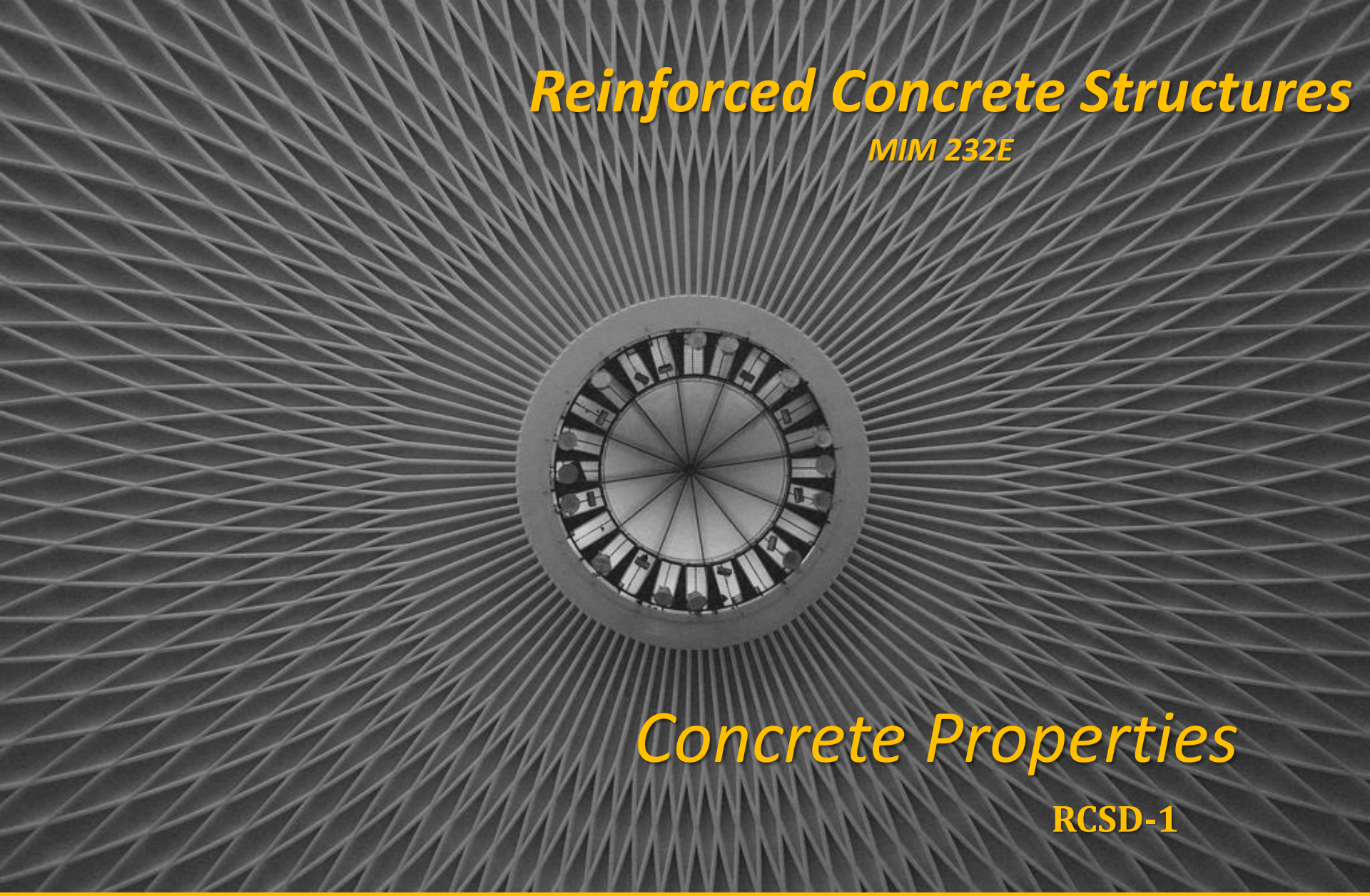

Reinforced Concrete Structures

MIM 232E

Concrete Properties

RCSD-1

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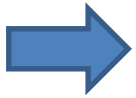
Concrete

Properties

- Concrete is a composite material (cement+aggregate (sand + gravels + crushed stones) + water+chemicals)
- Concrete is plastic when it is wet  Formability
- ~10 hour setting time; reaches high compressive strength
- High compressive strength & quite low tensile strength

Properties

- Concrete : Cement+ water+aggregate+ chem.additives

	1 m^3 concrete(vol.)
cement	%10
Aggregate (sand+gravel, crushed stone etc.)	%70
water	%20

- 1 m^3 concrete (~2500kgs)

  - %0.5-5 air, additive for a purpose (%0.5-2 of cement)

Cement

- TS EN 197-1/2002

- Function: reaction with water,
  covering aggregates,
  filling the voids between pieces and binding them each other
- Cement may be produced for various purposes (heat, impermeability, etc.)

- It is selected depend on structure dimension and qualification

TS EN 197-1/2004

CEM I → *Portland cement*

CEM II

CEM III

CEM IV

CEM V

Cement

- Usually originates from limestone
- Main material of cement is clinker
- CEM I (clinker used; 95-100%) ---------Portland cement (most common)

Portland Cement

- Mixing limestone and kiln
- heat up with 1300 ~ 1500^{o}C and grinding the clinker
- 70% of final strength in 28 days
- Some types; Normal Portland cement (NPÇ 350)
  High strength Portland Cement (YPÇ 500)
  High initial strength Portland Cement (İPÇ 600)

Cement

Compressive strength and setting time;

- Rapid early strength R
- Normal early strength N

Strength Class	strength (N/mm^2)			Setting initiation (min)	Setting time (hour)
	2 days	7 days	28 days		
32,5N	-	≥ 16,0	≥ 32,5	≥ 75	10
32,5 R	≥ 10,0	-			
42,5N	≥ 10,0	-	≥ 42,5	≥ 60	10
42,5 R	≥ 20,0	-			
52,5N	≥ 20,0	-	≥ 52,5	≥ 45	6
52,5 R	≥ 30,0	-			

Water

- TS EN 1008/2003
- Function:

  İnitiating and sustaining chemical reaction

  Providing formable/flowing consistency to concrete
- In concrete;

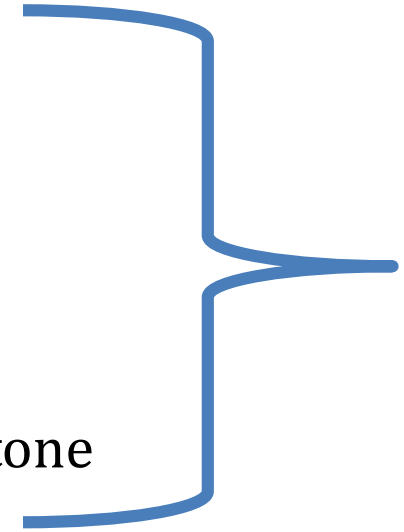
  -Salty, acidic, oily, dirty water is **not used**

  - Sea water is not allowed

Concrete components

Aggregate

- Aggregate TS 706 EN 12620/2003
- Sand + Gravel
- Sand + Crushed stone
- Sand + Gravel+ Crushed stone



- Standarts and dimention ranges are available
- Sea water/gravel is **not allowed**.

Chemical admixtures

- Chemical admixtures is used for:
  - Increase some properties of concrete
  - Gaining to some properties to concrete

- Such as;
  - Mitigation of setting time
  - Increase the strength (by reducing water)
  - Preventing freezing
  - Preventing corrosion etc.

Concepts

- Cement content: Cement amount in $1m^3$ concrete (kgs)

  - Common, 300

- Water/cement ratio: the ratio of water to cement in $1m^3$ concrete
  - the most important factor on strength
  - commonly, 0.40~0.55

- Consistency: formability of wet concrete

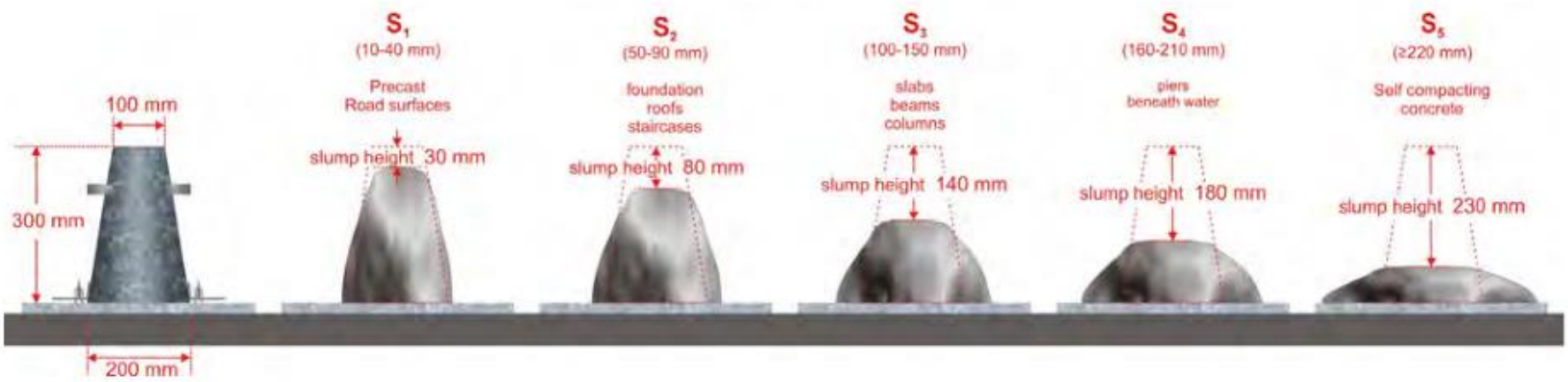
  SLUMP experiment

  Depends on structure type

Concepts

After a defined limit, the more water the concrete mixture contains, the less its strength and the higher its porosity. Apart from its strength, the concrete is also characterized by its workability. This defines the amount of the water that is going to be used for the production of the mixture. The slump height is the workability criterion of concrete.

A specific value of slump height is suggested, ddepending on the use of the concrete mixture, as shown in the following picture.



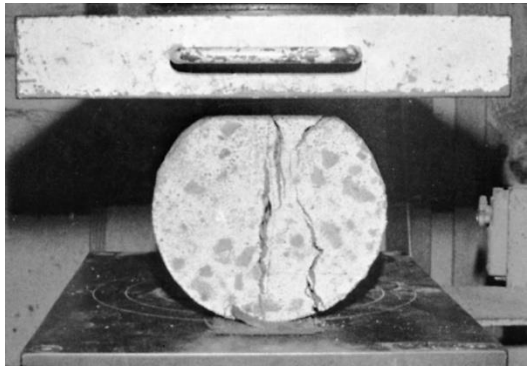
Concepts

- **Compressive Strength**

  The maximum stress that can be carried by 28 days 15cmx30cm standard cylinder concrete sample under axial compression

- **Tensile Strength:**

  The stress that causes the cracking of concrete



General

Dalgıç vibratör

Dalgıç vibratör uygulaması

Transporting, casting/pouring, compacting

- Transmixer, concrete pump, wheelborrow
- Compacting by vibrator (types...)
  - Benefits
    - Omits the voids, increase the strength
    - Enhanced the adherence
    - Concrete become more durable againist env. Effects.

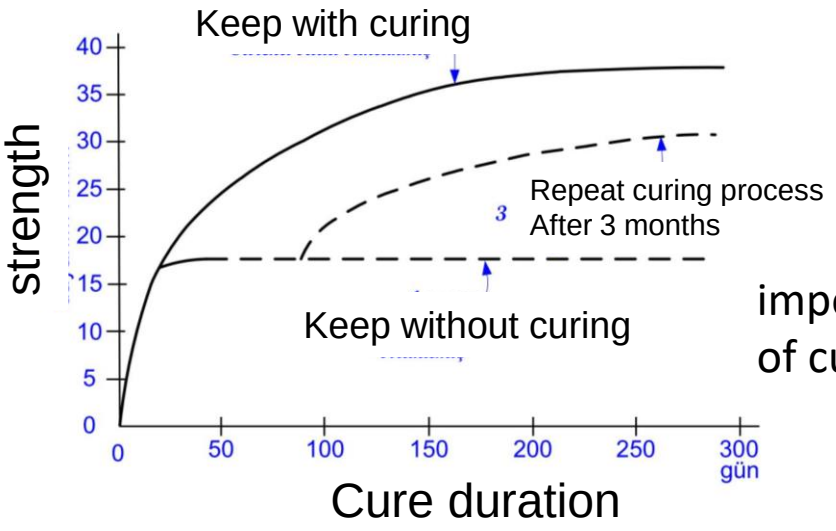
- Concrete pouring is completed without having a break.
  If needed, jointings 45^0 and with rough surface

General

Cure

- Ideal temperature 20-25^{0}C
- attentive cure for desired strength
- Excessively low and high temperature decreases the strength
- Pouring, +5C~+32C

Without curing, the strength remains smaller



importance of cure

General

Formwork- Scaffold

- must be able to carry the wet concrete
- Brace/diagonals for horizontal loads
- Resistance to vibrator
- Saturating the formwork to water before casting etc.

Yeterli çapraz eleman olmaması nedeniyle kalıp göçmesi

Removing the formwork

The following table presents the minimum time requirements before removing the formwork. It regards typical constructions for usual temperatures:

Constructional elements	*Cement strength category*		
	32.5	42.5	52.5
Lateral sides of beams', slabs', columns', shear walls' formworks	3 days	2 days	2 days
Slabs' formworks and beam span form-works when the span is lesser than 5 m	8 days	5 days	4 days
Slabs' formworks and beam span form-works when span is equal to or greater than 5 m	16 days	10 days	8 days
Safety columns of frame beams and slabs with a span greater than 5 m	28 days	28 days	22 days

Factors on concrete strength

- W/C ratio
- Cement type, content, strength
- Aggregate properties
- Water quality
- Chemical admixtures
- Compacting quality
- Environmental effects
- Curing quality

Classification TS500/2000

- Low strength concrete for non-loadbearing members, reinforced or non-reinforced

- C16, C18, C20, C25, C30, C35, C40, C45, C50

Reinforced, normal class strength (TS500)

- C55, C60, C70, C80, C90, C100

Reinforced, high class strength (not defined in TS500)

For Loadbearing members

Sort by weight per unit of volume	W (kgs/m^3)
Light weight concrete	800-2000
Normal weigth concrete	2000-2600
Heavyweigth concrete	>2600

Others:

- High performance concrete (rapid early strength)
- Self-compacting concrete
- light transmitting concrete LiTraCon

Self-compacting concrete

The science dealing with construction materials has created a new type of concrete, the self-compacting or self-consolidating concrete which is ideal for earthquake resistant structures that have narrow spaced reinforcement. It is a kind of 'gravel-concrete' (with aggregates ranging from 12 to 16 mm). It contains 4th generation plasticizers and has a strength equal or greater than C25/30. Its slump height is far greater than the S_5 class (therefore its workability is determined by the spread test). It literally flows inside the formwork and it does not need vibration!

Mechanical Properties

TS500/2000

$$E_{cj} = 3250\sqrt{f_{ckj}} + 14000 \ \text{N/mm}^2$$

$$f_{ctk} = 0.35\sqrt{f_{ck}} \ \text{N/mm}^2$$

$$G_{cj} = \frac{E_{cj}}{2(1+\mu_c)}$$

$$\mu_c = 0.2$$

- **Characteristic concrete compressive strength (fck):**
  The strength anticipated in project.
  İt is tested after casting if it is ok ?

Tanımlar:

f_c	Concrete compresive strength
f_{ck}	Characteristic Concrete compresive strength
f_{ctk}	Characteristic Concrete tensile strength
E_c	Concrete modulus of elasticity
G_c	Concrete shear modulus
μ_c	Poisson ratio

j...(the value at j days)

Characteristic Strength

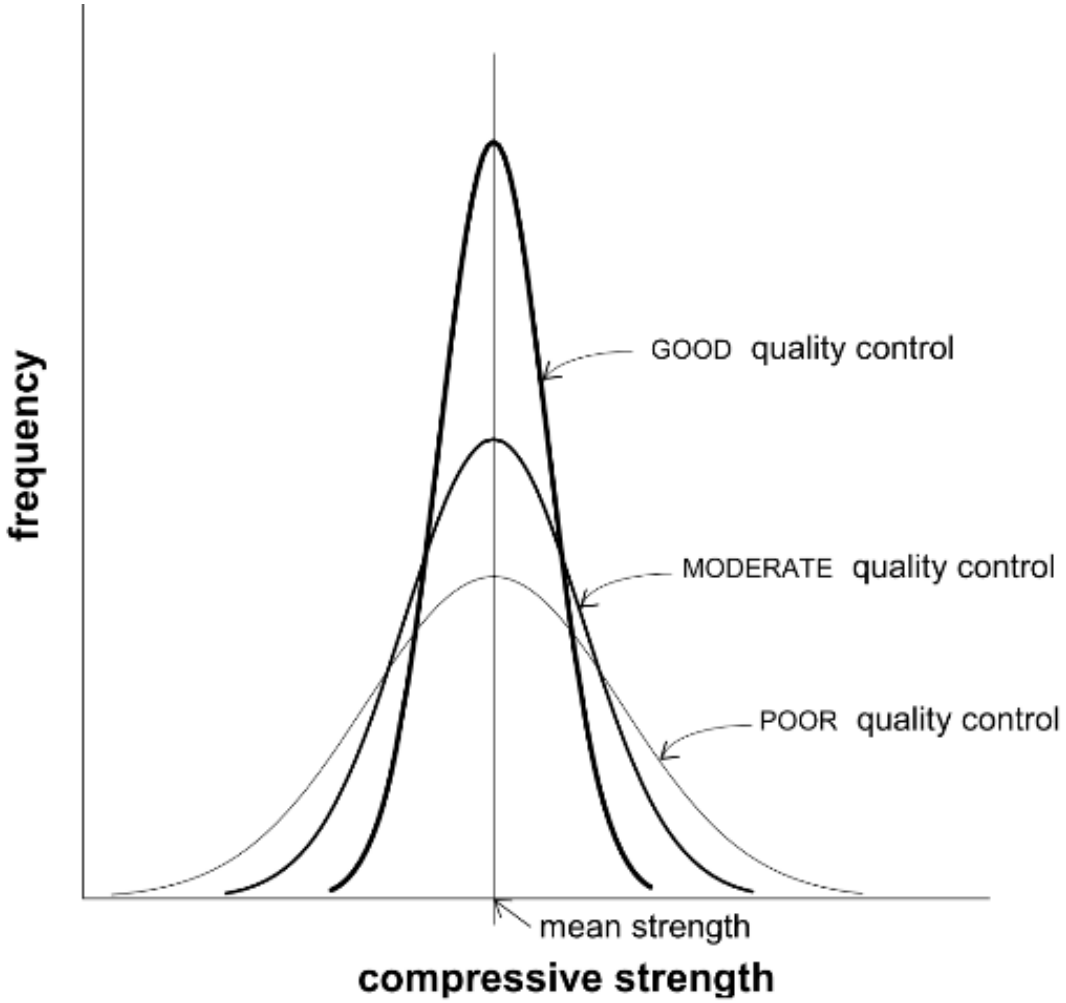


Fig. 2.4 Influence of quality control on the frequency distribution of concrete strength

"**Characteristic strength** is defined as the strength of material below which not more than 5 percent of the test results are expected to fall"

Characteristic Strength

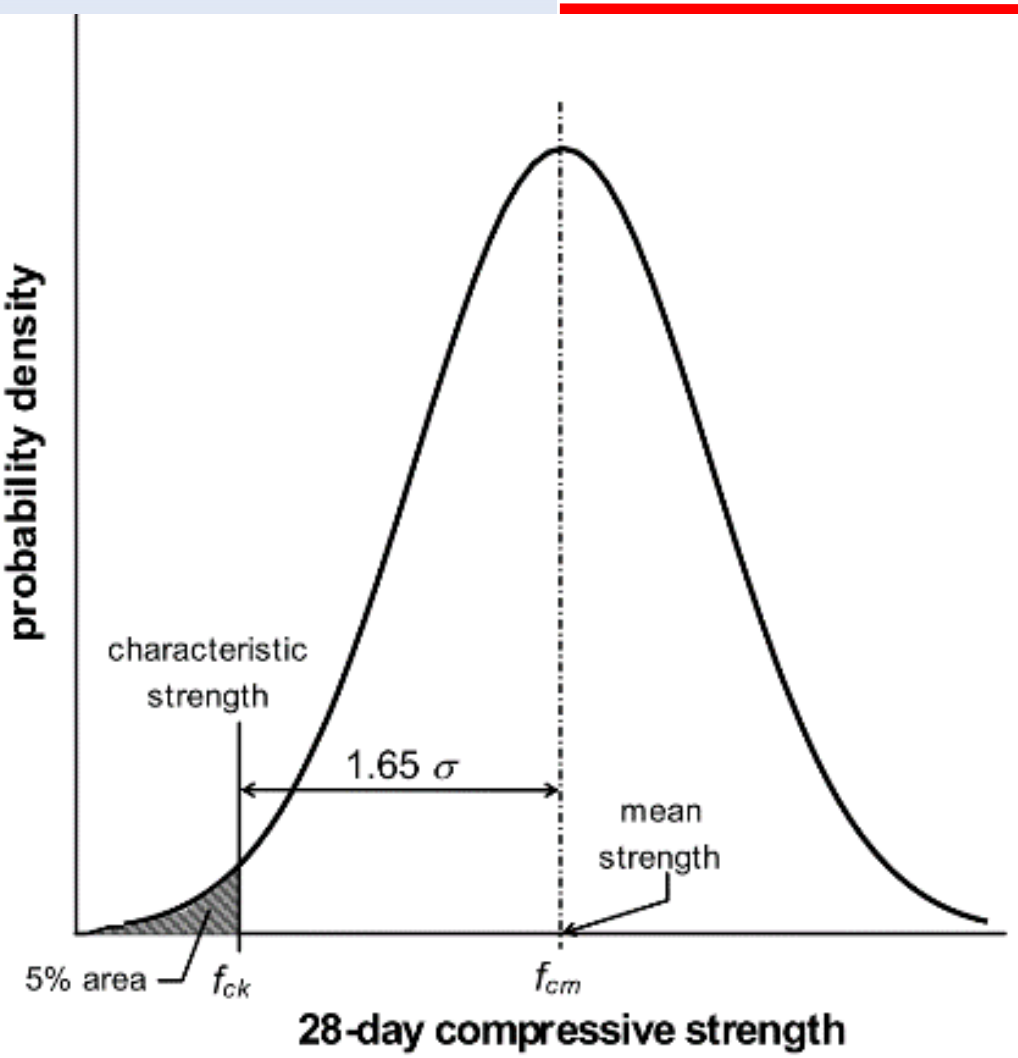
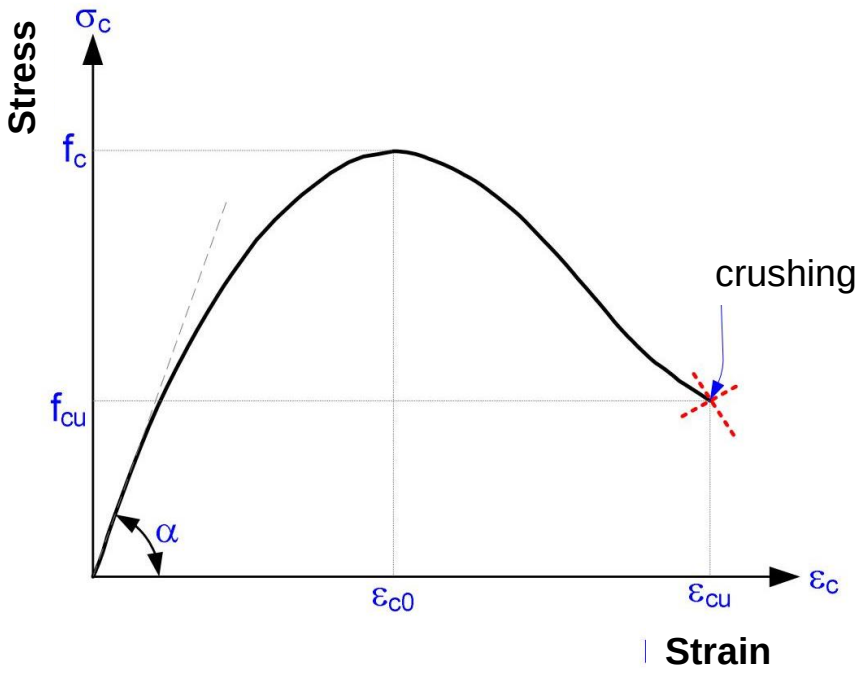


Fig. 2.5 Idealised normal distribution of concrete strength

Concrete

Concrete Stress-Strain (σ-ε) Relationship



fc : max. Stress (strength)
fcu: crushing stress

$E_c = \tan \alpha$ (modulus of elasticity of concrete)

Concrete also carry some amount of loads after the peak load up to a strain value. Then it reaches the ultimate strain and fails.

Concrete class and properties (TS500)

TS500 (Table 3.2)

Class	**fck** (characteristic concrete compressive strength) MPa	Equilevent cube (150mm) concrete strength MPa	**fctk** (characteristic concrete tensile strength) MPa	Modulus of elasticity (28 days) MPa
C16	16	20	1,4	27 000
C18	18	22	1,5	27 500
C20	20	25	1,6	28 000
C25	25	30	1,8	30 000
C30	30	37	1,9	32 000
C35	35	45	2,1	33 000
C40	40	50	2,2	34 000
C45	45	55	2,3	36 000
C50	50	60	2,5	37 000

concrete

↑

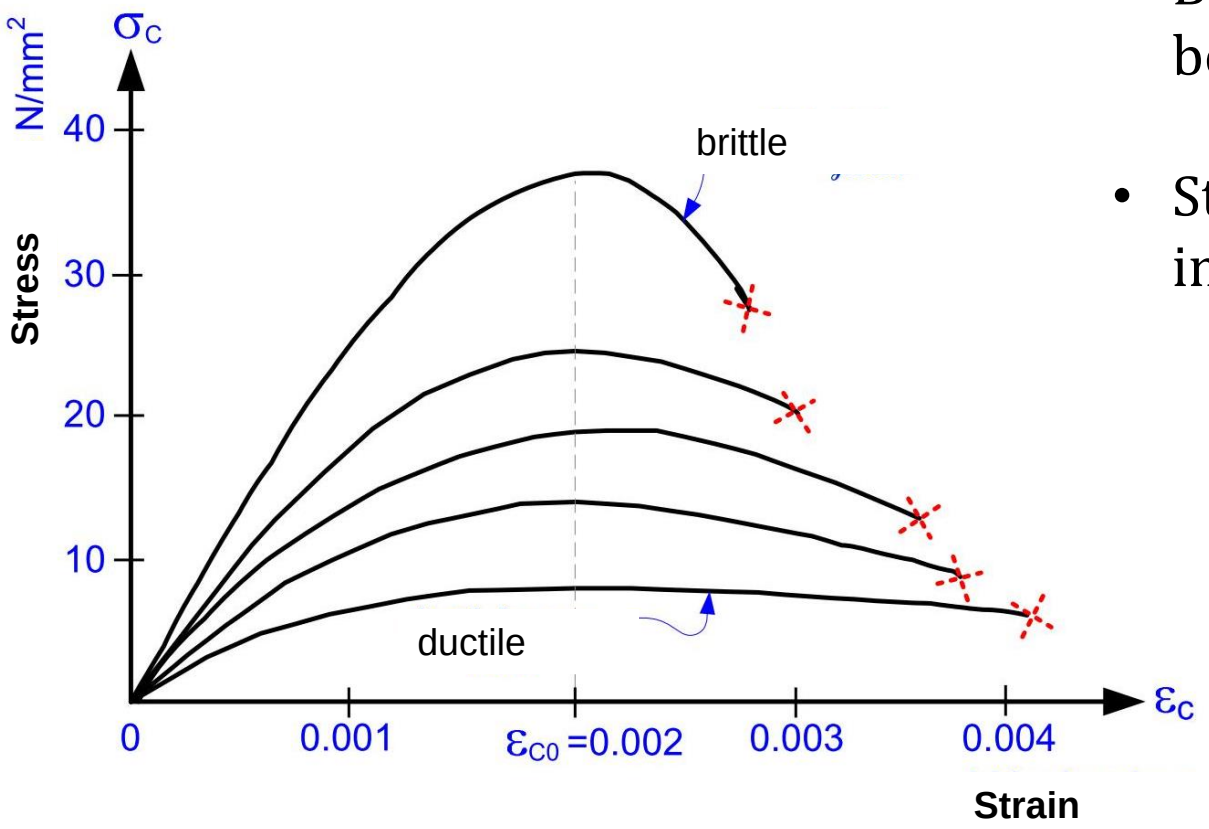
C25

↓

Characteristic concrete compressive strength (fck): 25 N/mm^2 (MPa) (28 days)

- Concrete; good in compression, poor in tension
- C20~30 widely used
- > C30 generally tall bldg./bridges etc.
- Min. C20 in EQ zones

Stress-Strain (σ-ε) Relationship due to strength



- Brittle & ductile behavior
- Strength & ductility in inverse ratio

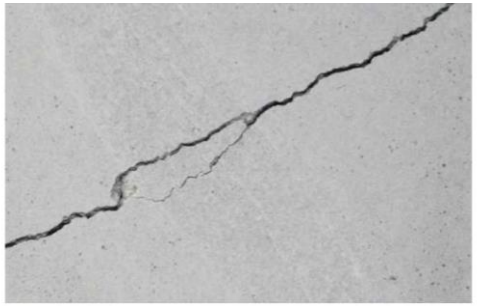
Concrete

shrinkage

- W/C ratio for hydration is 0.25;
  more water is for workability

- Remained water evaporates and concrete volume decreases. Even without loading, shortening deformation and cracking occur and this phenomenia is called as shrinkage.

- To omit/reduce; cure , (wet)



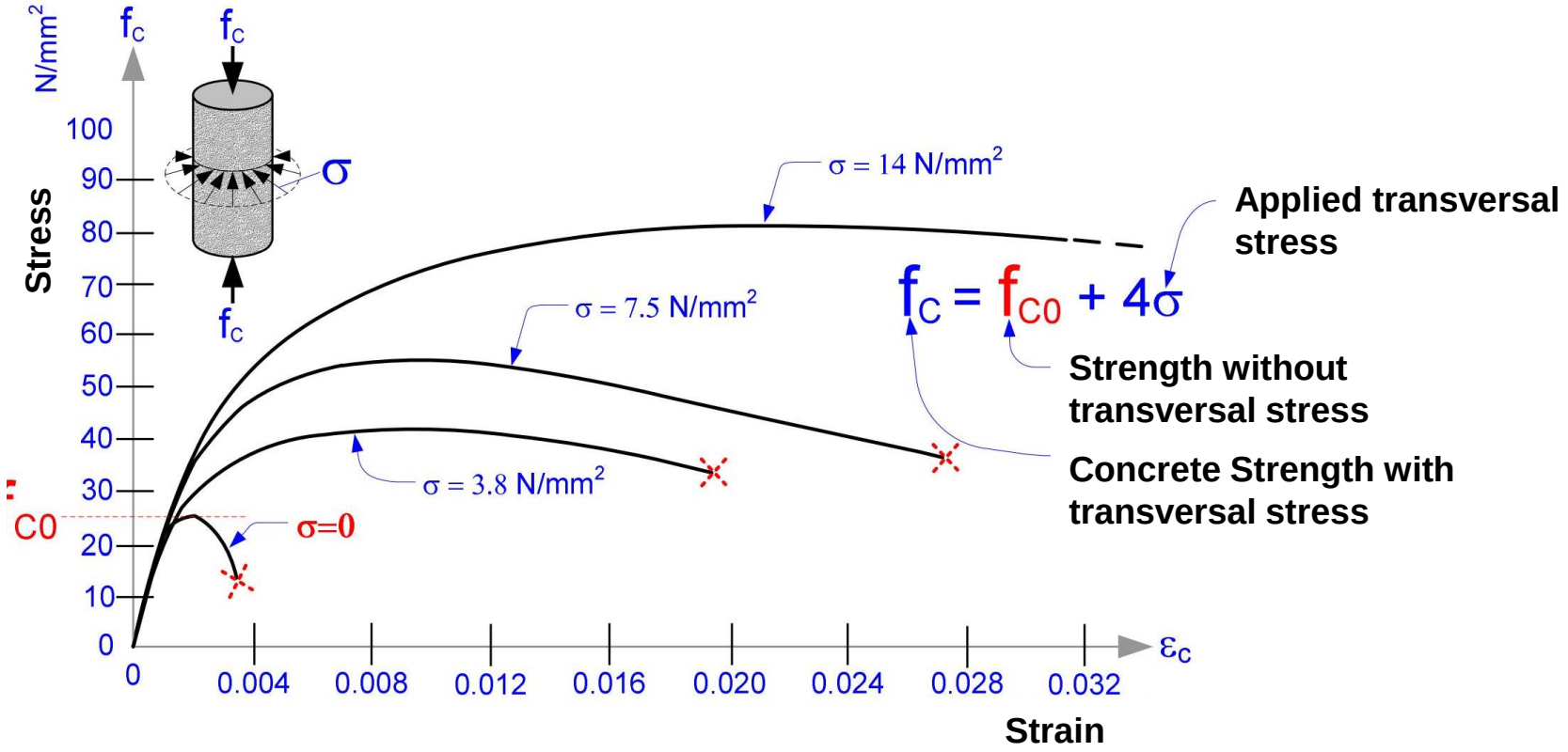
http://mmf2.ogu.edu.tr/atopcu/index.htm

Creep

- **Creep :** Increase of shortening in concrete under constant loading.
- Under compression, water is put out, voids become smaller and deformations occur.
- Shrinkage and creep amount increases in poorly compacted /cured concrete.

Confinement effect

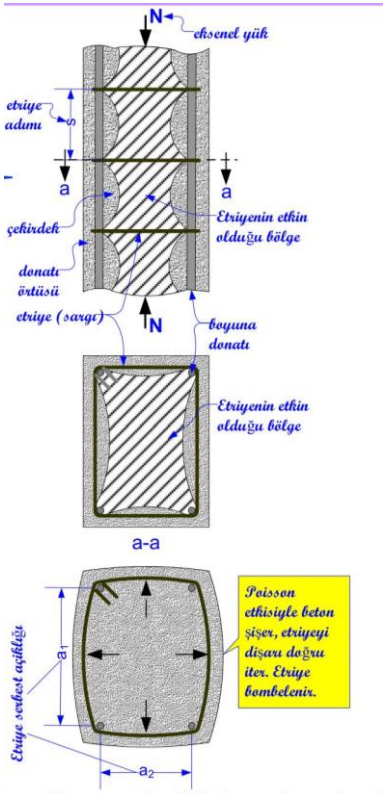
- Behavior under triaxial stress



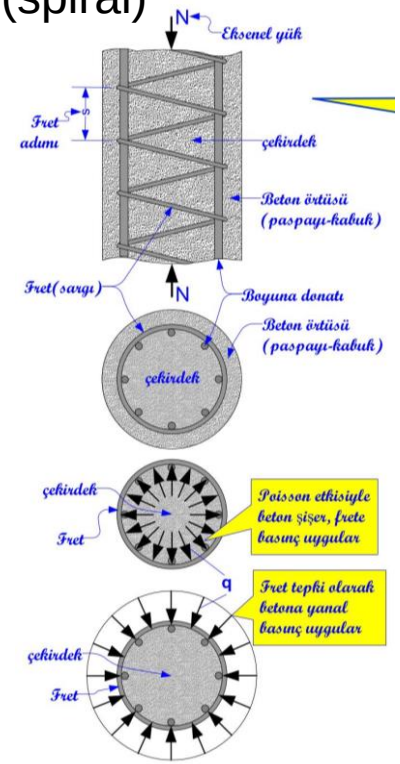
- Due to increase of lateral pressure, deformation capacity, load carrying capaciti and ductility increases.

Confinement effect in RC Column

Column with Stirrup



Column with fret (spiral)

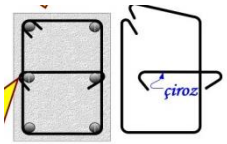


Confinement applies lateral pressure to column;
Strength and ductility increase

Most efficient: Spiral reinforcement

Spacings «s» ↘ ductility, strength ↗

Increase of the reinforcement area improves the behavior



Confinement effect in RC Column

- Confinement -stirrup-fret (spiral) - effect