# CONCRETE TECHNOLOGY

# تكنلوجيا الخرسانة 2

## المرحلة الثالثة

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# Lecture 3:A

## Hardened Concrete

# Introduction to Hardened Concrete

**Definition:** Hardened concrete is concrete that has undergone the hydration process, This stage begins after the hardening phase (i.e., after 24 hours) and lasts throughout the concrete's lifespan. It has **the strength to resist the loads** affecting the structure loads over time.

**Reminder that concrete hardens as cement reacts with water, forming calcium silicate hydrate (C-S-H) gel that binds aggregates together.**

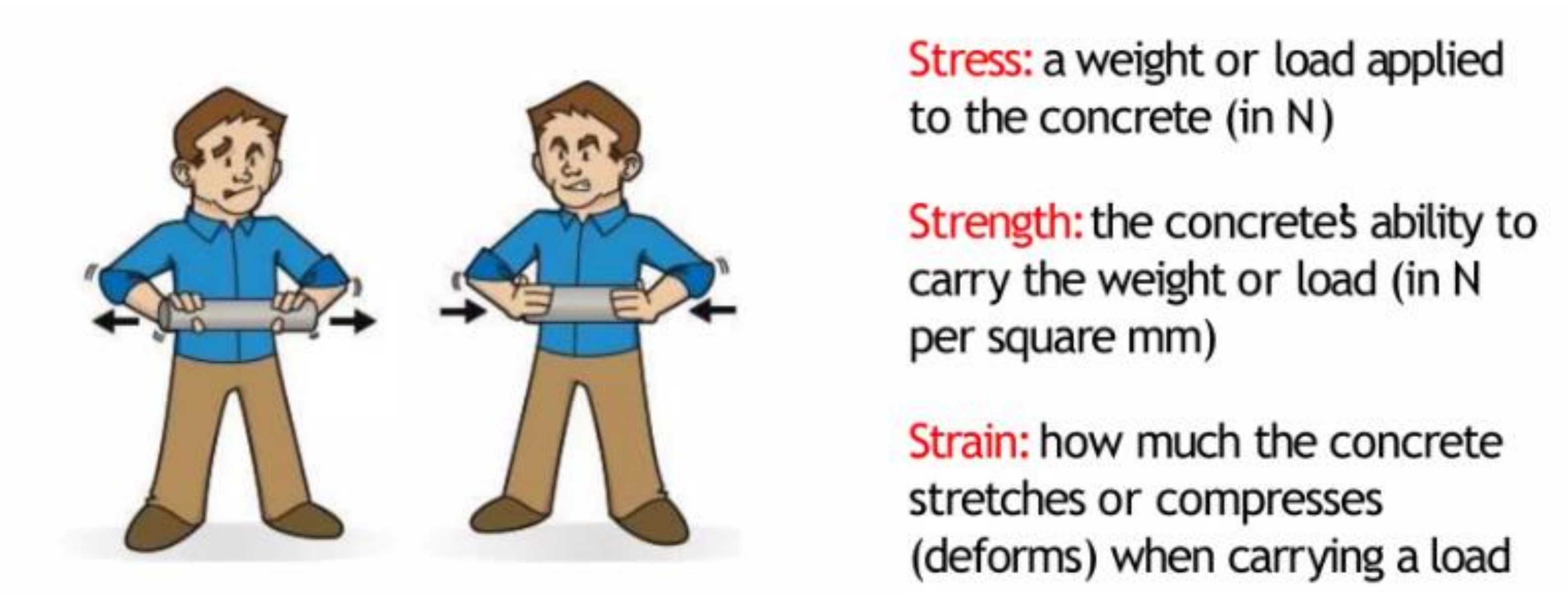
## PROPERTIES OF HARDENED CONCRETE

1. **Strength of concrete :** The primary measure of concrete's capacity to resist loads without failure.
2. **Shrinkage :** refers to volume reduction as concrete dries
3. **Creep :** describes the deformation under sustained load.
4. **Modulus of elasticity :** a measure of a material's stiffness, indicating its ability to resist deformation under stress.
5. **Durability :** The ability of concrete to withstand environmental conditions over time.

# <u>1- Strength of Concrete</u>

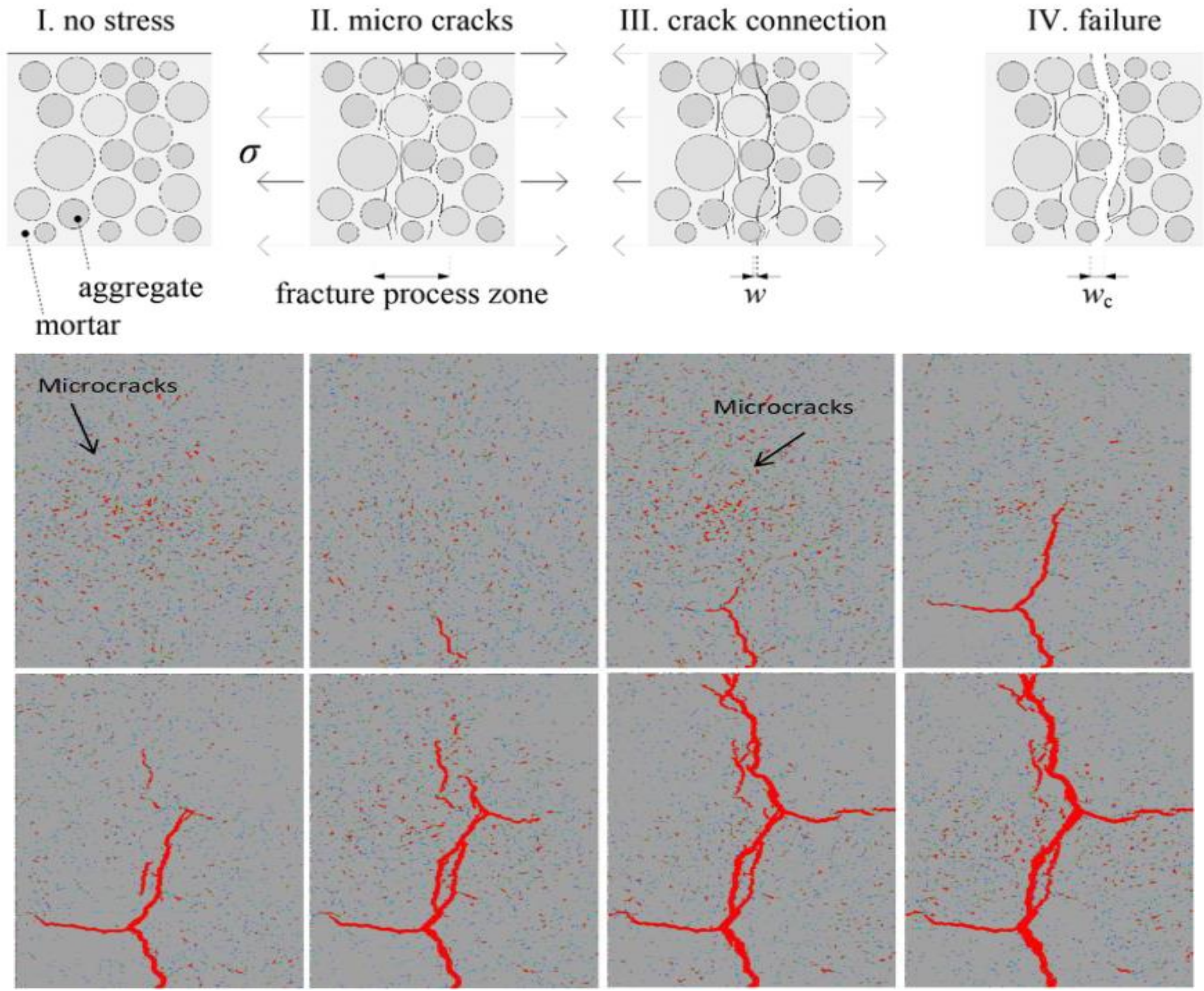
The strength of concrete is commonly considered its most valuable property of concrete. Nevertheless, strength usually gives an overall picture of the quality of concrete because strength is directly related to the structure of the hydrated cement paste. Moreover, the strength of concrete is almost invariably a vital element of structural design and is specified for compliance purposes.

- Strength of concrete is *the ultimate load that causes failure (or is its resistance to rupture)* and its units are force units divided by area ($N/mm^2$ = Mpa).



# Fracture and Failure

- Concrete specimens subjected to any state of stress can support loads of up to 40-60% of ultimate without any apparent signs of distress.
- Below this level, any sustained load results in creep strain which is proportional to the applied stress and can be defined in terms of specific creep (i.e. creep strain per unit stress).
- As the load is increased above this level, soft but distinct noises of internal disruption can be heard until, at about 70- 90% of ultimate, small fissures or cracks appear on the surface.
- At ultimate load and beyond; the specimens are increasingly disrupted and eventually fractured into a large number of separate pieces.
- The formation and propagation of small microscopic 2-5 cracks μm long (microcracks) have long been recognized as the causes of fracture and failure of concrete and the marked non-linearity of the stress–strain curve near and beyond ultimate.


I. no stress
II. micro cracks
III. crack connection
IV. failure
σ
aggregate
mortar
fracture process zone
w
w_c
Microcracks
Microcracks

## The stages of cracking (fracture) in concrete:

There appear to be at least **three stages** in the cracking process:

***Stage I*:** Even before loading, intrinsic volume changes in concrete due to shrinkage or thermal movements can cause strain concentrations at the aggregate– paste interface. Within this stage localized cracks are initiated at the microscopic level at isolated points throughout the specimen where the tensile strain concentration is the largest. This shows **that these cracks are stable and, at this load stage, do not propagate.**

***Stage II*:** As the applied load is increased beyond Stage I, initially **stable cracks begin to propagate**. There will not be a clear distinction between Stages I and II since stable crack initiation is likely to overlap crack propagation and there will be gradual transition from one stage to another. During Stage II the crack system multiplies and propagates but in a slow stable manner in the sense that, if loading is stopped and the stress level remains constant propagation ceases. The extent of the stable crack propagation stage will depend markedly upon the applied state of stress, being very short for ‘brittle’ fractures under predominantly tensile stress states and longer for more ‘plastic’ fractures under predominantly compressive states of stress.

***__Stage III__*****:** This occurs when, under load, the crack system has developed to such a stage that it becomes **unstable** and the release of strain energy is sufficient to make **the cracks self-propagate until complete disruption and failure occurs**. Once Stage III is reached failure will occur whether or not the stress is increased. This stage starts at about 70–90 per cent of ultimate stress and is reflected in an overall expansion of the structure as signified by a reversal in the volume change behavior. As stated above, the load stage at which this occurs corresponds approximately to the long-term strength of concrete.