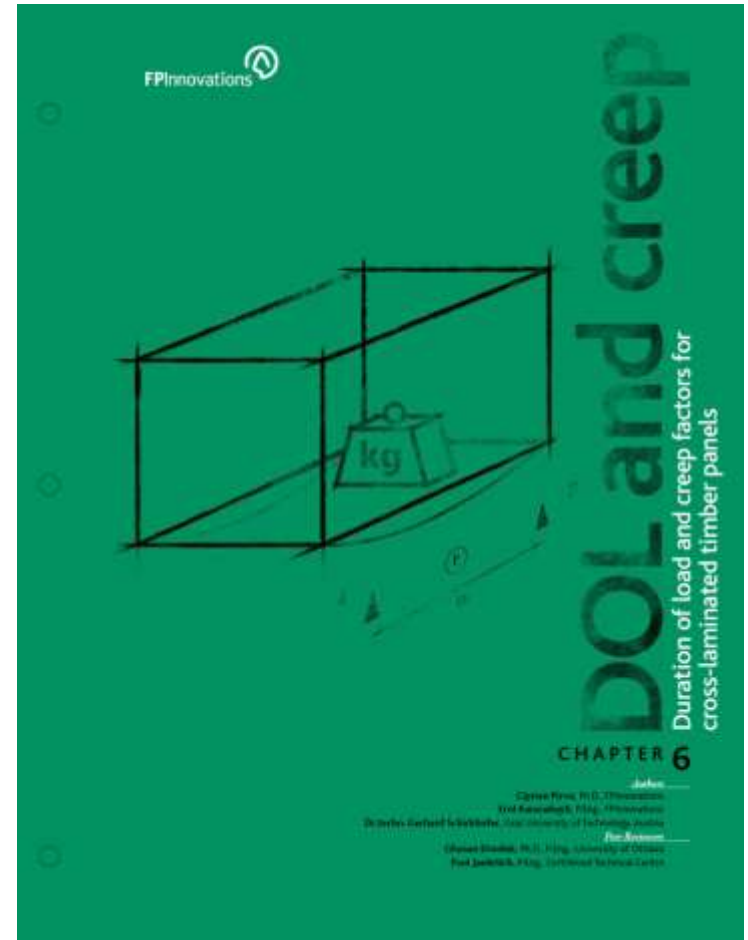
## ➤ Long-term

- Refine the current approach for accounting for creep of wood products in wood engineering codes.

# FPInnovations Special Publication

## CLT Handbook

- *Special Publication SP-528E*
- *Available from FPInnovations at:*  
[publications@fpinnovations.ca](mailto:publications@fpinnovations.ca)



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