



*Test of a 4 m deep reinforced concrete slab strip at the University of Toronto in 2015.  
This remains the largest reinforced concrete shear test ever performed.*

CIV102 Course Notes – Appendices

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## Appendix A – Common Material Properties

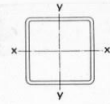
### Average Properties of Some Typical Materials

Note that except for density, stiffness and coefficient of thermal expansion, all values have a considerable range

| Material           | Weight<br>(kN/m <sup>3</sup> ) | Stiffness<br>E<br>(MPa) | Tensile Strength<br>(MPa) |          | Compressive<br>Strength<br>(MPa) | Resilience<br>(MJ/m <sup>3</sup> ) | Toughness<br>(MJ/m <sup>3</sup> )<br>tens./comp. | Ductility<br>Max. Elong. (%)<br>Plastic/Elastic | $\alpha$<br>10 <sup>-6</sup> /°C | Cost<br>\$/kg | Comment                                    |
|--------------------|--------------------------------|-------------------------|---------------------------|----------|----------------------------------|------------------------------------|--|---|----------------------------------|---------------|--|
|                    |                                |                         | Yield                     | Ultimate |                                  |                                    |  |   |                                  |               |  |
| Low Alloy Steel    | 77                             | 200,000                 | 420                       | 560      | 420                              | 0.44                               | 135  | 25/0.21   | 12                               | 0.60          | Used in buildings, bridges, cars, etc.     |
| High Tensile Steel | 77                             | 200,000                 | 1650                      | 1860     | 1650                             | 6.8                                | 55   | 4/0.83  | 12                               | 1.50          | Wire ropes, cables                         |
| High Alloy Steel   | 77                             | 200,000                 | 700                       | 800      | 700                              | 1.22                               | 200  | 25/0.35   | 12                               | 2.00          | Pressure Vessels and tanks                 |
| Piano Wire         | 77                             | 200,000                 | -                         | 3000     | -                                | 22                                 | 22   | 0.2/1.50  | 12                               | 1.50          | Brittle material, not used in structures   |
| Cast Iron          | 70                             | 150,000                 | -                         | 110      | 770                              | 0.04                               | 0.06/6   | 1/0.7   | 11                               | 0.50          | Traditional cast iron, moulded             |
| Wrought Iron       | 75                             | 185,000                 | 200                       | 350      | 200                              | 0.11                               | 90   | 30/0.11   | 12                               | 1.00          | 99% pure iron, hammered, fibrous           |
| Aluminum           | 27                             | 69,000                  | 40                        | 80       | 60                               | 0.012                              | 19   | 40/0.06   | 24                               | 1.80          | Light, ductile, non-corrosive, soft metal  |
| Aluminum Alloy     | 27                             | 73,000                  | 470                       | 580      | 500                              | 1.51                               | 50   | 11/0.64   | 24                               | 2.50          | Used for canoes, aircraft, etc.            |
| Copper             | 88                             | 124,000                 | 70                        | 230      | 200                              | 0.02                               | 85   | 55/0.06   | 20                               | 7.47          | Very ductile metal – rounded curve         |
| Bronze             | 79                             | 105,000                 | 200                       | 390      | 350                              | 0.2                                | 40   | 12/0.19   | 17                               | 2.80          | Tin + copper alloy – stronger              |
| Gold               | 189                            | 82,000                  | 40                        | 220      | 180                              | 0.01                               | 80   | 50/0.05   | 14                               | 40k           | Heavy, expensive metal                     |
| Granite            | 26                             | 52,000                  | -                         | 11       | 140                              | 0.001                              | 0.01/0.26  | 0/0.02  | 8                                | 0.15          | Strongest and most durable building stone  |
| Limestone          | 25                             | 58,000                  | -                         | 8        | 62                               | 0.0006                             | 0.01/0.09  | 0/0.01  | 6                                | 0.03          | Soft, useful building store                |
| Slate              | 28                             | 95,000                  | -                         | 60       | 100                              | 0.019                              | 0.02/0.10  | 0/0.06  |                                  | 0.08          | Stratified rock with high tensile strength |
| Brick              | 19                             | 20,000                  | -                         | 3        | 20                               | 0.0002                             | 0.01/0.03  | 0/0.01  | 9                                | 0.10          | Fired clay                                 |
| Concrete           | 24                             | 30,000                  | -                         | 3        | 35                               | 0.002                              | 0.01/0.10  | 0/0.01  | 9                                | 0.12          | Mixture of cement, sand, stone, water      |
| Glass              | 27                             | 69,000                  | -                         | 100      | 200                              | 0.072                              | 0.07/0.8   | 0/0.15  | 20                               | 1.50          | Solidified liquid sand                     |
| Oak                | 7.5                            | 14,000                  | 75                        | 90       | 60                               | 0.23                               | 0.3/2.5  | 0.5/0.47  | 3                                | 3.2           | Strong, tough, heavy hardwood              |
| Spruce             | 4.4                            | 11,000                  | 55                        | 70       | 50                               | 0.19                               | 0.2/2.2  | 0.5/0.50  | 7                                | 2.0           | Light, strong, durable softwood            |
| Tendon             | 10                             | 900                     | 70                        | 80       | -                                | 2.7                                | 4  | 1/7.8   |                                  | -             | Used as tension ties in mammals            |
| Bone               | 20                             | 17,000                  | 150                       | 180      | 180                              | 0.66                               | 1  | 0.5/0.9   |                                  | -             | Used as struts and beams in mammals        |
| Rubber             | 9.2                            | 7                       | -                         | 20       | 20                               | 15                                 | 20   | 4/300   | 500                              | 2.0           | Strange, useful material – low stiffness   |
| Spider's Silk      | 10                             | 4,000                   | -                         | 1400     | -                                | 160                                | 170  | 10/35   |                                  | -             | Most resilient material                    |
| Carbon Fibre       | 15                             | 160,000                 | -                         | 1800     | -                                | 10                                 | 10   | 0.1/1.1   |                                  | 50.0          | Carbon fibre composites used in aircraft   |
| Nylon Fibre        | 11                             | 5,500                   | -                         | 900      | -                                | 74                                 | 75   | 2/16  | 80                               | 8.00          | Excellent if stiffness not required        |
| Kevlar Fibre       | 14                             | 130,000                 | -                         | 3600     | -                                | 50                                 | 60   | 1/2.7   |                                  | 50.00         | Super material in many ways                |



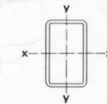
## Appendix B – HSS Tables



## STEEL

## SQUARE Hollow Structural Sections

| Designation     | Size               | Mass | Dead Load | Area            | I                               | S                               | r    | Z                               | Torsion J                       | Surface Area      | Shear C <sub>rt</sub> |
|-----------------|--------------------|------|-----------|-----------------|---------------------------------|---------------------------------|------|---------------------------------|---------------------------------|-------------------|-----------------------|
| mm x mm x mm    | mm x mm x mm       | kg/m | kN/m      | mm <sup>2</sup> | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm   | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>4</sup> | m <sup>2</sup> /m | mm <sup>2</sup>       |
| HSS 305x305x13  | HSS 305x305x12.7   | 113  | 1.110     | 14 400          | 202                             | 1 330                           | 118  | 1 560                           | 324 000                         | 1.18              | 6 450                 |
| x 11            | x 11.1             | 100  | 0.982     | 12 800          | 181                             | 1 190                           | 119  | 1 390                           | 288 000                         | 1.18              | 5 790                 |
| x 9.5           | x 9.53             | 86.5 | 0.848     | 11 000          | 158                             | 1 040                           | 120  | 1 210                           | 250 000                         | 1.19              | 5 080                 |
| x 8.0           | x 7.95             | 72.8 | 0.714     | 9 280           | 135                             | 886                             | 121  | 1 030                           | 211 000                         | 1.19              | 4 340                 |
| x 6.4           | x 6.35             | 58.7 | 0.576     | 7 480           | 110                             | 723                             | 121  | 833                             | 171 000                         | 1.20              | 3 550                 |
| HSS 254x254x13  | HSS 254x254x12.7   | 93.0 | 0.912     | 11 800          | 113                             | 888                             | 97.6 | 1 060                           | 183 000                         | 0.972             | 5 160                 |
| x 11            | x 11.1             | 82.4 | 0.808     | 10 500          | 102                             | 799                             | 98.4 | 945                             | 163 000                         | 0.978             | 4 600                 |
| x 9.5           | x 9.53             | 71.3 | 0.699     | 9 090           | 89.3                            | 703                             | 99.1 | 825                             | 142 000                         | 0.983             | 4 110                 |
| x 8.0           | x 7.95             | 60.1 | 0.590     | 7 660           | 76.5                            | 602                             | 99.9 | 702                             | 121 000                         | 0.989             | 3 530                 |
| x 6.4           | x 6.35             | 48.6 | 0.476     | 6 190           | 62.7                            | 494                             | 101  | 571                             | 97 900                          | 0.994             | 2 900                 |
| HSS 203x203x13  | HSS 203x203x12.7   | 72.7 | 0.713     | 9 260           | 54.7                            | 538                             | 76.8 | 650                             | 90 700                          | 0.769             | 3 870                 |
| x 11            | x 11.1             | 64.6 | 0.634     | 8 230           | 49.6                            | 488                             | 77.6 | 584                             | 81 200                          | 0.775             | 3 530                 |
| x 9.5           | x 9.53             | 56.1 | 0.550     | 7 150           | 43.9                            | 432                             | 78.4 | 513                             | 71 000                          | 0.780             | 3 150                 |
| x 8.0           | x 7.95             | 47.5 | 0.465     | 6 050           | 37.9                            | 373                             | 79.2 | 438                             | 60 500                          | 0.786             | 2 730                 |
| x 6.4           | x 6.35             | 38.4 | 0.377     | 4 900           | 31.3                            | 308                             | 79.9 | 359                             | 49 300                          | 0.791             | 2 290                 |
| HSS 178x178x13  | HSS 178x178x12.7   | 62.6 | 0.614     | 7 970           | 35.2                            | 366                             | 66.4 | 484                             | 59 200                          | 0.668             | 3 230                 |
| x 11            | x 11.1             | 55.7 | 0.547     | 7 100           | 32.1                            | 361                             | 67.2 | 436                             | 53 200                          | 0.673             | 2 970                 |
| x 9.5           | x 9.53             | 48.5 | 0.476     | 6 180           | 28.6                            | 322                             | 68.0 | 385                             | 46 700                          | 0.678             | 2 650                 |
| x 8.0           | x 7.95             | 41.1 | 0.403     | 5 240           | 24.8                            | 279                             | 68.8 | 330                             | 39 900                          | 0.684             | 2 320                 |
| x 6.4           | x 6.35             | 33.4 | 0.327     | 4 250           | 20.6                            | 231                             | 69.6 | 271                             | 32 700                          | 0.689             | 1 940                 |
| x 4.8           | x 4.78             | 25.5 | 0.250     | 3 250           | 16.1                            | 181                             | 70.3 | 209                             | 25 200                          | 0.695             | 1 520                 |
| HSS 152x152x13  | HSS 152x152x12.7   | 52.4 | 0.514     | 6 680           | 21.0                            | 275                             | 56.0 | 341                             | 36 000                          | 0.566             | 2 580                 |
| x 11            | x 11.1             | 46.9 | 0.460     | 5 970           | 19.3                            | 253                             | 56.8 | 310                             | 32 500                          | 0.571             | 2 400                 |
| x 9.5           | x 9.53             | 40.9 | 0.401     | 5 210           | 17.3                            | 227                             | 57.6 | 275                             | 28 700                          | 0.577             | 2 180                 |
| x 8.0           | x 7.95             | 34.8 | 0.341     | 4 430           | 15.1                            | 198                             | 58.4 | 237                             | 24 600                          | 0.582             | 1 920                 |
| x 6.4           | x 6.35             | 28.3 | 0.278     | 3 610           | 12.6                            | 166                             | 59.2 | 195                             | 20 300                          | 0.588             | 1 610                 |
| x 4.8           | x 4.78             | 21.7 | 0.213     | 2 760           | 9.93                            | 130                             | 59.9 | 152                             | 15 700                          | 0.593             | 1 270                 |
| HSS 127x127x11  | HSS 127x127x11.1   | 38.0 | 0.373     | 4 840           | 10.4                            | 164                             | 46.4 | 205                             | 18 000                          | 0.470             | 1 840                 |
| x 9.5           | x 9.53             | 33.3 | 0.327     | 4 240           | 9.47                            | 149                             | 47.2 | 183                             | 16 000                          | 0.475             | 1 690                 |
| x 8.0           | x 7.95             | 28.4 | 0.279     | 3 620           | 8.35                            | 132                             | 48.0 | 159                             | 13 900                          | 0.481             | 1 510                 |
| x 6.4           | x 6.35             | 23.2 | 0.228     | 2 960           | 7.05                            | 111                             | 48.8 | 132                             | 11 500                          | 0.486             | 1 290                 |
| x 4.8           | x 4.78             | 17.9 | 0.175     | 2 280           | 5.60                            | 88.1                            | 49.6 | 103                             | 8 920                           | 0.492             | 1 030                 |
| HSS 102x102x9.5 | HSS 102x102x9.53   | 25.7 | 0.252     | 3 280           | 4.44                            | 87.4                            | 36.8 | 110                             | 7 740                           | 0.374             | 1 210                 |
| x 8.0           | x 7.95             | 22.1 | 0.217     | 2 820           | 3.98                            | 78.4                            | 37.6 | 96.6                            | 6 780                           | 0.379             | 1 110                 |
| x 6.4           | x 6.35             | 18.2 | 0.178     | 2 320           | 3.42                            | 67.3                            | 38.4 | 81.3                            | 5 670                           | 0.385             | 968                   |
| x 4.8           | x 4.78             | 14.1 | 0.138     | 1 790           | 2.75                            | 54.2                            | 39.2 | 64.3                            | 4 450                           | 0.390             | 789                   |
| HSS 89x89x9.5   | HSS 89x89x9.53     | 21.9 | 0.215     | 2 790           | 2.79                            | 62.7                            | 31.6 | 80.2                            | 4 970                           | 0.323             | 968                   |
| x 8.0           | x 7.95             | 18.9 | 0.186     | 2 410           | 2.53                            | 57.0                            | 32.4 | 71.2                            | 4 390                           | 0.328             | 908                   |
| x 6.4           | x 6.35             | 15.6 | 0.153     | 1 990           | 2.20                            | 45.3                            | 33.2 | 60.5                            | 3 700                           | 0.334             | 806                   |
| x 4.8           | x 4.78             | 12.2 | 0.119     | 1 550           | 1.79                            | 34.0                            | 40.3 | 48.2                            | 3 030                           | 0.339             | 687                   |
| HSS 76x76x8.0   | HSS 76.2x76.2x7.95 | 15.8 | 0.155     | 2 010           | 1.49                            | 39.0                            | 27.2 | 49.7                            | 2 630                           | 0.278             | 706                   |
| x 6.4           | x 6.35             | 13.1 | 0.129     | 1 670           | 1.31                            | 34.4                            | 28.0 | 42.7                            | 2 250                           | 0.283             | 645                   |
| x 4.8           | x 4.78             | 10.3 | 0.101     | 1 310           | 1.08                            | 28.5                            | 28.8 | 34.4                            | 1 800                           | 0.288             | 546                   |
| HSS 64x64x6.4   | HSS 63.5x63.5x6.35 | 10.6 | 0.104     | 1 350           | 0.701                           | 22.1                            | 22.8 | 28.0                            | 1 230                           | 0.232             | 484                   |
| x 4.8           | x 4.78             | 8.35 | 0.082     | 1 060           | 0.593                           | 18.7                            | 23.6 | 22.9                            | 1 000                           | 0.238             | 424                   |
| x 3.8           | x 3.81             | 6.85 | 0.067     | 872             | 0.506                           | 15.9                            | 24.1 | 19.2                            | 836                             | 0.241             | 368                   |
| x 3.2           | x 3.18             | 5.82 | 0.057     | 741             | 0.441                           | 13.9                            | 24.4 | 16.5                            | 717                             | 0.243             | 323                   |
| HSS 51x51x6.4   | HSS 50.8x50.8x6.35 | 8.05 | 0.079     | 1 030           | 0.317                           | 12.5                            | 17.6 | 16.3                            | 580                             | 0.181             | 323                   |
| x 4.8           | x 4.78             | 6.45 | 0.063     | 821             | 0.278                           | 10.9                            | 18.4 | 13.8                            | 485                             | 0.187             | 303                   |
| x 3.8           | x 3.81             | 5.33 | 0.052     | 679             | 0.242                           | 9.54                            | 18.9 | 11.7                            | 410                             | 0.190             | 271                   |
| x 3.2           | x 3.18             | 4.55 | 0.045     | 580             | 0.214                           | 8.42                            | 19.2 | 10.2                            | 355                             | 0.192             | 242                   |
| x 2.8           | x 2.79             | 4.05 | 0.040     | 516             | 0.194                           | 7.64                            | 19.4 | 9.15                            | 318                             | 0.194             | 221                   |
| HSS 38x38x4.8   | HSS 38.1x38.1x4.78 | 4.54 | 0.044     | 578             | 0.100                           | 5.27                            | 13.2 | 6.91                            | 184                             | 0.136             | 181                   |
| x 3.8           | x 3.81             | 3.81 | 0.037     | 485             | 0.091                           | 4.77                            | 13.7 | 6.04                            | 160                             | 0.139             | 174                   |
| x 3.2           | x 3.18             | 3.28 | 0.032     | 418             | 0.082                           | 4.31                            | 14.0 | 5.34                            | 141                             | 0.141             | 161                   |
| x 2.5           | x 2.54             | 2.71 | 0.026     | 345             | 0.071                           | 3.71                            | 14.3 | 4.51                            | 118                             | 0.144             | 142                   |
| HSS 32x32x3.8   | HSS 31.8x31.8x3.81 | 3.06 | 0.030     | 389             | 0.048                           | 3.01                            | 11.1 | 3.92                            | 87.0                            | 0.114             | 126                   |
| x 3.2           | x 3.18             | 2.65 | 0.026     | 338             | 0.044                           | 2.77                            | 11.4 | 3.51                            | 77.6                            | 0.116             | 121                   |
| x 2.5           | x 2.54             | 2.20 | 0.022     | 281             | 0.039                           | 2.44                            | 11.7 | 3.01                            | 66.1                            | 0.118             | 110                   |
| HSS 25x25x3.2   | HSS 25.4x25.4x3.18 | 2.01 | 0.020     | 257             | 0.020                           | 1.56                            | 8.79 | 2.05                            | 36.3                            | 0.091             | 80.6                  |
| x 2.5           | x 2.54             | 1.69 | 0.017     | 216             | 0.018                           | 1.41                            | 9.12 | 1.79                            | 31.6                            | 0.093             | 77.4                  |



## STEEL

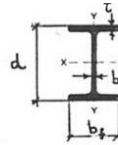
## RECTANGULAR Hollow Structural Sections

| Designation    | Size               | Mass | Dead Load | Area            | I <sub>x</sub>                  | S <sub>x</sub>                  | r <sub>x</sub> | Z <sub>x</sub>                  | I <sub>y</sub>                  | S <sub>y</sub>                  | r <sub>y</sub> | Z <sub>y</sub>                  | Torsion J                       | Shear C <sub>rt</sub> |
|----------------|--------------------|------|-----------|-----------------|---------------------------------|---------------------------------|----------------|---------------------------------|---------------------------------|---------------------------------|----------------|---------------------------------|---------------------------------|-----------------------|
| mm x mm x mm   | mm x mm x mm       | kg/m | kN/m      | mm <sup>2</sup> | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm             | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm             | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>4</sup> | mm <sup>2</sup>       |
| HSS 305x203x13 | HSS 305x203x12.7   | 93.0 | 0.912     | 11 800          | 147                             | 964                             | 111            | 1 190                           | 78.1                            | 769                             | 81.2           | 896                             | 167 000                         | 6 450                 |
| x 11           | x 11.1             | 82.4 | 0.808     | 10 500          | 132                             | 867                             | 112            | 1 060                           | 70.5                            | 693                             | 81.9           | 802                             | 149 000                         | 5 790                 |
| x 9.5          | x 9.53             | 71.3 | 0.699     | 9 090           | 116                             | 782                             | 113            | 925                             | 62.1                            | 611                             | 82.7           | 701                             | 130 000                         | 5 080                 |
| x 8.0          | x 7.95             | 60.1 | 0.590     | 7 660           | 99.4                            | 652                             | 114            | 787                             | 53.3                            | 524                             | 83.4           | 596                             | 111 000                         | 4 340                 |
| x 6.4          | x 6.35             | 48.6 | 0.476     | 6 190           | 81.5                            | 535                             | 115            | 640                             | 43.8                            | 431                             | 84.1           | 486                             | 89 800                          | 3 550                 |
| HSS254x152x13  | HSS254x152x12.7    | 72.7 | 0.713     | 9 260           | 75.2                            | 592                             | 90.1           | 746                             | 33.6                            | 441                             | 60.2           | 522                             | 78 200                          | 5 160                 |
| x 11           | x 11.1             | 64.6 | 0.634     | 8 230           | 68.2                            | 537                             | 91.0           | 671                             | 30.6                            | 401                             | 61.0           | 470                             | 70 200                          | 4 660                 |
| x 9.5          | x 9.53             | 56.1 | 0.550     | 7 150           | 60.3                            | 475                             | 91.9           | 589                             | 27.2                            | 357                             | 61.7           | 413                             | 61 800                          | 4 110                 |
| x 8.0          | x 7.95             | 47.5 | 0.465     | 6 050           | 52.0                            | 409                             | 92.7           | 503                             | 23.5                            | 309                             | 62.4           | 353                             | 52 600                          | 3 530                 |
| x 6.4          | x 6.35             | 38.4 | 0.377     | 4 900           | 42.9                            | 338                             | 93.6           | 411                             | 19.5                            | 256                             | 63.1           | 290                             | 43 000                          | 2 900                 |
| HSS 203x152x13 | HSS 203x152x12.7   | 62.6 | 0.614     | 7 970           | 43.0                            | 123                             | 73.4           | 528                             | 27.3                            | 358                             | 58.5           | 432                             | 56 400                          | 3 870                 |
| x 11           | x 11.1             | 55.7 | 0.547     | 7 100           | 39.1                            | 385                             | 74.2           | 476                             | 24.9                            | 327                             | 59.3           | 390                             | 50 800                          | 3 530                 |
| x 9.5          | x 9.53             | 48.5 | 0.476     | 6 180           | 34.8                            | 343                             | 75.1           | 419                             | 22.3                            | 292                             | 60.0           | 344                             | 44 600                          | 3 150                 |
| x 8.0          | x 7.95             | 41.1 | 0.403     | 5 240           | 30.2                            | 297                             | 75.9           | 360                             | 19.3                            | 254                             | 60.7           | 295                             | 38 200                          | 2 730                 |
| x 6.4          | x 6.35             | 33.4 | 0.327     | 4 250           | 25.0                            | 246                             | 76.7           | 295                             | 16.1                            | 211                             | 61.5           | 243                             | 31 200                          | 2 260                 |
| x 4.8          | x 4.78             | 25.5 | 0.250     | 3 250           | 19.5                            | 192                             | 77.5           | 228                             | 12.6                            | 165                             | 62.2           | 188                             | 24 100                          | 1 760                 |
| HSS 203x102x13 | HSS 203x102x12.7   | 52.4 | 0.514     | 6 680           | 31.2                            | 307                             | 68.4           | 405                             | 10.2                            | 201                             | 39.1           | 246                             | 27 000                          | 3 870                 |
| x 11           | x 11.1             | 46.9 | 0.460     | 5 970           | 28.7                            | 282                             | 69.3           | 367                             | 9.46                            | 186                             | 39.8           | 224                             | 24 600                          | 3 530                 |
| x 9.5          | x 9.53             | 40.9 | 0.401     | 5 210           | 25.8                            | 253                             | 70.3           | 325                             | 8.56                            | 168                             | 40.5           | 199                             | 21 900                          | 3 150                 |
| x 8.0          | x 7.95             | 34.8 | 0.341     | 4 430           | 22.5                            | 211                             | 71.2           | 281                             | 7.54                            | 148                             | 41.2           | 172                             | 18 900                          | 2 730                 |
| x 6.4          | x 6.35             | 28.3 | 0.278     | 3 610           | 18.8                            | 185                             | 72.2           | 232                             | 6.35                            | 125                             | 42.0           | 143                             | 15 600                          | 2 260                 |
| x 4.8          | x 4.78             | 21.7 | 0.213     | 2 760           | 14.7                            | 145                             | 73.1           | 180                             | 5.03                            | 99.0                            | 42.7           | 111                             | 12 200                          | 1 760                 |
| HSS 178x127x13 | HSS 178x127x12.7   | 52.4 | 0.514     | 6 680           | 26.4                            | 297                             | 62.8           | 377                             | 15.5                            | 243                             | 48.1           | 298                             | 33 600                          | 3 230                 |
| x 11           | x 11.1             | 46.9 | 0.460     | 5 970           | 24.2                            | 272                             | 63.7           | 342                             | 14.2                            | 224                             | 48.8           | 270                             | 30 400                          | 2 970                 |
| x 9.5          | x 9.53             | 40.9 | 0.401     | 5 210           | 21.7                            | 244                             | 64.6           | 303                             | 12.8                            | 202                             | 49.6           | 240                             | 26 900                          | 2 660                 |
| x 8.0          | x 7.95             | 34.8 | 0.341     | 4 430           | 18.9                            | 213                             | 65.4           | 261                             | 11.2                            | 177                             | 50.3           | 207                             | 23 100                          | 2 320                 |
| x 6.4          | x 6.35             | 28.3 | 0.278     | 3 610           | 15.8                            | 178                             | 66.2           | 232                             | 6.35                            | 125                             | 41.9           | 171                             | 19 900                          | 1 840                 |
| x 4.8          | x 4.78             | 21.7 | 0.213     | 2 760           | 12.4                            | 140                             | 67.1           | 167                             | 7.41                            | 117                             | 51.8           | 133                             | 14 700                          | 1 520                 |
| HSS 152x102x11 | HSS 152x102x11.1   | 38.0 | 0.373     | 4 840           | 13.6                            | 179                             | 53.1           | 230                             | 7.13                            | 140                             | 38.4           | 172                             | 16 300                          | 2 400                 |
| x 9.5          | x 9.53             | 33.3 | 0.327     | 4 240           | 12.4                            | 162                             | 54.0           | 205                             | 6.50                            | 128                             | 39.1           | 154                             | 14 500                          | 2 180                 |
| x 8.0          | x 7.95             | 28.4 | 0.279     | 3 620           | 10.9                            | 143                             | 54.8           | 178                             | 5.76                            | 113                             | 39.9           | 134                             | 12 600                          | 1 920                 |
| x 6.4          | x 6.35             | 23.2 | 0.228     | 2 960           | 9.18                            | 121                             | 55.7           | 148                             | 4.88                            | 96.1                            | 40.6           | 112                             | 10 500                          | 1 610                 |
| x 4.8          | x 4.78             | 17.9 | 0.175     | 2 280           | 7.28                            | 95.6                            | 56.5           | 116                             | 3.89                            | 76.6                            | 41.3           | 87.8                            | 8 160                           | 1 270                 |
| HSS 127x76x9.5 | HSS 127x76.2x9.53  | 25.7 | 0.252     | 3 280           | 6.12                            | 96.4                            | 43.2           | 126                             | 2.69                            | 70.5                            | 28.6           | 87.5                            | 6 800                           | 1 690                 |
| x 8.0          | x 7.95             | 22.1 | 0.217     | 2 820           | 5.48                            | 86.4                            | 44.1           | 111                             | 2.43                            | 63.8                            | 29.4           | 77.2                            | 5 810                           | 1 510                 |
| x 6.4          | x 6.35             | 18.2 | 0.178     | 2 320           | 4.70                            | 74.0                            | 45.1           | 93.3                            | 2.15                            | 53.3                            | 30.1           | 63.2                            | 4 880                           | 1 290                 |
| x 4.8          | x 4.78             | 14.1 | 0.138     | 1 790           | 3.78                            | 59.5                            | 45.9           | 73.8                            | 1.70                            | 44.7                            | 30.8           | 51.7                            | 3 860                           | 1 030                 |
| HSS 127x64x9.5 | HSS 127x63.5x9.53  | 23.8 | 0.234     | 3 030           | 5.28                            | 83.2                            | 41.7           | 112                             | 1.70                            | 53.6                            | 23.7           | 67.4                            | 4 460                           | 1 690                 |
| x 8.0          | x 7.95             | 20.5 | 0.201     | 2 610           | 4.77                            | 75.1                            | 42.7           | 98.9                            | 1.56                            | 49.1                            | 24.4           | 60.0                            | 4 130                           | 1 510                 |
| x 6.4          | x 6.35             | 16.9 | 0.166     | 2 150           | 4.11                            | 64.8                            | 43.7           | 83.6                            | 1.36                            | 42.9                            | 25.1           | 51.0                            | 3 510                           | 1 290                 |
| x 4.8          | x 4.78             | 13.1 | 0.129     | 1 670           | 3.33                            | 52.4                            | 44.6           | 66.3                            | 1.12                            | 35.2                            | 25.9           | 40.7                            | 2 800                           | 1 030                 |
| HSS 127x51x9.5 | HSS 127x50.8x9.53  | 21.9 | 0.215     | 2 790           | 4.45                            | 70.0                            | 39.9           | 97.7                            | 0.961                           | 37.8                            | 18.6           | 48.9                            | 2 930                           | 1 690                 |
| x 8.0          | x 7.95             | 18.9 | 0.186     | 2 410           | 4.05                            | 63.8                            | 41.0           | 86.9                            | 0.893                           | 35.3                            | 19.3           | 44.0                            | 2 650                           | 1 510                 |
| x 6.4          | x 6.35             | 15.6 | 0.153     | 1 990           | 3.53                            | 55.5                            | 42.1           | 73.8                            | 0.798                           | 31.4                            | 20.0           | 37.9                            | 2 290                           | 1 290                 |
| x 4.8          | x 4.78             | 12.2 | 0.119     | 1 550           | 2.83                            | 43.3                            | 45.9           | 58.9                            | 0.665                           | 25.5                            | 18.6           | 31.4                            | 1 840                           | 958                   |
| HSS 102x76x9.5 | HSS 102x76.2x9.53  | 21.9 | 0.215     | 2 790           | 3.41                            | 67.2                            | 35.0           | 87.6                            | 0.75                            | 35.3                            | 27.7           | 71.3                            | 4 170                           | 1 210                 |
| x 8.0          | x 7.95             | 18.9 | 0.186     | 2 410           | 3.10                            | 61.0                            | 35.8           | 77.7                            | 0.96                            | 31.4                            | 28.5           | 63.5                            | 4 170                           | 1 110                 |
| x 6.4          | x 6.35             | 15.6 | 0.153     | 1 990           | 2.68                            | 52.8                            | 36.7           | 65.9                            | 0.71                            | 24.8                            | 29.3           | 54.0                            | 3 530                           | 960                   |
| x 4.8          | x 4.78             | 12.2 | 0.119     | 1 550           | 2.18                            | 43.0                            | 37.5           | 52.5                            | 1.39                            | 36.6                            | 30.1           | 43.1                            | 2 800                           | 789                   |
| HSS 102x51x9.5 | HSS 102x50.8x7.95  | 15.8 | 0.155     | 2 010           | 2.21                            | 43.5                            | 33.2           | 58.8                            | 0.709                           | 27.9                            | 18.8           | 35.4                            | 1 950                           | 1 110                 |
| x 6.4          | x 6.35             | 13.1 | 0.129     | 1 670           | 1.95                            | 38.4                            | 34.2           | 50.6                            | 0.638                           | 25.1                            | 19.5           | 30.7                            | 1 690                           | 910                   |
| x 4.8          | x 4.78             | 10.3 | 0.101     | 1 310           | 1.36                            | 31.8                            | 35.1           | 40.8                            | 0.536                           | 21.1                            | 20.3           | 24.9                            | 1 370                           | 789                   |
| x 3.8          | x 3.81             | 8.37 | 0.082     | 1 070           | 1.36                            | 26.8                            | 35.1           | 33.9                            | 0.456                           | 18.0                            | 20.7           | 20.8                            | 1 140                           | 658                   |
| x 3.2          | x 3.18             | 7.09 | 0.069     | 903             | 1.17                            | 23.1                            | 36.1           | 29.0                            | 0.397                           | 15.6                            | 21.0           | 17.9                            | 979                             | 565                   |
| HSS 89x64x8.0  | HSS 88.9x63.5x7.95 | 15.8 | 0.155     | 2 010           | 1.87                            | 42.1                            | 30.5           | 54.9                            | 0.70                            | 34.3                            | 23.3           | 43.2                            | 2 450                           | 900                   |
| x 6.4          | x 6.35             | 13.1 | 0.129     | 1 670           | 1.65                            | 37.1                            | 31.4           | 47.1                            | 0.966                           | 30.4                            | 24.0           | 37.2                            | 2 100                           | 806                   |
| x 4.8          | x 4.78             | 10.3 | 0.101     | 1 310           | 1.36                            | 30.6                            | 32.3           | 38.0                            | 0.803                           | 25.3                            | 24.8           | 30.1                            | 1 690                           | 667                   |
| x 3.8          | x 3.81             | 8.37 | 0.082     | 1 070           | 1.15                            | 25.8                            | 32.8           | 31.5                            | 0.679                           | 21.4                            | 25.2           | 25.0                            | 1 400                           | 561                   |
| x 3.2          | x 3.18             | 7.09 | 0.069     | 903             | 0.990                           | 22.3                            | 33.1           | 27.0                            | 0.588                           | 18.5                            | 25.5           | 21.4                            | 1 190                           | 405                   |
| HSS 76x51x8.0  | HSS 76.2x50.8x7.95 | 12.6 | 0.123     | 1 600           | 1.01                            | 26.6                            | 25.1           | 35.9                            | 0.522                           | 20.5                            | 18.0           | 26.7                            | 1 770                           | 645                   |
| x 6.4          | x 6.35             | 10.4 | 0.101     | 1 310           | 0.817                           | 23.1                            | 27.0           | 26.7                            | 0.474                           | 16.7                            | 19.3           | 19.3                            | 1 400                           | 561                   |
| x 4.8          | x 4.78             | 8.35 | 0.082     | 1 060           | 0.774                           | 20.3                            | 27.0           | 25.7                            | 0.407                           | 16.0                            | 19.6           | 19.3                            | 911                             | 546                   |
| x 3.8          | x 3.81             | 6.85 | 0.067     | 872             | 0.660                           | 17.3                            | 27.5           | 21.6                            | 0.349                           | 13.8                            | 20.0           | 16.3                            | 762                             | 445                   |
| HSS 51x25x3.2  | HSS 50.8x25.4x3.18 | 3.28 | 0.032     | 418             | 0.122                           | 4.81                            | 17.1           | 6.33                            | 0.040                           | 3.14                            | 9.77           | 3.84                            | 106                             | 242                   |
| x 2.5          | x 2.54             | 2.71 | 0.026     | 345             | 0.105                           | 4.15                            | 17.5           | 5.35                            | 0.035                           | 2.75                            | 10.1           | 3.27                            | 89.8                            | 206                   |



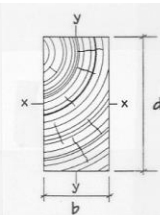
## Appendix C – Steel Wide Flange Beams and Sawn Timber Section Tables

Wide Flange Rolled Steel Beams  
Dimensions and Section Properties



| Designation | Dimensions |                |    |                | Dead Load | Area            | Strong Axis x-x                 |                                 |                | Weak Axis y-y                   |                                 |                | Torsion Constant                | Shear Depth |
|-------------|------------|----------------|----|----------------|-----------|-----------------|---------------------------------|---------------------------------|----------------|---------------------------------|---------------------------------|----------------|---------------------------------|-------------|
|             | d          | b <sub>f</sub> | t  | b <sub>w</sub> |           |                 | I <sub>x</sub>                  | S <sub>x</sub>                  | r <sub>x</sub> | I <sub>y</sub>                  | S <sub>y</sub>                  | r <sub>y</sub> |                                 |             |
| mm × kg/m   | mm         | mm             | mm | mm             | kN/m      | mm <sup>2</sup> | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm             | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm             | 10 <sup>3</sup> mm <sup>4</sup> | mm          |
| W920 × 446  | 933        | 423            | 43 | 24.0           | 4.38      | 57000           | 8470                            | 18200                           | 385            | 540                             | 2550                            | 97.3           | 26800                           | 822         |
| × 365       | 916        | 419            | 34 | 20.3           | 3.57      | 46400           | 6710                            | 14600                           | 380            | 421                             | 2010                            | 95.3           | 14400                           | 813         |
| × 313       | 932        | 309            | 34 | 21.1           | 3.06      | 39800           | 5480                            | 11800                           | 371            | 170                             | 1100                            | 65.4           | 11600                           | 806         |
| × 238       | 915        | 305            | 26 | 16.5           | 2.33      | 30400           | 4060                            | 8880                            | 365            | 123                             | 806                             | 63.6           | 5140                            | 796         |
| W840 × 329  | 862        | 401            | 32 | 19.7           | 3.23      | 42000           | 5350                            | 12400                           | 357            | 349                             | 1740                            | 91.2           | 11500                           | 764         |
| × 210       | 846        | 293            | 24 | 15.4           | 2.06      | 26800           | 3110                            | 7340                            | 341            | 103                             | 700                             | 62.0           | 4050                            | 738         |
| × 176       | 835        | 292            | 19 | 14.0           | 1.72      | 22400           | 2460                            | 5900                            | 331            | 78.2                            | 536                             | 59.1           | 2220                            | 722         |
| W760 × 257  | 773        | 381            | 27 | 16.6           | 2.52      | 32800           | 3420                            | 8840                            | 323            | 250                             | 1310                            | 87.3           | 6380                            | 689         |
| × 173       | 762        | 267            | 22 | 14.4           | 1.70      | 22100           | 2060                            | 5400                            | 305            | 68.7                            | 515                             | 55.8           | 2690                            | 663         |
| × 147       | 753        | 265            | 17 | 13.2           | 1.44      | 18700           | 1660                            | 4410                            | 298            | 52.9                            | 399                             | 53.2           | 1560                            | 651         |
| W690 × 217  | 695        | 355            | 25 | 15.4           | 2.13      | 27700           | 2340                            | 6740                            | 291            | 185                             | 1040                            | 81.7           | 4560                            | 618         |
| × 152       | 688        | 254            | 21 | 13.1           | 1.49      | 19400           | 1510                            | 4380                            | 279            | 57.8                            | 455                             | 54.6           | 2200                            | 604         |
| × 125       | 678        | 253            | 16 | 11.7           | 1.23      | 16000           | 1190                            | 3500                            | 273            | 44.1                            | 349                             | 52.5           | 1180                            | 594         |
| W610 × 195  | 622        | 327            | 24 | 15.4           | 1.91      | 24900           | 1680                            | 5400                            | 260            | 142                             | 871                             | 75.5           | 3970                            | 554         |
| × 155       | 611        | 324            | 19 | 12.7           | 1.51      | 19700           | 1290                            | 4220                            | 256            | 108                             | 666                             | 74.0           | 1950                            | 545         |
| × 125       | 612        | 229            | 20 | 11.9           | 1.22      | 15900           | 985                             | 3220                            | 249            | 39.3                            | 343                             | 49.7           | 1540                            | 537         |
| × 101       | 603        | 228            | 15 | 10.5           | 0.99      | 13000           | 764                             | 2530                            | 242            | 29.5                            | 259                             | 47.6           | 781                             | 527         |
| W530 × 182  | 551        | 315            | 24 | 15.2           | 1.78      | 23100           | 1240                            | 4480                            | 232            | 127                             | 808                             | 74.1           | 3740                            | 492         |
| × 150       | 543        | 312            | 20 | 12.7           | 1.47      | 19200           | 1010                            | 3710                            | 229            | 103                             | 659                             | 73.2           | 2160                            | 487         |
| × 109       | 539        | 211            | 19 | 11.6           | 1.06      | 13900           | 667                             | 2480                            | 219            | 29.5                            | 280                             | 46.1           | 1260                            | 471         |
| × 82        | 528        | 209            | 13 | 9.5            | 0.81      | 10500           | 479                             | 1810                            | 214            | 20.3                            | 194                             | 44.0           | 530                             | 463         |
| W460 × 144  | 472        | 283            | 22 | 13.6           | 1.41      | 18400           | 726                             | 3080                            | 199            | 83.6                            | 591                             | 67.4           | 2440                            | 421         |
| × 97        | 466        | 193            | 19 | 11.4           | 0.95      | 12300           | 445                             | 1910                            | 190            | 22.8                            | 237                             | 43.1           | 1130                            | 408         |
| × 82        | 460        | 191            | 16 | 9.9            | 0.80      | 10400           | 370                             | 1610                            | 189            | 18.6                            | 195                             | 42.3           | 691                             | 404         |
| × 61        | 450        | 189            | 11 | 8.1            | 0.60      | 7760            | 259                             | 1150                            | 183            | 12.2                            | 129                             | 39.7           | 289                             | 395         |
| W410 × 114  | 420        | 261            | 19 | 11.6           | 1.12      | 14600           | 462                             | 2200                            | 178            | 57.2                            | 439                             | 62.6           | 1490                            | 376         |
| × 74        | 413        | 180            | 16 | 9.7            | 0.73      | 9550            | 275                             | 1330                            | 170            | 15.6                            | 173                             | 40.4           | 637                             | 364         |
| × 60        | 407        | 178            | 13 | 7.7            | 0.58      | 7580            | 216                             | 1060                            | 169            | 12.0                            | 135                             | 39.8           | 328                             | 363         |
| × 39        | 399        | 140            | 9  | 6.4            | 0.38      | 4990            | 127                             | 634                             | 160            | 4.0                             | 57.7                            | 28.5           | 111                             | 348         |
| W360 × 314  | 399        | 401            | 40 | 24.9           | 3.07      | 39900           | 1100                            | 5530                            | 166            | 426                             | 2120                            | 103            | 18500                           | 345         |
| × 122       | 363        | 257            | 22 | 13.0           | 1.19      | 15500           | 365                             | 2010                            | 153            | 61.5                            | 478                             | 63.0           | 2100                            | 322         |
| × 79        | 354        | 205            | 17 | 9.4            | 0.78      | 10100           | 227                             | 1280                            | 150            | 24.2                            | 236                             | 48.9           | 814                             | 317         |
| × 64        | 347        | 203            | 14 | 7.7            | 0.63      | 8140            | 178                             | 1030                            | 148            | 18.8                            | 186                             | 48.1           | 438                             | 312         |
| × 45        | 352        | 171            | 10 | 6.9            | 0.44      | 5730            | 122                             | 691                             | 146            | 8.18                            | 95.7                            | 37.8           | 160                             | 313         |
| × 33        | 349        | 127            | 8  | 5.8            | 0.32      | 4170            | 82.7                            | 474                             | 141            | 2.91                            | 45.8                            | 26.4           | 85.9                            | 305         |
| W310 × 253  | 356        | 319            | 40 | 24.4           | 2.48      | 32200           | 682                             | 3830                            | 146            | 215                             | 1350                            | 81.7           | 14800                           | 304         |
| × 118       | 314        | 307            | 19 | 11.9           | 1.15      | 15000           | 275                             | 1750                            | 135            | 90.2                            | 588                             | 77.5           | 1600                            | 282         |
| × 79        | 306        | 254            | 15 | 8.8            | 0.77      | 10100           | 177                             | 1160                            | 132            | 39.9                            | 314                             | 62.9           | 657                             | 277         |
| × 60        | 303        | 203            | 13 | 7.5            | 0.59      | 7590            | 129                             | 849                             | 130            | 18.3                            | 180                             | 49.1           | 397                             | 274         |
| × 39        | 310        | 165            | 10 | 5.8            | 0.38      | 4940            | 85.1                            | 549                             | 131            | 7.27                            | 88.1                            | 38.4           | 126                             | 279         |
| × 21        | 303        | 101            | 6  | 5.1            | 0.21      | 2690            | 37.0                            | 244                             | 117            | 0.983                           | 19.5                            | 19.1           | 29.4                            | 258         |
| W250 × 115  | 269        | 259            | 22 | 13.5           | 1.12      | 14600           | 189                             | 1410                            | 114            | 64.1                            | 495                             | 66.3           | 2130                            | 236         |
| × 49        | 247        | 202            | 11 | 7.4            | 0.48      | 6250            | 70.6                            | 572                             | 106            | 15.1                            | 150                             | 49.2           | 241                             | 223         |
| × 33        | 258        | 146            | 9  | 6.1            | 0.32      | 4170            | 48.9                            | 379                             | 108            | 4.73                            | 64.7                            | 33.7           | 98.5                            | 231         |
| W200 × 59   | 210        | 205            | 14 | 9.1            | 0.58      | 7560            | 61.1                            | 582                             | 89.9           | 20.4                            | 199                             | 51.9           | 465                             | 187         |
| × 36        | 201        | 165            | 10 | 6.2            | 0.35      | 4580            | 34.4                            | 342                             | 86.7           | 7.64                            | 92.6                            | 40.8           | 146                             | 181         |
| × 27        | 207        | 133            | 8  | 5.8            | 0.26      | 3390            | 25.8                            | 249                             | 87.2           | 3.30                            | 49.6                            | 31.2           | 71.3                            | 185         |
| W150 × 30   | 157        | 153            | 9  | 6.6            | 0.29      | 3790            | 17.2                            | 219                             | 67.4           | 5.56                            | 72.6                            | 38.3           | 101                             | 141         |
| × 14        | 150        | 100            | 6  | 4.3            | 0.13      | 1730            | 6.87                            | 91.5                            | 63.0           | 0.92                            | 18.4                            | 23.0           | 17.0                            | 133         |

Sawn Timber Sections  
Dimensions and Section Properties



| Size and Designation<br><i>b</i> × <i>d</i> | Nominal Dimensions | Dead Load | Area            | Strong Axis x-x                 |                                 |                       | Weak Axis y-y                   |                                 |                       | Torsion Constant                |
|---|--------------------|-----------|-----------------|---------------------------------|---------------------------------|-----------------------|---------------------------------|---------------------------------|-----------------------|---------------------------------|
|   |                    |           |                 | <i>I</i> <sub>x</sub>           | <i>S</i> <sub>x</sub>           | <i>r</i> <sub>x</sub> | <i>I</i> <sub>y</sub>           | <i>S</i> <sub>y</sub>           | <i>r</i> <sub>y</sub> | <i>J</i>                        |
| mm  | in.                | kN/m      | mm <sup>2</sup> | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm                    | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm                    | 10 <sup>6</sup> mm <sup>4</sup> |
| 292 × 495                                   | 12 × 20            | 0.907     | 145000          | 2950                            | 11900                           | 143                   | 1030                            | 7030                            | 84.3                  | 2570                            |
| × 445                                       | × 18               | 0.816     | 130000          | 2140                            | 9640                            | 129                   | 923                             | 6320                            | 84.3                  | 2190                            |
| × 394                                       | × 16               | 0.722     | 115000          | 1490                            | 7550                            | 114                   | 817                             | 5600                            | 84.3                  | 1760                            |
| × 343                                       | × 14               | 0.629     | 100000          | 982                             | 5730                            | 99.0                  | 712                             | 4870                            | 84.3                  | 1370                            |
| × 292                                       | × 12               | 0.535     | 85300           | 606                             | 4150                            | 84.3                  | 606                             | 4150                            | 84.3                  | 1030                            |
| 241 × 495                                   | 10 × 20            | 0.749     | 119000          | 2440                            | 9840                            | 143                   | 577                             | 4790                            | 69.9                  | 1600                            |
| × 445                                       | × 18               | 0.673     | 107000          | 1770                            | 7950                            | 129                   | 519                             | 4310                            | 69.6                  | 1360                            |
| × 394                                       | × 16               | 0.596     | 95000           | 1230                            | 6240                            | 114                   | 460                             | 3810                            | 69.6                  | 1130                            |
| × 343                                       | × 14               | 0.519     | 82700           | 810                             | 4730                            | 99.0                  | 400                             | 3320                            | 69.6                  | 900                             |
| × 292                                       | × 12               | 0.442     | 70400           | 500                             | 3420                            | 84.3                  | 341                             | 2830                            | 69.6                  | 671                             |
| × 241                                       | × 10               | 0.365     | 58100           | 281                             | 2330                            | 69.6                  | 281                             | 2330                            | 69.6                  | 476                             |
| 191 × 495                                   | 8 × 20             | 0.594     | 94600           | 1930                            | 7800                            | 143                   | 287                             | 3010                            | 55.1                  | 868                             |
| × 445                                       | × 18               | 0.534     | 85000           | 1400                            | 6300                            | 129                   | 258                             | 2710                            | 55.1                  | 751                             |
| × 394                                       | × 16               | 0.472     | 75300           | 974                             | 4940                            | 114                   | 229                             | 2400                            | 55.1                  | 636                             |
| × 343                                       | × 14               | 0.411     | 65500           | 642                             | 3750                            | 99.0                  | 199                             | 2090                            | 55.1                  | 515                             |
| × 292                                       | × 12               | 0.350     | 55800           | 396                             | 2710                            | 84.3                  | 170                             | 1780                            | 55.1                  | 403                             |
| × 241                                       | × 10               | 0.289     | 46000           | 223                             | 1850                            | 69.6                  | 140                             | 1470                            | 55.1                  | 285                             |
| × 191                                       | × 8                | 0.229     | 36500           | 111                             | 1160                            | 55.1                  | 111                             | 1160                            | 55.1                  | 188                             |
| 140 × 445                                   | 6 × 18             | 0.391     | 62300           | 1030                            | 4620                            | 129                   | 102                             | 1450                            | 40.4                  | 325                             |
| × 394                                       | × 16               | 0.346     | 55200           | 714                             | 3620                            | 114                   | 90.1                            | 1290                            | 40.4                  | 279                             |
| × 343                                       | × 14               | 0.301     | 48000           | 471                             | 2750                            | 99.0                  | 78.4                            | 1120                            | 40.4                  | 232                             |
| × 292                                       | × 12               | 0.257     | 40900           | 290                             | 1990                            | 84.3                  | 66.8                            | 954                             | 40.4                  | 186                             |
| × 241                                       | × 10               | 0.212     | 33700           | 163                             | 1360                            | 69.6                  | 55.1                            | 787                             | 40.4                  | 139                             |
| × 191                                       | × 8                | 0.168     | 26700           | 81.3                            | 851                             | 55.1                  | 43.7                            | 624                             | 40.4                  | 94.9                            |
| × 140                                       | × 6                | 0.123     | 19600           | 32.0                            | 457                             | 40.4                  | 32.0                            | 457                             | 40.4                  | 54.2                            |
| 89 × 387                                    | 4 × 16             | 0.216     | 34400           | 430                             | 2220                            | 112                   | 22.7                            | 511                             | 25.7                  | 77.5                            |
| × 337                                       | × 14               | 0.188     | 30000           | 284                             | 1680                            | 97.3                  | 19.8                            | 445                             | 25.7                  | 65.9                            |
| × 286                                       | × 12               | 0.160     | 25500           | 174                             | 1210                            | 82.6                  | 16.8                            | 378                             | 25.7                  | 53.8                            |
| × 235                                       | × 10               | 0.131     | 20900           | 96.3                            | 819                             | 67.8                  | 13.8                            | 310                             | 25.7                  | 41.9                            |
| × 184                                       | × 8                | 0.103     | 16400           | 46.2                            | 502                             | 53.1                  | 10.8                            | 243                             | 25.7                  | 30.1                            |
| × 140                                       | × 6                | 0.078     | 12500           | 20.4                            | 291                             | 40.4                  | 8.22                            | 185                             | 25.7                  | 19.8                            |
| × 114                                       | × 5                | 0.064     | 10200           | 11.0                            | 193                             | 32.9                  | 6.70                            | 151                             | 25.7                  | 13.8                            |
| × 89  | × 4                | 0.050     | 7920            | 5.23                            | 118                             | 25.7                  | 5.23                            | 117                             | 25.7                  | 8.85                            |
| 64 × 337                                    | 3 × 14             | 0.135     | 21600           | 204                             | 1210                            | 97.3                  | 7.36                            | 230                             | 18.5                  | 25.8                            |
| × 286                                       | × 12               | 0.115     | 18300           | 125                             | 872                             | 82.6                  | 6.25                            | 195                             | 18.5                  | 21.4                            |
| × 235                                       | × 10               | 0.094     | 15000           | 69.2                            | 589                             | 67.8                  | 5.13                            | 160                             | 18.5                  | 17.0                            |
| × 184                                       | × 8                | 0.074     | 11800           | 33.2                            | 361                             | 53.1                  | 4.02                            | 126                             | 18.5                  | 12.5                            |
| × 140                                       | × 6                | 0.056     | 8960            | 14.6                            | 209                             | 40.4                  | 3.06                            | 95.6                            | 18.5                  | 8.68                            |
| × 114                                       | × 5                | 0.046     | 7300            | 7.90                            | 139                             | 32.9                  | 2.49                            | 77.8                            | 18.5                  | 6.41                            |
| × 89  | × 4                | 0.036     | 5700            | 3.76                            | 84.5                            | 25.7                  | 1.94                            | 60.8                            | 18.5                  | 4.29                            |
| 38 × 337                                    | 2 × 14             | 0.071     | 12800           | 121                             | 719                             | 97.3                  | 1.54                            | 81.1                            | 11.0                  | 5.72                            |
| × 286                                       | × 12               | 0.060     | 10900           | 74.1                            | 518                             | 82.6                  | 1.31                            | 68.8                            | 11.0                  | 4.79                            |
| × 235                                       | × 10               | 0.049     | 8930            | 41.1                            | 350                             | 67.8                  | 1.07                            | 56.6                            | 11.0                  | 3.87                            |
| × 184                                       | × 8                | 0.038     | 6990            | 19.7                            | 214                             | 53.1                  | 0.84                            | 44.3                            | 11.0                  | 2.91                            |
| × 140                                       | × 6                | 0.029     | 5320            | 8.69                            | 124                             | 40.4                  | 0.64                            | 33.7                            | 11.0                  | 2.11                            |
| × 114                                       | × 5                | 0.024     | 4330            | 4.69                            | 82.3                            | 32.9                  | 0.52                            | 27.4                            | 11.0                  | 1.65                            |
| × 89  | × 4                | 0.019     | 3380            | 2.23                            | 50.2                            | 25.7                  | 0.41                            | 21.4                            | 11.0                  | 1.19                            |
| × 64  | × 3                | 0.013     | 2430            | 0.83                            | 25.9                            | 18.5                  | 0.29                            | 15.4                            | 11.0                  | 0.73                            |
| × 38  | × 2                | 0.008     | 1440            | 0.17                            | 9.15                            | 11.0                  | 0.17                            | 9.15                            | 11.0                  | 0.29                            |

## Appendix D – Wood Properties

Section 9

Wood  
Structures

5<sup>th</sup> Percentile estimates of strength under one month loading. For safe working stresses reduce these breaking stresses by factor of safety of 1.5.

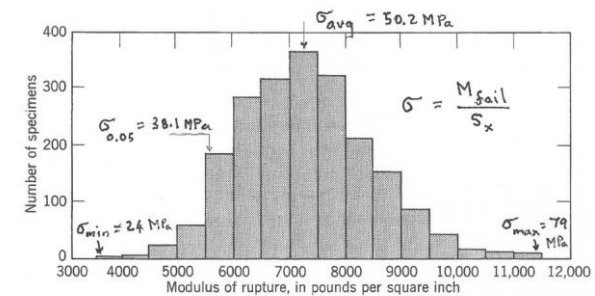
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Table 4.3 Average clear-wood strength values\* for commercial species in air-dry condition

| Property                  |                   |          |  |            |            |                          |                             |   |                      |  |                                      |  |
|---------------------------|-------------------|----------|--|------------|------------|--------------------------|-----------------------------|---|----------------------|--|--------------------------------------|--|
| Species                   | Relative density† |          | Shrinkage, green to air-dry based on dimensions when green (%) |            |            | Modulus of rupture (MPa) | Modulus of elasticity (MPa) | Compression parallel to grain, crushing strength max. (MPa) | Shear strength (MPa) | Compression perpendicular to grain, fiber stress at proportional limit (MPa) | Tension perpendicular to grain (MPa) |  |
|                           | Nominal           | Oven-dry | Radial   | Tangential | Volumetric |                          |                             |   |                      |  |                                      |  |
| SOFTWOODS                 |                   |          |  |            |            |                          |                             |   |                      |  |                                      |  |
| Cedar                     |                   |          |  |            |            |                          |                             |   |                      |  |                                      |  |
| Eastern white             | 0.30              | 0.31     | –  | –          | 3.8        | 42.3                     | 4380                        | 24.8  | 6.93                 | 2.68   | 2.63                                 |  |
| Western red               | 0.34              | 0.34     | –  | –          | 4.8        | 53.8                     | 8270                        | 33.9  | 5.58                 | 3.43   | 1.46                                 |  |
| Yellow                    | 0.43              | 0.46     | –  | –          | 5.0        | 79.7                     | 11 000                      | 45.9  | 9.21                 | 4.74   | 3.49                                 |  |
| Douglas-fir               | 0.49              | 0.51     | –  | –          | 7.0        | 88.6                     | 13 500                      | 50.1  | 9.53                 | 6.01   | 3.06                                 |  |
| Fir                       |                   |          |  |            |            |                          |                             |   |                      |  |                                      |  |
| Amabilis (Pacific silver) | 0.39              | 0.41     | –  | –          | 7.5        | 68.9                     | 11 400                      | 40.8  | 7.54                 | 3.61   | 3.06                                 |  |
| Balsam                    | 0.35              | 0.37     | 1.2  | 4.3        | 5.7        | 58.3                     | 9 650                       | 34.3  | 6.25                 | 3.14   | 2.08                                 |  |
| Hemlock                   |                   |          |  |            |            |                          |                             |   |                      |  |                                      |  |
| Eastern                   | 0.43              | 0.45     | 2.4  | 4.7        | 6.2        | 67.1                     | 9 720                       | 41.0  | 8.75                 | 4.28   | 2.06                                 |  |
| Western                   | 0.43              | 0.47     | –  | –          | 8.1        | 81.1                     | 12 300                      | 46.7  | 6.48                 | 4.53   | 2.93                                 |  |
| Tamarack                  | 0.51              | 0.54     | –  | –          | 7.1        | 76.0                     | 9 380                       | 44.8  | 9.00                 | 6.15   | 3.47                                 |  |
| Larch, western            | 0.58              | 0.64     | –  | –          | 8.0        | 107.0                    | 14 300                      | 60.9  | 9.25                 | 7.31   | 3.62                                 |  |
| Pine                      |                   |          |  |            |            |                          |                             |   |                      |  |                                      |  |
| Eastern white             | 0.37              | 0.38     | –  | –          | 4.5        | 65.0                     | 9 380                       | 36.2  | 6.10                 | 3.39   | 2.63                                 |  |
| Jack                      | 0.44              | 0.45     | 2.1  | 3.8        | 5.7        | 77.9                     | 10 200                      | 40.5  | 8.23                 | 5.70   | 3.65                                 |  |
| Lodgepole                 | 0.41              | 0.46     | –  | –          | 6.6        | 76.0                     | 10 900                      | 43.2  | 8.54                 | 3.65   | 3.78                                 |  |
| Ponderosa                 | 0.46              | 0.49     | –  | –          | 6.1        | 73.3                     | 9 510                       | 42.3  | 7.03                 | 5.22   | 3.47                                 |  |
| Red                       | 0.40              | 0.42     | 1.9  | 4.1        | 6.5        | 69.7                     | 9 450                       | 37.9  | 7.50                 | 4.96   | 3.54                                 |  |
| Western white             | 0.37              | 0.40     | –  | –          | 6.0        | 64.1                     | 10 100                      | 36.1  | 6.34                 | 3.23   | 2.64                                 |  |
| Spruce                    |                   |          |  |            |            |                          |                             |   |                      |  |                                      |  |
| Black                     | 0.43              | 0.44     | 1.7  | 4.0        | 6.5        | 78.3                     | 10 400                      | 41.5  | 8.65                 | 4.25   | 3.43                                 |  |
| Engelmann                 | 0.40              | 0.42     | –  | –          | 6.8        | 69.5                     | 10 700                      | 42.4  | 7.55                 | 3.70   | 2.72                                 |  |
| Red                       | 0.40              | 0.42     | –  | –          | 6.2        | 71.5                     | 11 000                      | 38.5  | 9.20                 | 3.77   | 3.70                                 |  |
| Sitka                     | 0.39              | 0.39     | –  | –          | 6.0        | 69.8                     | 11 200                      | 37.8  | 6.78                 | 4.10   | 2.48                                 |  |
| White                     | 0.37              | 0.39     | 1.4  | 4.0        | 6.8        | 62.7                     | 9 930                       | 36.9  | 6.79                 | 3.45   | 3.28                                 |  |
| HARDWOODS                 |                   |          |  |            |            |                          |                             |   |                      |  |                                      |  |
| Aspen, trembling          | 0.41              | –        | 2.7  | 5.7        | 8.3        | 67.6                     | 11 200                      | 36.3  | 6.76                 | 3.52   | 4.19                                 |  |
| Birch, yellow             | 0.61              | –        | –  | –          | 9.9        | 106.0                    | 14 100                      | 52.1  | 14.67                | 7.24   | 7.52                                 |  |
| Maple, sugar              | 0.66              | –        | 2.9  | 6.4        | 9.3        | 115.0                    | 14 100                      | 56.4  | 16.71                | 9.72   | 9.21                                 |  |
| Oak, red                  | 0.61              | –        | –  | –          | 6.9        | 98.7                     | 11 900                      | 49.8  | 14.38                | 8.89   | 6.52                                 |  |

\* For use in stress-laminated decks only.

\*\* Dimension lumber with thickness of 89 mm or greater shall have specified strengths in accordance with Table 13–11.2 (b).



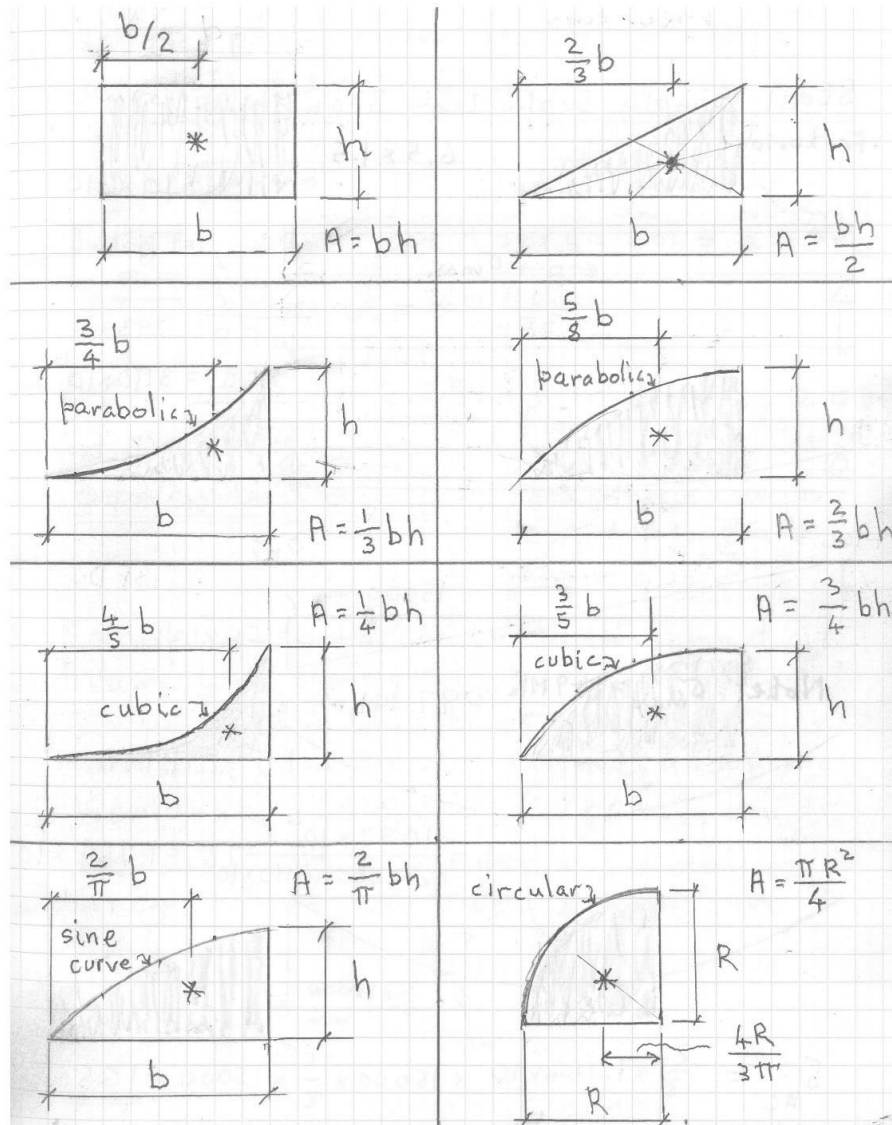
(b) Frequency distribution of bending strength of green Douglas fir. 2110 small clear specimens cut from a single tree. Short-term loading.

## Appendix E – Common Unit Conversions

| Working with SI units  |   |  |
|--|---|--|
| Lengths, Strains and Curvatures                                    | Pressures and Stresses                            | Forces and Moments                               |
| 1 m = 1,000 mm   | 1 Pa = 1 N/m <sup>2</sup>                         | 1 kN = 1,000 N                                   |
| 1 m <sup>2</sup> = 10 <sup>6</sup> mm <sup>2</sup>                 | 1 kPa = 1 kN/m <sup>2</sup>                       | 1 MN = 10 <sup>6</sup> N                         |
| 1 m <sup>3</sup> = 10 <sup>9</sup> mm <sup>3</sup>                 | 1 MPa = 1 MN/m <sup>2</sup>                       |  |
|  | 1 MPa = 1 N/mm <sup>2</sup>                       | 1 Nm = 1,000 Nmm                                 |
| 1 mm/m = 10 <sup>3</sup> mm/mm                                     |   | 1 kNm = 10 <sup>6</sup> Nmm                      |
| 1 rad/m = 10 <sup>6</sup> mrad/mm                                  |   |  |
| Working with other unit systems and other miscellaneous quantities |   |  |
| 1 foot = 12 inches   | 1 inch = 25.4 mm                                  |  |
| 1 cubit = 18 inches  | 1 foot = 304.8 mm                                 | 9.81 m/s <sup>2</sup> = 32.2 feet/s <sup>2</sup> |
| 1 yard = 3 feet  | 1 mile = 1609 m                                   | 1 kNm = 0.738 kip ft                             |
| 1 chain = 22 yards   | 1 ha = 2.47 acres                                 | 1 kNm = 8.85 kip in                              |
| 1 furlong = 10 chains  |   |  |
| 1 mile = 8 furlongs  | 1 kg = 2.20 lbs                                   | 1 hp = 746 Watt                                  |
| 1 mile = 1,760 yards   | 1 stone = 14.0 lbs                                |  |
|  |   | 1 km/h = 0.278 m/s                               |
| 1 acre = 10 square chains  | 1 lbs/ft <sup>3</sup> = 16.02 kg/m <sup>3</sup>   | 1 km/h = 0.621 miles/h                           |
| 1 square mile = 640 acres  | 100 lbs/ft <sup>3</sup> = 15.72 kN/m <sup>3</sup> | 1 knot = 1.852 km/h                              |
| 1 ha = 10,000 square m   |   | 1 MPa = 145.0 psi                                |
|  | 1 N = 0.225 lbs (force)                           | 1 kN/m <sup>2</sup> = 20.9 lbs/ft <sup>2</sup>   |
|  | 1 kip = 4.45 kN                                   |  |



## Appendix F – Areas and Centroids of Common Shapes



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**Appendix G – Common Canadian Reinforcing Bar Information**

| <b>Designation</b> | <b>Linear Density<br/>(kg/m)</b> | <b>Nominal Diameter<br/>(mm)</b> | <b>Cross-Sectional Area<br/>(mm<sup>2</sup>)</b> |
|--------------------|----------------------------------|----------------------------------|--|
| 10M                | 0.785                            | 11.3                             | 100  |
| 15M                | 1.570                            | 16.0                             | 200  |
| 20M                | 2.355                            | 19.6                             | 300  |
| 25M                | 3.925                            | 25.2                             | 500  |
| 30M                | 5.495                            | 29.9                             | 700  |
| 35M                | 7.850                            | 35.7                             | 1000   |
| 45M                | 11.775                           | 43.7                             | 1500   |
| 55M                | 19.625                           | 56.4                             | 2500   |