Appendix B

Table 3.2 Section Properties of Standard Dressed (S4S) Sawn Lumber

Nominal size $b \times d$	Standard dressed size (S4S) $b \times d$ inches × inches	Area of Section A in^2	X-X-AXIS		Y-Y-AXIS		Approximate weight in pounds per linear foot (lb/ft) of piece when density of wood equals:					
			Section modulus S_x in^3	Moment of inertia I_x in^4	Section modulus S_y in^3	Moment of inertia I_y in^4	25 lb/ft^3	30 lb/ft^3	35 lb/ft^3	40 lb/ft^3	45 lb/ft^3	50 lb/ft^3
1 × 3	3/4 × 2-1/2	1.875	0.781	0.977	0.234	0.088	0.326	0.391	0.456	0.521	0.586	0.651
1 × 4	3/4 × 3-1/2	2.625	1.531	2.680	0.328	0.123	0.456	0.547	0.638	0.729	0.820	0.911
1 × 6	3/4 × 5-1/2	4.125	3.781	10.40	0.516	0.193	0.716	0.859	1.003	1.146	1.289	1.432
1 × 8	3/4 × 7-1/4	5.438	6.570	23.82	0.680	0.255	0.944	1.133	1.322	1.510	1.699	1.888
1 × 10	3/4 × 9-1/4	6.938	10.70	49.47	0.867	0.325	1.204	1.445	1.686	1.927	2.168	2.409
1 × 12	3/4 × 11-1/4	8.438	15.82	88.99	1.055	0.396	1.465	1.758	2.051	2.344	2.637	2.930
2 × 3	1-1/2 × 2-1/2	3.750	1.563	1.953	0.938	0.703	0.651	0.781	0.911	1.042	1.172	1.302
2 × 4	1-1/2 × 3-1/2	5.250	3.063	5.359	1.313	0.984	0.911	1.094	1.276	1.458	1.641	1.823
2 × 5	1-1/2 × 4-1/2	6.750	5.063	11.39	1.688	1.266	1.172	1.406	1.641	1.875	2.109	2.344
2 × 6	1-1/2 × 5-1/2	8.250	7.563	20.80	2.063	1.547	1.432	1.719	2.005	2.292	2.578	2.865
2 × 8	1-1/2 × 7-1/4	10.88	13.14	47.63	2.719	2.039	1.888	2.266	2.643	3.021	3.398	3.776
2 × 10	1-1/2 × 9-1/4	13.88	21.39	98.93	3.469	2.602	2.409	2.891	3.372	3.854	4.336	4.818
2 × 12	1-1/2 × 11-1/4	16.88	31.64	178.0	4.219	3.164	2.930	3.516	4.102	4.688	5.273	5.859
2 × 14	1-1/2 × 13-1/4	19.88	43.89	290.8	4.969	3.727	3.451	4.141	4.831	5.521	6.211	6.901
3 × 4	2-1/2 × 3-1/2	8.750	5.104	8.932	3.646	4.557	1.519	1.823	2.127	2.431	2.734	3.038
3 × 5	2-1/2 × 4-1/2	11.25	8.438	18.98	4.688	5.859	1.953	2.344	2.734	3.125	3.516	3.906
3 × 6	2-1/2 × 5-1/2	13.75	12.60	34.66	5.729	7.161	2.387	2.865	3.342	3.819	4.297	4.774
3 × 8	2-1/2 × 7-1/4	18.13	21.90	79.39	7.552	9.440	3.147	3.776	4.405	5.035	5.664	6.293
3 × 10	2-1/2 × 9-1/4	23.13	35.65	164.9	9.635	12.04	4.015	4.818	5.621	6.424	7.227	8.030
3 × 12	2-1/2 × 11-1/4	28.13	52.73	296.6	11.72	14.65	4.883	5.859	6.836	7.813	8.789	9.766
3 × 14	2-1/2 × 13-1/4	33.13	73.15	484.6	13.80	17.25	5.751	6.901	8.051	9.201	10.35	11.50
3 × 16	2-1/2 × 15-1/4	38.13	96.90	738.9	15.89	19.86	6.619	7.943	9.266	10.59	11.91	13.24
4 × 4	3-1/2 × 3-1/2	12.25	7.146	12.51	7.146	12.51	2.127	2.552	2.977	3.403	3.828	4.253
4 × 5	3-1/2 × 4-1/2	15.75	11.81	26.58	9.188	16.08	2.734	3.281	3.828	4.375	4.922	5.469
4 × 6	3-1/2 × 5-1/2	19.25	17.65	48.53	11.23	19.65	3.342	4.010	4.679	5.347	6.016	6.684
4 × 8	3-1/2 × 7-1/4	25.38	30.66	111.1	14.80	25.90	4.405	5.286	6.168	7.049	7.930	8.811
4 × 10	3-1/2 × 9-1/4	32.38	49.91	230.8	18.89	33.05	5.621	6.745	7.869	8.993	10.12	11.24
4 × 12	3-1/2 × 11-1/4	39.38	73.83	415.3	22.97	40.20	6.836	8.203	9.570	10.94	12.30	13.67
4 × 14	3-1/2 × 13-1/2	47.25	106.3	717.6	27.56	48.23	8.203	9.844	11.48	13.13	14.77	16.41
4 × 16	3-1/2 × 15-1/2	54.25	140.1	1086.1	31.64	55.38	9.42	11.30	13.19	15.07	16.95	18.84

Table 3.2 Continued

Nominal size $b \times d$	Standard dressed size (S4S) $b \times d$ inches × inches	Area of Section A in^2	X-X-AXIS		Y-Y-AXIS		Approximate weight in pounds per linear foot (lb/ft) of piece when density of wood equals:					
			Section modulus S^{xx} in^3	Moment of inertia I_{xx} in^4	Section modulus S_{yy} in^3	Moment of inertia I_{yy} in^4	25 lb/ft^3	30 lb/ft^3	35 lb/ft^3	40 lb/ft^3	45 lb/ft^3	50 lb/ft^3
5 × 5	4-1/2 × 4-1/2	20.25	15.19	34.17	15.19	34.17	3.516	4.219	4.922	5.625	6.328	7.031
6 × 6	5-1/2 × 5-1/2	30.25	27.73	76.26	27.73	76.26	5.252	6.302	7.352	8.403	9.453	10.50
6 × 8	5-1/2 × 7-1/2	41.25	51.56	193.4	37.81	104.0	7.161	8.594	10.03	11.46	12.89	14.32
6 × 10	5-1/2 × 9-1/2	52.25	82.73	393.0	47.90	131.7	9.071	10.89	12.70	14.51	16.33	18.14
6 × 12	3-1/2 × 11-1/2	63.25	121.2	697.1	57.98	159.4	10.98	13.18	15.37	17.57	19.77	21.96
6 × 14	5-1/2 × 13-1/2	74.25	167.1	1128	68.06	187.2	12.89	15.47	18.05	20.63	23.20	25.78
6 × 16	5-1/2 × 15-1/2	85.25	220.2	1707	78.15	214.9	14.80	17.76	20.72	23.68	26.64	29.60
6 × 18	5-1/2 × 17-1/2	96.25	280.7	2456	88.23	242.6	16.71	20.05	23.39	26.74	30.08	33.42
6 × 20	5-1/2 × 19-1/2	107.3	348.6	3398	98.31	270.4	18.62	22.34	26.07	29.79	33.52	37.24
6 × 22	5-1/2 × 21-1/2	118.3	423.7	4555	108.4	298.1	20.53	24.64	28.74	32.85	36.95	41.06
6 × 24	5-1/2 × 23-1/2	129.3	506.2	5948	118.5	325.8	22.44	26.93	31.41	35.90	40.39	44.88
8 × 8	7-1/2 × 7-1/2	56.25	70.31	263.7	70.31	263.7	9.766	11.72	13.67	15.63	17.58	19.53
8 × 10	7-1/2 × 9-1/2	71.25	112.8	535.9	89.06	334.0	12.37	14.84	17.32	19.79	22.27	24.74
8 × 12	7-1/2 × 11-1/2	86.25	165.3	950.5	107.8	404.3	14.97	17.97	20.96	23.96	26.95	29.95
8 × 14	7-1/2 × 13-1/2	101.3	227.8	1538	126.6	474.6	17.58	21.09	24.61	28.13	31.64	35.16
8 × 16	7-1/2 × 15-1/2	116.3	300.3	2327	145.3	544.9	20.18	24.22	28.26	32.29	36.33	40.36
8 × 18	7-1/2 × 17-1/2	131.3	382.8	3350	164.1	615.2	22.79	27.34	31.90	36.46	41.02	45.57
8 × 20	7-1/2 × 19-1/2	146.3	475.3	4634	182.8	685.5	25.39	30.47	35.55	40.63	45.70	50.78
8 × 22	7-1/2 × 21-1/2	161.3	577.8	6211	201.6	755.9	27.99	33.59	39.19	44.79	50.39	55.99
8 × 24	7-1/2 × 23-1/2	176.3	690.3	8111	220.3	826.2	30.60	36.72	42.84	48.96	55.08	61.20
10 × 10	9-1/2 × 9-1/2	90.25	142.9	678.8	142.9	678.8	15.67	18.80	21.94	25.07	28.20	31.34
10 × 12	9-1/2 × 11-1/2	109.3	209.4	1204	173.0	821.7	18.97	22.76	26.55	30.35	34.14	37.93
10 × 14	9-1/2 × 13-1/2	128.3	288.6	1948	203.1	964.5	22.27	26.72	31.17	35.63	40.08	44.53
10 × 16	9-1/2 × 15-1/2	147.3	380.4	2948	233.1	1107	25.56	30.68	35.79	40.90	46.02	51.13
10 × 18	9-1/2 × 17-1/2	166.3	484.9	4243	263.2	1250	28.86	34.64	40.41	46.18	51.95	57.73
10 × 20	9-1/2 × 19-1/2	185.3	602.1	5870	293.3	1393	32.16	38.59	45.03	51.46	57.89	64.32
10 × 22	9-1/2 × 21-1/2	204.3	731.9	7868	323.4	1536	35.46	42.55	49.64	56.74	63.83	70.92
10 × 24	9-1/2 × 23-1/2	223.3	874.4	10270	353.5	1679	38.76	46.51	54.26	62.01	69.77	77.52

12 × 12	11-1/2 × 11-1/2	132.3	253.5	1458	253.5	1458	22.96	27.55	32.14	36.74	41.33	45.92
12 × 14	11-1/2 × 13-1/2	155.3	349.3	2358	297.6	1711	26.95	32.34	37.73	43.13	48.52	53.91
12 × 16	11-1/2 × 15-1/2	178.3	460.5	3569	341.6	1964	30.95	37.14	43.32	49.51	55.70	61.89
12 × 18	11-1/2 × 17-1/2	201.3	587.0	5136	385.7	2218	34.94	41.93	48.91	55.90	62.89	69.88
12 × 20	11-1/2 × 19-1/2	224.3	728.8	7106	429.8	2471	38.93	46.72	54.51	62.29	70.08	77.86
12 × 22	11-1/2 × 21-1/2	247.3	886.0	9524	473.9	2725	42.93	51.51	60.10	68.68	77.27	85.85
12 × 24	11-1/2 × 23-1/2	270.3	1058	12440	518.0	2978	46.92	56.30	65.69	75.07	84.45	93.84
14 × 14	13-1/2 × 13-1/2	182.3	410.1	2768	410.1	2768	31.64	37.97	44.30	50.63	56.95	63.28
14 × 16	13-1/2 × 15-1/2	209.3	540.6	4189	470.8	3178	36.33	43.59	50.86	58.13	65.39	72.66
14 × 18	13-1/2 × 17-1/2	236.3	689.1	6029	531.6	3588	41.02	49.22	57.42	65.63	73.83	82.03
14 × 20	13-1/2 × 19-1/2	263.3	855.6	8342	592.3	3998	45.70	54.84	63.98	73.13	82.27	91.41
14 × 22	13-1/2 × 21-1/2	290.3	1040	11180	653.1	4408	50.39	60.47	70.55	80.63	90.70	100.8
14 × 24	13-1/2 × 23-1/2	317.3	1243	14600	713.8	4818	55.08	66.09	77.11	88.13	99.14	110.2
16 × 16	15-1/2 × 15-1/2	240.3	620.6	4810	620.6	4810	41.71	50.05	58.39	66.74	75.08	83.42
16 × 18	15-1/2 × 17-1/2	271.3	791.1	6923	700.7	5431	47.09	56.51	65.93	75.35	84.77	94.18
16 × 20	15-1/2 × 19-1/2	302.3	982.3	9578	780.8	6051	52.47	62.97	73.46	83.96	94.45	104.9
16 × 22	15-1/2 × 21-1/2	333.3	1194	12840	860.9	6672	57.86	69.43	81.00	92.57	104.1	115.7
16 × 24	15-1/2 × 23-1/2	364.3	1427	16760	941.0	7293	63.24	75.89	88.53	101.2	113.8	126.5
18 × 18	17-1/2 × 17-1/2	306.3	893.2	7816	893.2	7816	53.17	63.80	74.44	85.07	95.70	106.3
18 × 20	17-1/2 × 19-1/2	341.3	1109	10810	995.3	8709	59.24	71.09	82.94	94.79	106.6	118.5
18 × 22	17-1/2 × 21-1/2	376.3	1348	14490	1097	9602	65.32	78.39	91.45	104.5	117.6	130.6
18 × 24	17-1/2 × 23-1/2	411.3	1611	18930	1199	10500	71.40	85.68	99.96	114.2	128.5	142.8
20 × 20	19-1/2 × 19-1/2	380.3	1236	12050	1236	12050	66.02	79.22	92.42	105.6	118.8	132.0
20 × 22	19-1/2 × 21-1/2	419.3	1502	16150	1363	13280	72.79	87.34	101.9	116.5	131.0	145.6
20 × 24	19-1/2 × 23-1/2	458.3	1795	21090	1489	14520	79.56	95.47	111.4	127.3	143.2	159.1
22 × 22	21-1/2 × 21-1/2	462.3	1656	17810	1656	17810	80.25	96.30	112.4	128.4	144.5	160.5
22 × 24	21-1/2 × 23-1/2	505.3	1979	23250	1810	19460	87.72	105.3	122.8	140.3	157.9	175.4
24 × 24	23-1/2 × 23-1/2	552.3	2163	25420	2163	25420	95.88	115.1	134.2	153.4	172.6	191.8

From National Design Specification for Wood Construction 1991

Table 3.3 Design Values For Visually Graded Dimension Lumber

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E	
DOUGLAS FIR-LARCH								
Select Structural		1450	1000	95	625	1700	1,900,000	
No. 1 and Better	2″-4″ thick	1150	775	95	625	1500	1,800,000	
No. 1		1000	675	95	625	1450	1,700,000	
No. 2	2″ & wider	875	575	95	625	1300	1,600,000	WCLIB*
No. 3		500	325	95	625	750	1,400,000	WWPA**
Stud		*675*	*450*	*95*	*625*	*825*	*1,400,000*	
Construction	*2″-4″ thick*	*1000*	*650*	*95*	*625*	*1600*	*1,500,000*	
Standard		*550*	*375*	*95*	*625*	*1350*	*1,400,000*	
Utility	*2″-4″ wide*	*275*	*175*	*95*	*625*	*875*	*1,300,000*	
DOUGLAS FIR-LARCH (NORTH)								
Select Structural	2″-4″ thick	1300	800	95	625	1900	1,900,000	
No. 1/No. 2		825	500	95	625	1350	1,600,000	
No. 3	2″ & wider	475	300	95	625	775	1,400,000	NLGA***
Stud		*650*	*375*	*95*	*625*	*850*	*1,400,000*	
Construction	*2″-4″ thick*	*950*	*575*	*95*	*625*	*1750*	*1,500,000*	
Standard		*525*	*325*	*95*	*625*	*1400*	*1,400,000*	
Utility	*2″-4″ wide*	*250*	*150*	*95*	*625*	*925*	*1,300,000*	

* West Coast Lumber Inspection Bureau

** Western Wood Products Association

*** Northeastern Lumber Grading Agency

From National Design Specification for Wood Construction 1991

Table 3.3 Continued

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E	
DOUGLAS FIR-SOUTH								
Select Structural		1300	875	90	520	1550	1,400,000	
No. 1	2″-4″ thick	900	600	90	520	1400	1,300,000	
No. 2		825	525	90	520	1300	1,200,000	
No. 3	2″ & wider	475	300	90	520	750	1,100,000	WWPA
Stud		*650*	*425*	*90*	*520*	*825*	*1,100,000*	
Construction	*2″-4″ thick*	*925*	*600*	*90*	*520*	*1550*	*1,200,000*	
Standard		*525*	*350*	*90*	*520*	*1300*	*1,100,000*	
Utility	*2″-4″ wide*	*250*	*150*	*90*	*520*	*875*	*1,000,000*	
EASTERN HEMLOCK-TAMARACK								
Select Structural		1250	575	85	555	1200	1,200,000	
No. 1	2″-4″ thick	775	350	85	555	1000	1,100,000	
No. 2		575	275	85	555	825	1,100,000	
No. 3	2″ & wider	350	150	85	555	475	900,000	NELMA*
Stud		*450*	*200*	*85*	*555*	*525*	*900,000*	*NSLB***
Construction	*2″-4″ thick*	*675*	*300*	*85*	*555*	*1050*	*1,000,000*	
Standard		*375*	*175*	*85*	*555*	*850*	*900,000*	
Utility	*2″-4″ wide*	*175*	*75*	*85*	*555*	*550*	*800,000*	

* Northeastern Lumber Manufacturers Association

** Northern Softwood Lumber Bureau

EASTERN SOFTWOODS								
Select Structural		1250	575	70	335	1200	1,200,000	
No. 1	2″-4″ thick	775	350	70	335	1000	1,100,000	
No. 2		575	275	70	335	825	1,100,000	
No. 3	2″ & wider	350	150	70	335	475	900,000	NELMA
Stud		*450*	*200*	*70*	*335*	*525*	*900,000*	*NSLB*
Construction	*2″-4″ thick*	*675*	*300*	*70*	*335*	*1050*	*1,000,000*	
Standard		*375*	*175*	*70*	*335*	*850*	*900,000*	
Utility	*2″-4″ wide*	*175*	*75*	*70*	*335*	*550*	*800,000*	
EASTERN WHITE PINE								
Select Structural		1250	575	70	350	1200	1,200,000	
No. 1	2″-4″ thick	775	350	70	350	1000	1,100,000	
No. 2		575	275	70	350	825	1,100,000	
No. 3	2″ & wider	350	150	75	350	475	900,000	NELMA
Stud		*450*	*200*	*70*	*350*	*525*	*900,000*	*NSLB*
Construction	*2″-4″ thick*	*675*	*300*	*70*	*350*	*1050*	*1,000,000*	
Standard		*375*	*175*	*70*	*350*	*850*	*900,000*	
Utility	*2″-4″ wide*	*175*	*75*	*70*	*350*	*550*	*800,000*	
HEM-FIR								
Select Structural		1400	900	75	405	1500	1,600,000	
No. 1 & Btr	2″-4″ thick	1050	700	75	405	1350	1,500,000	
No. 1		950	600	75	405	1300	1,500,000	
No. 2	2″ & wider	850	500	75	405	1250	1,300,000	WCLIB
No. 3		500	300	75	405	725	1,200,000	WWPA
Stud		*675*	*400*	*75*	*405*	*800*	*1,200,000*	
Construction	*2″-4″ thick*	*975*	*575*	*75*	*405*	*1500*	*1,300,000*	
Standard		*550*	*325*	*75*	*405*	*1300*	*1,200,000*	
Utility	*2″-4″ wide*	*250*	*150*	*75*	*405*	*850*	*1,100,000*	

Table 3.3 Continued

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E	
HEM-FIR (NORTH)								
Select Structural	2″-4″ thick	1300	775	75	370	1650	1,700,000	
No. 1/No. 2		1000	550	75	370	1450	1,600,000	
No. 3	2″ & wider	575	325	75	370	850	1,400,000	NLGA
Stud		*775*	*425*	*75*	*370*	*925*	*1,400,000*	
Construction	*2″-4″ thick*	*1150*	*625*	*75*	*370*	*1750*	*1,500,000*	
Standard		*625*	*350*	*75*	*370*	*1500*	*1,400,000*	
Utility	*2″-4″ wide*	*300*	*175*	*75*	*370*	*975*	*1,300,000*	
MIXED MAPLE								
Select Structural		1000	600	100	620	875	1,300,000	
No. 1	2″-4″ thick	725	425	100	620	700	1,200,000	
No. 2		700	425	100	620	550	1,100,000	
No. 3	2″ & wider	400	250	100	620	325	1,000,000	NELMA
Stud		*550*	*325*	*100*	*620*	*350*	*1,000,000*	
Construction	*2″-4″ thick*	*800*	*475*	*100*	*620*	*725*	*1,100,000*	
Standard		*450*	*275*	*100*	*620*	*575*	*1,000,000*	
Utility	*2″-4″ wide*	*225*	*125*	*100*	*620*	*375*	*900,000*	

MIXED OAK								
Select Structural		1150	675	85	800	1000	1,100,000	
No. 1	2″-4″ thick	825	500	85	800	825	1,000,000	
No. 2		800	475	85	800	625	900,000	
No. 3	2″ & wider	475	275	85	800	375	800,000	NELMA
Stud		*625*	*375*	*85*	*800*	*400*	*800,000*	
Construction	*2″-4″ thick*	*925*	*550*	*85*	*800*	*850*	*900,000*	
Standard		*525*	*300*	*85*	*800*	*650*	*800,000*	
Utility	*2″-4″ wide*	*250*	*150*	*85*	*800*	*425*	*800,000*	
NORTHERN RED OAK								
Select Structural		1400	800	110	885	1150	1,400,000	
No. 1	2″-4″ thick	1000	575	110	885	925	1,400,000	
No. 2		975	575	110	885	725	1,300,000	
No. 3	2″ & wider	550	325	110	885	425	1,200,000	NELMA
Stud		*750*	*450*	*110*	*885*	*450*	*1,200,000*	
Construction	*2″-4″ thick*	*1100*	*650*	*110*	*885*	*975*	*1,200,000*	
Standard		*625*	*350*	*110*	*885*	*750*	*1,100,000*	
Utility	*2″-4″ wide*	*300*	*175*	*110*	*885*	*500*	*1,000,000*	
NORTHERN SPECIES								
Select Structural	2″-4″ thick	950	450	65	350	1100	1,100,000	
No. 1/No. 2		575	275	65	350	825	1,100,000	
No. 3	2″ & wider	350	150	65	350	475	1,000,000	NLGA
Stud		*450*	*200*	*65*	*350*	*525*	*1,000,000*	
Construction	*2″-4″ thick*	*675*	*300*	*65*	*350*	*1050*	*1,000,000*	
Standard		*375*	*175*	*65*	*350*	*850*	*900,000*	
Utility	*2″-4″ wide*	*175*	*75*	*65*	*350*	*550*	*900,000*	

Table 3.3 Continued

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E	
NORTHERN WHITE CEDAR								
Select Structural		775	450	60	370	750	800,000	
No. 1	2″-4″ thick	575	325	60	370	600	700,000	
No. 2		550	325	60	370	475	700,000	
No. 3	2″ & wider	325	175	60	370	275	600,000	NELMA
Stud		*425*	*250*	*60*	*370*	*300*	*600,000*	
Construction	*2″-4″ thick*	*625*	*375*	*60*	*370*	*625*	*700,000*	
Standard		*350*	*200*	*60*	*370*	*475*	*600,000*	
Utility	*2″-4″ wide*	*175*	*100*	*60*	*370*	*325*	*600,000*	
RED MAPLE								
Select Structural		1300	750	105	615	1100	1,700,000	
No. 1	2″-4″ thick	925	550	105	615	900	1,600,000	
No. 2		900	525	105	615	700	1,500,000	
No. 3	2″ & wider	525	300	105	615	400	1,300,000	NELMA
Stud		*700*	*425*	*105*	*615*	*450*	*1,300,000*	
Construction	*2″-4″ thick*	*1050*	*600*	*105*	*615*	*925*	*1,400,000*	
Standard		*575*	*325*	*105*	*615*	*725*	*1,300,000*	
Utility	*2″-4″ wide*	*275*	*150*	*105*	*615*	*475*	*1,200,000*	

RED OAK								
Select Structural		1150	675	85	820	1000	1,400,000	
No. 1	2″-4″ thick	825	500	85	820	825	1,300,000	
No. 2		800	475	85	820	625	1,200,000	
No. 3	2″ & wider	475	275	85	820	375	1,100,000	NELMA
Stud		*625*	*375*	*85*	*820*	*400*	*1,100,000*	
Construction	*2″-4″ thick*	*925*	*550*	*85*	*820*	*850*	*1,200,000*	
Standard		*525*	*300*	*85*	*820*	*650*	*1,100,000*	
Utility	*2″-4″ wide*	*250*	*150*	*85*	*820*	*425*	*1,000,000*	
REDWOOD								
Clear Structural		1750	1000	145	650	1850	1,400,000	
Select Structural		1350	800	80	650	1500	1,400,000	
Select Structural, open grain		1100	625	85	425	1100	1,100,000	
No. 1	2″-4″ thick	975	575	80	650	1200	1,300,000	
No. 1, open grain		775	450	80	425	900	1,100,000	
No. 2	2″ & wider	925	525	80	650	950	1,200,000	
No. 2, open grain		725	425	80	425	700	1,000,000	RIS*
No. 3		525	300	80	650	550	1,100,000	
No. 3, open grain		425	250	80	425	400	900,000	
Stud		*575*	*325*	*80*	*425*	*450*	*900,000*	
Construction	*2″-4″ thick*	*825*	*475*	*80*	*425*	*925*	*900,000*	
Standard		*450*	*275*	*80*	*425*	*725*	*900,000*	
Utility	*2″-4″ wide*	*225*	*125*	*80*	*425*	*475*	*800,000*	

* Redwood Inspection Service

Table 3.3 Continued

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E	
SPRUCE-PINE-FIR								
Select Structural	2″-4″ thick	1250	675	70	425	1400	1,500,000	
No. 1/No. 2		875	425	70	425	1100	1,400,000	
No. 3	2″ & wider	500	250	70	425	625	1,200,000	NLGA
Stud		*675*	*325*	*70*	*425*	*675*	*1,200,000*	
Construction	*2″-4″ thick*	*975*	*475*	*70*	*425*	*1350*	*1,300,000*	
Standard		*550*	*275*	*70*	*425*	*1100*	*1,200,000*	
Utility	*2″-4″ wide*	*250*	*125*	*70*	*425*	*725*	*1,100,000*	
SPRUCE-PINE-FIR (SOUTH)								
Select Structural		1300	575	70	335	1200	1,300,000	
No. 1	2″-4″ thick	850	400	70	335	1050	1,200,000	
No. 2		750	325	70	335	975	1,100,000	NELMA
No. 3	2″ & wider	425	200	70	335	550	1,000,000	NSLB
Stud		*575*	*250*	*70*	*335*	*600*	*1,000,000*	*WCLIB*
Construction	*2″-4″ thick*	*850*	*375*	*70*	*335*	*1200*	*1,000,000*	*WWPA*
Standard		*475*	*225*	*70*	*335*	*1000*	*900,000*	
Utility	*2″-4″ wide*	*225*	*100*	*70*	*335*	*650*	*900,000*	

WESTERN CEDARS								
Select Structural		1000	600	75	425	1000	1,100,000	
No. 1	2″-4″ thick	725	425	75	425	825	1,000,000	
No. 2		700	425	75	425	650	1,000,000	
No. 3	2″ & wider	400	250	75	425	375	900,000	WCLIB
Stud		*550*	*325*	*75*	*425*	*400*	*900,000*	*WWPA*
Construction	*2″-4″ thick*	*800*	*475*	*75*	*425*	*850*	*900,000*	
Standard		*450*	*275*	*75*	*425*	*650*	*800,000*	
Utility	*2″-4″ wide*	*225*	*125*	*75*	*425*	*425*	*800,000*	
WESTERN WOODS								
Select Structural		875	400	70	335	1050	1,200,000	
No. 1	2″-4″ thick	650	300	70	335	925	1,100,000	
No. 2		650	275	70	335	875	1,000,000	
No. 3	2″ & wider	375	175	70	335	500	900,000	WCLIB
Stud		*500*	*225*	*70*	*335*	*550*	*900,000*	*WWPA*
Construction	*2″-4″ thick*	*725*	*325*	*70*	*335*	*1050*	*1,000,000*	
Standard		*400*	*175*	*70*	*335*	*900*	*900,000*	
Utility	*2″-4″ wide*	*200*	*75*	*70*	*335*	*600*	*800,000*	

Table 3.3a Size Adjustment Factor C_F for Visually Graded Dimension Lumber

Grades	Width (in.)	F_b		F_t	F_c
		Thickness 2 and 3 in.	Thickness 4 in.		
	2, 3, and 4	1.5	1.5	1.5	1.15
Select	5	1.4	1.4	1.4	1.1
Structural	6	1.3	1.3	1.3	1.1
No. 1 and Better	8	1.2	1.3	1.2	1.05
No.	10	1.1	1.2	1.1	1.0
No. 2	12	1.0	1.1	1.0	1.0
No. 3	14 and wider	0.9	1.0	0.9	0.9
Stud	2, 3, and 4	1.1	1.1	1.1	1.05
	5 and 6	1.0	1.0	1.0	1.0
Construction and Standard	2, 3, and 4	1.0	1.0	1.0	1.0
Utility	4	1.0	1.0	1.0	1.0
	2 and 3	0.4	—	0.4	0.6

Table 3.3b Flat Use Factor C_{fu}

Width in.	Thickness (in.)	
	2 and 3	4
2 and 3	1.0	—
4	1.1	1.0
5	1.1	1.05
6	1.15	1.05
8	1.15	1.05
10 and wider	1.2	1.1

Table 3.3c Wet Service Adjustment Factor C_M

Type of stress	F_b	F_t	F_v	$F_{c\perp}$	F_c	E
C_M	0.85*	1.0	0.97	0.67	0.8†	0.9

* When $(F_b)(C_F) \leq 1150$ psi, $C_M = 1.0$.
† When $(F_c)(C_F) \leq 750$ psi, $C_M = 1.0$.

Table 3.3d Shear Stress Factor C_H

Length of split on wide face of 2-in. (nominal) lumber	C_H	Length of split on wide face of 3-in. (nominal) and thicker lumber	C_H	Size of shake* in 2-in. (nominal) and thicker lumber	C_H
No split	2.00	No split	2.00	No shake	2.00
½ × wide face	1.67	½ × narrow face	1.67	⅙ × narrow face	1.67
¾ × wide face	1.50	¾ × narrow face	1.50	¼ × narrow face	1.50
1 × wide face	1.33	1 × narrow face	1.33	⅓ × narrow face	1.33
1-½ × wide face or more	1.00	1-½ × narrow face or more	1.00	½ × narrow face or more	1.00

* Shake is measured at the end between lines enclosing the shake and perpendicular to the loaded surface.

Table 3.4 Base Design Values For Visually Graded Mixed Southern Pine Dimension Lumber

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E	
MIXED SOUTHERN PINE								
Select Structural		2050	1200	100	565	1800	1,600,000	
No. 1	2″-4″ thick	1450	875	100	565	1650	1,500,000	
No. 2		1300	775	90	565	1650	1,400,000	
No. 3	2″-4″ wide	750	450	90	565	950	1,200,000	
Stud		775	450	90	565	950	1,200,000	SPIB*
Construction	2″-4″ thick	1000	600	100	565	1700	1,300,000	
Standard		550	325	90	565	1450	1,200,000	
Utility	4″ wide	275	150	90	565	950	1,100,000	

Select Structural		1850	1100	90	565	1700	1,600,000
No. 1	2″-4″ thick	1300	750	90	565	1550	1,500,000
No. 2		1150	675	90	565	1550	1,400,000
No. 3	5″-6″ wide	675	400	90	565	875	1,200,000
Stud		675	400	90	565	875	1,200,000
Select Structural	2″-4″ thick	1750	1000	90	565	1600	1,600,000
No. 1		1200	700	90	565	1450	1,500,000
No. 2	8″ wide	1050	625	90	565	1450	1,400,000
No. 3		625	375	90	565	850	1,200,000
Select Structural	2″-4″ thick	1500	875	90	565	1600	1,600,000
No. 1		1050	600	90	565	1450	1,500,000
No. 2	10″ wide	925	550	90	565	1450	1,400,000
No. 3		565	325	90	565	825	1,200,000
Select Structural	2″-4″ thick	1400	825	90	565	1550	1,600,000
No. 1		975	575	90	565	1400	1,500,000
No. 2	12″ wide	875	525	90	565	1400	1,400,000
No. 3		500	300	90	565	800	1,200,000

* Southern Pine Inspection Bureau

Table 3.4a Size Adjustment Factor C_F for Southern Pine Including Mixed

	For dimension lumber 4 in. thick, 8 in. and wider	For 12 in. and wider lumber
C_F	1.1	0.9

Table 3.4b Wet Service Adjustment Factor C_M

Type of stress	F_b	F_t	F_v	$F_{c\perp}$	F_c	E
C_M	0.85*	1.0	0.97	0.67	0.8†	0.9

* When $(F_b)(C_F) \leq 1150$ psi, $C_M = 1.0$.
† When $(F_b) \leq 750$ psi, $C_M = 1.0$.

Table 3.4c Flat Use Factor C_{fu}

Width (in.)	Thickness (in.)	
	2 and 3	4
2 and 3	1.0	—
4	1.1	1.0
5	1.1	1.05
6	1.15	1.05
8	1.15	1.05
10 and wider	1.2	1.1

Table 3.4d Shear Stress Factor C_H

Length of split on wide face of 2-in. (nominal) lumber	C_H	Length of split on wide face of 3-in. (nominal) and thicker lumber	C_H	Size of shake* in 2-in. (nominal) and thicker lumber	C_H
No split	2.00	No split	2.00	No shake	2.00
1/2 × wide face	1.67	1/2 × narrow face	1.67	1/6 × narrow face	1.67
3/4 × wide face	1.50	3/4 × narrow face	1.50	1/4 narrow face	1.50
1 × wide face	1.33	1 × narrow face	1.33	1/3 narrow face	1.33
1-1/2 × wide face or more	1.0	1-1/2 × narrow face or more	1.00	1/2 × narrow face or more	1.00

* Shake is measured at the end between lines enclosing the shake and perpendicular to the loaded surface.

Table 3.5 Base Design Values for Visually Graded Southern Pine Dimension Lumber

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E	
SOUTHERN PINE								
Dense Select Structural		3050	1650	100	660	2250	1,900,000	
Select Structural		2850	1600	100	565	2100	1,800,000	
Non-Dense Select Structural		2650	1350	100	480	1950	1,700,000	
No. 1 Dense		2000	1100	100	660	2000	1,800,000	
No. 1	2″-4″ thick	1850	1050	100	565	1850	1,700,000	
No. 1 Non-Dense		1700	900	100	480	1700	1,600,000	
No. 2 Dense	2″-4″ wide	1700	875	90	660	1850	1,700,000	
No. 2		1500	825	90	565	1650	1,600,000	SPIB*
No. 2 Non-Dense		1350	775	90	480	1600	1,400,000	
No. 3		850	475	90	565	975	1,400,000	
Stud		875	500	90	565	975	1,400,000	
Construction	2″-4″ thick	1100	625	100	565	1800	1,500,000	
Standard		625	350	90	565	1500	1,300,000	
Utility	4″ wide	300	175	90	565	975	1,300,000	
Dense Select Structural		2700	1500	90	660	2150	1,900,000	
Select Structural		2550	1400	90	565	2000	1,800,000	
Non-Dense Select Structural		2350	1200	90	480	1850	1,700,000	
No. 1 Dense		1750	950	90	660	1900	1,800,000	

No. 1	2″-4″ thick	1650	900	90	565	1750	1,700,000	
No. 1 Non-Dense		1500	800	90	480	1600	1,600,000	
No. 2 Dense	5″-6″ wide	1450	775	90	660	1750	1,700,000	
No. 2		1250	725	90	565	1600	1,600,000	
No. 2 Non-Dense		1150	675	90	480	1500	1,400,000	
No. 3		750	425	90	565	925	1,400,000	
Stud		775	425	90	565	925	1,400,000	
Dense Select Structural		2450	1350	90	660	2050	1,900,000	SPIB
Select Structural		2300	1300	90	565	1900	1,800,000	
Non-Dense Select Structural		2100	1100	90	480	1750	1,700,000	
No. 1 Dense	2″-4″ thick	1650	875	90	660	1800	1,800,000	
No. 1		1500	825	90	565	1650	1,700,000	
No. 1 Non-Dense	8″ wide	1350	725	90	480	1550	1,600,000	
No. 2 Dense		1400	675	90	660	1700	1,700,000	
No. 2		1200	650	90	565	1550	1,600,000	
No. 2 Non-Dense		1100	600	90	480	1450	1,400,000	
No. 3		700	400	90	565	875	1,400,000	
Dense Select Structural		2150	1200	90	660	2000	1,900,000	
Select Structural		2050	1100	90	565	1850	1,800,000	
Non-Dense Select Structural		1850	950	90	480	1750	1,700,000	
No. 1 Dense	2″-4″ thick	1450	775	90	660	1750	1,800,000	
No. 1		1300	725	90	565	1600	1,700,000	
No. 1 Non-Dense	10″ wide	1200	650	90	480	1500	1,600,000	
No. 2 Dense		1200	625	90	660	1650	1,700,000	
No. 2		1050	575	90	565	1500	1,600,000	
No. 2 Non-Dense		950	550	90	480	1400	1,400,000	
No. 3		600	325	90	565	850	1,400,000	

Table 3.5 Continued

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E	
Dense Select Structural		2050	1100	90	660	1950	1,900,000	
Select Structural		1900	1050	90	565	1800	1,800,000	
Non-Dense Select Structural		1750	900	90	480	1700	1,700,000	
No. 1 Dense	2″-4″ thick	1350	725	90	660	1700	1,800,000	
No. 1		1250	675	90	565	1600	1,700,000	
No. 1 Non-Dense	12″ wide[4]	1150	600	90	480	1500	1,600,000	
No. 2 Dense		1150	575	90	660	1600	1,700,000	
No. 2		975	550	90	565	1450	1,600,000	
No. 2 Non-Dense		900	525	90	480	1350	1,400,000	
No. 3		575	325	90	565	825	1,400,000	
SOUTHERN PINE (Dry service conditions—19% or less moisture content)								
Dense Structural 86	2-1/2″-4″ thick	2600	1750	155	660	2000	1,800,000	
Dense Structural 72		2200	1450	130	660	1650	1,800,000	SPIB
Dense Structural 65	2″ & wider	2000	1300	115	660	1500	1,800,000	
SOUTHERN PINE (Wet service conditions)								
Dense Structural 86	2-1/2″-4″ thick	2100	1400	145	440	1300	1,600,000	
Dense Structural 72		1750	1200	120	440	1100	1,600,000	SPIB
Dense Structural 65	2-1/2″ & wider	1600	1050	110	440	1000	1,600,000	

* Southern Pine Inspection Bureau

From National Design Specification for Wood Construction 1991

Table 3.5a Wet Service Adjustment Factor C_M

Type of stress	F_b	F_t	F_v	$F_{c\perp}$	F_c	E
C_M	1.00	1.0	1.00	0.67	0.91	1.00

Table 3.5b Shear Stress Factor C_H

Length of split on wide face of 5-in. (nominal) and thicker lumber	C_H	Size of shake* in 5-in. (nominal) and thicker lumber	C_H
No split	2.00	No shake	2.00
½ × narrow width	1.67	⅙ × narrow face	1.67
¾ × narrow width	1.50	¼ × narrow face	1.50
1 × narrow width	1.33	⅓ × narrow face	1.33
1½ × narrow width	1.00	½ × narrow face or more	1.00

* Shake is measured at the end between lines enclosing the shake and perpendicular to the loaded surface.

Table 3.6 Design Values for Visually Graded Decking

Species and commercial grade	Size classification	Design values in pounds per square inches		
		F_b	$F_{c\perp}$	E
Douglas Fir-Larch				
Select Dex	2–4 in. thick	1750.0	625.0	1,800,000
Commercial Dex	6–8 in. wide	1450.0	625.0	1,700,000
Hem-Fir				
Select Dex	2–4 in. thick	1400.0	405.0	1,500,000
Commercial Dex	6–8 in. wide	1150.0	405.0	1,400,000
Redwood				
Select, Close Grain	2 in. thick	1850.0	—	1,400,000
Select		1450.0	—	1,100,000
Commercial	6 in. and wider	1200.0	—	1,000,000
Deck heart and Deck common	2 in. thick, 4 in. wide	400.0	420.0	900,000
	2 in. thick, 6 in. wide	700.0	420.0	900,000
Southern Pine *(Dry service conditions—19% or less moisture content)*				
Dense Standard	2–4 in. thick	2000.0	660.0	1,800,000
Dense Select		1650.0	660.0	1,600,000
Select		1400.0	565.0	1,600,000
Dense Commercial		1650.0	660.0	1,600,000
Commercial	2 in. and wider	1400.0	565.0	1,600,000
Southern Pine *(Wet service conditions)*				
Dense Standard	2½–4 in. thick	1600.0	440.0	1,600,000
Dense Select		1350.0	440.0	1,400,000
Select		1150.0	375.0	1,400,000
Dense Commercial		1350.0	440.0	1,400,000
Commercial	2 in. and wider	1150.0	375.0	1,400,000

From National Design Specification for Wood Construction 1991

Table 3.6a Wet Service Factor (C_M)*

Type of stress	F_b	$F_{c\perp}$	E
C_M	0.85†	0.67	0.9

* For Southern Pine use tabulated design values for wet service conditions without further adjustment.

† When $(F_b)(C_F) \leq 1150$ psi, $C_M = 1.0$.

Table 3.7 Load Duration Factor (C_D)

Load duration	C_D	Typical design load
Permanent	0.9	Dead load
10 years	1.0	Occupancy live load
2 months	1.15	Snow load
7 days	**1.25**	**Construction load**
10 minutes	1.6	Wind/earthquake load
Impact	2.0	Impact load

From National Design Specification for Wood Construction 1991

Table 3.8 Temperature Factor (C_t)

Design values	In service moisture content	C_t		
		$T \leq 100°F$	$100°F < T \leq 125°F$	$125°F < T \leq 150°F$
F_t, E	Wet or dry	1.0	0.9	0.9
F_b, F_v, F_c, and $F_{c\perp}$	Dry Wet	1.0 1.0	0.8 0.7	0.7 0.5

From National Design Specification for Wood Construction 1991

Table 3.9 Bearing Area Factor (C_b)*

l_b (in.)	0.5	1.0	1.5	2.0	3.0	4.0	6 or more
C_b	1.75	1.38	1.25	1.19	1.13	1.10	1.00

* For round bearing area such as washers, the bearing length l_b will be equal to the diameter.

From National Design Specification for Wood Construction 1991

Table 3.10 Key to Span Rating and Species Group

KEY TO SPAN RATING AND SPECIES GROUP	Thickness (in.)	Span Rating (APA RATED SHEATHING grade)						
		12/0	16/0	20/0	24/0	32/16	40/20	48/24
		Span Rating (STURD-I-FLOOR grade)						
						16 oc	20 oc	24 oc	48 oc
For panels with "Span Rating" as across top, and thickness as at left, use stress for species group given in table.	5/16	4	3	1					
	3/8			4	1				
	15/32 & 1/2				4	1(1)			
	19/32 & 5/8					4	1		
(1) Thicknesses not applicable to APA RATED STURD-I-FLOOR	23/32 & 3/4						4	1	
(2) For APA RATED STURD-I-FLOOR 24 oc, use Group 4 stresses.	7/8							3(2)	
	1-1/8								1

From Plywood Design Specification by The American Plywood Association 1997.

Table 3.12 Effective Section Properties for Plywood
FACE PLIES OF DIFFERENT SPECIES GROUP FROM INNER PLIES
(INCLUDES ALL PRODUCT STANDARD GRADES EXCEPT THOSE NOTED IN TABLE 2.)

			Stress applied parallel to face grain				Stress applied perpendicular to face grain			
Nominal thickness (in.)	Approximate weight (psf)	t_v Effective thickness for shear (in.)	A Area ($in.^2/ft$)	I Moment of inertia ($in.^4/ft$)	KS Effective section modulus ($in.^3/ft$)	lb/Q Rolling shear constant ($in.^2/ft$)	A Area ($in.^2/ft$)	I Moment of inertia ($in.^4/ft$)	KS Effective section modulus ($in.^3/ft$)	lb/Q Rolling shear constant ($in.^2/ft$)
Unsanded Panels										
5/16-U	1.0	0.268	1.491	0.022	0.112	2.569	0.660	0.001	0.023	4.497
3/8-U	1.1	0.278	1.866	0.039	0.152	3.110	0.799	0.002	0.033	5.444
15/32- & 1/2-U	1.5	0.298	2.292	0.067	0.213	3.921	1.007	0.004	0.056	2.450
19/32- & 5/8-U	1.8	0.319	2.330	0.121	0.379	5.004	1.285	0.010	0.091	3.106
23/32- & 3/4-U	2.2	0.445	3.247	0.234	0.496	6.455	1.563	0.036	0.232	3.613
7/8-U	2.6	0.607	3.509	0.340	0.678	7.175	1.950	0.112	0.397	4.791
1-U	3.0	0.842	3.916	0.493	0.859	9.244	3.145	0.210	0.660	6.533
1-1/8-U	3.3	0.859	4.725	0.676	1.047	9.960	3.079	0.288	0.768	7.931

Table 3.12 Continued

Nominal thickness (in.)	Approximate weight (psf)	t_s Effective thickness for shear (in.)	Stress applied parallel to face grain: A Area ($in.^2/ft$)	I Moment of inertia ($in.^4/ft$)	KS Effective section modulus ($in.^3/ft$)	lb/Q Rolling shear constant ($in.^2/ft$)	Stress applied perpendicular to face grain: A Area ($in.^2/ft$)	I Moment of inertia ($in.^4/ft$)	KS Effective section modulus ($in.^3/ft$)	lb/Q Rolling shear constant ($in.^2/ft$)
Sanded Panels										
1/4-S	0.8	0.267	0.996	0.008	0.059	2.010	0.348	0.001	0.009	2.019
11/32-S	1.0	0.284	0.996	0.019	0.093	2.765	0.417	0.001	0.016	2.589
3/8-S	1.1	0.288	1.307	0.027	0.125	3.088	0.626	0.002	0.023	3.510
15/32-S	1.4	0.421	1.947	0.066	0.214	4.113	1.204	0.006	0.067	2.434
1/2-S	1.5	0.425	1.947	0.077	0.236	4.466	1.240	0.009	0.087	2.752
19/32-S	1.7	0.546	2.423	0.115	0.315	5.471	1.389	0.021	0.137	2.861
5/8-S	1.8	0.550	2.475	0.129	0.339	5.824	1.528	0.027	0.164	3.119
23/32-S	2.1	0.563	2.822	0.179	0.389	6.581	1.737	0.050	0.231	3.818
3/4-S	2.2	0.568	2.884	0.197	0.412	6.762	2.081	0.063	0.285	4.079
7/8-S	2.6	0.586	2.942	0.278	0.515	8.050	2.651	0.104	0.394	5.078
1-S	3.0	0.817	3.721	0.423	0.664	8.882	3.163	0.185	0.591	7.031
1-1/8-S	3.3	0.836	3.854	0.548	0.820	9.883	3.180	0.271	0.744	8.428
Touch-Sanded Panels										
1/2-T	1.5	0.342	2.698	0.083	0.271	4.252	1.159	0.006	0.061	2.746
19/32- & 5/8-T	1.8	0.408	2.354	0.123	0.327	5.346	1.555	0.016	0.135	3.220
23/32- & 3/4-T	2.2	0.439	2.715	0.193	0.398	6.589	1.622	0.032	0.219	3.635
1-1/8-T	3.3	0.839	4.548	0.633	0.977	11.258	4.067	0.272	0.743	8.535

From Plywood Design Specification by The American Plywood Association 1997.

Table 3.13 Effective Section Properties for Plywood (Structural I and Marine)
STRUCTURAL I AND MARINE

			Stress applied parallel to face grain				Stress applied perpendicular to face grain			
Nominal thickness (in.)	Approximate weight (psf)	t_v Effective thickness for shear (in.)	A Area ($in.^2/ft$)	I Moment of inertia ($in.^4/ft$)	KS Effective section modulus ($in.^3/ft$)	lb/Q Rolling shear constant ($in.^2/ft$)	A Area ($in.^2/ft$)	I Moment of inertia ($in.^4/ft$)	KS Effective section modulus ($in.^3/ft$)	lb/Q Rolling shear constant ($in.^2/ft$)
Unsanded Panels										
5/16-U	1.0	0.356	1.619	0.022	0.126	2.567	1.188	0.002	0.029	6.037
3/8-U	1.1	0.371	2.226	0.041	0.195	3.107	1.438	0.003	0.043	7.307
15/32- & 1/2-U	1.5	0.535	2.719	0.074	0.279	4.157	2.175	0.012	0.116	2.408
19/32- & 5/8-U	1.8	0.707	3.464	0.154	0.437	5.685	2.742	0.045	0.240	3.072
23/32- & 3/4-U	2.2	0.739	4.219	0.236	0.549	6.148	2.813	0.064	0.299	3.540
7/8-U	2.6	0.776	4.388	0.346	0.690	6.948	3.510	0.131	0.457	4.722
1-U	3.0	1.088	5.200	0.529	0.922	8.512	5.661	0.270	0.781	6.435
1-1/8-U	3.3	1.118	6.654	0.751	1.164	9.061	5.542	0.408	0.999	7.833

Table 3.13 Continued

Nominal thickness (in.)	Approximate weight (psf)	t_v Effective thickness for shear (in.)	Stress applied parallel to face grain: A Area ($in.^2/ft$)	I Moment of inertia ($in.^4/ft$)	KS Effective section modulus ($in.^3/ft$)	lb/Q Rolling shear constant ($in.^2/ft$)	Stress applied perpendicular to face grain: A Area ($in.^2/ft$)	I Moment of inertia ($in.^4/ft$)	KS Effective section modulus ($in.^3/ft$)	lb/Q Rolling shear constant ($in.^2/ft$)
Sanded Panels										
1/4-S	0.8	0.342	1.280	0.012	0.083	2.009	0.626	0.001	0.013	2.723
11/32-S	1.0	0.365	1.280	0.026	0.133	2.764	0.751	0.001	0.023	3.397
3/8-S	1.1	0.373	1.680	0.038	0.177	3.086	1.126	0.002	0.033	4.927
15/32-S	1.4	0.537	1.947	0.067	0.246	4.107	2.168	0.009	0.093	2.405
1/2-S	1.5	0.545	1.947	0.078	0.271	4.457	2.232	0.014	0.123	2.725
19/32-S	1.7	0.709	3.018	0.116	0.338	5.566	2.501	0.034	0.199	2.811
5/8-S	1.8	0.717	3.112	0.131	0.361	5.934	2.751	0.045	0.238	3.073
23/32-S	2.1	0.741	3.735	0.183	0.439	6.109	3.126	0.085	0.338	3.780
3/4-S	2.2	0.748	3.848	0.202	0.464	6.189	3.745	0.108	0.418	4.047
7/8-S	2.6	0.778	3.952	0.288	0.569	7.539	4.772	0.179	0.579	5.046
1-S	3.0	1.091	5.215	0.479	0.827	7.978	5.693	0.321	0.870	6.981
1-1/8-S	3.3	1.121	5.593	0.623	0.955	8.841	5.724	0.474	1.098	8.377
Touch-Sanded Panels										
1/2-T	1.5	0.543	2.698	0.084	0.282	4.511	2.486	0.020	0.162	2.720
19/32- & 5/8-T	1.8	0.707	3.127	0.124	0.349	5.500	2.799	0.050	0.259	3.183
23/32- & 3/4-T	2.2	0.739	4.059	0.201	0.469	6.592	3.625	0.078	0.350	3.596

From Plywood Design Specification by The American Plywood Association 1997.

Table 3.14 Allowable Stresses for Plywood (psi)*

ALLOWABLE STRESSES FOR PLYWOOD (psi) conforming to Voluntary Product Standard PS 1-95 for Construction and Industrial Plywood. Stresses are based on normal duration of load, and on common structural applications where panels are 24″ or greater in width. For other use conditions, see Section 3.3 for modifications.

Type of stress		Species group of face ply	Grade stress level[1] S-1 Wet	S-1 Dry	S-2 Wet	S-2 Dry	S-3 Dry only
EXTREME FIBER STRESS IN BENDING (F_b)		1	1430	2000	1190	1650	1650
TENSION IN PLANE OF PLIES (F_t)	F_b & F_t	2, 3	980	1400	820	1200	1200
Face Grain Parallel or Perpendicular to Span (At 45° to Face Grain Use 1/6 F_t)		4	940	1330	780	1110	1110
COMPRESSION IN PLANE OF PLIES		1	970	1640	900	1540	1540
		2	730	1200	680	1100	1100
Parallel to Perpendicular to Face Grain	F_c	3	610	1060	580	990	990
(At 45° to Face Grain Use 1/3 F_c)		4	610	1000	580	950	950
SHEAR THROUGH THE THICKNESS[3]		1	155	190	155	190	160
Parallel or Perpendicular to Face Grain	F_v	2, 3	120	140	120	140	120
(At 45° to Face Grain Use 2 F_v)		4	110	130	110	130	115
ROLLING SHEAR (IN THE PLANE OF PLIES)		Marine & Structural I	63	75	63	75	—
Parallel or Perpendicular to Face Grain (At 45° to Face Grain Use 1-1/3 F_s)	F_s	All Other[2]	44	53	44	53	48

Table 3.14 Continued

Type of stress		Species group of face ply	Grade stress level(1) S-1 Wet	S-1 Dry	S-2 Wet	S-2 Dry	S-3 Dry only
MODULUS OR RIGIDITY		1	70,000	90,000	70,000	90,000	82,000
(OR SHEAR MODULUS)		2	60,000	75,000	60,000	75,000	68,000
Shear in Plane Perpendicular to Plies	G	3	50,000	60,000	50,000	60,000	55,000
(through the thickness)		4	45,000	50,000	45,000	50,000	45,000
(At 45° to Face Grain Use 4G)							
BEARING (ON FACE)		1	210	340	210	340	340
Perpendicular to Plane of Plies	$F_{c\perp}$	2, 3	135	210	135	210	210
		4	105	160	105	160	160
MODULUS OF ELASTICITY IN		1	1,500,000	1,800,000	1,500,000	1,800,000	1,800,000
BENDING IN PLANE OF PLIES		2	1,300,000	1,500,000	1,300,000	1,500,000	1,500,000
	E	3	1,100,000	1,200,000	1,000,000	1,200,000	1,200,000
For Grain Parallel or Perpendicular to Span		4	900,000	1,000,000	900,000	1,000,000	1,000,000

(1) See pages 12 and 13 for Guide.
To qualify for stress level S-1, gluelines must be exterior and veneer grades N, A, and C (natural, not repaired) are allowed in either face or back.
For stress level S-2, gluelines must be exterior and veneer grade B, C-Plugged and D are allowed on the face or back.
Stress level S-3 includes all panels with interior or intermediate (IMG) gluelines.
(2) Reduce stresses 25% for 3-layer (4- or 5-ply) panels over 5/8″ thick. Such layups are possible under PS 1-95 for APA RATED SHEATHING, APA RATED STURD-I-FLOOR, UNDERLAYMENT, C-C Plugged and C-D Plugged grades over 5/8″ through 3/4″ thick.
(3) Shear-through-the-thickness stresses for MARINE and SPECIAL EXTERIOR grades may be increased 33%. See Section 3.8.1 for conditions under which stresses for other grades may be increased.
* Stresses are based on normal duration of load, and on common structural applications where panels are 24 in. or greater in width.
From Plywood Design Specification by The American Plywood Association 1997.

Table 3.15 Design Equations for Different Support Conditions

Type	One span	Two spans	Three spans
Bending moment (in.-lb)	$M = \frac{wl^2}{96}$	$M = \frac{wl^2}{96}$	$M = \frac{wl^2}{120}$
Shear (lb)	$V = \frac{wl}{24}$	$V = \frac{5wl}{96}$	$V = \frac{wl}{20}$
Deflection (in.)	$\Delta = \frac{5wl^4}{4608EI}$	$\Delta = \frac{wl^4}{2220EI}$	$\Delta = \frac{wl^4}{1740EI}$

Notation:
l = length of span (in.)
w = uniform load per foot of span (lb/ft)
E = modules of elasticity (psi)
I = moment of inertia ($in.^4$)

Source: Reproduced from the 1998 edition of *Construction Methods and Management* by S. W. Nunnally, with the permission of the publisher, Prentice-Hall. Table 12-3, pp. 340–341.

Table 3.16 Bending Moment, Shear, and Deflection Equations*

Design condition	Support conditions: One span	Two spans	Three or more spans
Bending			
Wood	$l = 4.0d\left(\frac{F_b b}{w}\right)^{1/2}$	$l = 4.0d\left(\frac{F_b b}{w}\right)^{1/2}$	$l = 4.46d\left(\frac{F_b b}{w}\right)^{1/2}$
	$l = 9.8\left(\frac{F_b S}{w}\right)^{1/2}$	$l = 9.8\left(\frac{F_b S}{w}\right)^{1/2}$	$l = 10.95\left(\frac{F_b S}{w}\right)^{1/2}$
Plywood	$l = 9.8\left(\frac{F_b KS}{w}\right)^{1/2}$	$l = 9.8\left(\frac{F_b KS}{w}\right)^{1/2}$	$l = 10.95\left(\frac{F_b KS}{w}\right)^{1/2}$
Shear			
Wood	$l = 16\frac{F_v A}{w} + 2d$	$l = 12.8\frac{F_v A}{w} + 2d$	$l = 13.3\frac{F_v A}{w} + 2d$
Plywood	$l = 24\frac{F_s Ib/Q}{w} + 2d$	$l = 19.2\frac{F_s Ib/Q}{w} + 2d$	$l = 20\frac{F_s Ib/Q}{w} + 2d$
Deflection	$l = 5.51\left(\frac{EI\Delta}{w}\right)^{1/4}$	$l = 6.86\left(\frac{EI\Delta}{w}\right)^{1/4}$	$l = 6.46\left(\frac{EI\Delta}{w}\right)^{1/4}$
If $\Delta = \frac{l}{180}$	$l = 1.72\left(\frac{EI}{w}\right)^{1/3}$	$l = 2.31\left(\frac{EI}{w}\right)^{1/3}$	$l = 2.13\left(\frac{EI}{w}\right)^{1/3}$

If $\Delta = \frac{l}{240}$	$l = 1.57\left(\frac{EI}{w}\right)^{1/3}$	$l = 2.10\left(\frac{EI}{w}\right)^{1/3}$	$l = 1.94\left(\frac{EI}{w}\right)^{1/3}$
If $\Delta = \frac{l}{360}$	$l = 1.37\left(\frac{EI}{w}\right)^{1/3}$	$l = 1.83\left(\frac{EI}{w}\right)^{1/3}$	$l = 1.69\left(\frac{EI}{w}\right)^{1/3}$

Notation:

l = length of span, center to center of supports (in.)
F_b = allowable unit stress in bending (psi)
F_bKS = plywood section capacity in bending (lb × in./ft)
F_c = allowable unit stress in compression parallel to grain (psi)
$F_{c\perp}$ = allowable unit stress in compression perpendicular to grain (psi)
F_sIb/Q = plywood section capacity in rolling shear (lb/ft)
F_v = allowable unit stress in horizontal shear (psi)
f_c = actual unit stress in compression parallel to grain (psi)
$f_{c\perp}$ = actual unit stress in compression perpendicular to grain (psi)
f_t = actual unit stress in tension (psi)
A = area of section (in.^{2})*
E = modulus of elasticity (psi)
I = moment of inertia (in.^{4})*
P = applied force (compression to tension) (lb)
S = section modulus (in.^{3})*
Δ = deflection (in.)
b = width of member (in.)
d = *depth of member (in.)*
w = uniform load per foot of span (lb/ft)

*For a rectangular member: $A = bd$, $S = bd^2/6$, $I = bd^3/12$.

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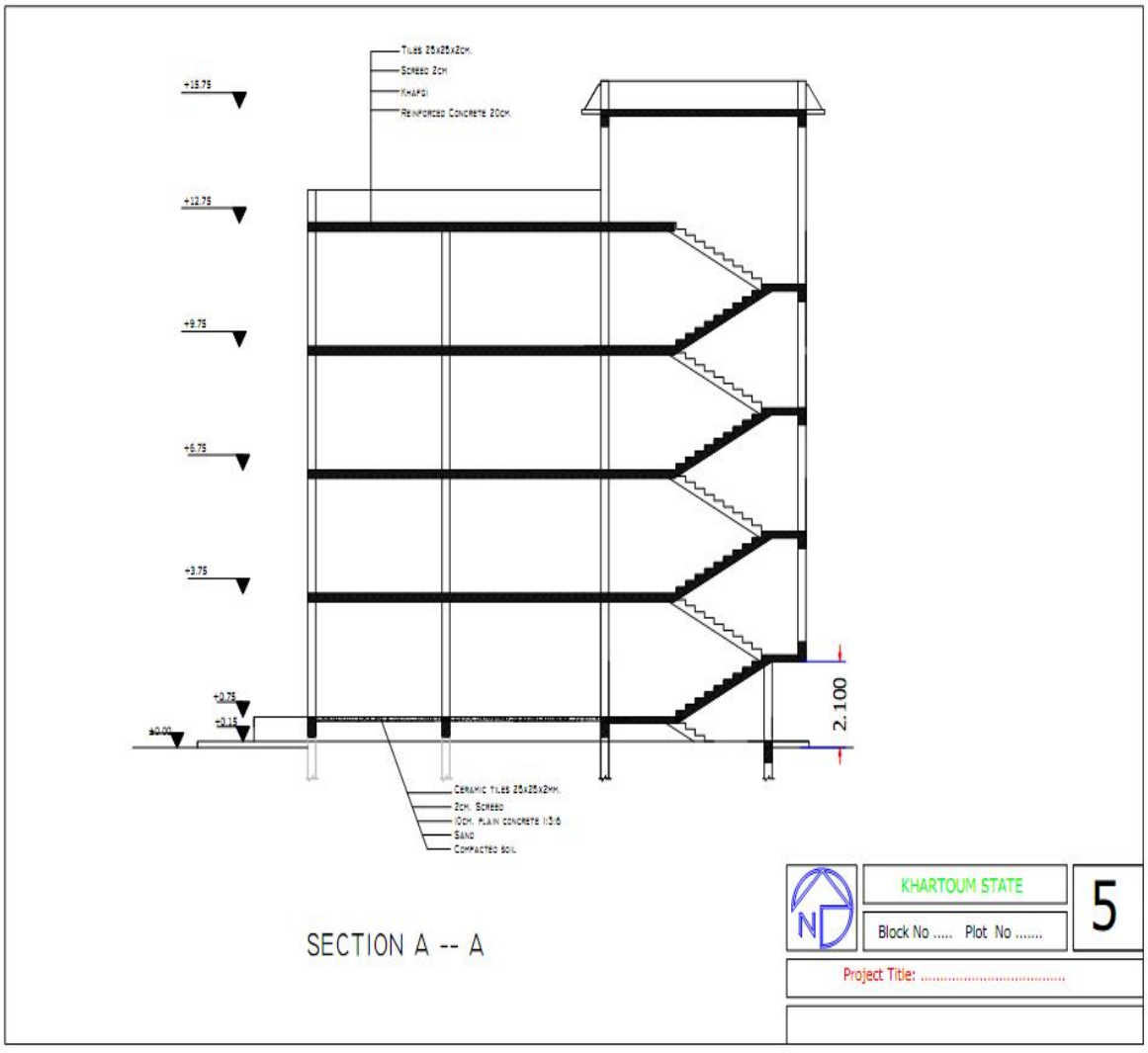
Conversion of Units of Measure Between U.S. Customary System And Metric System

Multiply	by	To obtain
cm	0.3937	in
cm^3	0.061024	in^3
ft	0.3048	m
ft^3	0.028317	m^3
Ft-lb	1.35582	J
in	2.5401	cm
in^3	16.387	cm^3
Kg	2.20462	lb
Km	3280.8	ft
Km/hr	0.62137	Mi/hr
KPa	0.14504	lb/in^2
lb	4.4482	N
lb/in^2	6894.8	Pa
m	3.28083	ft
m^3	35.3147	ft^3
N	0.22481	lb
ft	12.5	in

Case Study Drawings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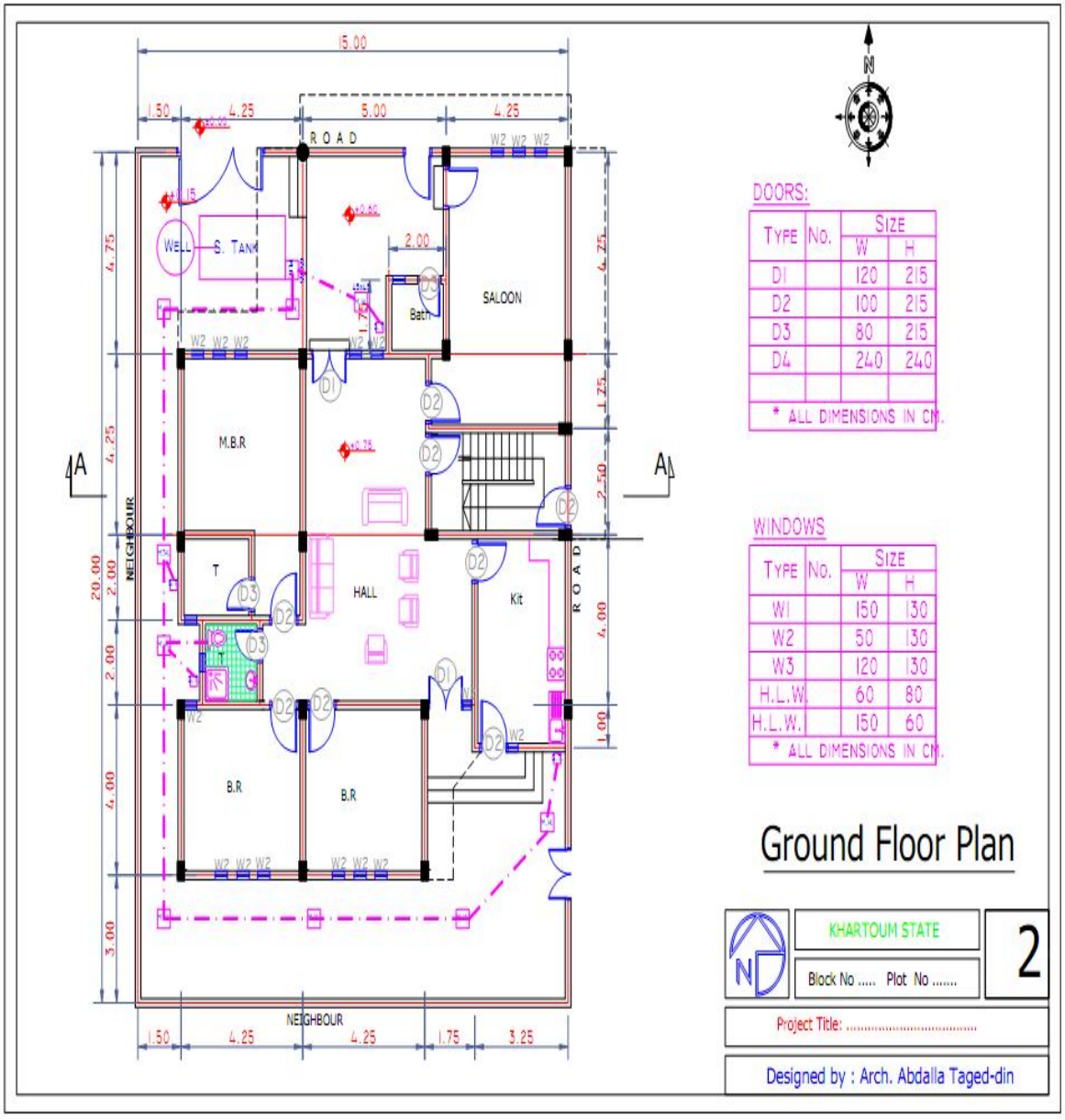
+12.75
+9.75
+6.75
+3.75
+0.75
±0.00
+0.15
2.100
CERAMIC TILES 25X25X2MM.
2CM. SCREED
10CM. PLAIN CONCRETE 1:3:6
SAND
COMPACTED SOIL
SECTION A -- A
KHARTOUM STATE
Block No ..... Plot No .....
5
Project Title: .....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4.25
5.00
4.25
ROAD
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WELL
S. TANK
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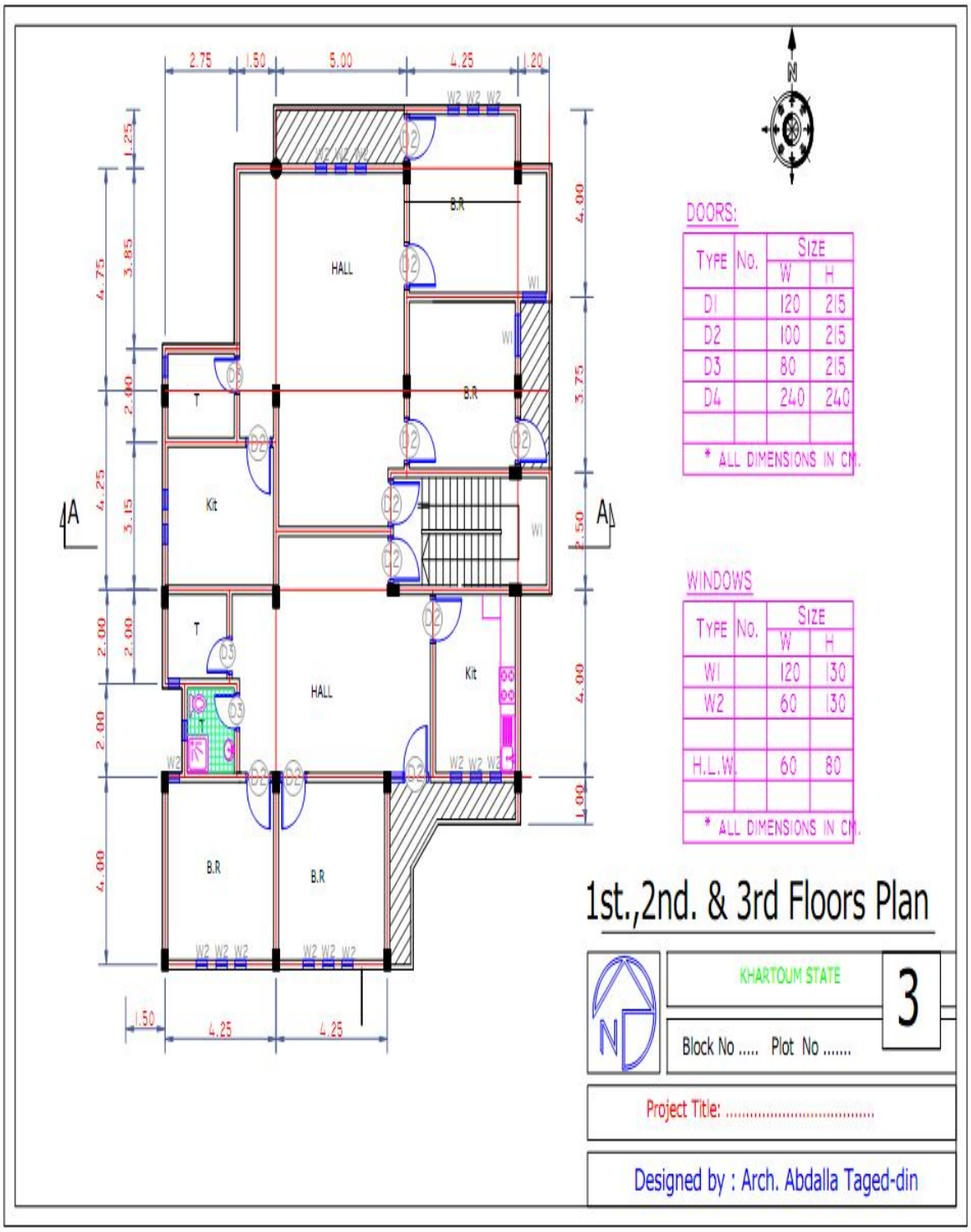
SALOON
Bath
M.B.R
HALL
Kit
T
B.R
B.R
NEIGHBOUR
NEIGHBOUR
ROAD
A
A
20.00
4.75
4.25
2.00
2.00
4.00
3.00
1.75
2.50
4.00
1.00
1.50
4.25
4.25
1.75
3.25
N
DOORS:
TYPE | No. | SIZE W | H
D1 | | 120 | 215
D2 | | 100 | 215
D3 | | 80 | 215
D4 | | 240 | 240
* ALL DIMENSIONS IN CM.
WINDOWS
TYPE | No. | SIZE W | H
W1 | | 150 | 130
W2 | | 50 | 130
W3 | | 120 | 130
H.L.W. | | 60 | 80
H.L.W. | | 150 | 60
* ALL DIMENSIONS IN CM.
Ground Floor Plan
KHARTOUM STATE
Block No ..... Plot No .....
2
Project Title: .....
Designed by : Arch. Abdalla Taged-din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4.25
1.20
HALL
B.R
T
Kit
HALL
Kit
B.R
B.R
A
A
N
DOORS:
TYPE | No. | SIZE W | H
D1 | | 120 | 215
D2 | | 100 | 215
D3 | | 80 | 215
D4 | | 240 | 240
* ALL DIMENSIONS IN CM.
WINDOWS
TYPE | No. | SIZE W | H
W1 | | 120 | 130
W2 | | 60 | 130
H.L.W. | | 60 | 80
* ALL DIMENSIONS IN CM.
1st.,2nd. & 3rd Floors Plan
KHARTOUM STATE
3
Block No ..... Plot No .....
Project Title: .....
Designed by : Arch. Abdalla Taged-din