Predicting bending creep of Laminated Veneer Lumber (LVL) Sengon (*Paraserianthes falcataria*) beams from initial creep test data

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Creep is a deflection or deformation of structures due to permanent loading over time.

Creep can cause **serviceability problems** due to excessive deformation or to a reduction in strength.

The total deformation during the service life of a building must be limited.

Understanding creep behaviour of material and structure will allow one to predict the behaviour of a building during its service life. **Including buildings using wood and wood based (wood engineered) materials.**

This research:

Bending creep of laminated veneer lumber Sengon - *Paraserianthes falcataria* (LVL Sengon). LVL Sengon is manufactured by **laminating veneers** obtained from Sengon timber. Each veneer has a thickness from 2.5 to 3.2 mm and plies parallel to length using melamine urea formaldehyde (UF) adhesive under 0.6-0.7 MPa pressure.

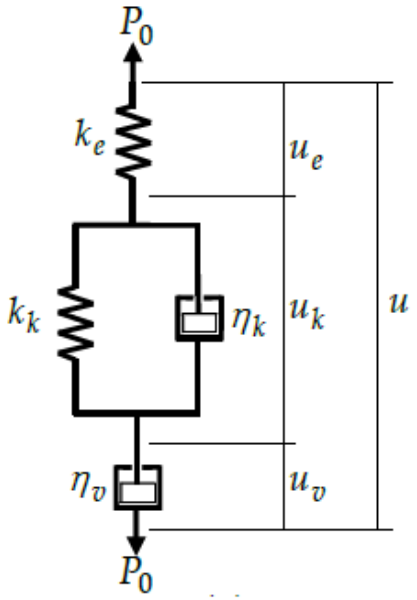
Engineering properties	Solid Sengon	LVL Sengon
Density	0.26	0.41
MOE (MPa)	1250-3300	5700-9000
MOR (MPa)	26.61	38.78
Tension // (MPa)	20.00	46.69
Compression // (MPa)	13.29	22.82
Compression ⊥ (MPa)	3.52	5.40
Shear (MPa)	0.60	-

Bending creep experiment

Creep experiments has been done on LVL Sengon beams for **3 (three) months** in a temperature- and humidity- controlled room. The dimensions of LVL Sengon beam is 40 mm in thickness, 80 mm in width, and 2000 mm in (clear) length. Beam edges are simply supported and loaded at mid-span by loading levels of 30%, 40%, and 50% of the ultimate load, which correspond to 215 N, 285 N and 355 N, respectively.

There are **three unwrapped beams** and **one wrapped (with plastic sheet) beam** for each loading level.

Creep model of LVL Sengon



LVL Sengon is assumed to be **a viscoelastic material**. A viscoelastic material exhibits elasticity under rapid loading, then its strain increases slowly and continuously. **Viscoelasticity combines elasticity and viscosity (viscous flow)**.

$$u(t) = \beta_1 + \beta_2(1 - e^{-(\beta_3)t}) + \beta_4 t$$

$$\beta_1 = P_0 / k_e,\ \beta_2 = P_0 / k_k,\ \beta_3 = k_k / \eta_k, \text{ and } \beta_4 = P_0 / \eta_v$$

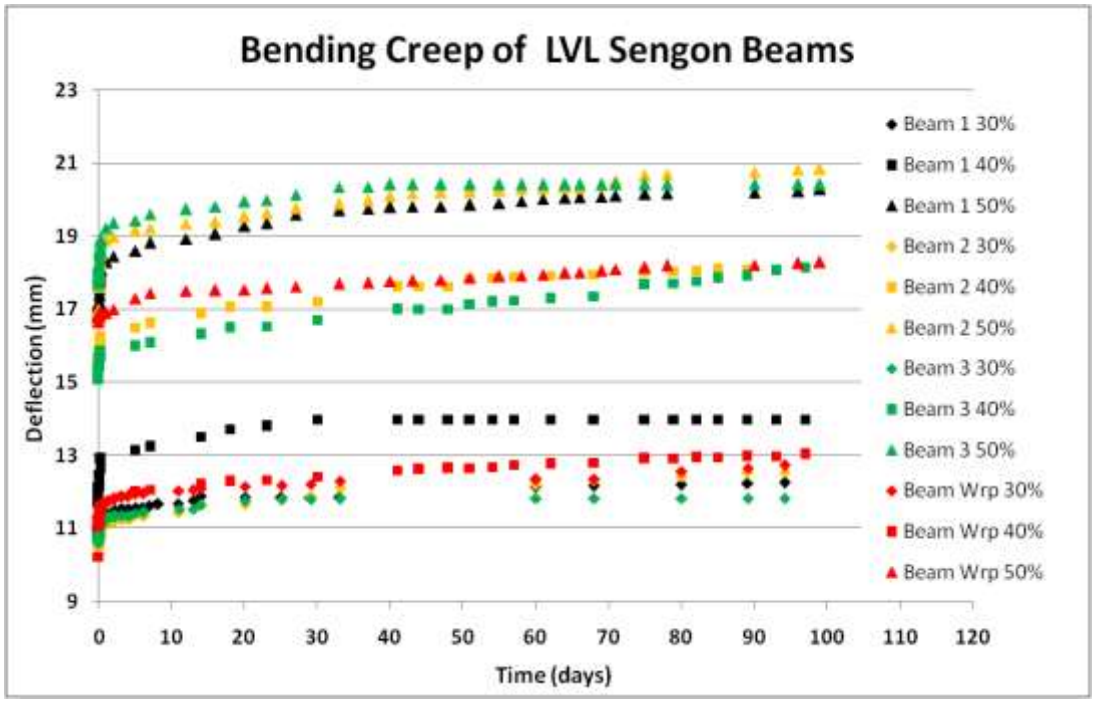
Initial elastic deformation is denoted by β_1 that is associated with the spring constant k_e. β_2 and β_3 correspond to the delayed elastic or recoverable creep components and are associated with the combined effect of the spring constant k_k and the dashpot constant η_k, and finally β_4 represents the irrecoverable creep component contributed by the dashpot constant η_v.

Modification of Burger creep model

$$u(t) = \beta_1 + \beta_2(1 - e^{-(\beta_3)t}) + \beta_4 t^{\beta_5}$$ Value of β_5 is 0<x<1.

Dinwoodie [8, 10] states that any further models of creep tests are demanded to be able to predict long-term performance from short-term data. For timber and the various board materials, the third term in the right-hand side of the Burger creep model needs to be modified to a non-linear form by powering the variable t with the viscous modification factor β_5.

Result

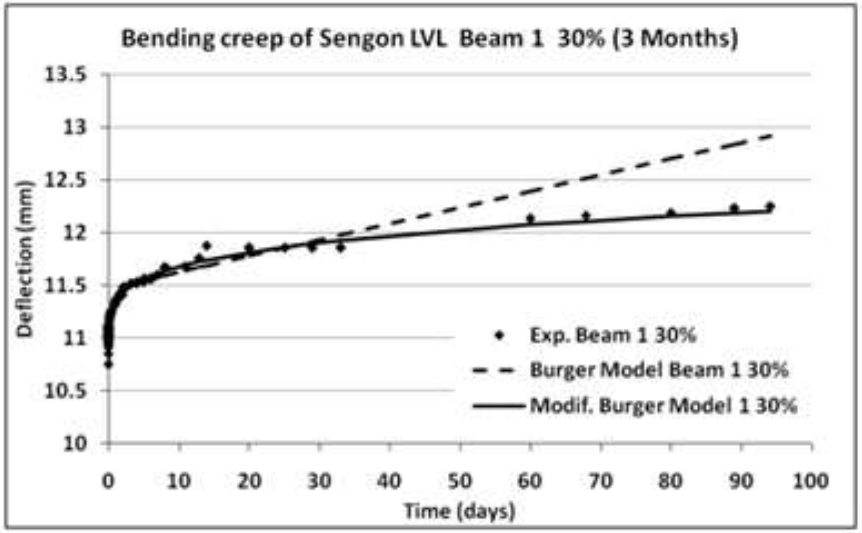


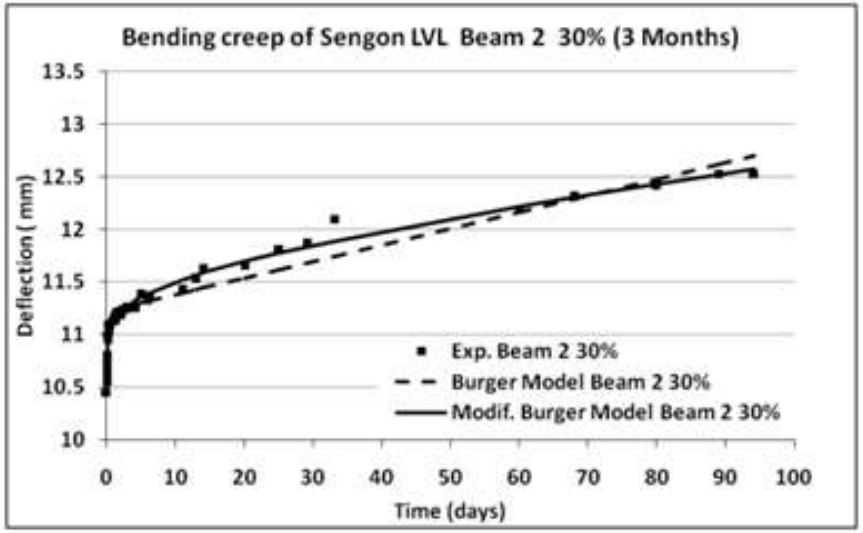
By using the Toolbox Solver program available in Microsoft Excel, the parameters in Eq. (1) and (2) that represent the Burger and Modified Burger creep model are determined, and plotted to bending creep data.

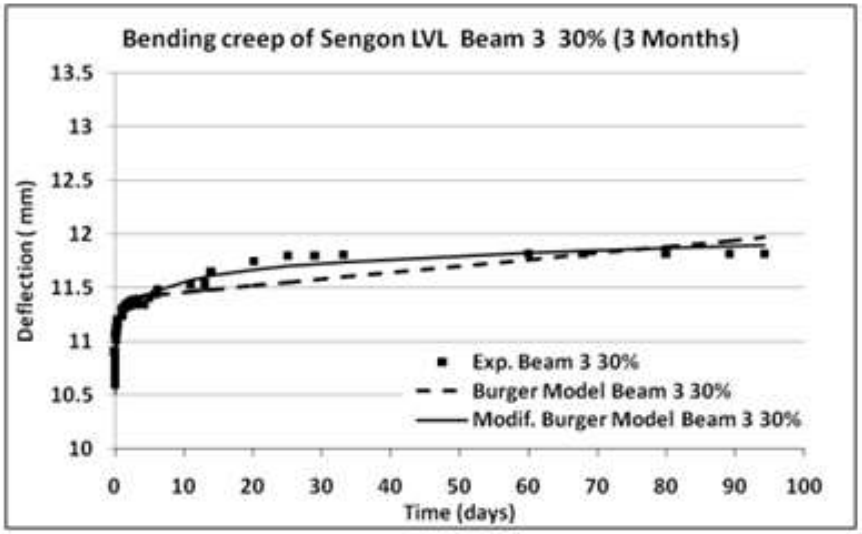
Load Level 30%	Beam 1		Beam 2		Beam 3		Wrapped Beam	
	Burger	Modified Burger	Burger	Modified Burger	Burger	Modified Burger	Burger	Modified Burger
β1	11.014462	10.743241	10.630519	10.045564	10.755228	9.8913208	11.275741	11.112222
β2	0.4596346	0.1059182	0.5918641	7.1551585	0.6417043	0.1212905	0.557184	0.1632276
β3	1.5091411	326.13852	3.9302119	0.0012219	2.1939024	0.1449747	2.9283197	6.87342
β4	0.0152939	0.5014498	0.0157328	1.0624344	0.0060496	1.3068948	0.0105215	0.4635783
β5		0.217885		0.1097768		0.0798948		0.2106864
r^2	**0.7613996**	**0.9918171**	**0.9595336**	**0.9913091**	**0.9602579**	**0.9879488**	**0.9666538**	**0.9851335**

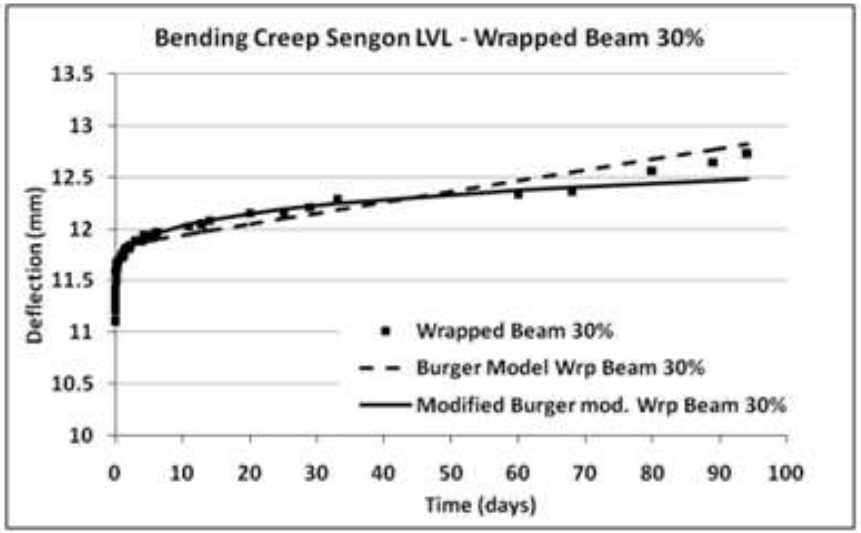
Load Level 40%	Beam 1		Beam 2		Beam 3		Wrapped Beam	
	Burger	Modified Burger	Burger	Modified Burger	Burger	Modified Burger	Burger	Modified Burger
β1	11.963632	11.665513	15.579611	15.083565	15.257304	15.195111	11.044243	10.417463
β2	1.5549819	0.6343554	1.1255464	1.0117962	0.709855	0.5395663	1.0175549	0.1
β3	3.0377474	4.9188426	2.9299405	0.0185637	5.9720318	19.664109	3.0567505	2.4553115
β4	0.0065362	0.7927475	0.0171349	1.1316776	0.0222004	0.0680656	0.0107038	1.2869235
β5		0.1802985		0.1469388		0.7713479		0.1336519
r^2	**0.9765191**	**0.9898161**	**0.9765191**	**0.994404**	**0.9947873**	**0.9960177**	**0.9682679**	**0.9888365**

Load Level 50%	Beam 1		Beam 2		Beam 3		Wrapped Beam	
	Burger	Modified Burger	Burger	Modified Burger	Burger	Modified Burger	Burger	Modified Burger
β1	16.929935	16.600675	16.717006	16.555549	17.979456	16.470662	16.823075	16.815437
β2	1.6432949	0.6772799	2.2854176	1.8998207	1.8091653	0.2722463	0.5707824	0.3599286
β3	4.8883584	18.898913	11.168978	23.369226	2.7157508	28.777776	0.2670009	0.4405904
β4	0.0270193	0.9640834	0.020849	0.2313281	0.0076878	2.4088906	0.0089837	0.0528588
β5		0.2500661		0.5183995		0.0986125		0.6584842
r^2	**0.887781**	**0.9977287**	**0.9823285**	**0.9942495**	**0.9588157**	**0.9915616**	**0.9939356**	**0.9945301**

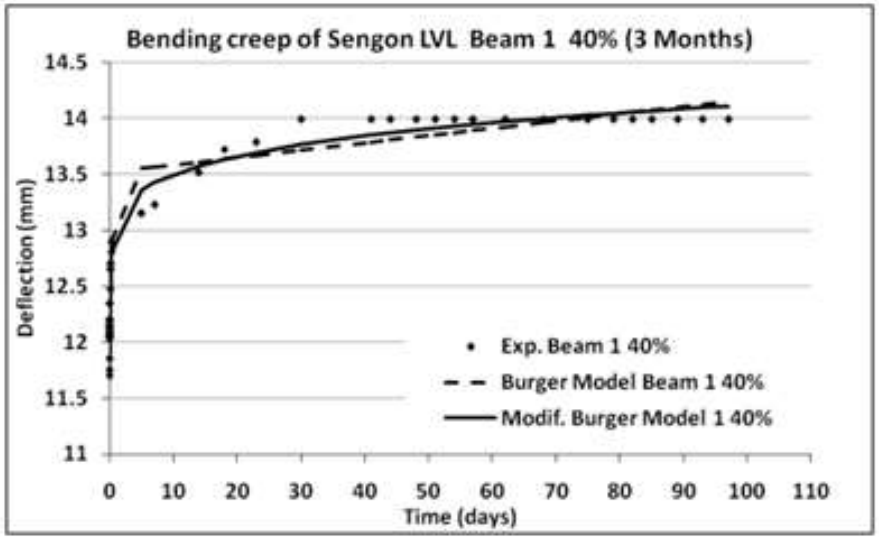


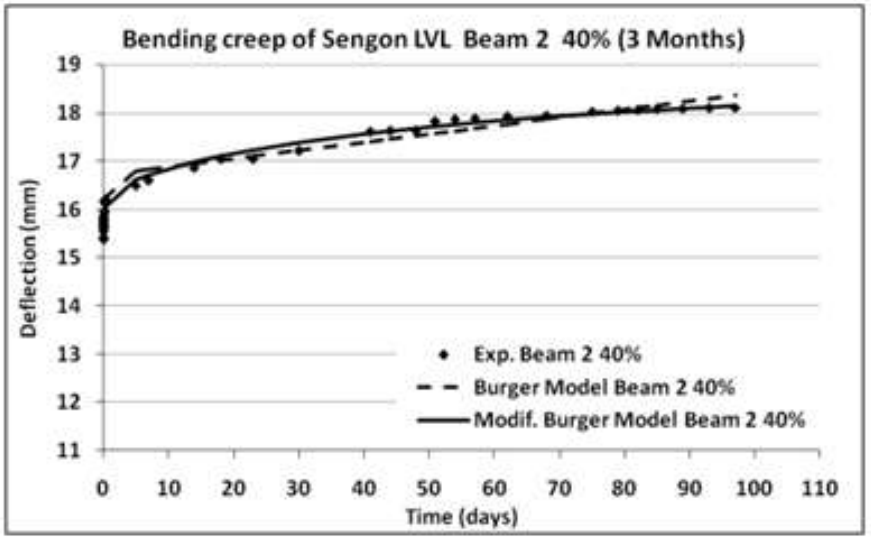


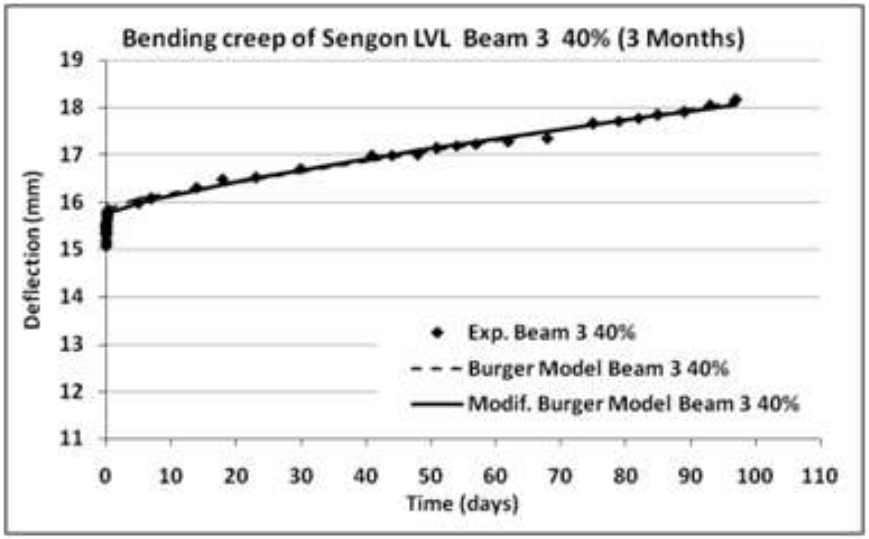


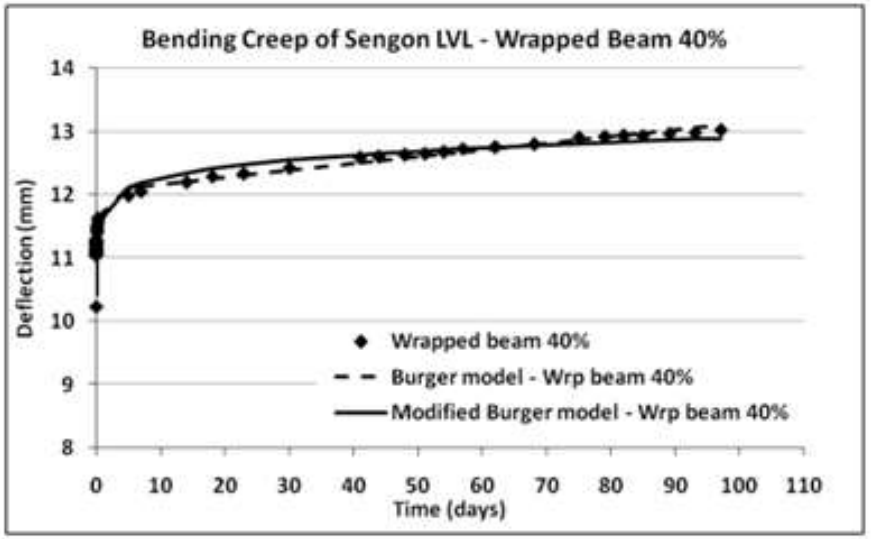


Curve fitting of bending creep data – load level 30%

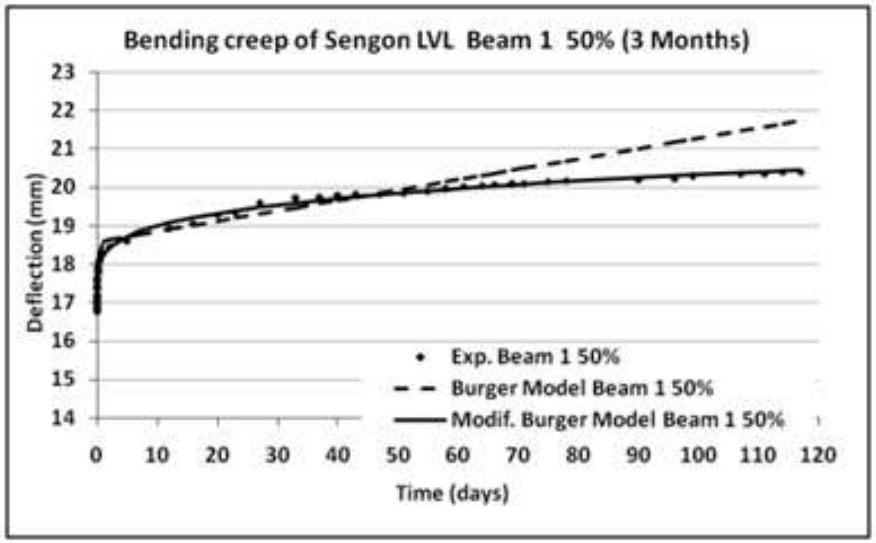


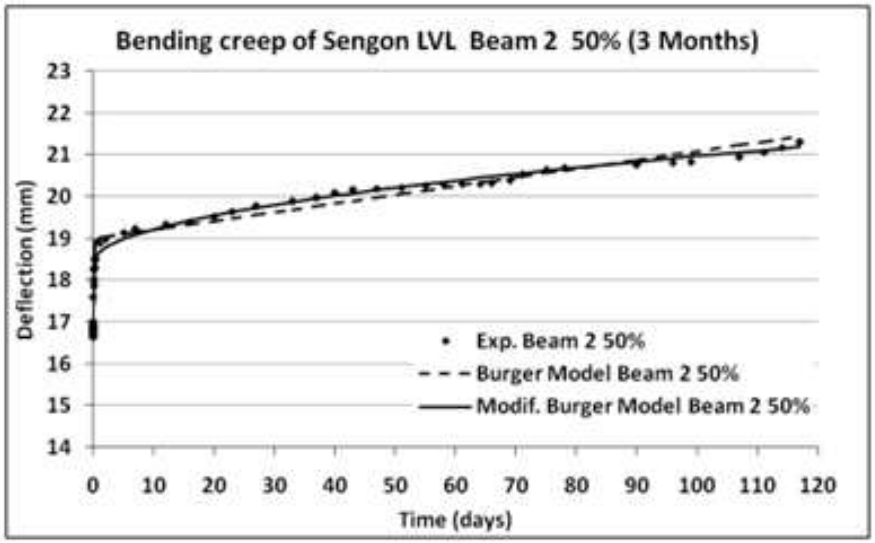


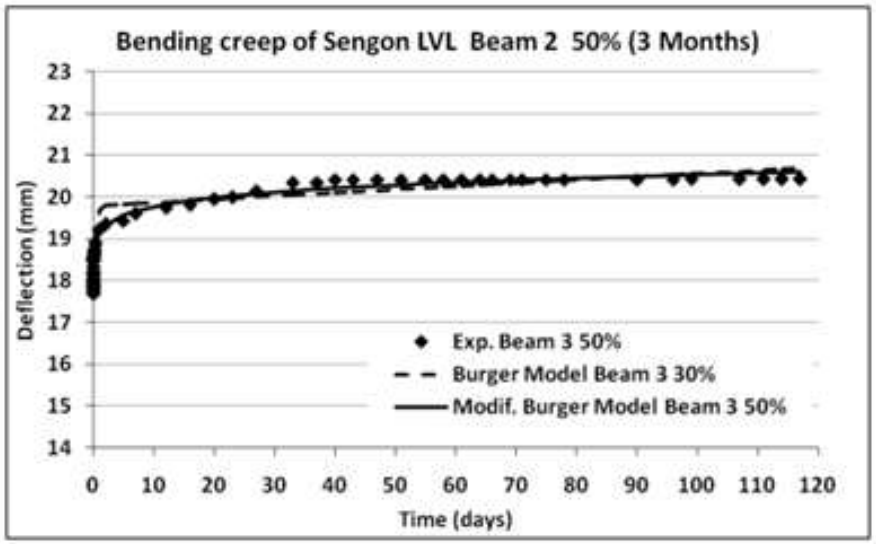


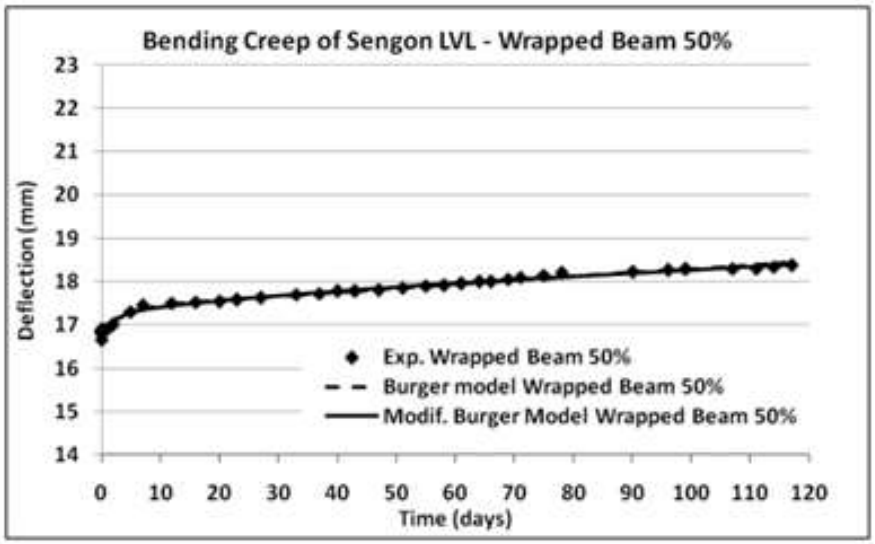


Curve fitting of bending creep data – load level 40%

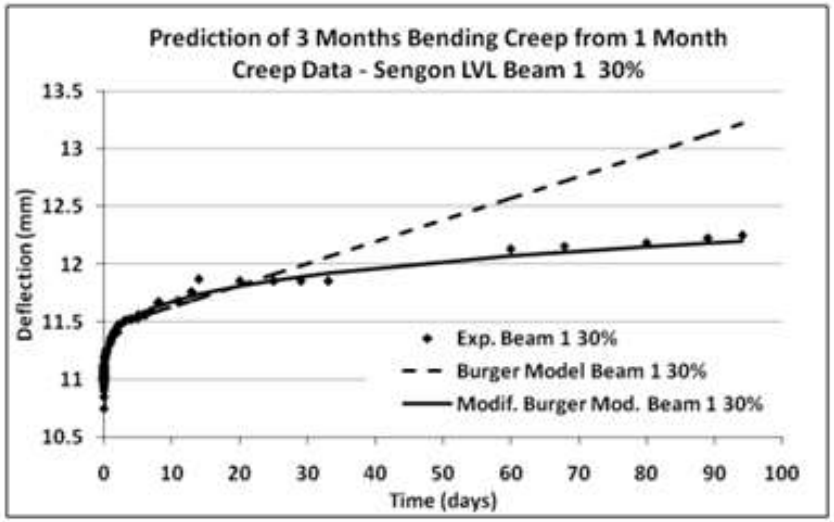


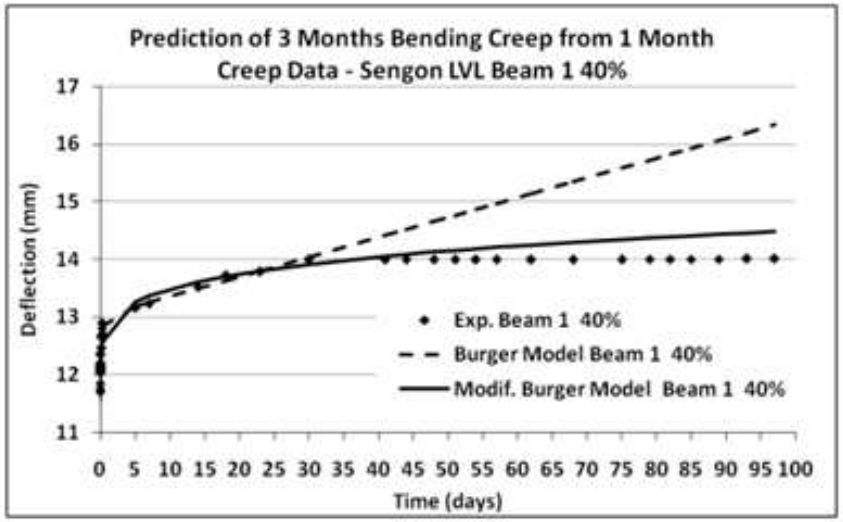


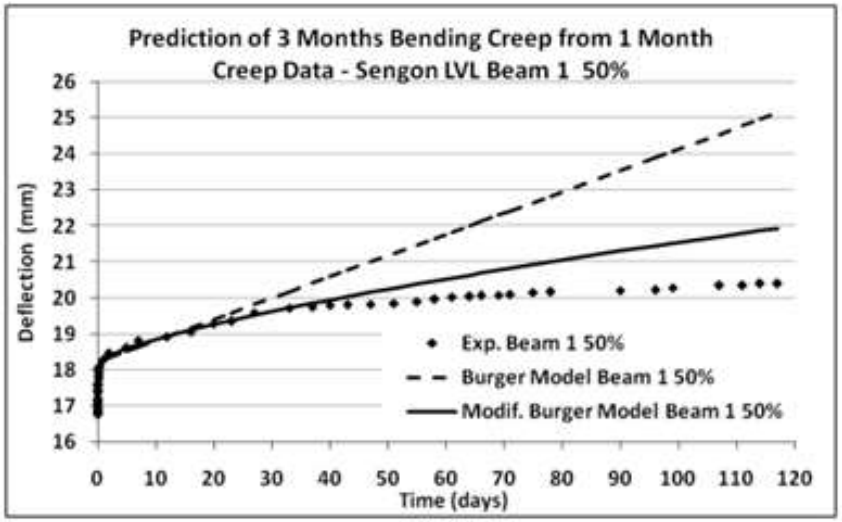




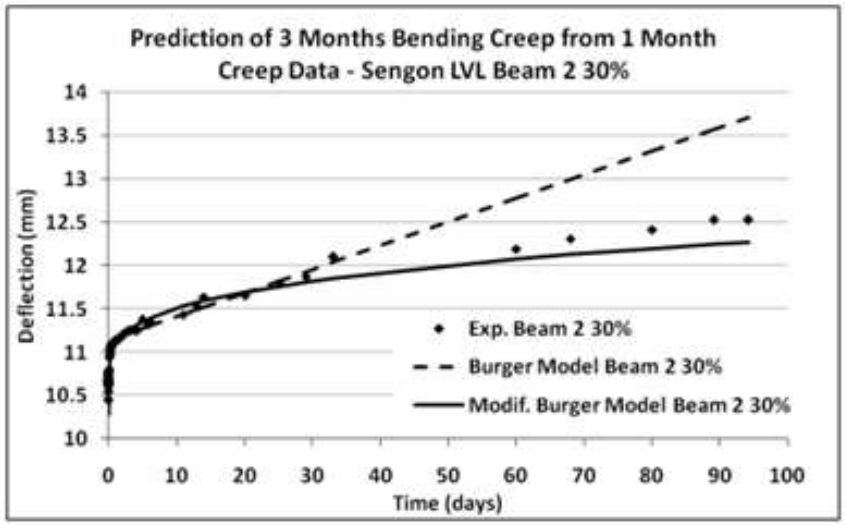
Curve fitting of bending creep data – load level 50%.

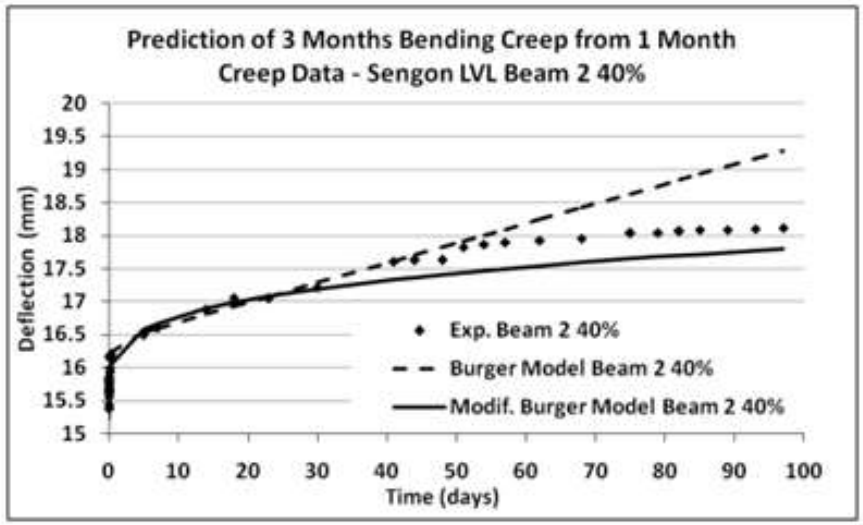


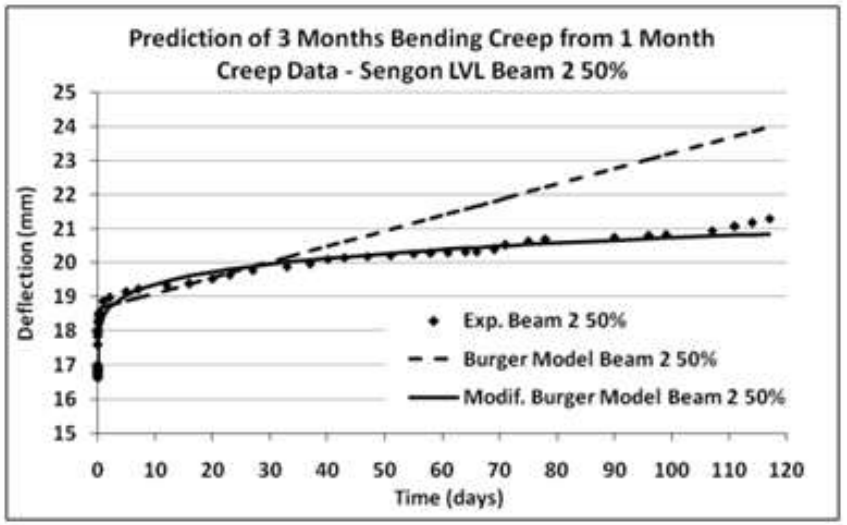




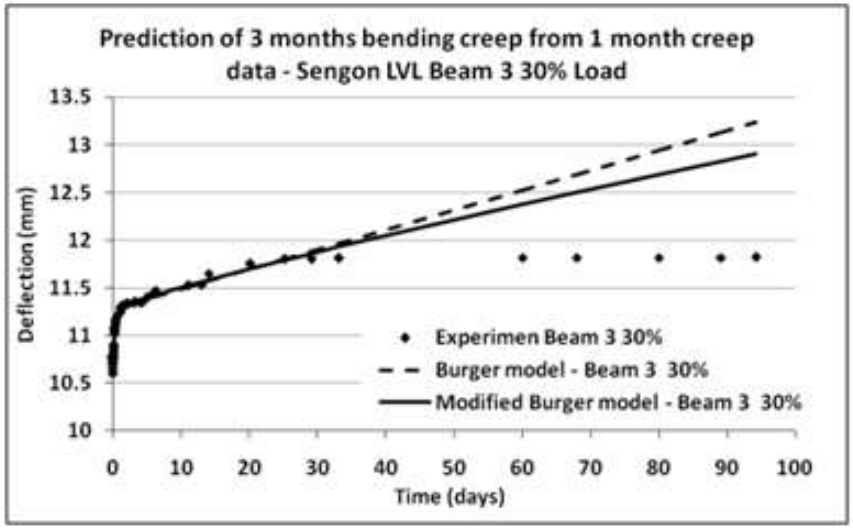
Prediction 3 months of bending creep from 1-month creep data (Beam 1)

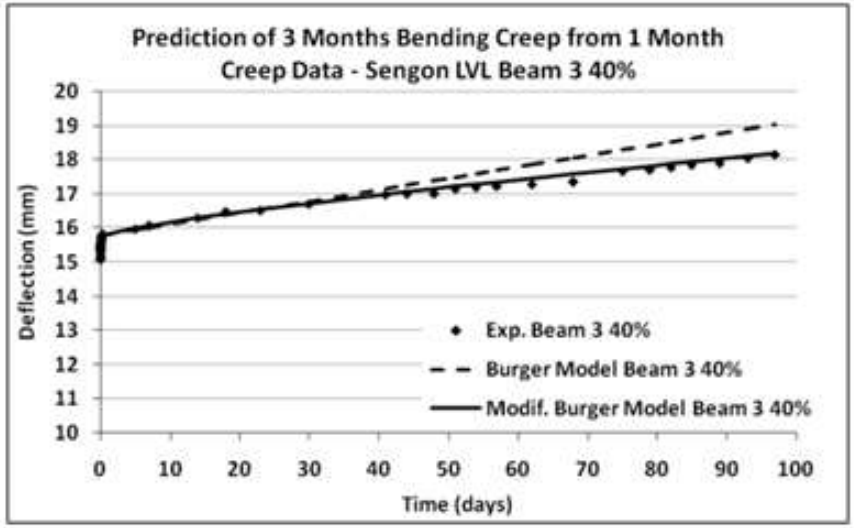


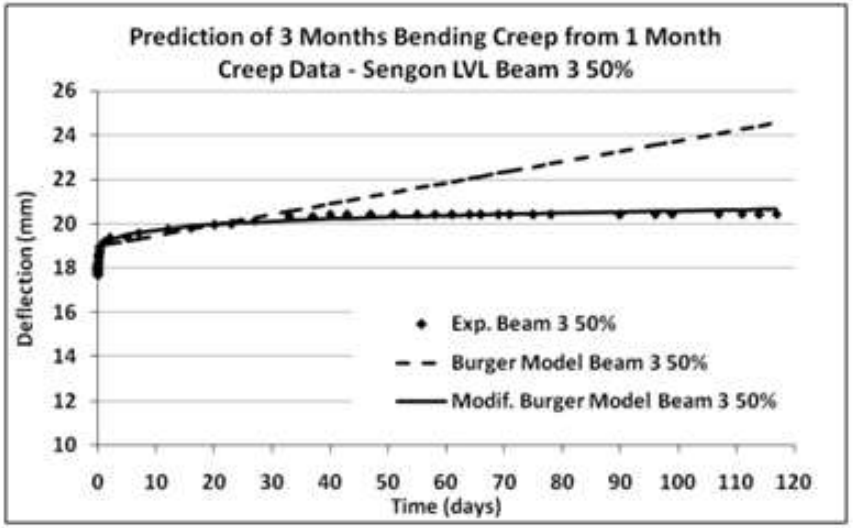




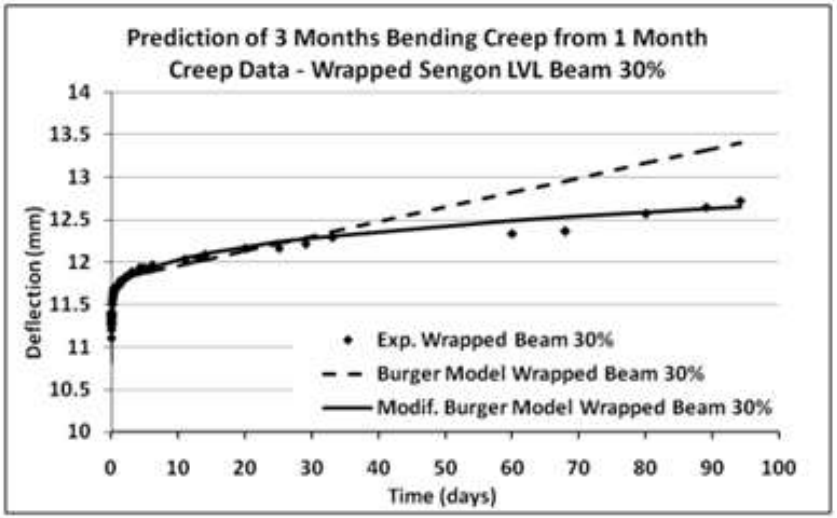
Prediction 3 months of bending creep from 1-month creep data (Beam 2)

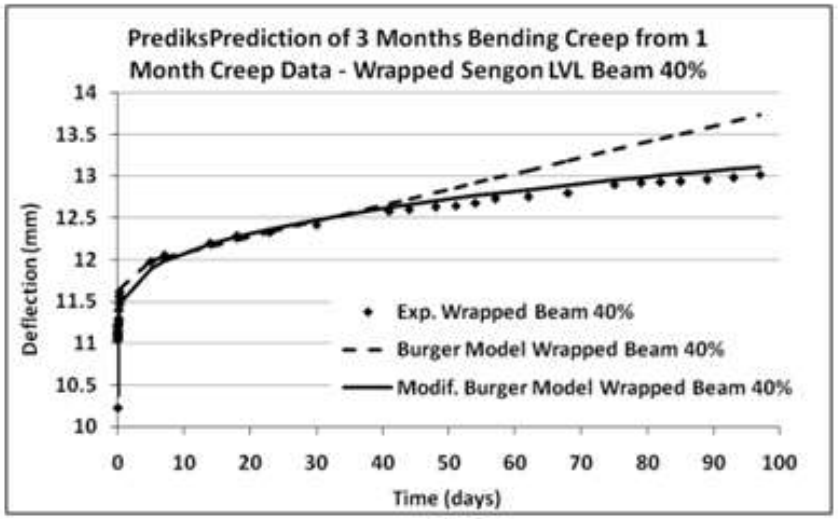


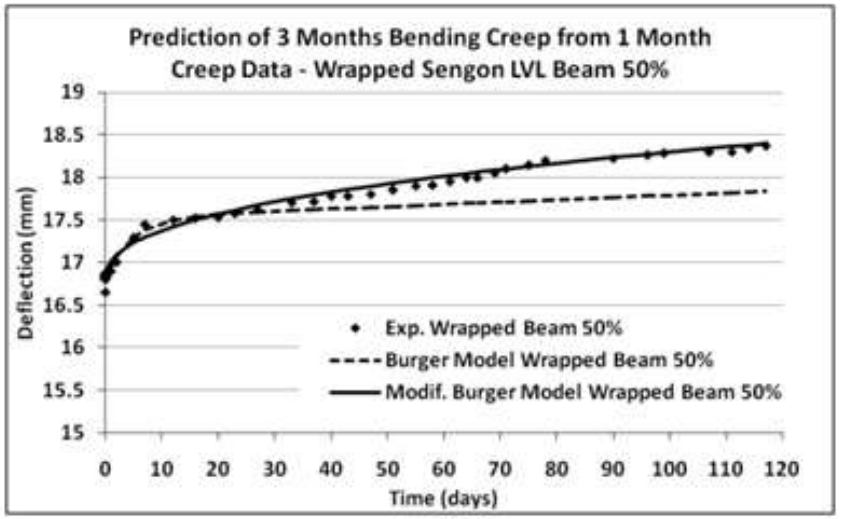




Prediction 3 months of bending creep from 1-month creep data (Beam 3)







Prediction 3 months of bending creep from 1-month creep data (Wrapped Beam)

Conclusion:

1. The Modified Burger model can be used to predict bending creep of LVL Sengon beam.
2. A longer bending creep testing is required to obtain a more satisfactory result on bending creep of LVL Sengon.

Thank you for your attention