MMM COURSEWORK

GROUP 4

SARA MOTWANI, YEAR 1

INTRODUCTION:
In studying the mechanics of materials for construction of structures, Stress and Strain become the two key factors to take into consideration. Stress can be defined as the force (or load) acting on the surface per unit cross sectional area. Strain can be defined as the change in length per unit original length. When deciding on materials to use it's important to consider the Stress-Strain curves of the specimens that help us analyze whether the materials are suitable to bear the load of the building. The stress-strain curves also help us identify the ductility and brittleness of the specimen under testing and also analyze failure under a certain force.

Formulas Used:
Stress, $\sigma = P/A$
P = Force applied (in Newton)
A = Cross sectional area of Specimen

Strain, $\epsilon = \delta/L$
δ = deformation due to stress
L = original length before deformation

Reduction in Area = [(Original Area-Area of Failure)/Original Area] x 100

Elongation = [(Final length-Original Length)/Original Length] x 100

True Failure Stress = Failure Load/Area of Failure

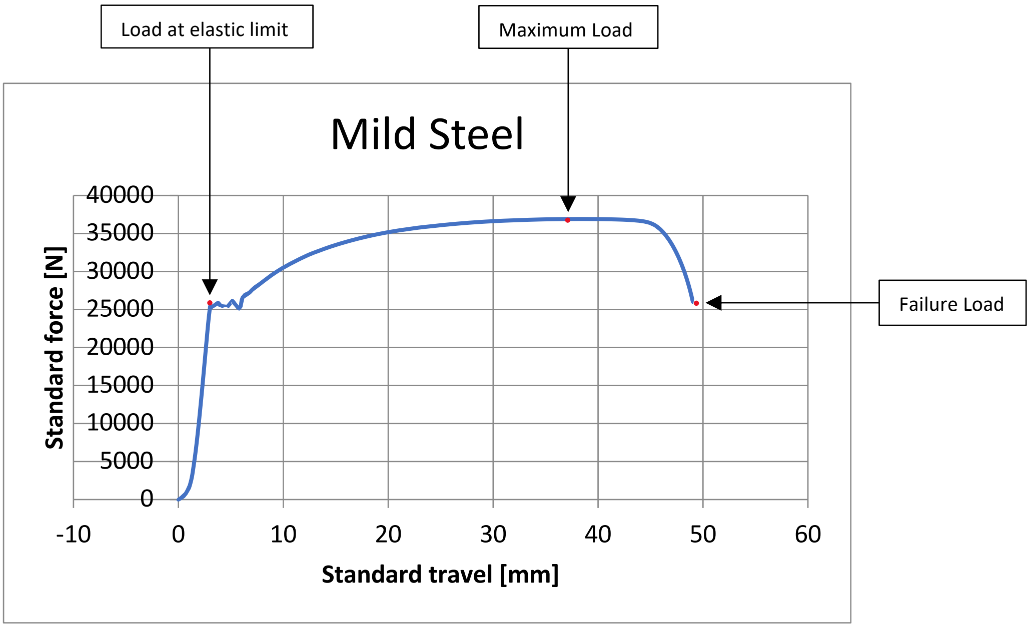
PART 1: TENSILE TESTS

Measured Value	Unit	Mild Steel	Cast Iron	Timber	
				Load // to grain	Load ⊥ to grain
Pre-testing dimensions	mm	81.8889786599791 ~81.89	84.71015 ~84.71	54.0392823621146 ~54.04	45.7400964457943 ~45.74
Pre-testing X-sectional area	mm^2	78.53981634 ~78.54	78.53981634 ~78.54	119	119
Load at elastic limit	kN	25.93195508 ~25.93	21.66849414 ~21.67	6.863 ~6.86	1.035 ~1.04
Maximum Load	kN	36.90749609375 ~36.91	24.23926 ~24.24	17.26002 ~17.26	1.495786 ~1.50
Failure load	kN	25.8547 ~ 25.85	19.74604296875 ~ 19.75	4.143299 ~4.14	1.48756 ~1.49
Reduction in area	%	68.64	34.39		
Area of failure	mm^2	24.63	51.53		
Elongation at failure	%	59.89	26.95		

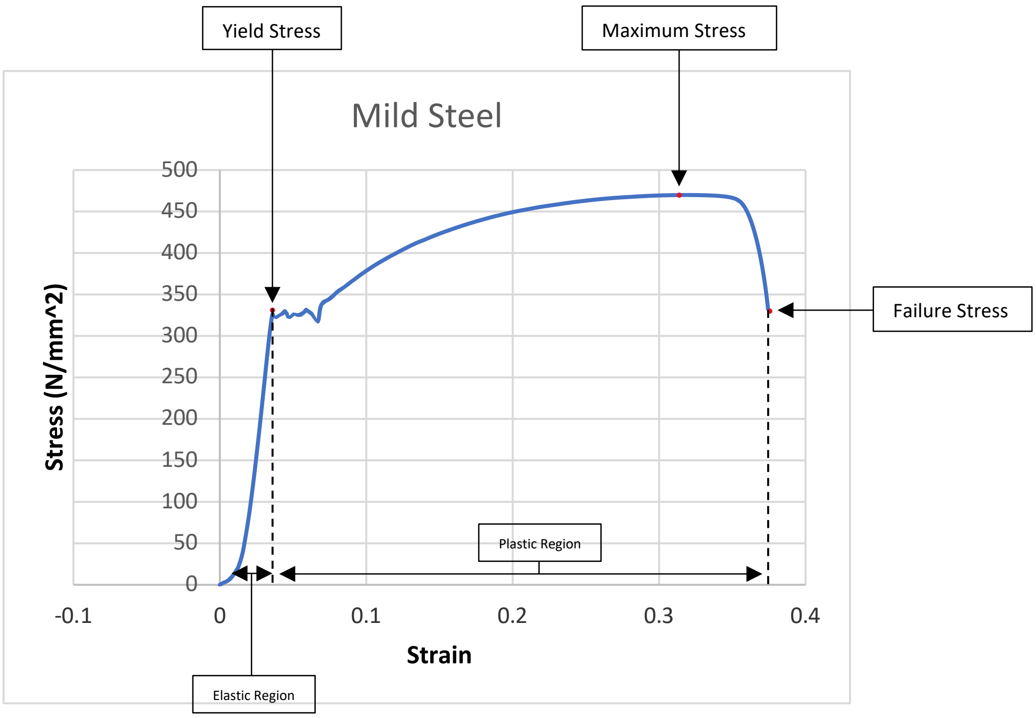
Property	Unit	Mild Steel	Cast Iron	Timber	
				Load // to grain	Load ⊥ to grain
Elastic limit (or yield) stress	MPa	326.75923 ~326.76	279.6889423 ~279.69	57.6722 ~57.67	8.6975 ~8.70
Maximum Stress	MPa	469.9013838 ~469.90	308.4140297 ~308.41	145.042 ~145.04	12.504 ~12.504
Failure Stress	MPa	329.1914848 ~329.19	251.4138397 ~251.41	34.815 ~34.82	12.504 ~12.504
True Failure Stress	MPa	1049.723914 ~1049.72	383.1950896 ~383.20		

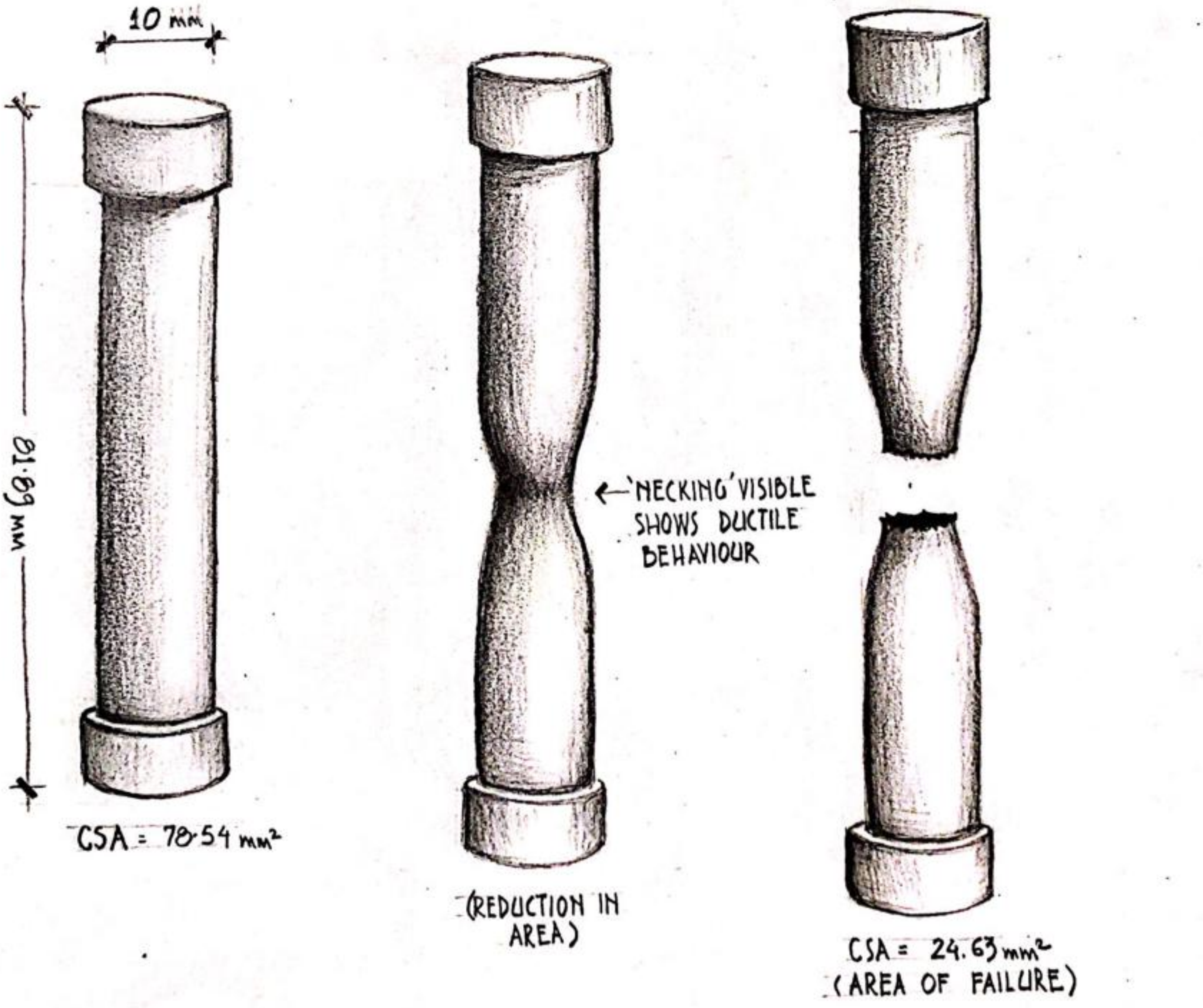
1. METALS: TENSION

Load-Displacement Graph for Mild Steel



Stress-Strain Graph for Mild Steel

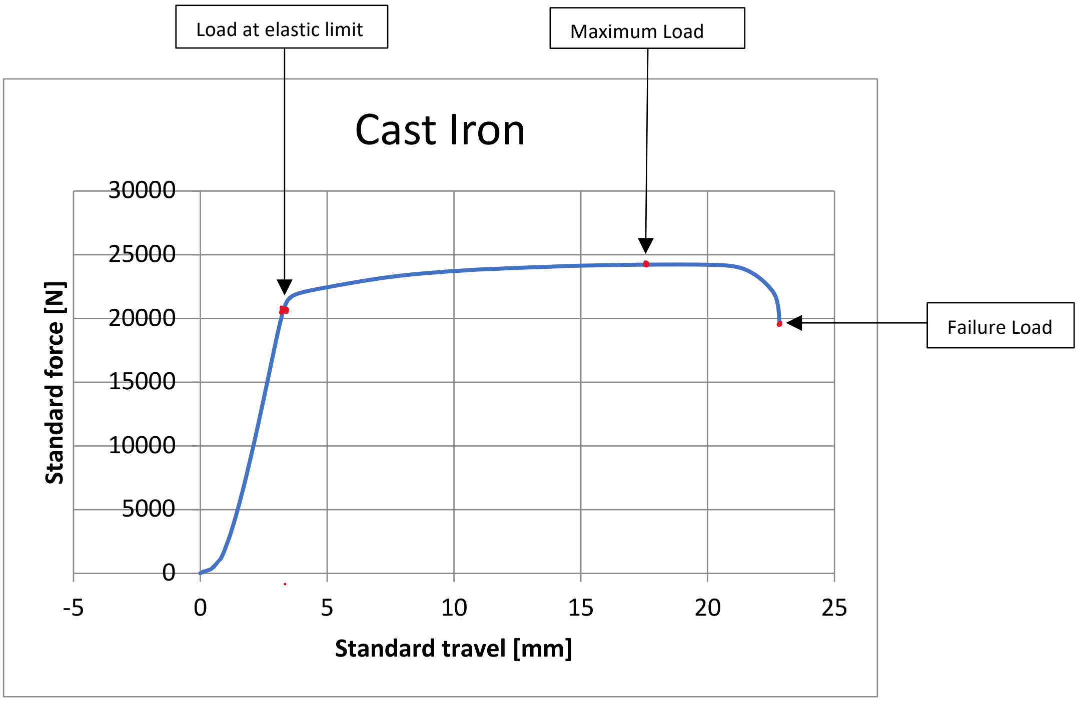




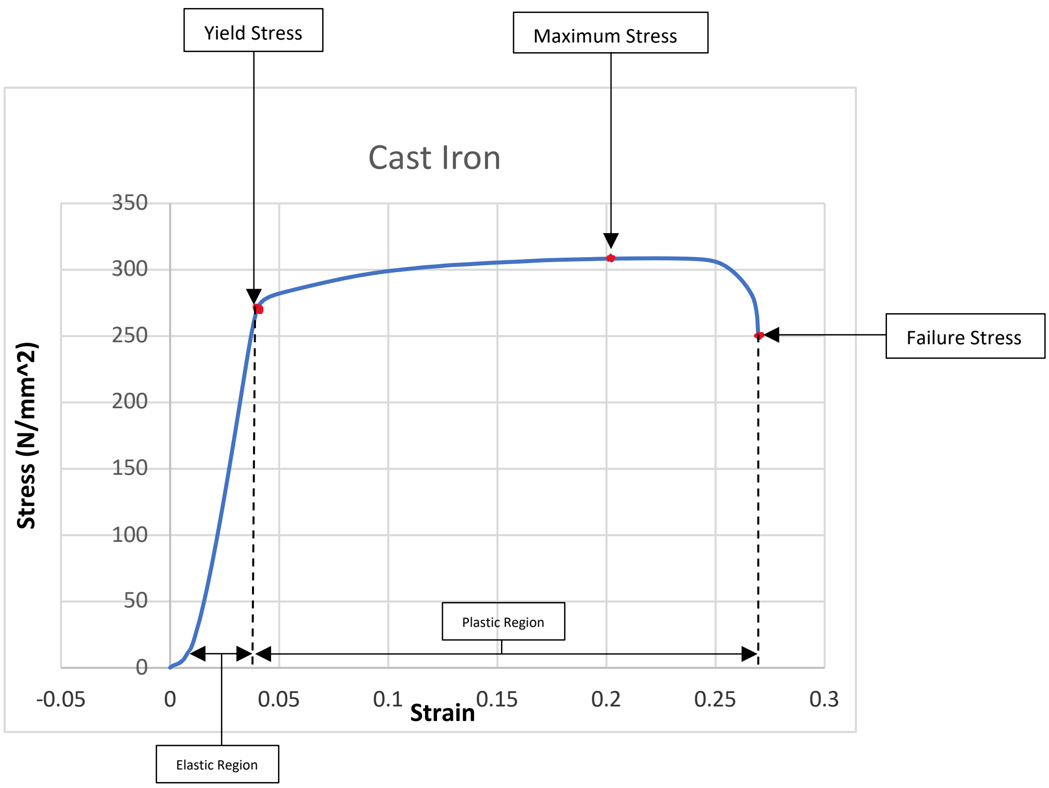
MILD STEEL
(TENSION)

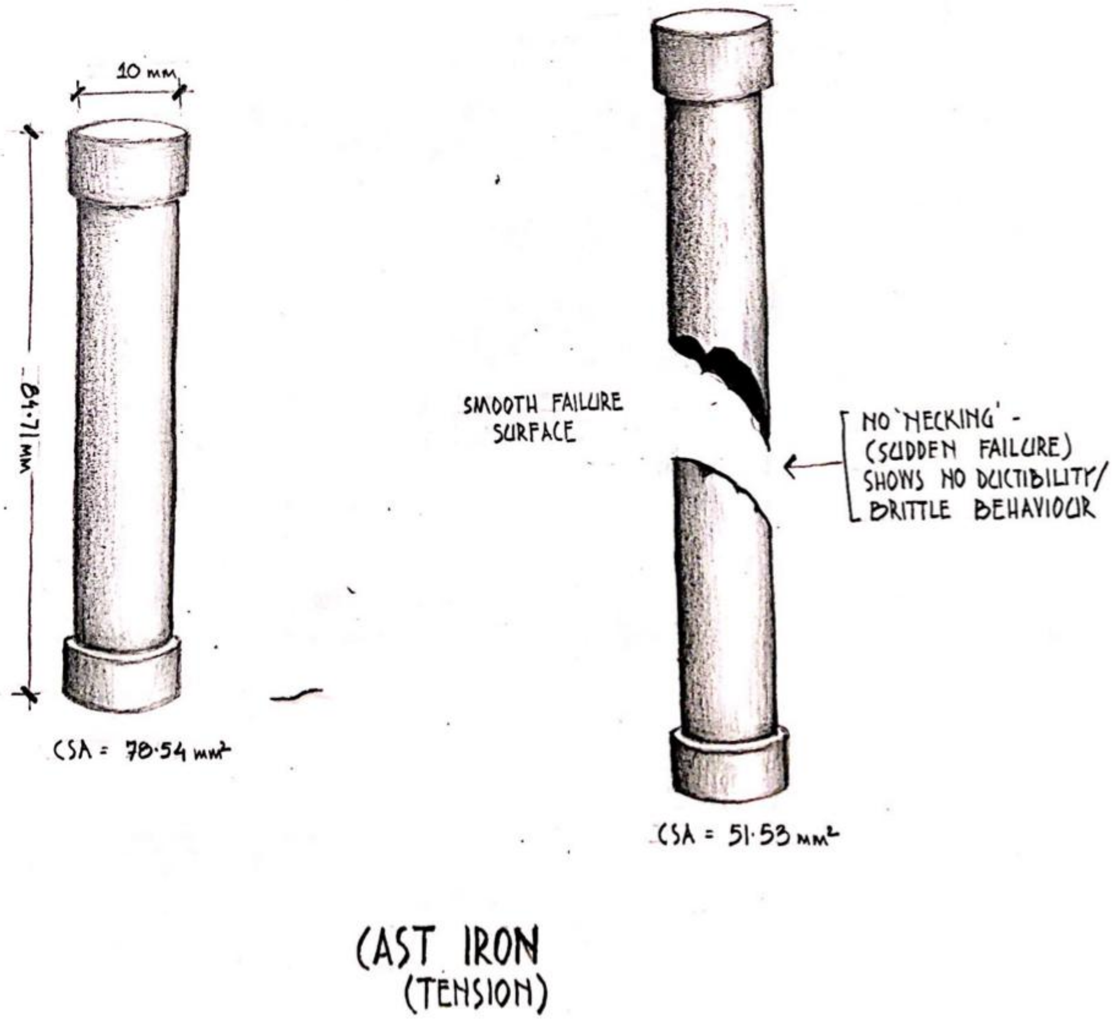
CSA = CROSS SECTIONAL AREA

Load-Displacement Graph for Cast Iron



Stress-Strain Graph for Cast Iron





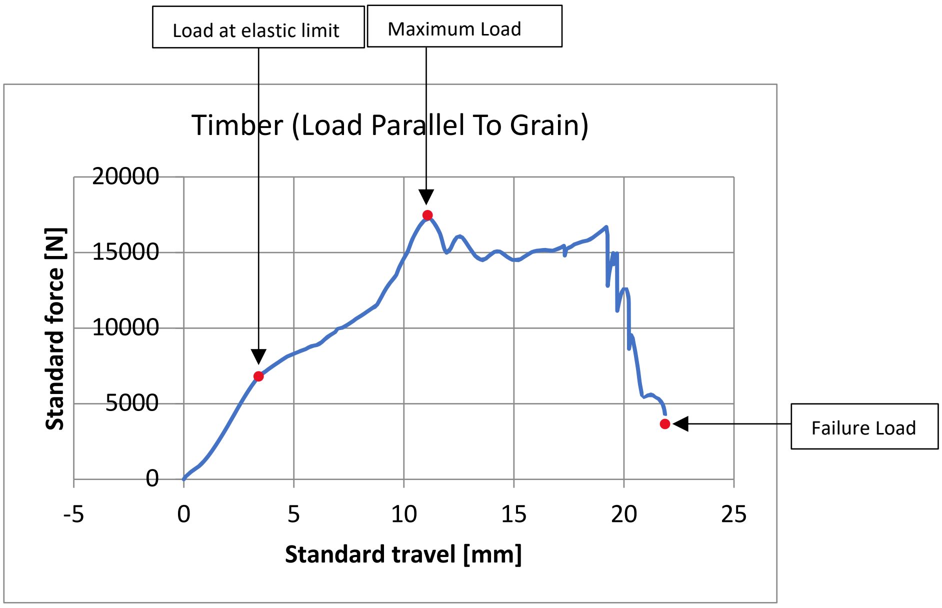
OBSERVATIONS AND CONCLUSION:
While comparing the Stress-Strain curves for Mild Steel and Cast Iron, it can be observed that the yield stress of Mild Steel is greater than that of Cast Iron which indicates that Mild Steel remains within the elastic region for much larger stresses than cast iron before going into the plastic range. This also reveals the fact that mild steel has higher ultimate tensile strength (max. stress a material can bare without failing). This fact is also supported by the observation that the true failure stress of mild steel is greater than that of cast iron.

Analyzing the diagrams of specimen failure, it is observed that mild steel undergoes necking (phenomenon of reduction of cross-sectional area on application of tensile stress) which shows its ductility. The fact that there is less reduction in area in cast iron than in mild steel shows that it is brittle while mild steel is ductile.

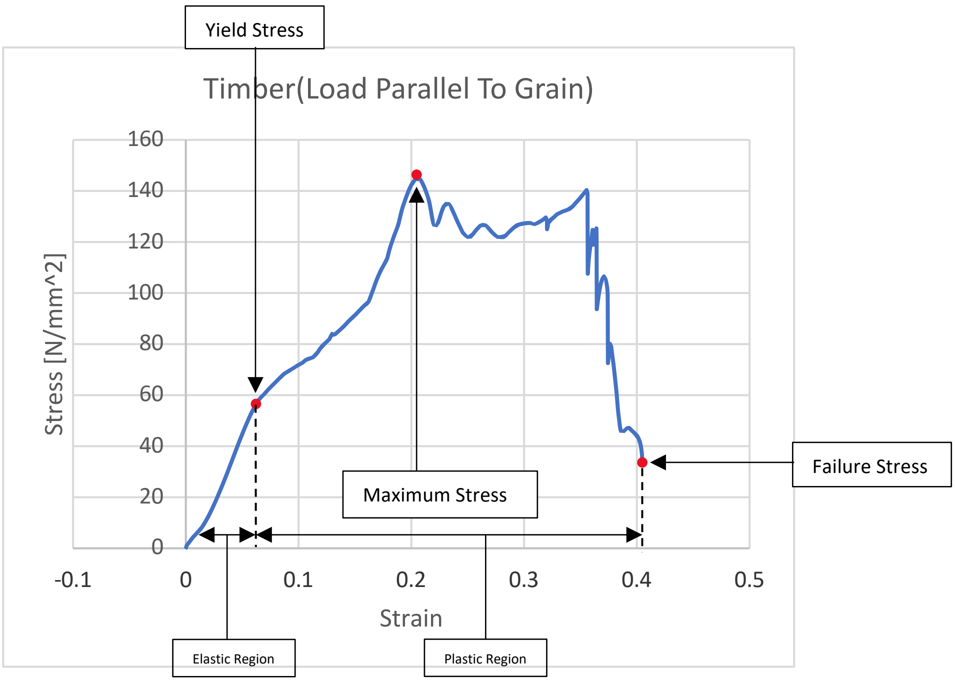
It is also noteworthy that at failure cast iron fails without giving much warning and reveals smooth broken surfaces while mild steel fails after significant necking.

2. TIMBER: TENSION

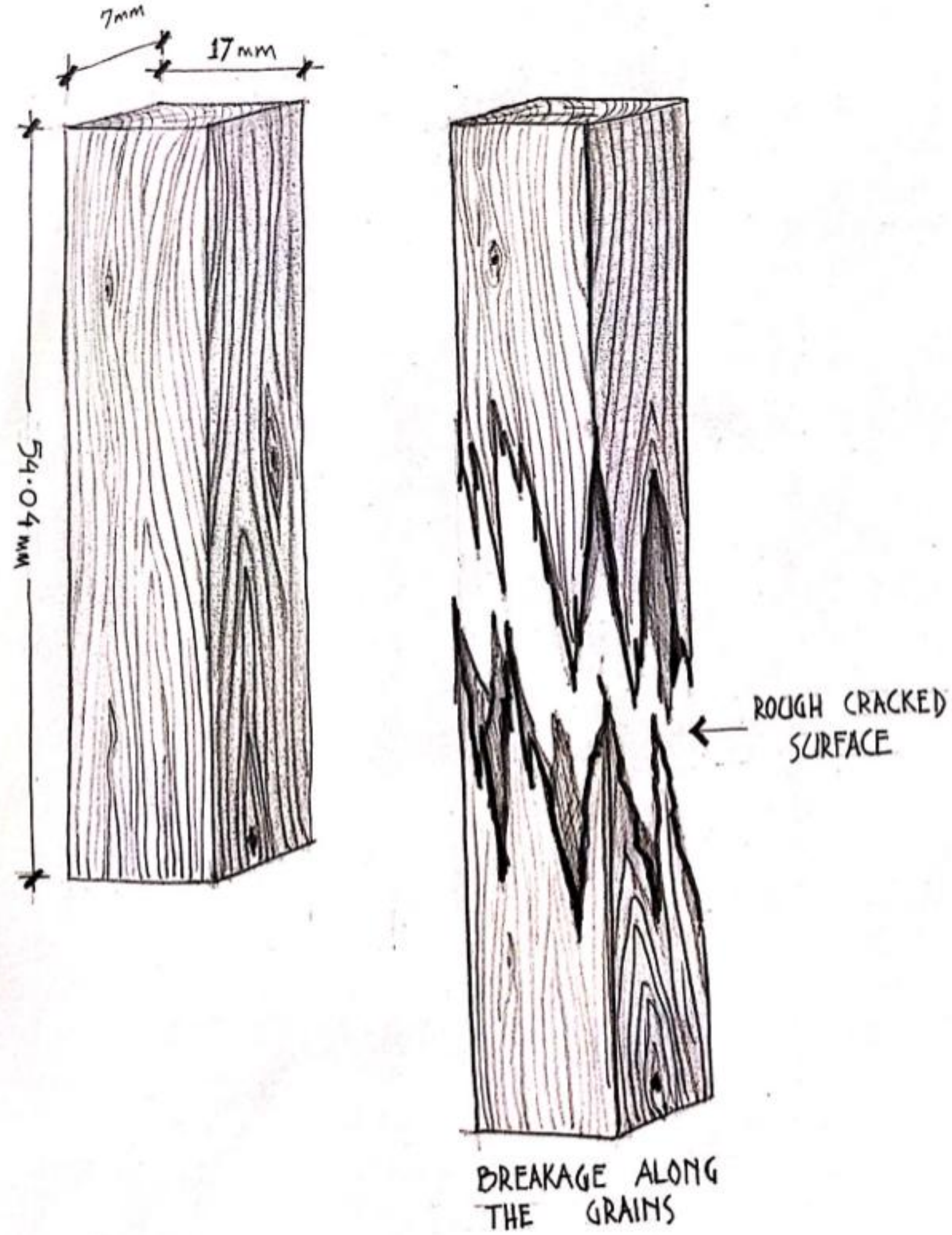
Load-Displacement Graph for Timber (Load Parallel to Grain)



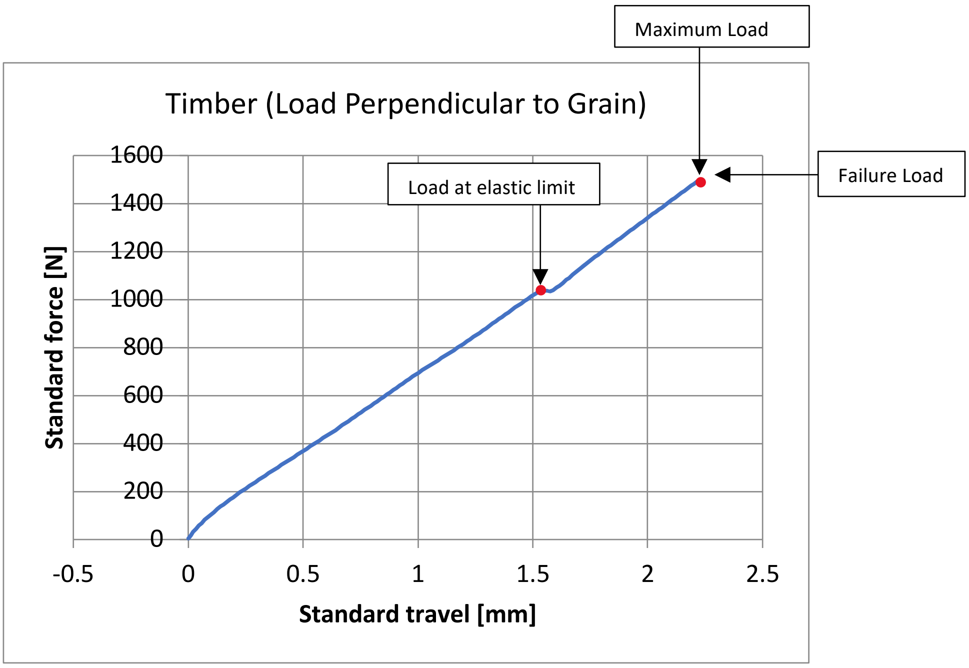
Stress-Strain Graph for Timber (Load Parallel to Grain)



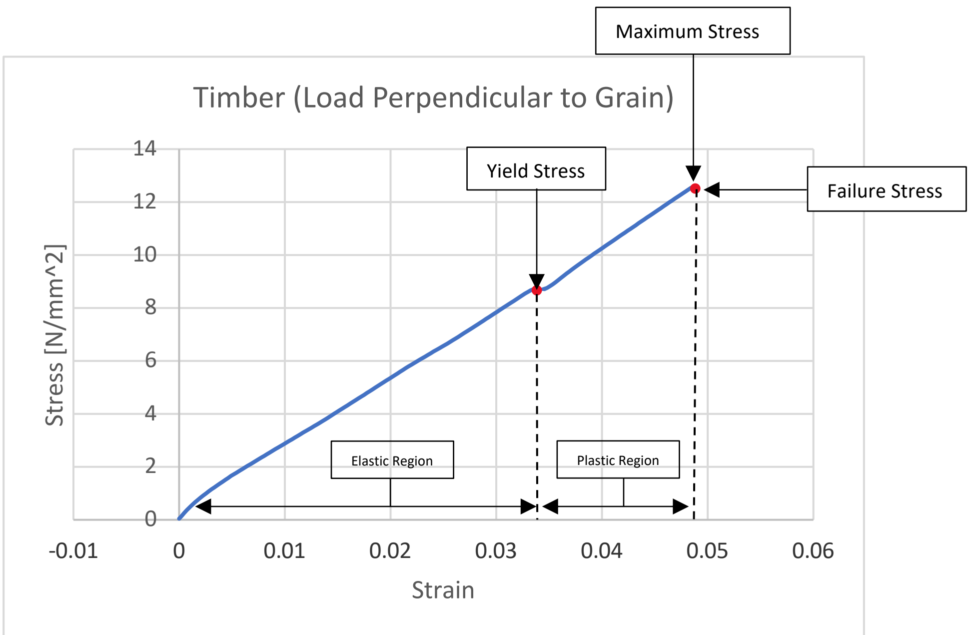
TIMBER TENSION
(GRAIN PARALLEL TO LOAD)

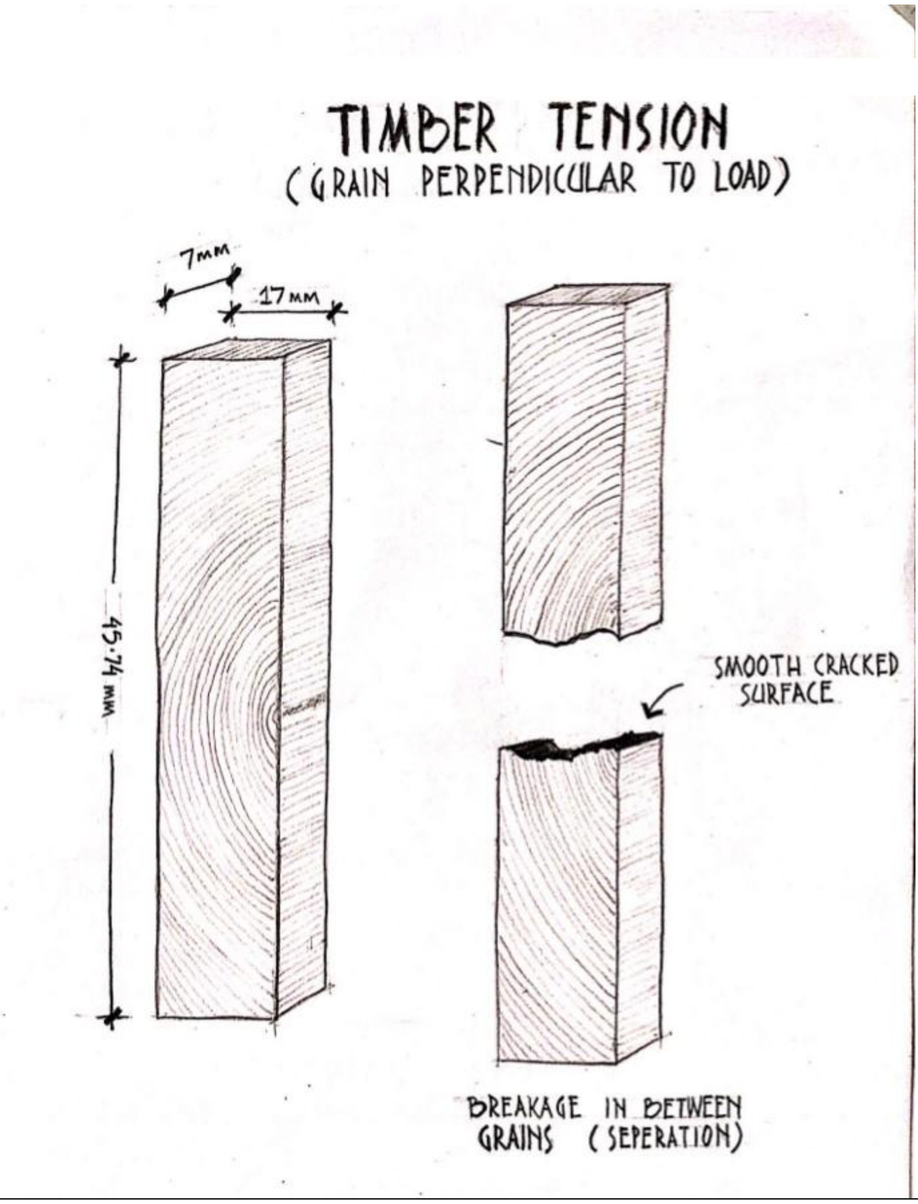


Load-Displacement Graph for Timber
(Load Perpendicular to Grain)



Stress-Strain Graph for Timber
(Load Perpendicular To Grain)





OBSERVATIONS AND CONCLUSION:
While comparing the Stress-Strain curves for Timber in parallel and in perpendicular, it is essential to define the term anisotropy. Anisotropy is the phenomenon wherein a specimen exhibits different properties along different directions, in the case of wood this property is strength. Wood reacts differently to stress when its applied parallel to its grains and perpendicular to its grains.

From the table we can note that the load at elastic limit for parallel is almost 7 times as that for perpendicular and the maximum load for parallel is almost 17 times that for perpendicular. These facts indicate that the strength of grains parallel to the force is much more than when the grains are perpendicular to the force. Also, the stress at failure for parallel is much greater than the stress at failure for perpendicular which indicates that timber grains parallel to force can bear higher values of stress before failing as compared to perpendicular.

Looking at the diagrams for failure, it can be observed that when the grains are parallel to load the cracked surface looks rough because of breakage along grains. However, in perpendicular, on failure there is a smooth cracked surface because of breakage in between grains

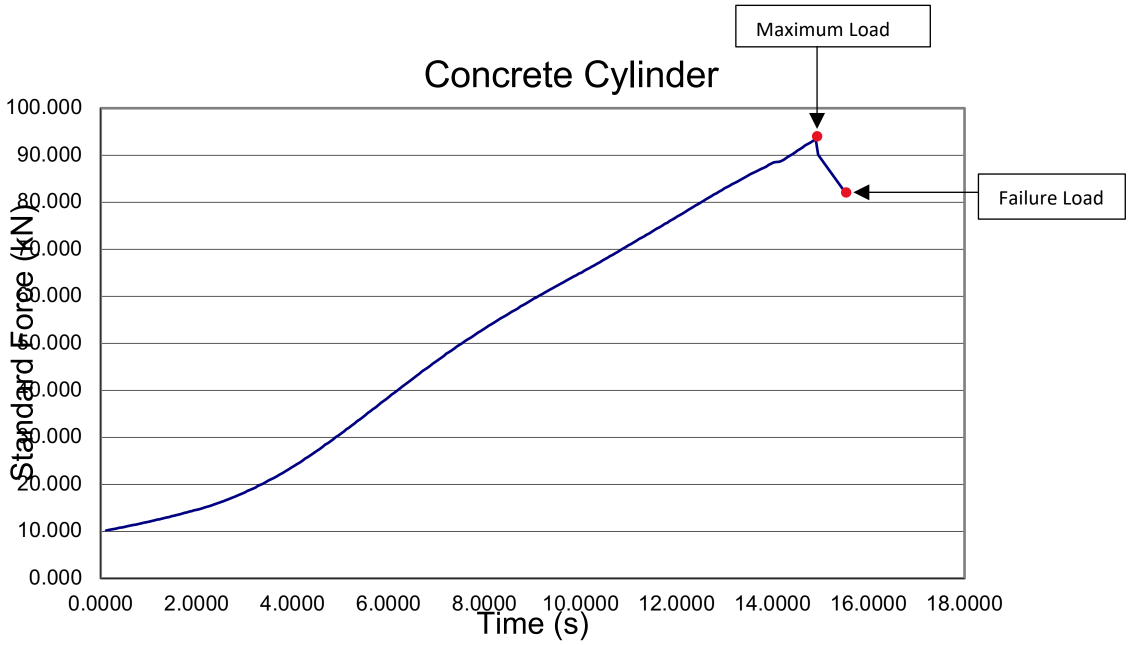
PART 2: COMPRESSION TESTS

Measure Value	Unit	Concrete		Timber	
		Cylinder	Cube	Load // to grain	Load ⊥ to grain
Pre-testing dimensions	mm	200	100	174.09	197.44
Pre-testing X-sectional area	mm^2	7853.981634 ~7853.98	10000	2500	2500
Maximum load	kN	93.396 ~93.40	602.167 ~602.17	87.09254 ~87.09	8.5176 ~8.52
Failure load (if any)	kN	82.813 ~82.81	578.659 ~578.66	39.0053 ~39.01	7.1144 ~7.11

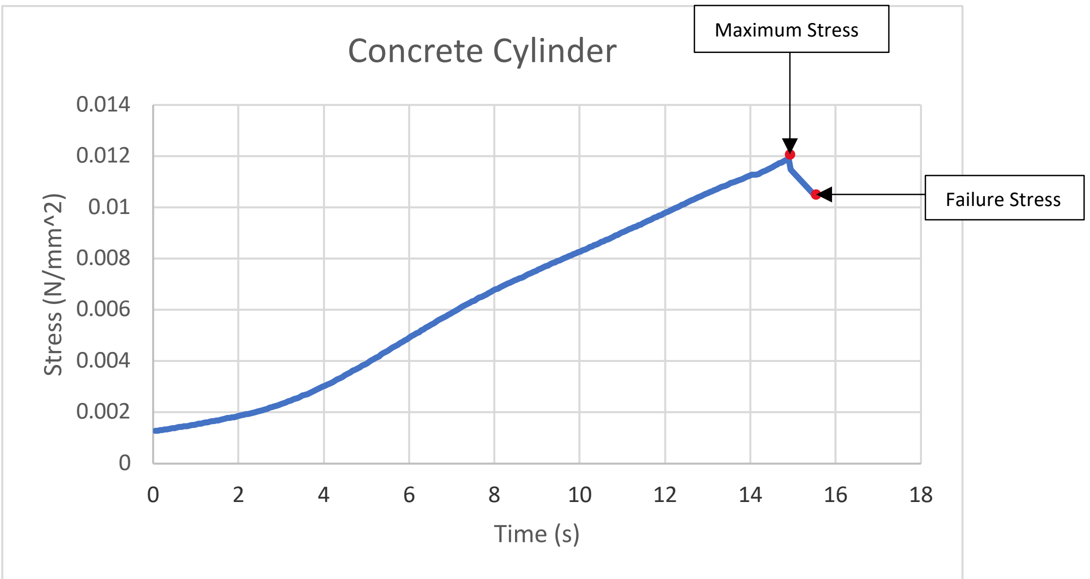
Property	Unit	Concrete		Timber	
		Cylinder	Cube	Load // to grain	Load ⊥ to grain
Maximum Stress	MPa	11.892 ~11.89	60.217 ~60.22	34.837 ~34.84	3.407 ~3.41
Failure Stress (if any)	MPa	10.5441 ~10.54	57.8658 ~57.87	15.602 ~15.60	2.8458 ~2.85

1. CONCRETE: COMPRESSION

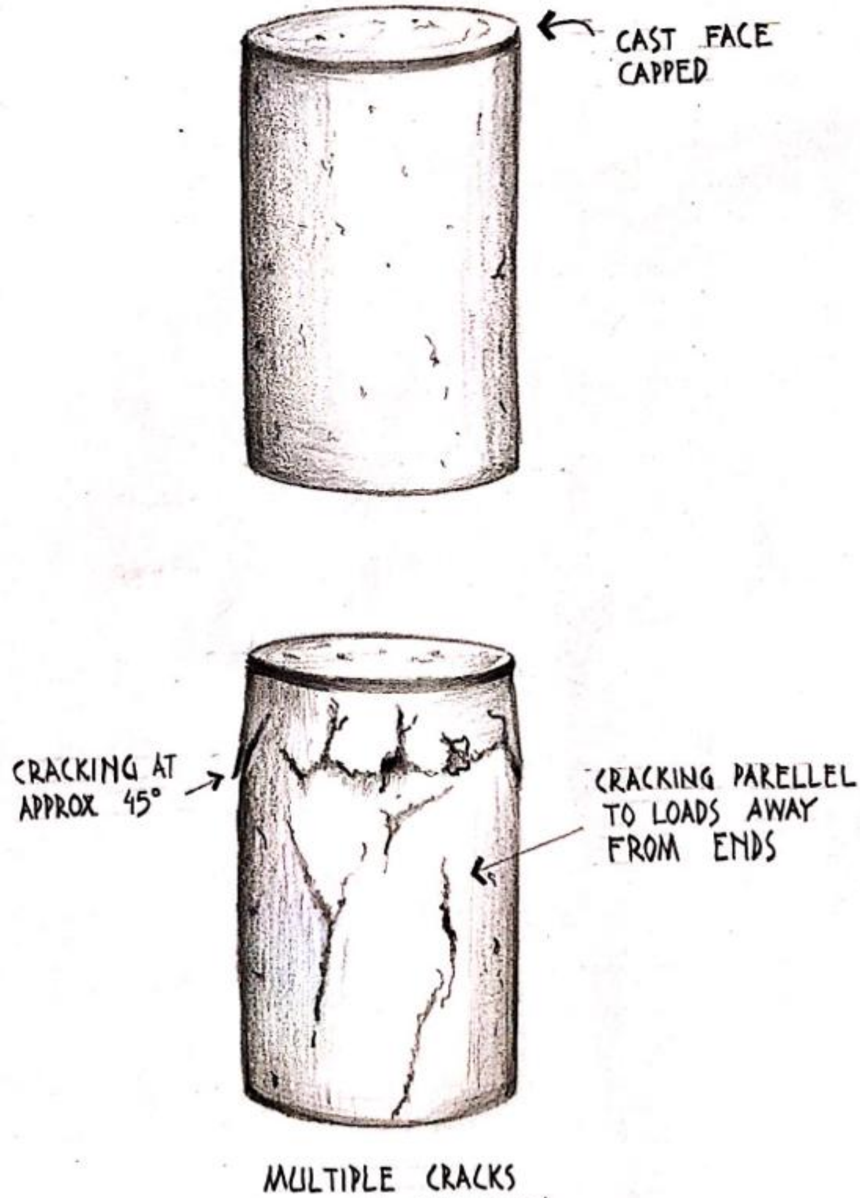
Load-Displacement Graph for Concrete Cylinder



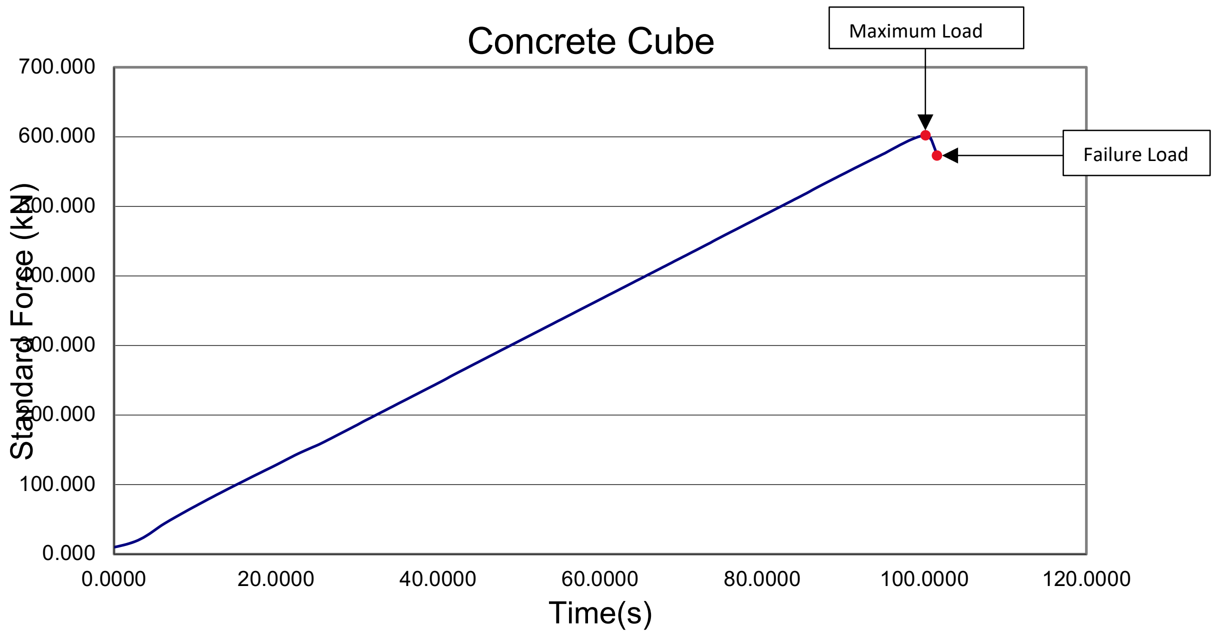
Stress-Strain Graph for Concrete Cylinder



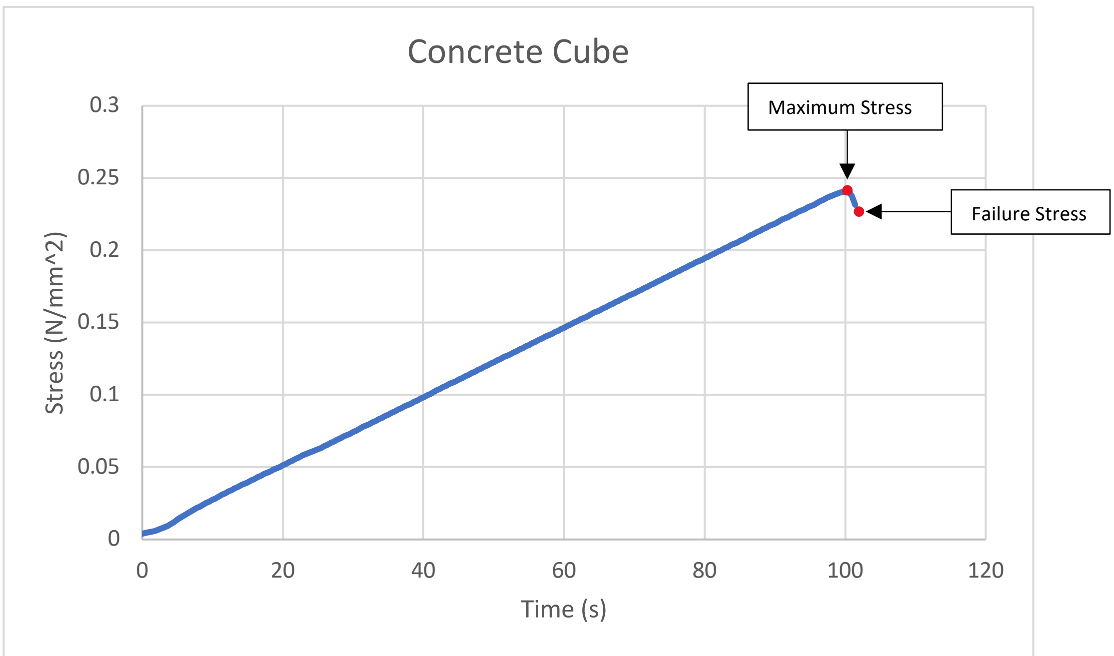
CONCRETE CYLINDER
(COMPRESSION)



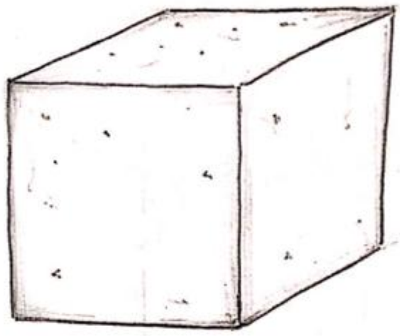
Load-Displacement Graph for Concrete Cube

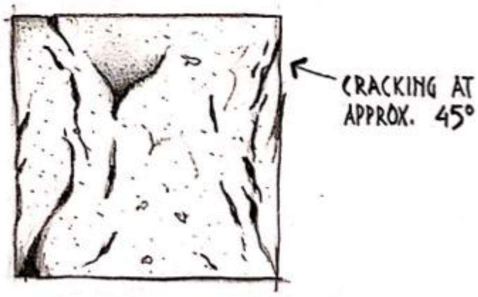


Stress-Strain Graph for Concrete Cube

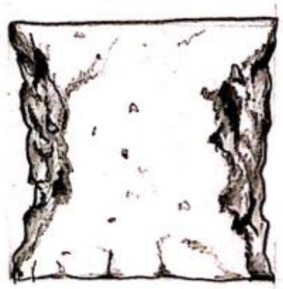


CONCRETE CUBE
(COMPRESSION)





CRACKING (FAILURE)



TYPICAL FAILURE PATTERN

OBSERVATIONS AND CONCLUSION:

Here specimens of the same type and nature but different shapes are observed- a concrete cube and cylinder. It can be noted that the maximum load for cube is nearly 7 times that of the cylinder and also the failure load for cube is nearly 7.5 times that of the cylinder. This indicates that concrete is much more capable of bearing larger loads in a cube form than in the cylindrical form.

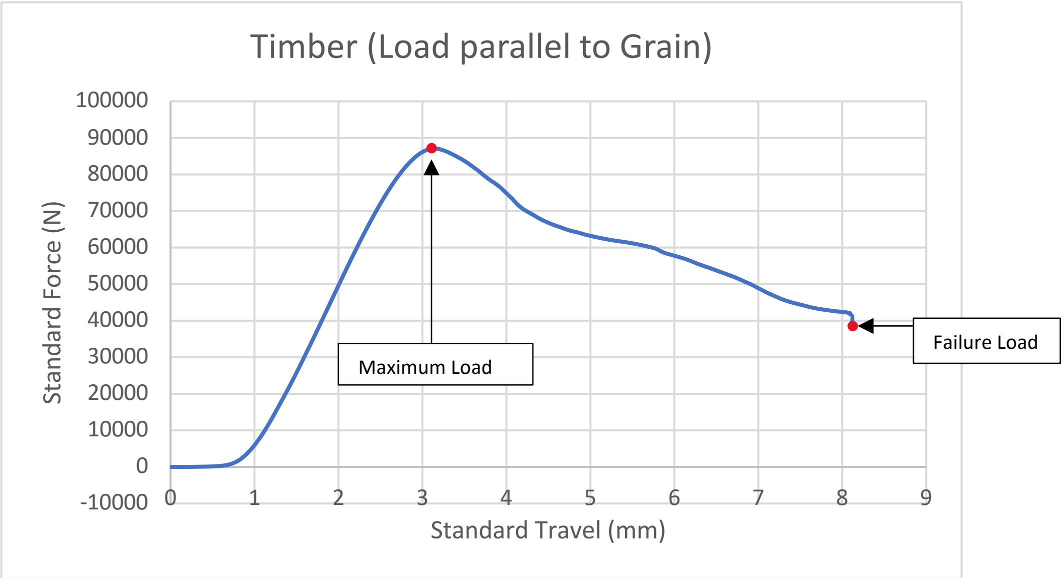
The ratio of cylinder to cube strength (is obtained by taking the ratios of their maximum stresses) = $\frac{11.89}{60.22}$ = 0.19744271 ~ 0.197

According to British standards, the strength of a concrete cylinder is 0.8 times that of a concrete cube (ref. bibliography 3). The discrepancies in the values may be due to microcracks within the specimen, its preparation quality and curing time of the concrete.

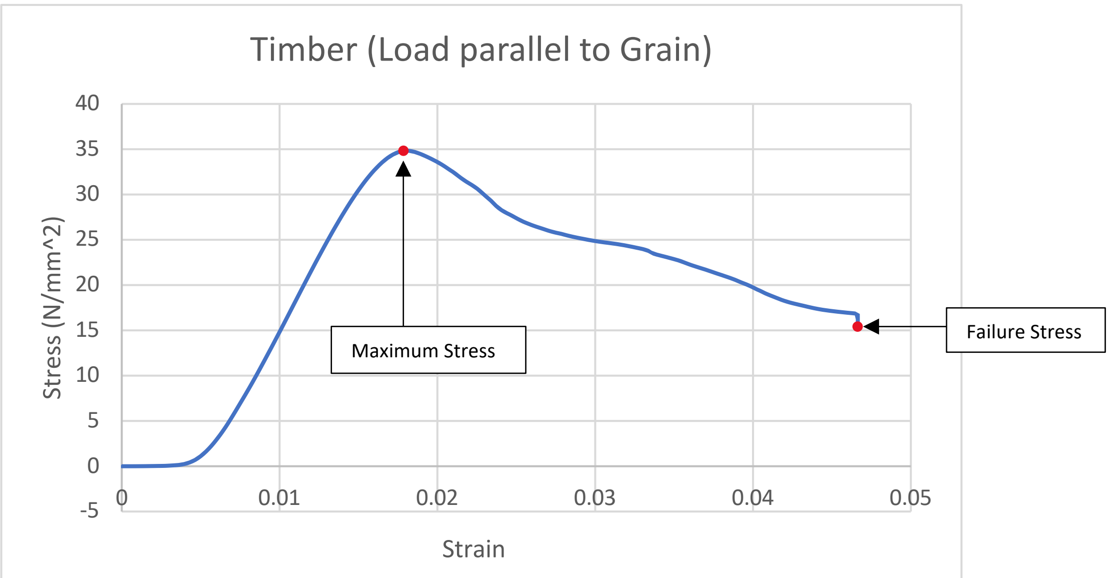
From the diagrams of failure, it is clearly visible how in both the specimens the failure causes cracking at approximately 45°. Multiple cracks, mainly vertical are observed on failure and a typical failure pattern is observed.

2. TIMBER: COMPRESSION

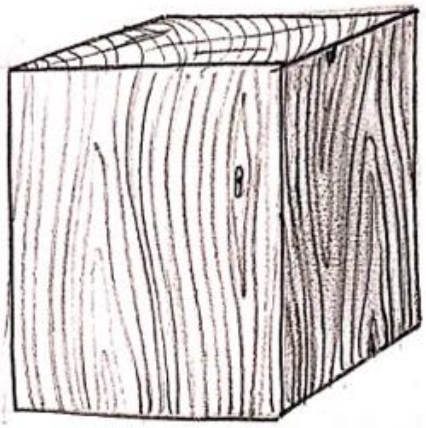
Load-Displacement Graph for Timber
(Load Parallel to Grain)

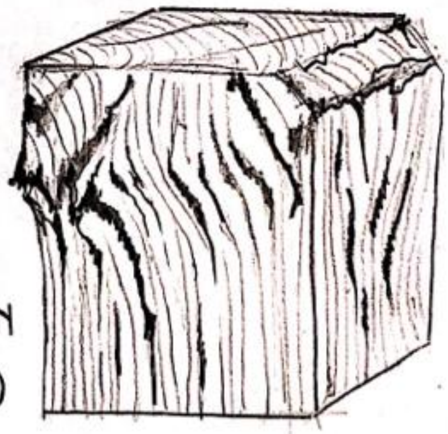


Stress-Strain Graph for Timber
(Load Parallel to Grain)

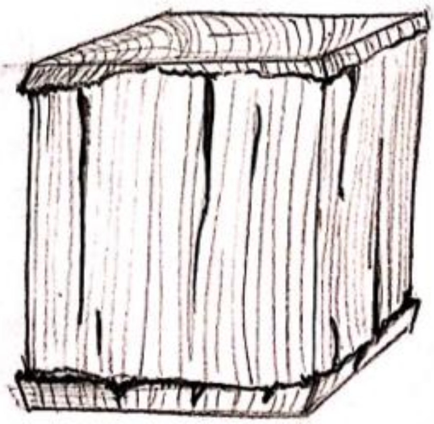


TIMBER COMPRESSION
(GRAIN PARALLEL TO LOAD)



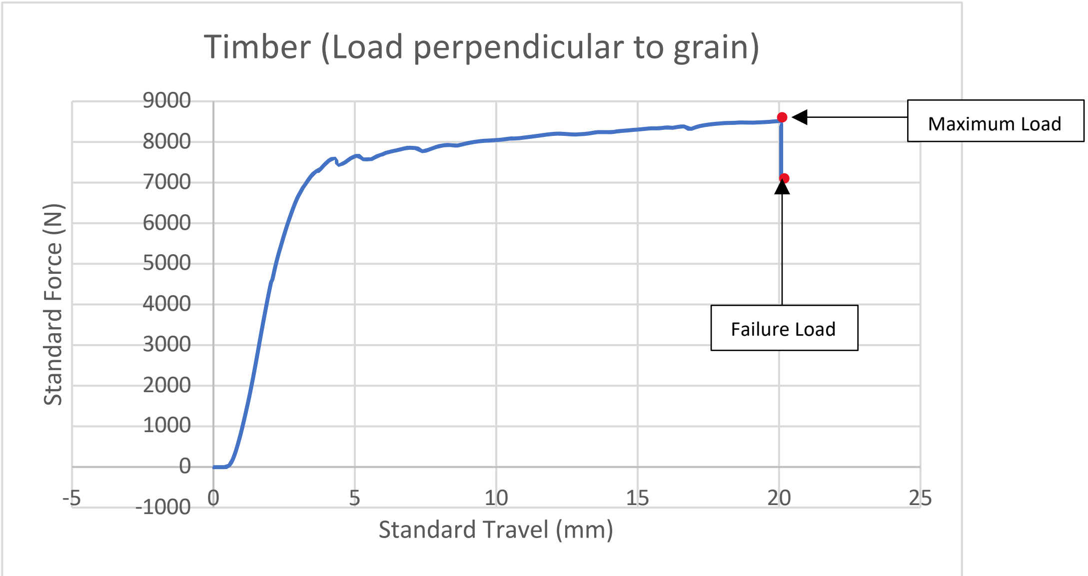


CRACKING BETWEEN GRAINS (AND SLIGHT RECOVERY)

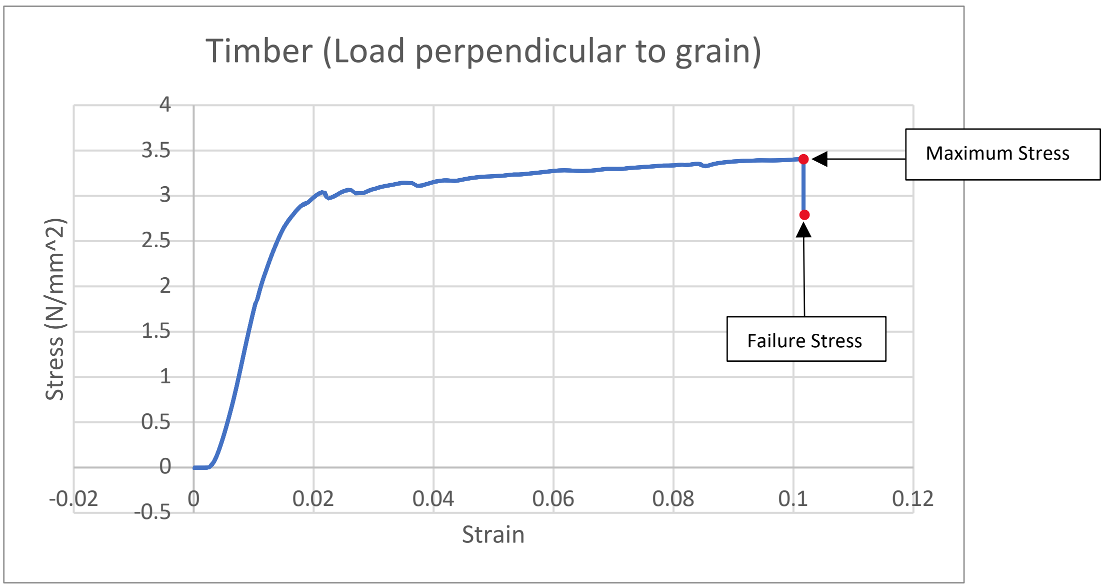


BUCKLING OF GRAINS AT EITHER END

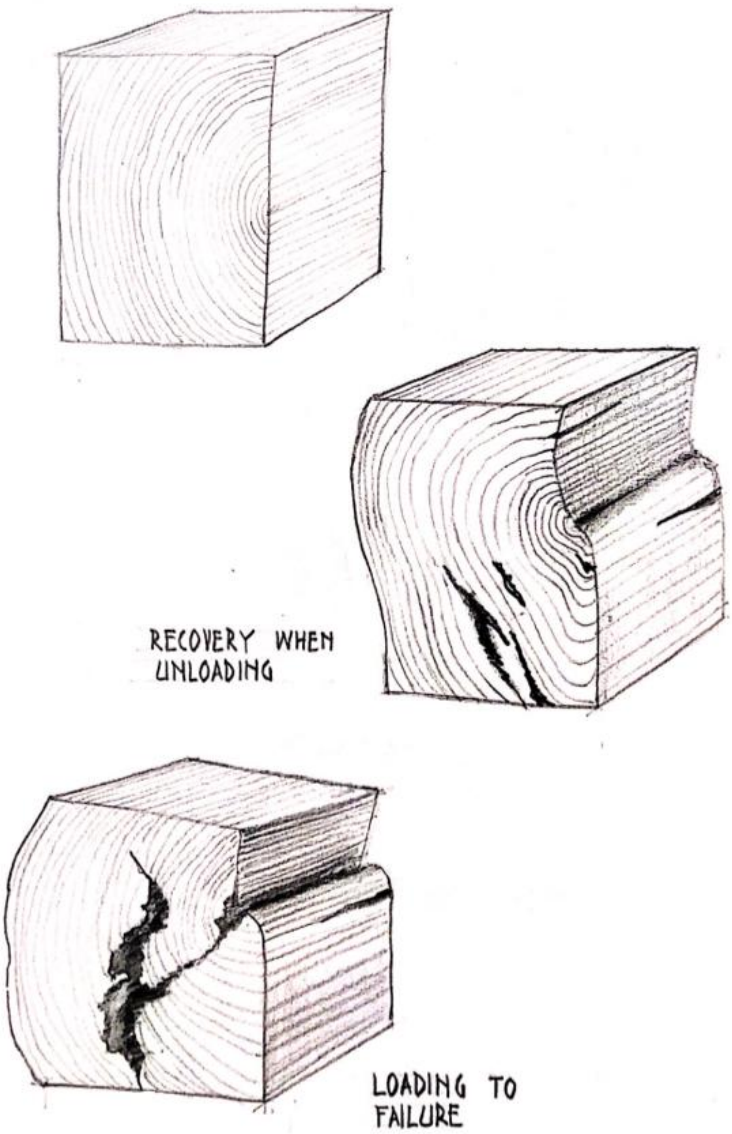
Load-Displacement Graph for Timber
(Load Perpendicular to Grain)



Stress-Strain Graph for Timber
(Load Perpendicular to Grain)



TIMBER COMPRESSION
(GRAIN PERPENDICULAR TO LOAD)



OBSERVATIONS AND CONCLUSION:
While comparing the Stress-Strain curves for Timber in parallel and in perpendicular, it is essential to define the term anisotropy. Anisotropy is the phenomenon wherein a specimen exhibits different properties along different directions, in the case of wood this property is strength. Wood reacts differently to stress when its applied parallel to its grains and perpendicular to its grains.

The maximum stress for parallel is nearly 10 times that for perpendicular and the failure stress for parallel is nearly 5 times as that for perpendicular. This indicates that wood is much stronger when the grains are parallel to the direction of force tan when they are perpendicular.

Also, in diagrams of failure of the specimens it is observed that when the grains are parallel to the force there is either a cracking between the grains and a slight recovery or there is buckling of grains at either end of the specimen. In the case of perpendicular, there is slight recovery of specimen when unloading followed by loading to failure.

BIBLIOGRAPHY:

1. Collins, D. (2019). *Stress and strain: Mechanical properties of materials*. [online] Linear Motion Tips. Available at: https://www.linearmotiontips.com/mechanical-properties-of-materials-stress-and-strain/ [Accessed 17 Nov. 2020].

2. docplayer.net. (n.d.). *Part 120. Method for determination of the compressive strength of concrete cores - PDF Free Download*. [online] Available at: https://docplayer.net/53220668-Part-120-method-for-determination-of-the-compressive-strength-of-concrete-cores.html [Accessed 4 Nov. 2020].

3. Kumari, R. (2015). Review Paper Based On the Relation between the Strength of Concrete Cubes and Cylinders. *Journal of Engineering Research and Applications www.ijera.com*, [online] 5(2), pp.52–54. Available at: http://www.ijera.com/papers/Vol5_issue8/Part%20-%202/I58025254.pdf [Accessed 16 Nov. 2020].

4. moodle.ucl.ac.uk. (n.d.). *UCL Moodle: Log in to the site*. [online] Available at: https://moodle.ucl.ac.uk/mod/resource/view.php?id=2449626 [Accessed 11 Nov. 2020].

5. Diego (2018). *Exploring the Stress / Strain Curve for Mild Steel - The Chicago Curve*. [online] The Chicago Curve. Available at: https://www.cmrp.com/blog/faq/analysis-design/exploring-stress-strain-curve-mild-steel.html [Accessed 17 Nov. 2020].

6. www.lassp.cornell.edu. (n.d.). *isotropic and anisotropic*. [online] Available at: http://www.lassp.cornell.edu/sethna/SimScience/cracks/glossary/isotropic.html#:~:text=anisotropic%3A%20Properties%20of%20a%20material [Accessed 18 Nov. 2020].