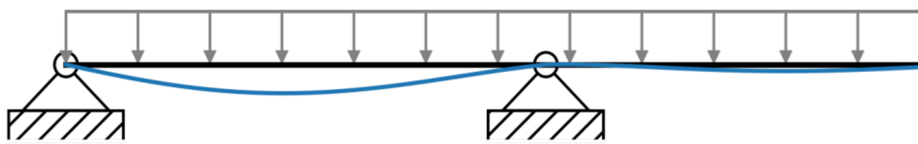
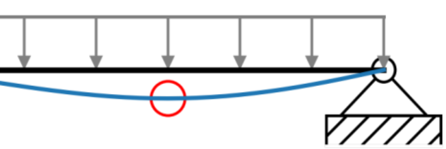
Design Resources:
CLT Deflection





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Overview

The following document contains tables can be used to find the flexural deformation of a multi-span CLT panel, including shear deformation. The span tables have been created using the python libraries planesections and limitstates. See example XX on the limitstates documentation for information on how the output tables have been made.

Deflection Modification table

There are a total of threes tables, which can be used to get deflections in CLT panels. Table 1 gives the flexural deflection of prg-320 SPF(E1/V2) CLT panels, per kPa of load applied, for several spans between 1-3. Tables 2/3 give the ratio between total deflection (including shear deformation) and flexural deflection for panels with an arbitrary EI/GA ratio.

Assumptions:

1. The CLT spans are symmetrically loaded.
2. The output deflection is for the worst-case location in the span, as indicated in the tables notes
3.

Using the Flexural Deflection Table:

The following steps should be used to find the flexural deflection of a CLT panel using Table 1:

1. Get sections flexural stiffness (EI), Shear stiffness (GA), and span length (L).
2. Select values. Linearly interpolate if the panel's EI is different than the PRG panel.

Using the Deflection Modification Table:

The following steps should be used to modify the deflection of the CLT panel using span tables (Table 2):

1. Get sections flexural stiffness (EI), Shear stiffness (GA), and span length (L).
2. Calculate the deflection of the panel using flexural stiffness alone.
3. Find the ratio between EI and GA.
4. Using the tables, select an appropriate modification factor.
5. Multiply the flexural deformation by the shear deformation multiplication factor.

Examples:

Example 1: Flexural Deformation

A custom CLT panel that has three 3.5m spans and is subjected to a super-imposed dead load of 2.2kPa, and snow load of 2.1kPa. Determine the maximum flexural deflection of the CLT for the load combination 1.0S + 2.0D, if the section properties are given below:

1. Get Information

   $EI = 900 * 10^9 \ N * mm^2$

   $GA = 6 * 10^6 \ N$

   $L = 3500m$

2. Calculate Panel deflection

   Using the tables, we ahve

   $$q_d = q_{d,SDL} + q_{d,self} = 2.8kPa + 0.175m * \ 500\frac{kg}{m^3} * 9.81\frac{N}{kg} * \frac{1kN}{1000N} \cong 3.7kPa$$

   $$q_{sls} = 1.0q_L + 2.0q_d = 1.0 * 2.4kPa + 2 * 3.7kPa = 9.8kPa$$

   A symmetrically loaded, two span CLT panel can be as a simple span cantilever. Deflections are calculated per unit m.

   $$u_{flex} = \frac{qL^4}{185EI} * 1m = \frac{9.8*kPa*(6000mm)^4}{185*4166*10^9 \ N*mm^2} * 1000mm \cong \frac{16.5mm}{m}$$

Example 2: Modifying Shear Deformation

A 175 E1 prg320 rated CLT panel that has two 6m spans is subjected to a super-imposed dead load of 2.8kPa, and live load of 2.4kPa from office occupancy. Determine the maximum deflection of the CLT, including shear deformation, for the load combination 1.0L + 2.0D:

1. Get Information

   $EI = 4166 * 10^9 \ N * mm^2$

   $GA = 15 * 10^6 \ N$

   $L = 6m$

2. Calculate Panel deflection

   Calcualte the dead load, a self weight of using 500kg/m^3 is conservatively taken for E1 SPF.

   $$q_d = q_{d,SDL} + q_{d,self} = 2.8kPa + 0.175m * \ 500\frac{kg}{m^3} * 9.81\frac{N}{kg} * \frac{1kN}{1000N} \cong 3.7kPa$$

$q_{sls} = 1.0q_L + 2.0q_d = 1.0 * 2.4kPa + 2 * 3.7kPa = 9.8kPa$

A symmetrically loaded, two span CLT panel can be as a simple span cantilever. Deflections are calculated per unit m.

$u_{flex} = \frac{qL^4}{185EI} * 1m = \frac{9.8*kPa*(6000mm)^4}{185*4166*10^9\ N*mm^2} * 1000mm \cong \frac{16.5mm}{m}$

Note, deflection could also be calculated using Table 1

3. Calculate the ratio of EI / GA

$r = \frac{EI}{GA} = \frac{4166*10^9 Nmm^2}{15*10^6\ N} \cong 277 * 10^3 mm^2$

4. Select a Modification factor

@6000mm, and two spans, we have

$\lambda_{250} = 1.18\,,\ \ \lambda_{300} = 1.22$

By linearly interpolating

$\lambda_{277} \cong 1.2$

5. Calculate deflection

@6000mm, and two spans, we have

$u_{total} = u_{flex} * \lambda_{277} = 16.5mm * 1.2 = 20mm$

Table 1: Flexural Deflection Table (m)

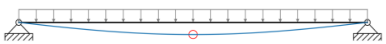
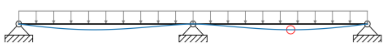
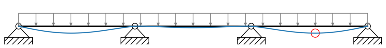
Span	Panel	EI (10^9 Nmm^2)	GA (10^6 N)	Deflection (mm/kPa applied) Span Length (m)											
				2	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**
One	V2 105	884	7.2	0.24	0.58	1.19	2.21	3.77	6.04	9.21	13.5	19.1	26.3	35.4	46.6
	E1 105	1088	7.4	0.19	0.47	0.97	1.80	3.06	4.91	7.48	11.0	15.5	21.4	28.7	37.9
	V2 175	3388	14	0.06	0.15	0.31	0.58	0.98	1.58	2.40	3.52	4.98	6.86	9.23	12.2
	E1 175	4166	14	0.05	0.12	0.25	0.47	0.80	1.28	1.95	2.86	4.05	5.58	7.50	9.89
	V2 245	8338	22			0.13	0.23	0.40	0.64	0.97	1.42	2.01	2.77	3.73	4.91
	E1 245	10300	22			0.10	0.19	0.32	0.52	0.79	1.16	1.64	2.26	3.03	4.00
	V2 315	16723	29				0.12	0.20	0.32	0.49	0.71	1.01	1.39	1.87	2.46
	E1 315	20536	29				0.10	0.16	0.26	0.40	0.58	0.82	1.13	1.52	2.01
Two	V2 105	884	7.2	0.10	0.24	0.50	0.92	1.57	2.51	3.83	5.61	7.94	10.9	14.7	19.4
	E1 105	1088	7.4	0.08	0.19	0.40	0.75	1.27	2.04	3.11	4.56	6.45	8.89	12.0	15.8
	V2 175	3388	14			0.13	0.24	0.41	0.66	1.00	1.46	2.07	2.85	3.84	5.06
	E1 175	4166	14			0.11	0.20	0.33	0.53	0.81	1.19	1.68	2.32	3.12	4.11
	V2 245	8338	22				0.10	0.17	0.26	0.40	0.59	0.84	1.15	1.55	2.04
	E1 245	10300	22					0.13	0.22	0.33	0.48	0.68	0.94	1.26	1.66
	V2 315	16723	29						0.13	0.20	0.30	0.42	0.58	0.78	1.02
	E1 315	20536	29						0.11	0.16	0.24	0.34	0.47	0.63	0.83
Three	V2 105	884	7.2	0.12	0.30	0.63	1.17	1.99	3.19	4.87	7.13	10.1	13.9	18.7	24.6
	E1 105	1088	7.4	0.10	0.25	0.51	0.95	1.62	2.59	3.95	5.79	8.20	11.3	15.2	20.0
	V2 175	3388	14		0.08	0.16	0.30	0.52	0.83	1.27	1.86	2.63	3.63	4.88	6.43
	E1 175	4166	14			0.13	0.25	0.42	0.68	1.03	1.51	2.14	2.95	3.97	5.23
	V2 245	8338	22				0.12	0.21	0.34	0.51	0.75	1.06	1.46	1.97	2.60
	E1 245	10300	22				0.10	0.17	0.27	0.42	0.61	0.87	1.19	1.60	2.11
	V2 315	16723	29					0.11	0.17	0.26	0.38	0.53	0.73	0.99	1.30
	E1 315	20536	29						0.14	0.21	0.31	0.43	0.60	0.80	1.06

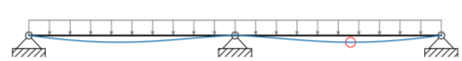
Table 2: Deflection Modification Table in m

Span	EI / GA (m^2)	**Shear Modification Factor (unitless)**											
		Span Length (m)											
		2	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**
One	0.025	1.06	1.04	1.03	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.00	1.00
	0.050	1.12	1.08	1.05	1.04	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.01
	0.075	1.18	1.12	1.08	1.06	1.05	1.04	1.03	1.02	1.02	1.02	1.01	1.01
	0.100	1.24	1.15	1.11	1.08	1.06	1.05	1.04	1.03	1.03	1.02	1.02	1.02
	0.150	1.36	1.23	1.16	1.12	1.09	1.07	1.06	1.05	1.04	1.03	1.03	1.03
	0.200	1.48	1.31	1.21	1.16	1.12	1.09	1.08	1.06	1.05	1.05	1.04	1.03
	0.250	1.60	1.38	1.27	1.20	1.15	1.12	1.10	1.08	1.07	1.06	1.05	1.04
	0.300	1.72	1.46	1.32	1.24	1.18	1.14	1.12	1.10	1.08	1.07	1.06	1.05
	0.350	1.84	1.54	1.37	1.27	1.21	1.17	1.13	1.11	1.09	1.08	1.07	1.06
	0.400	1.96	1.61	1.43	1.31	1.24	1.19	1.15	1.13	1.11	1.09	1.08	1.07
Two	0.025	1.17	1.11	1.07	1.05	1.04	1.03	1.03	1.02	1.02	1.02	1.01	1.01
	0.050	1.33	1.21	1.15	1.11	1.08	1.07	1.05	1.04	1.04	1.03	1.03	1.02
	0.075	1.50	1.32	1.22	1.16	1.12	1.10	1.08	1.07	1.06	1.05	1.04	1.04
	0.100	1.66	1.42	1.29	1.22	1.17	1.13	1.11	1.09	1.07	1.06	1.05	1.05
	0.150	1.99	1.64	1.44	1.32	1.25	1.20	1.16	1.13	1.11	1.09	1.08	1.07
	0.200	2.32	1.85	1.59	1.43	1.33	1.26	1.21	1.17	1.15	1.13	1.11	1.09
	0.250	2.64	2.06	1.73	1.54	1.41	1.33	1.27	1.22	1.18	1.16	1.13	1.12
	0.300	2.97	2.27	1.88	1.65	1.50	1.39	1.32	1.26	1.22	1.19	1.16	1.14
	0.350	3.29	2.48	2.03	1.76	1.58	1.46	1.37	1.31	1.26	1.22	1.19	1.16
	0.400	3.61	2.68	2.17	1.86	1.66	1.52	1.42	1.35	1.29	1.25	1.22	1.19
Three	0.025	1.12	1.08	1.05	1.04	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.01
	0.050	1.24	1.15	1.11	1.08	1.06	1.05	1.04	1.03	1.03	1.02	1.02	1.02
	0.075	1.36	1.23	1.16	1.12	1.09	1.07	1.06	1.05	1.04	1.03	1.03	1.03
	0.100	1.47	1.30	1.21	1.16	1.12	1.09	1.08	1.06	1.05	1.05	1.04	1.03
	0.150	1.71	1.46	1.32	1.23	1.18	1.14	1.11	1.09	1.08	1.07	1.06	1.05
	0.200	1.95	1.61	1.42	1.31	1.24	1.19	1.15	1.13	1.11	1.09	1.08	1.07
	0.250	2.19	1.76	1.53	1.39	1.30	1.23	1.19	1.16	1.13	1.11	1.10	1.08
	0.300	2.43	1.91	1.63	1.47	1.36	1.28	1.23	1.19	1.16	1.13	1.12	1.10
	0.350	2.66	2.07	1.74	1.54	1.42	1.33	1.27	1.22	1.18	1.16	1.14	1.12
	0.400	2.90	2.22	1.84	1.62	1.47	1.38	1.30	1.25	1.21	1.18	1.16	1.14

Notes:

One span:

Two Spans



Three spans:

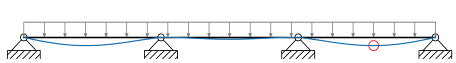


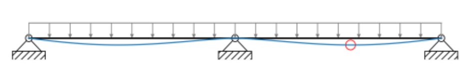
Table 3: Deflection Modification Table in mm

Span	EI / GA (10^3 mm^2)	Shear Modification Factor (unitless)											
		Span Length (mm)											
		2000	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**5500**	**6000**	**6500**	**7000**	**7500**
One	25	1.06	1.04	1.03	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.00	1.00
	50	1.12	1.08	1.05	1.04	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.01
	75	1.18	1.12	1.08	1.06	1.05	1.04	1.03	1.02	1.02	1.02	1.01	1.01
	100	1.24	1.15	1.11	1.08	1.06	1.05	1.04	1.03	1.03	1.02	1.02	1.02
	150	1.36	1.23	1.16	1.12	1.09	1.07	1.06	1.05	1.04	1.03	1.03	1.03
	200	1.48	1.31	1.21	1.16	1.12	1.09	1.08	1.06	1.05	1.05	1.04	1.03
	250	1.60	1.38	1.27	1.20	1.15	1.12	1.10	1.08	1.07	1.06	1.05	1.04
	300	1.72	1.46	1.32	1.24	1.18	1.14	1.12	1.10	1.08	1.07	1.06	1.05
	350	1.84	1.54	1.37	1.27	1.21	1.17	1.13	1.11	1.09	1.08	1.07	1.06
	400	1.96	1.61	1.43	1.31	1.24	1.19	1.15	1.13	1.11	1.09	1.08	1.07
Two	25	1.17	1.11	1.07	1.05	1.04	1.03	1.03	1.02	1.02	1.02	1.01	1.01
	50	1.33	1.21	1.15	1.11	1.08	1.07	1.05	1.04	1.04	1.03	1.03	1.02
	75	1.50	1.32	1.22	1.16	1.12	1.10	1.08	1.07	1.06	1.05	1.04	1.04
	100	1.66	1.42	1.29	1.22	1.17	1.13	1.11	1.09	1.07	1.06	1.05	1.05
	150	1.99	1.64	1.44	1.32	1.25	1.20	1.16	1.13	1.11	1.09	1.08	1.07
	200	2.32	1.85	1.59	1.43	1.33	1.26	1.21	1.17	1.15	1.13	1.11	1.09
	250	2.64	2.06	1.73	1.54	1.41	1.33	1.27	1.22	1.18	1.16	1.13	1.12
	300	2.97	2.27	1.88	1.65	1.50	1.39	1.32	1.26	1.22	1.19	1.16	1.14
	350	3.29	2.48	2.03	1.76	1.58	1.46	1.37	1.31	1.26	1.22	1.19	1.16
	400	3.61	2.68	2.17	1.86	1.66	1.52	1.42	1.35	1.29	1.25	1.22	1.19
Three	25	1.12	1.08	1.05	1.04	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.01
	50	1.24	1.15	1.11	1.08	1.06	1.05	1.04	1.03	1.03	1.02	1.02	1.02
	75	1.36	1.23	1.16	1.12	1.09	1.07	1.06	1.05	1.04	1.03	1.03	1.03
	100	1.47	1.30	1.21	1.16	1.12	1.09	1.08	1.06	1.05	1.05	1.04	1.03
	150	1.71	1.46	1.32	1.23	1.18	1.14	1.11	1.09	1.08	1.07	1.06	1.05
	200	1.95	1.61	1.42	1.31	1.24	1.19	1.15	1.13	1.11	1.09	1.08	1.07
	250	2.19	1.76	1.53	1.39	1.30	1.23	1.19	1.16	1.13	1.11	1.10	1.08
	300	2.43	1.91	1.63	1.47	1.36	1.28	1.23	1.19	1.16	1.13	1.12	1.10
	350	2.66	2.07	1.74	1.54	1.42	1.33	1.27	1.22	1.18	1.16	1.14	1.12
	400	2.90	2.22	1.84	1.62	1.47	1.38	1.30	1.25	1.21	1.18	1.16	1.14

Notes:

One span:

Two Spans



Three spans: