

Chapter 1

Average Properties of Metals

Table 1.1. Average Properties of Metals

$1GN = 10^9 N$; $1MN = 10^6 N$

<i>Metals</i>	<i>Density</i> 10^3 kg/m^3	<i>BHN</i>	<i>Modulus of Elasticity E</i> GN/m^2	<i>Modulus of Rigidity G</i> GN/m^2	<i>Poisson's Ratio</i> μ	<i>Yield Stress</i> MN/m^2	<i>Ultimate Tensile Strength</i> MN/m^2	<i>Coeff of Linear Expansion α</i> $\mu m/m^\circ k$	<i>Thermal Conductivity</i> $J/m/m^\circ k.s.$
Aluminium	2.70	23	76	25	0.34	24	75	23.8	230.4
Brass	8.45	180	95	34	0.3 to 0.4	412	508	10.7	134.8
Bronze (Phosphor)	8.85	160	110	41	—	446	549	17.3	69.56
Cast Iron	7.20	*	98	34	0.23	*	*	9	56.52
Copper	8.96	42	121	38	0.26	69	219	16.2	434.8
Lead	11.34	5	16	7	0.45	14	17	28.3	36
Monel Metal	8.58	125	156	66	0.32	206-274	480-588	14.0	26
Carbon Steels	7.84	**	202	77-87	0.30	**	**	11.1	52.17
Stainless Steels	7.91	280	199	73	0.30	586	961	9.0	15.2
Tungsten	19.30	230	407	174	0.17	—	3098	4.5	208.6
Zirconium	6.5	80	68	—	—	—	—	10.0	17.38

*See Table 1.2

**See Table 1.3

Table 1-2. Mechanical Properties and Applications of Cast Irons and Cast Steels

<i>IS Designation</i>	<i>Tensile Strength</i> MN/m ²	<i>Stress</i> MN/m ²	<i>Elongation per cent</i> (<i>Gauge length</i> $5.65 \sqrt{A}$)	<i>BHN</i>	<i>Typical Application</i>
Grey C.I. Castings		Transverse Rupture Stress			Machine tool frames, fly-wheels, pulleys, low speed gears etc.
Grade—15	127-186	279-409	—		
20	167-235	328-455	—	149 to 197	
25	216-274	378-500	—	179 to 223	
30	265-304	427-515	—	197 to 241	
35	314-343	542-562	—	207 to 241	
40	363-392	615-624	—	241 to 320	
Malleable Iron Black Heart		Minimum Proof Stress (0.5 per cent)			Bearing Caps, steering gear housing, rocker arms, universal joints, wheel hubs
Grade A	343	206	14	149 max	
Grade B	314	186	10	149 max	
Grade C	294	—	6	163 max	
White Heart					
Grade A	353-412	196-255	4 to 10	217 max	
Grade B	274-343	—	3 to 7	217 max	

(Contd.)

Pearlitic					
Grade A	686	539	2	241 to 285	
Grade B	637	422	3	212 to 248	
Grade C	539	353	4	192 to 241	
Grade D	490	314	5	170 to 229	
Grade E	441	206	7	149 to 201	
Spheroidal or Nodular Graphite Cast Iron		Minimum Proof Stress (0.2 per cent)			Intricate castings, frames for machines, dies for press formings, low speed gears, shaft etc.
IS Grade—SG 80/2	784	471	2	260 to 330	
SG 70/2	686	431	2	225 to 300	
SG 60/2	588	392	2	210 to 280	
SG 50/2	490	314	7	170 to 240	
SG 40/12	392	245	12	200 max	
SG 38/17	372	235	17	171 max	

Table 1-2. (Continued)

Cast Steels		Yield Strength (0.5 per cent proof stress)			Complicated castings, cast parts can be welded.
CS 65	637	392	17	190	
CS 71	696	559	15	207	
CS 85	833	696	12	248	
CS 105	1029	853	8	311	
CS 125	1225	1000	5	363	
Alloy Cast Iron		Yield strength			Castings, where toughness strength, wear-resistance is required as in crank shafts of automobile engines.
Nickel C.I.	245	117	—	180 min	
N-Mo C.I.	294	176	—	220 min	
Nitroalloy	412	225	—	1050 min	

Table 1.3. Mechanical Properties and Applications of Carbon Steels

<i>I.S. Designation</i>	<i>Tensile Strength</i> MN/m ²	<i>Yield Stress</i> MN/m ²	<i>Elongation</i> <i>Per cent</i> (Gauge Length $5.65 \sqrt{A}$)	<i>BHN</i>	<i>*E</i> GN/m ²	<i>G*</i> GN/m ²	<i>Typical Uses</i>
Structural Steel							
St 30	294-372	—	22 to 31	—	196	78-88	Structural rivets, wires, tubes, railway wheels, axles
St 42	412-529	—	19 to 27	—	„	„	Bridges, building construction
St 52	510-608	—	16 to 24	—	„	„	Railway wheels, seamless tubes
St 63	618-696	—	11 to 18	—	„	„	Tramway axles
St 78	765-882	—	10 to 12	—	„	„	Wagon wheels
Plain Carbon Steels							
C 07	314-392	196	27	—	„	„	Case hardening steels used for making camshafts, cams, lightduty gears, worms, gudgeon pins, selector forks, spindles, pawls, ratchets, chain wheels, tappets etc.
C 10	333-412	205	26	—	„	„	
C 14	363-441	216	26	137	„	„	
C 15	363-480	235	25	137	„	„	
C 20	431-510	255	24	156	„	„	
C 25	431-529	274	23	170	„	„	General purpose for light work, tie rods, cables, sprockets, hubs, tubes etc.

Table 1-3. (Contd.)

C 30	490-588	294	21	179	196	78-88	} Crankshafts, shafts, spindles, automobile axles, push rods, connecting rods, studs, bolts, lightly stressed gears etc.
C 35	510-608	304	20	187	"	"	
C 40	569-667	323	18	217	"	"	
C 45	618-696	353	15	229	"	"	} Keys, shafts, cylinders, wagon tyres, valve springs, washers, etc. Locomotive carriage and wagon tyres.
C 50	647-765	372	13	241	"	"	
C 60	735 Min.	412	11	255	"	"	
C 65	735 Min.	422	10	255	"	"	} Fish plates, fasteners, tubes, light duty gears etc.
C 15 Mn 75	412-490	245	25	163	"	"	
C 25 Mn 75	461-559	274	22	207	"	"	
C 35 Mn 75	539-637	314	20	223	"	"	} Gears, cylinders, cams, keys, sprockets, bolts etc.
C 50 Mn 1	706 Min.	392	11	255	"	"	
C 55 Mn 75	706 Min	392	13	265	"	"	

Table 1-4. Mechanical Properties and Applications of Alloy Steels

<i>IS Steel Designation</i>	<i>Tensile Strength MN/m²</i>	<i>Yield Stress MN/m²</i>	<i>Elongation Percent (Gauge Length 5.65 √A)</i>	<i>BHN</i>	<i>Typical Uses</i>
Alloy Steels					
20 Mn 2	588-735	413	18	170-217	Crankshafts, welded structures, steering levers, spindles etc.
	686-833	490	16	201-248	
27 Mn 2	588-735	413	18	170-217	
	686-833	490	16	201-248	
37 Mn 2	588-735	413	18	170-217	Axles, crankshafts, shafts, connecting rods etc.
	686-833	529	18	201 248	
	784-931	588	16	229-277	
35 Mn 2 Mo 38	882-1029	686	15	255-311	General engineering components, studs, shafts, levers, crankshafts, bolts etc.
	686-833	529	18	201-248	
	784-931	588	16	229-277	
	882-1029	686	15	255-311	
35 Mn 2 Mo 45	980-1127	784	13	285-341	
	784-931	588	16	229-277	
	882-1029	686	15	255-311	
	980-1127	784	13	285-341	

Table 1-4. (Contd.)

40 Cr 1	686-833 784-931 882-1029	529 588 686	18 16 15	201-248 229-277 255-311	Gears, connecting rods, wear-resistant plates for earth moving and concrete handling equipment
40 Cr 1 Mo 28	686-1127	529-784	18-13	201-341	Axle shafts, crankshafts, connecting rods, gears, high tensile bolts and studs, propeller shaft joints. Creep resistant steels for components requiring medium to high tensile properties and in the nitrided conditions for crankshafts, cylinder liners for aero and automobile engines, gears and machine parts requiring high surface hardness and wear resistance.
15 Cr 3 Mo 55	686-833	529	18		
25 Cr 3 Mo 55	784-931	588	16		
40 Cr 3 Mo 1 V 20	1323-1520	1098-1274	8	363-444	Components requiring high tensile strength
40 Cr 2 Al 1 Mo 18	686-1029	529-686	18-15	201-277	Components requiring high surface hardness and core strength
40 Ni 3	784-1029	588-686	16-15	229-311	Cold tough steel used at low temperatures such as in refrigerators, compressors. For heavy forgings, turbine blades, highly stress screws, bolts nuts.
35 Ni 1 Cr 60	686-1029	529-686	18-15	201-311	For crankshafts, connecting rods, gear shafts chain parts, clutches, flexible shafts for planetary gears, camshafts etc. (for heavy vehicles and aircrafts mainly)
30 Ni 4 Cr 1	1520 min	1274	8	444 min	Highly stress gears requiring high tensile strength.
40 Ni 1 Cr 1 Mo 28	784-1225	588-863	16-11	229-363	General machine parts like bolts gears.
40 Ni 2 Cr 1 Mo 28	784-1520	588-1274	16-6	229-444	For high strength machine parts, collets, spindles, screws, high tensile bolts and studs, gears, pinions, axle shafts, tappers, crankshafts, boring bars, arbour etc.
31 Ni 3 Cr 65 Mo 55	882-1520	686-1274	15-8	255-444	Highly stressed bolts, shafts, gears etc.
55 Si 2 Mn 90	1569-1961	1471	6	444-510	Used for springs in the hardened and tempered condition.
50 Cr IV 23	1862-2353	1765	4	500-580	
45 Cr 9 Si 4	—	—	—	255-293	For heat resistant outlet valves, in oil engines, lorries and cars.

Average values of E and C can be taken as 196 GN/m² and 78-88 GN/m² respectively.

Source IS—1570—1961 & IS/1871—1965