Concrete Stress strain Curve and their Relationship

Elasticity, stress and strain

When the external force is applied to the material body, it processes for change in shape and size.

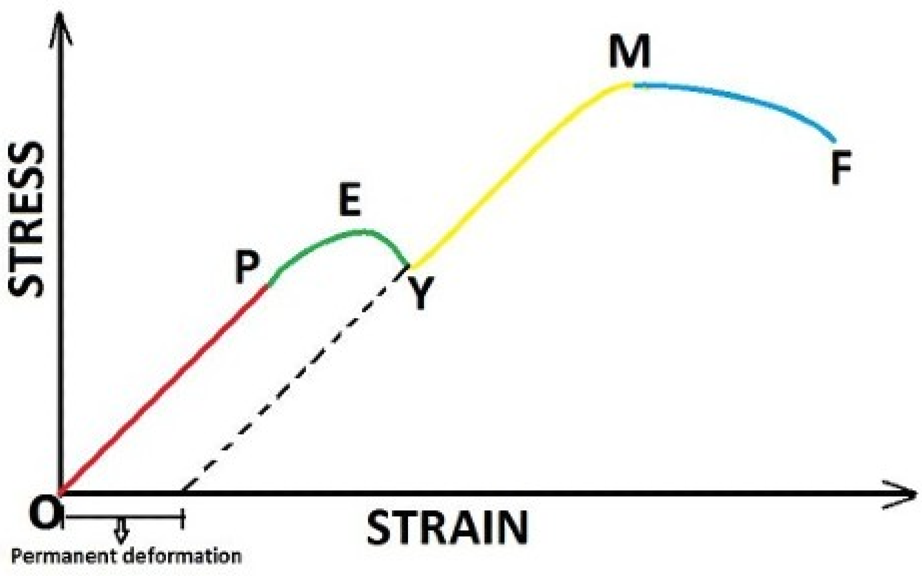
If the force is not too sufficiently large then the material body returns to its original state when force is removed. T

his property of the material body due to which it returns to its original state after the external force is removed is called Elasticity of the material body.

Stress is thus now defined as the internal forces per unit area of the deformed material body at that instant. In equilibrium conditions external and internal forces are equal thus, stress can be simply taken as external force per unit area at such time.

Strain is the change in dimension per unit original dimension of the deformed body.

Relationship between stress and strain for ideal elastic material



Graphical representation for the stress strain relationship of Ideal elastic material

To know the Concrete Stress strain curve and its Relationship and its property let's first have little knowledge about the stress and strain relationship for an ideal elastic material. So that, it becomes clear and easier to know about the concrete stress and strain behavior.

The graph above shown is for illustrating the relationship between tensile stress and normal strain of ideal elastic material. In the graph, from O to P, it is a straight line, which represents stress that stress produced in the body is directly proportional to the strain produced in it.

The point P is thus known as the proportionality limit. This represents the maximum value of stress below which stress is proportional to strain.

If the force is further increased, the graph is no more linear. Thus, stress and strain are no more proportions to each other up to point E (Elastic limit), however, deformation is still elastic in nature.

If the force is increased slightly further, beyond E (such as point Y) the material is permanently deformed and doesn't return to its original state when the force is removed.

There is a small strain in the body as represented by OO' in the diagram. Point Y is known as the yield point. The correspondent values of E and Y lie very near, so they are often taken as the same in graph scale.

Beyond Y the stress again increases with strain in a material body and becomes maximum at point M.

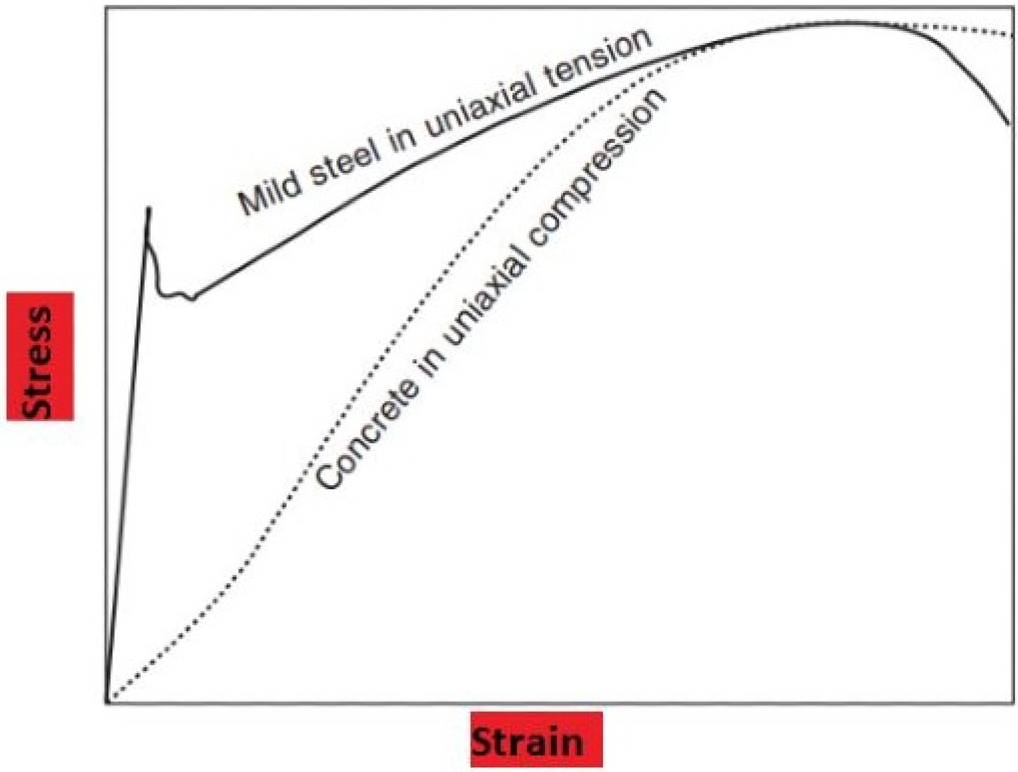
Here, it should be noted that the stress caused is not further due to restoring forces but rather intermolecular bonding between materials. This maximum stress caused in the material body is called breaking stress.

Beyond M, with an increase in strain, stress is decreased. This indicates that the intermolecular bonding also is also no further capable of holding the material together and thus there is slow slippage of the molecules of the material.

This phenomenon is called the flow of solid and in this phase distinctive necking is seen n the material body.

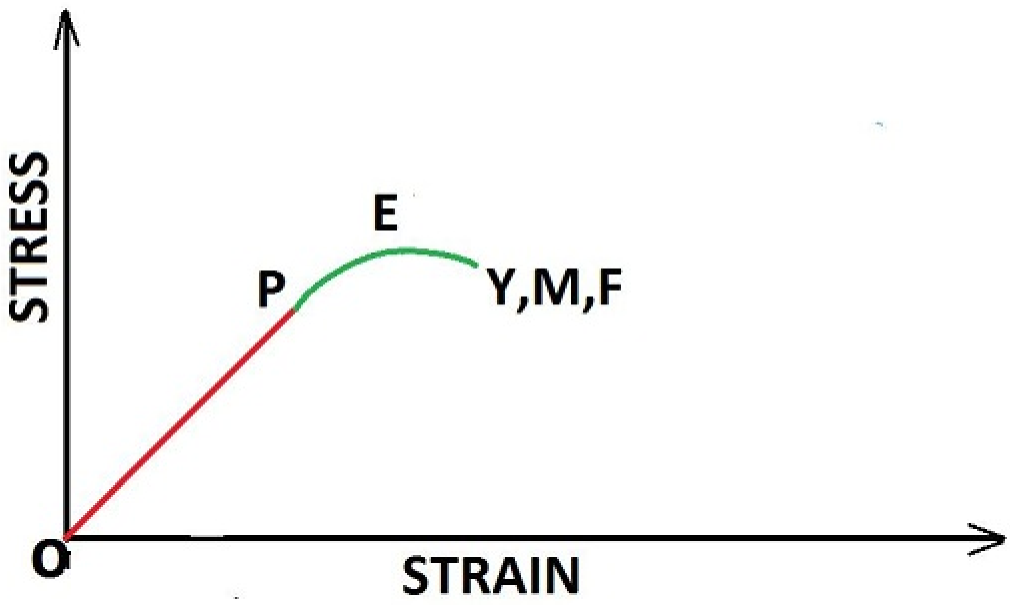
Ultimately at point F the material fails or break. This is called fractures point.

From the above, illustration it can be concluded that the graph is nearly as same for the ductile and elastic material like steel and other metals.

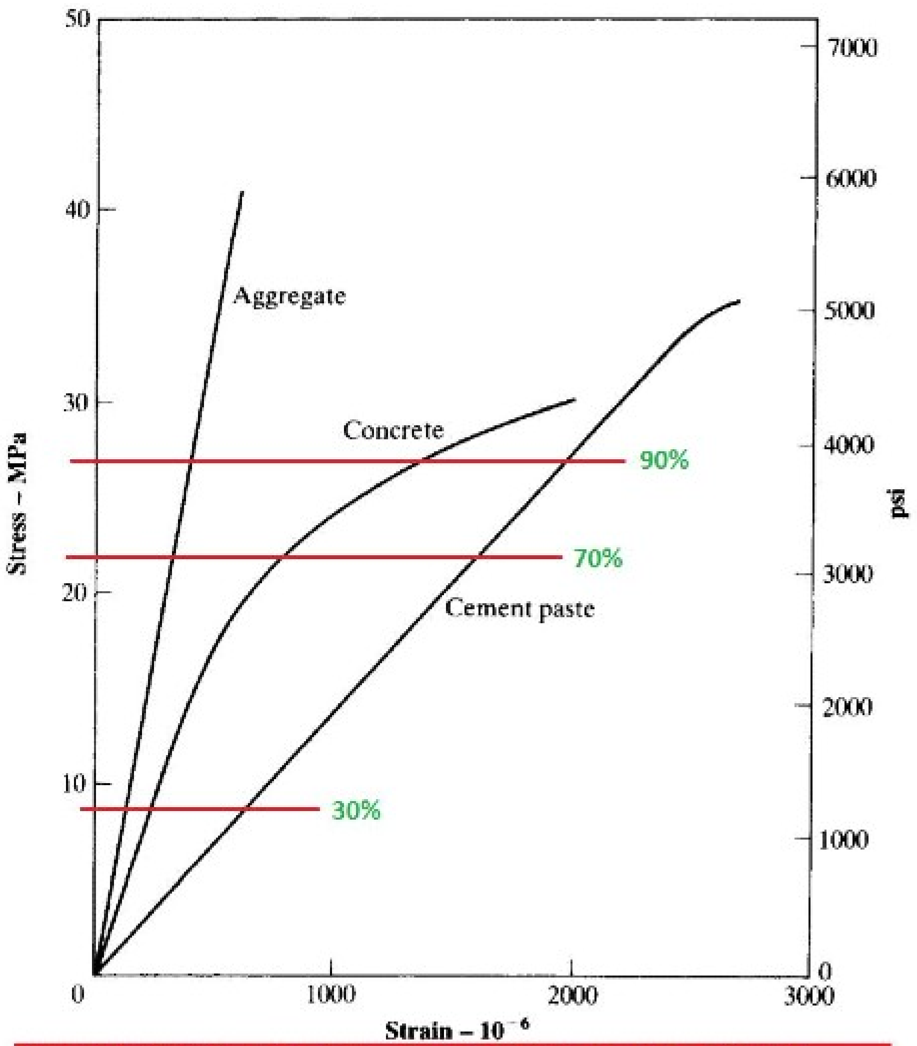


Comparision of stress and strain relationship for the steel and concrete

But for the Brittle material like, glass, aggregates, concrete there is no plastic deformation which means that the point Y, M, F all lies in a single point. Thus, the graph for such material tends to be as shown in fig below.



Concrete Stress strain Curve



Stress strain relation ship for concrete,aggregate and cement paste

The above graph represents the stress-strain relationship of the concrete along with a comparison to aggregate and cement paste.

The stress-strain value lies exactly between the aggregate and cement paste along with the early development of the curvilinear path representing shortening the value of the proportionality limit.

The curve path represents the rapid development of the micro-cracks (generally above 30% of the ultimate stress) due to which the strain development is greater for further stress.

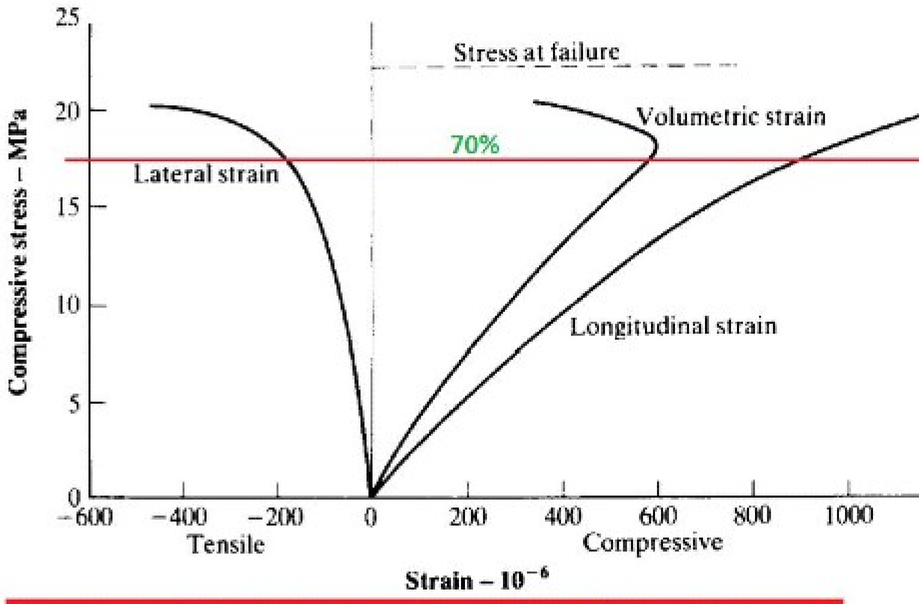
The curve portion from 30% of Ultimate stress to 70% of ultimate stress is called the stage of slow propagation of micro-cracks as the cracks are stable under sustained load (neglecting the creep effect).

The slow and stable development of micro-cracks helps in redistribution of local high stress to regions of lower stress and thus prevents the material from localized early failure.

From 70% to 90% of ultimate stress, the micro-cracks open through the cement paste and fine aggregate.

Thus, these oversize micro-cracks then join to the bond crack in concrete due to excessive load. And thus, rapid propagation of continuous crack patterns is formed.

This stage is known as the fast propagation of the crack. And on further sustain of the same load, the failure occurs within the seconds.



Stress strain relationship of concrete material in all three dimension

At 70% – 90% of the volumetric strain curve, the body is no more continuous as there is reversed strain, i.e., the increase in volume (than original initial volume) due to larger cracks and void formation.

Note that in the above graph, the lateral strain shows the tensile behavior, as we know concrete on compression laterally produce tensile strain. The lateral strain is exactly as same as the earlier mentioned graph.

Note:

Concrete is a material form of a heterogeneous mixture of cement and aggregates. Thus, due to this reason concrete doesn't have the same and simple stress-strain relationship as that of the homogeneous material like steel.

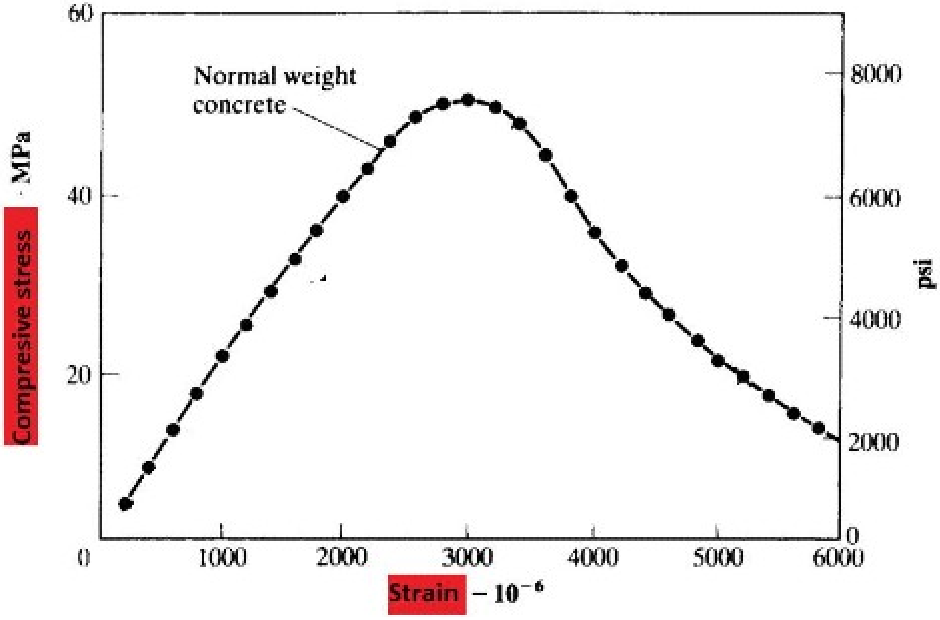
Thus, different conditions and methods are used to study the stress-strain behavior of the concrete. The above graph explanation is done considering the uniform increase in stress over concrete.

However, due to heterogeneous property, it is also subjected to a uniform increase in strain to observe corresponding behaviors of stress.

Further, the concrete has very little tensile strength. Thus, it is not preferable to perform a tensile stress test as that of the steel.

So, the different compressive test is performed for better study purpose. However, the tensile characteristic can also be observed by different tests and also while in compression (in a lateral stress-strain relationship).

And also, different behavior of stress and strain is observed for different loading conditions like uniaxial load, biaxial load, and multi-axial load(stress).



Stress-strain realtionship of concrete at uniform increase in strain

I hope this article on “Concrete Stress strain Curve” remains helpful for you.

Happy Learning – Civil Concept

Contributed by,

Civil Engineer – Rajan Shrestha

Read Also,

Concrete slump test procedure | Slump values and their uses

12 Difference between Design mix and Nominal mix of Concrete

What is Batching of Concrete | Different Types of batching

What is creep in concrete Structure? How creep occurs?