Job: 5

To perform tension test on hot rolled deformed steel bar.

Apparatus:

- 500 kN Shimadzu UTM
- Vernier calipers
- Weighing balance
- Steel tape
- Hot rolled deformed steel bar
- Extensometer

Objective:

- To determine different mechanical properties of steel.
- To study the stress strain behavior of mild steel.
- To check the adequacy of specimen according to ASTM standard.

Theory:

Steel: Steel is an alloy of iron.

Types of steel bars:

1. Hot rolled deformed steel bar
2. Cold worked/cold twisted/tor bar
3. Plane steel bar

Deformed steel bar:

It is usually formed from carbon **steel**, and is given ridges for better mechanical anchoring reinforced concrete.

Hot rolled deformed steel bar:

The steel bar on which moment is applied to form deformed steel bar during its manufacturing process is called hot rolled deformed steel bar.

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Cold-formed steel :

The steel bar on which moment is applied to form deformed steel bar after manufacturing process at low temperature is called cold deformed steel bar.

Ores of Iron :

- Magnetite (Fe_3O_4)
- Hamatite (Fe_2O_3)
- Pyrite (FeS2)

Types of iron:

- Pig Iron
- Cast iron
- Wrought Iron

Carbon content in steel:

There is a significant effect of carbon content on the properties of resulting steel. The yield strength tends to be higher and the ductility tends to be lower with the increase of carbon content.

Type of steel	Carbon content
Low carbon steel	<=0.21
Mild Carbon steel	0.15 – 0.3
Medium carbon steel (MS)	0.2 – 0.6
High carbon steel	0.6 – 1
Ultrahigh carbon steel	1 – 2
Cast iron	2 – 5

Chemical composition of Mild Steel.

- Carbon 0.15-0.3%
- Silicon 0.60% max
- Phosphorus 0.060% Max
- Chromium (Very small amount to provide resistance against corrosion)

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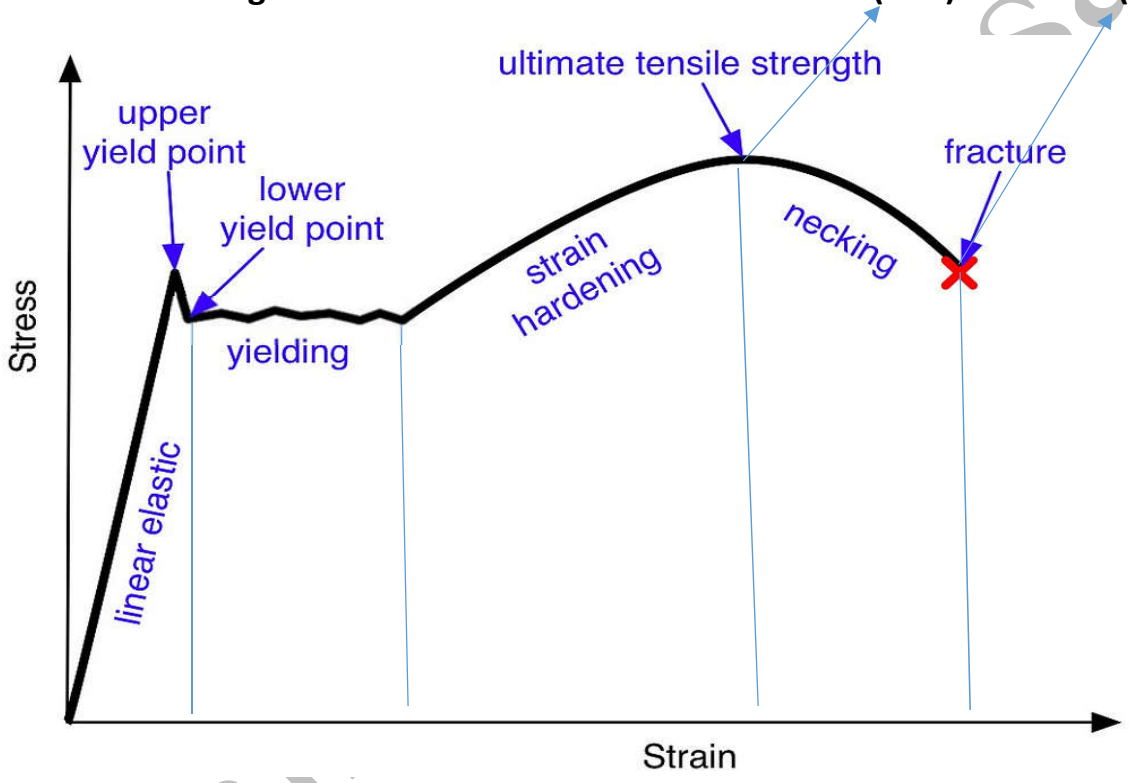
Tolerance: An allowable amount of variation of a specified quantity is called tolerance.

It should be 6% for nominal value.

Gauge Length:

The distance between two consecutive marked points on the bar is called gauge length. According to **ASTM 615** it should be **8inc.** But in over case it is 2inc(50mm).

Stress strain diagram for mild steel: **(ARS)** **(NRS)**



Components of stress strain diagram:

Proportional limit:

The maximum stress that may be developed during a simple tension test such that the stress is linear function of strain. There is no proportional limit for brittle materials.

Elastic limit:

The maximum stress that may be developed during a simple tension test such that there is no permanent deformation when the load is entirely removed. Hooks law is not valid after E.L.

Yielding:

Increase in strain without the corresponding increase in stress is called yielding. This may occur in certain types of materials such as mild steel just after the elastic limit.

Upper yield point (U):

This is a point at which there is a sudden drop in stress (or load) with further strain.

Lower yield point (L):

It is a point after which there is a significant extension at almost constant load.

Strain hardening or work hardening:

After the completion of initial yielding, the stress again starts increasing with the increase of the strain up to a peak point on the stress strain curve. This behavior is call strain hardening and the material becomes harder in this zone.

Ultimate tensile strength:

Maximum value of stress on stress strain diagram is called ultimate tensile strength. It is the point where the slope of the curve becomes zero. It is commonly considered as the maximum strength of the material.

Necking:

Localized decrease in the cross sectional area of the sample after the ultimate strength is called necking. This continues up to rupture/failure.

Cup and cone Failure:

In this experiment the failure mode has a characteristic appearance known as cup and cone fracture

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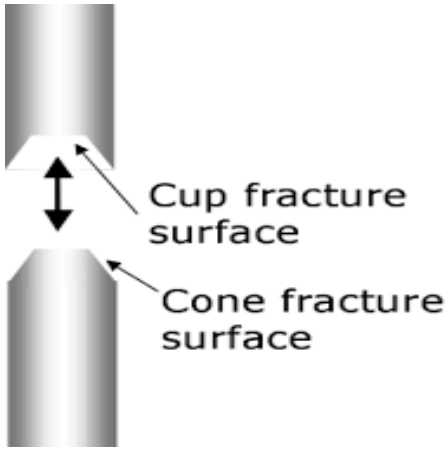

Fracture or rupture:

This is the final point on stress strain curve at which the specimen breaks by a cup and cone formation. It is always less than the ultimate strength. For brittle materials the ultimate and rupture strength are almost same.

Plasticity:

It is the ability of a material to be permanently deformed by the application of load. The work done on the material within this range is not stored as a potential energy but is converted into heat and is dissipated to the environment.

Elastic range:

When the specimen is loaded up to the elastic limit and all the strains are recovered upon unloading, the material is said to be in elastic range. In this zone all the work done on the specimen is stored as potential energy, which brings specimen beck to its original shape after the removal of load.

Resilience:

The ability of a material to absorb energy in the elastic range (i.e without permanent deformation) is called resilience.

Modulus of resilience: It is the amount of work done on a unit volume of material as a simple tensile force is increased from 0 to proportional limit. It is calculated as the area under the stress strain diagram from 0 to P.L.

Toughness:

The ability of a material to absorb energy in the plastic range (i.e. permanent deformation) is called toughness.

Modulus of toughness:

It is the amount of work done on a unit volume of material as a simple tensile force is increased from 0 to the failure of the specimen. It is calculated as the total.

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Measures of ductility:

- All ductile materials are stronger in tension and compression but weak in shear.
- All brittle materials are weak in tension and compression but strong in shear.

Methods of determining yield strength:

- **Halting of machine method:**

The stress may actually decrease momentarily resulting in upper and lower yield points. The yield point during a simple tension test can be observed by Halting of machine.

- **Offset method:**

For the materials that do not gave well-defined yield point, yield strength is determined by offset method. This consists of drawing a line parallel to the initial tangent of the stress strain diagram at0.2% (0.002 m/m or in/in) strain.

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- **Luderline method:**

When the specimen yields, a pattern of fine lines appears on the polished surface, they roughly interact at right angle to each other and 45 degrees approximately to the longitudinal axis of the bar.4.

- **Specific strain method**

In this method simply 0.5% of the total strain is marked to determine the corresponding stress, which is yielding stress.

ARS(Actual rupture strength) = Load/actual area

NRS (Normal rupture strength) = load /nominal area

Procedure:

- Measure the dimensions of a specimen Diameter, Total length of a specimen, Cross sectional area Mark gage length at three different portions on the specimen, covering effective length of a specimen.(this is required so that necked portion will remain between any two points of gage length on the specimen.)
- Grip the specimen in the fixed head of a machine. (Portion of the specimen has to be gripped .
- Fix the extensometer within the gauge length marked on the specimen. Adjust the dial of extensometer at zero.
- Adjust the dial of a machine to zero, to read load applied.

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- . Select suitable increments of loads to be applied so that corresponding elongation can be measured from dial gauge.
- . Keep speed of machine uniform. Record yield point, maximum load point, point of breaking of specimen.
- Remove the specimen from machine and study the fracture observes type of fracture.
- Measure dimensions of tested specimen. Fit the broken parts together and measure reduced diameter and final gage length.

Observation and Calculation:

Actual length = 507mm
Deformed length = 546 mm
Elongation = 39mm
Nominal diameter = 11.3mm
Reduced diameter = 8.5mm
Mass = 499g
Actual area = 125.37 mm^2

Sr. #	Gauge length	Elongated length	Change in length from first point	Change in length for each segment	%elongation
Units	mm	mm	mm	mm	
1	0	0	0	0	0
2	50	51	1	1	2
3	100	102	2	1	2
4	150	153	3	1	2
5	200	205	5	2	2.5
6	250	263	13	7	5.2
7	300	318	18	5	6
8	350	378	28	10	8
9	400	436	36	8	9
10	450	488	38	2	8.444444444
11	500	546	46	8	9.2

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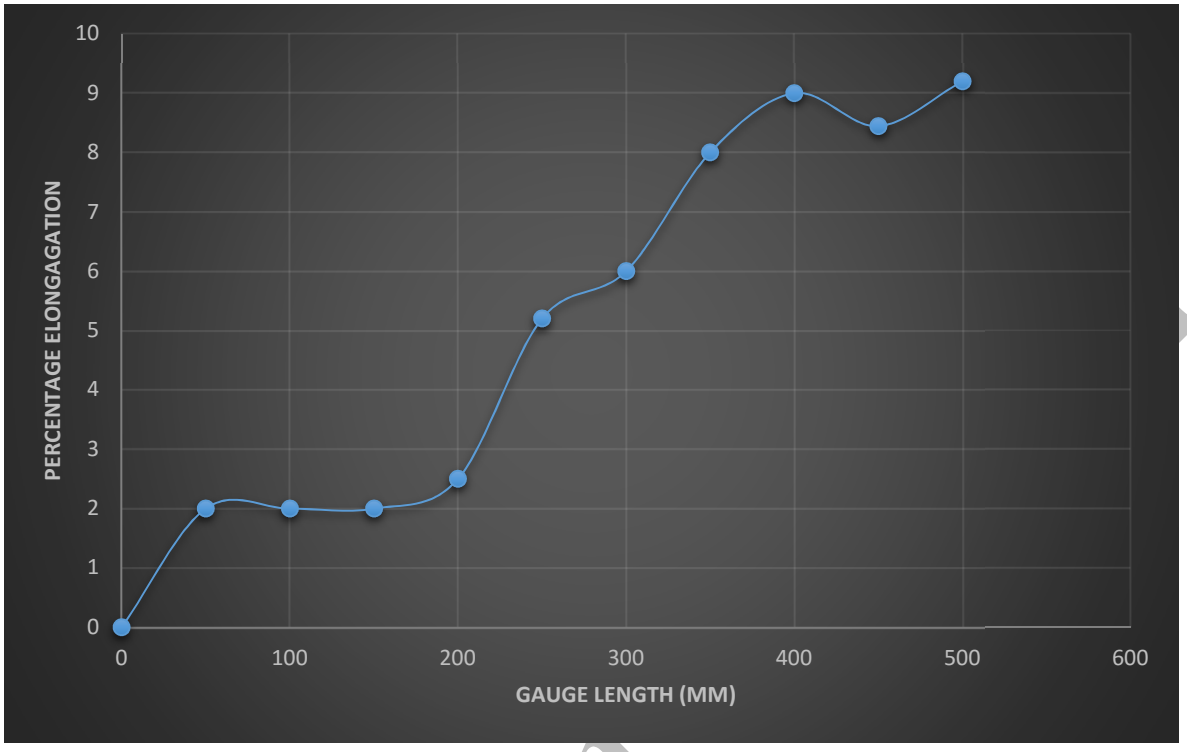

Sr#	Load (KN)	Extensometer reding	Elongation (mm)	Stress ($KNmm^{-2}$)	strain	Modulus of Elasticity ($KNmm^{-2}$)
1	0	0	0	0	0	#DIV/0!
2	2	1	0.025	0.01595278	4.93097E-05	323.5223738
3	4	5	0.125	0.03190556	0.000246548	129.4089495
4	6	8	0.2	0.04785834	0.000394477	121.3208902
5	8	11	0.275	0.06381112	0.000542406	117.6444996
6	10	14	0.35	0.0797639	0.000690335	115.5437049
7	12	32	0.8	0.09571668	0.001577909	60.66044508
8	14	44	1.1	0.11166946	0.002169625	51.46946855
9	16	52	1.3	0.12762224	0.002564103	49.77267289
10	18	57	1.425	0.14357502	0.002810651	51.08248007
11	20	65	1.625	0.1595278	0.003205128	49.77267289
12	22	72	1.8	0.17548058	0.003550296	49.42702933
13	24	78	1.95	0.19143336	0.003846154	49.77267289
14	26	87	2.175	0.20738614	0.004289941	48.34242367
15	28	100	2.5	0.22333892	0.004930966	45.29313233

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16	30	130	3.25	0.2392917	0.006410256	37.32950467
17	32	136	3.4	0.25524448	0.006706114	38.06145574
18	34	119	2.975	0.27119726	0.00586785	46.21748197
19	36	110	2.75	0.28715004	0.005424063	52.9400248
20	38	113	2.825	0.30310282	0.005571992	54.39756727
21	40	190	4.75	0.3190556	0.009368836	34.05498671
22	42	191	4.775	0.33500838	0.009418146	35.57052277
23	44	200	5	0.35096115	0.009861933	35.58746112
24	52	210	5.25	0.41477227	0.01035503	40.05515104
25	54	220	5.5	0.43072505	0.010848126	39.7050186
26	56	226	5.65	0.44667783	0.011143984	40.08241799
27	58	233	5.825	0.46263061	0.011489152	40.26673322
28	60	241	6.025	0.47858339	0.011883629	40.27249466
29	62	256	6.4	0.49453617	0.012623274	39.17653745
30	64	261	6.525	0.51048895	0.012869822	39.66557839
31	66	268	6.7	0.52644173	0.01321499	39.8367102
32	68	275	6.875	0.54239451	0.013560158	39.99912985
33	70	290	7.25	0.55834729	0.014299803	39.04580373
34	72.5	319	7.975	0.57828827	0.015729783	36.76390611
35	72.5	330	8.25	0.57828827	0.016272189	35.53844257
36	72.5	350	8.75	0.57828827	0.017258383	33.50767443
37	72.5	370	9.25	0.57828827	0.018244576	31.69644878
38	72.5	390	9.75	0.57828827	0.019230769	30.07098987
39	72.5	400	10	0.57828827	0.019723866	29.31921512
40	72.5	450	11.25	0.57828827	0.022189349	26.06152455
41	72.5	500	12.5	0.57828827	0.024654832	23.4553721
42	72.5	540	13.5	0.57828827	0.026627219	21.71793713
43	72.5	550	13.75	0.57828827	0.027120316	21.32306554
44	72.5	560	14	0.57828827	0.027613412	20.94229652
45	72.5	570	14.25	0.57828827	0.028106509	20.57488781
46	72.5	590	14.75	0.57828827	0.029092702	19.87743398
47	72.5	600	15	0.57828827	0.029585799	19.54614342
48	72.5	640	16	0.57828827	0.031558185	18.32450945
49	72.5	690	17.25	0.57828827	0.034023669	16.99664645
50	72.5	700	17.5	0.57828827	0.034516765	16.75383721
51	72.5	710	17.75	0.57828827	0.035009862	16.51786768
52	72.5	720	18	0.57828827	0.035502959	16.28845285
53	72.5	730	18.25	0.57828827	0.035996055	16.06532336
54	72.5	740	18.5	0.57828827	0.036489152	15.84822439
55	72.5	750	18.75	0.57828827	0.036982249	15.63691473

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56	72.5	760	19	0.57828827	0.037475345	15.43116585
57	72.5	770	19.25	0.57828827	0.037968442	15.2307611
58	72.5	780	19.5	0.57828827	0.038461538	15.03549493
59	72.5	790	19.75	0.57828827	0.038954635	14.84517221
60	72.5	800	20	0.57828827	0.039447732	14.65960756
61	72.5	830	20.75	0.57828827	0.040927022	14.12974223
62	73	860	21.5	0.58227646	0.042406312	13.73089145
63	73	900	22.5	0.58227646	0.044378698	13.1206296
64	73	940	23.5	0.58227646	0.046351085	12.56230494
65	73	970	24.25	0.58227646	0.047830375	12.17378004
66	73	1000	25	0.58227646	0.049309665	11.80856664
67	73	1030	25.75	0.58227646	0.050788955	11.46462781
68	73	1050	26.25	0.58227646	0.051775148	11.24625395
69	73	1070	26.75	0.58227646	0.052761341	11.03604359
70	73	1090	27.25	0.58227646	0.053747535	10.83354738
71	73	1100	27.5	0.58227646	0.054240631	10.73506058
72	73	1110	27.75	0.58227646	0.054733728	10.63834833
73	73	1120	28	0.58227646	0.055226824	10.54336307
74	73	1140	28.5	0.58227646	0.056213018	10.35839179
75	73	1150	28.75	0.58227646	0.056706114	10.26831882
76	73	1160	29	0.58227646	0.057199211	10.17979883
77	73.5	1170	29.25	0.58626466	0.057692308	10.16192071
78	74	1180	29.5	0.59025285	0.058185404	10.14434562
79	76	1375	34.375	0.60620563	0.067800789	8.940981966
80	77.2	1500	37.5	0.6157773	0.073964497	8.325309085
81	78		53	0.62215841	0.104536489	5.951590838
82	80		54.5	0.63811119	0.107495069	5.936190344
83	82		55	0.65406397	0.108481262	6.029280602
84	84		56	0.67001675	0.110453649	6.066044508
85	86		56.5	0.68596953	0.111439842	6.155514191
86	88		57	0.70192231	0.112426036	6.243414231
87	90		57.5	0.71787509	0.113412229	6.329785574
88	91		58	0.72585148	0.114398422	6.344943106
89	66.5		58	0.53042993	0.114398422	4.636689193

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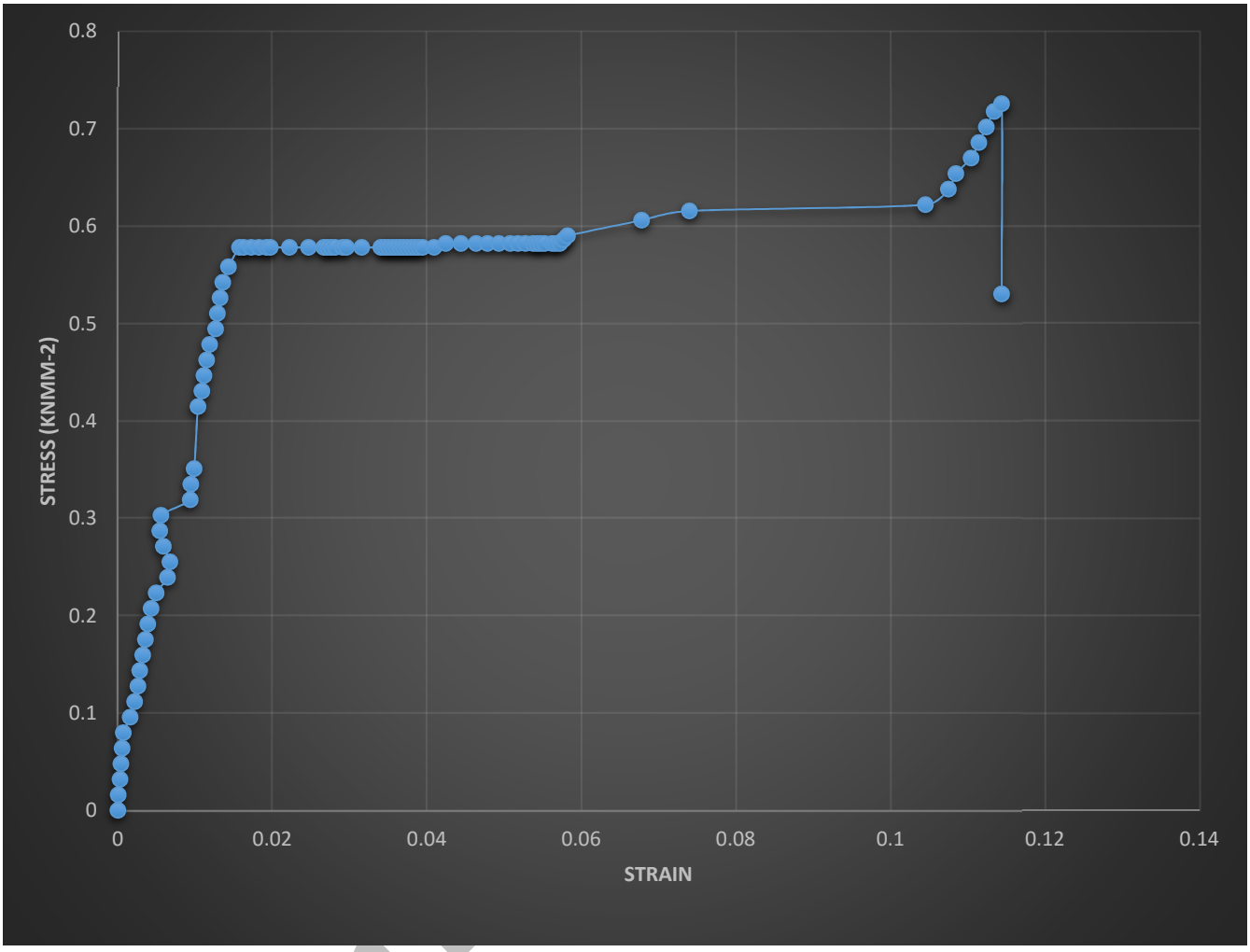

During yeilding zone stress = 0.57828827 KNmm-2
Ultimate tensile strength = 0.72585148 KNmm-2
Failure stress =0.53042993 KNmm-2

Commennt:

- Stress is directly proportional to strain upto proportional limit. Elastic deformatio is recoverable upto this point.
- In yeilding zone Stress remain constant and and strain increases.
- After yeilding zone Stress also increses but not in linear way with strain.
- After Ultimate strength of material stress decreases with increase in strain.