# ENGINEERING MATERIALS FOR SUSTAINABILITY- CV0424

## UNIT – 2

## DEPARTMENT OF CIVIL ENGINEERING

# Concrete & its Basics

# What is concrete?

Ordinarily concrete is made by mixing an inorganic material known as cement with water together with natural sand or stone dusts and natural stones which may be crushed or uncrushed.

# Energy and $CO_2$ from concrete.

| Item (for precast conc) | $CO_2$kg/kg | % |
|---|---|---|
| Cement | 0.095 | 62.7 |
| Admixture | 0.002 | 1.2 |
| Rebar & metal | 0.012 | 7.9 |
| Insulation | 0.002 | 1.4 |
| Aggregates | 0.003 | 1.7 |
| Production | 0.025 | 16.2 |
| Transport | 0.013 | 8.7 |

# Energy and $co_2$ from concrete

| Type of Plant | Energy MJ/$m^3$ Range(Average) |
|---|---|
| Concrete Element Plant | 400-1700 (790 ) |
| Ready mix | 160-700 (520 ) |
| Concrete Product Plants | 200-700 (350 ) |
| Multi Product Plants | 300-1500 (580 ) |

# Modern composite concerte

Modern concrete have addiditional ingredients other than the four components mentioned earlier

- Chemical admixture:accelerators, set retarders,water reducers,etc

- Mineral admixture:fly ash,silicafume,rice husk ash and other pozzolana.

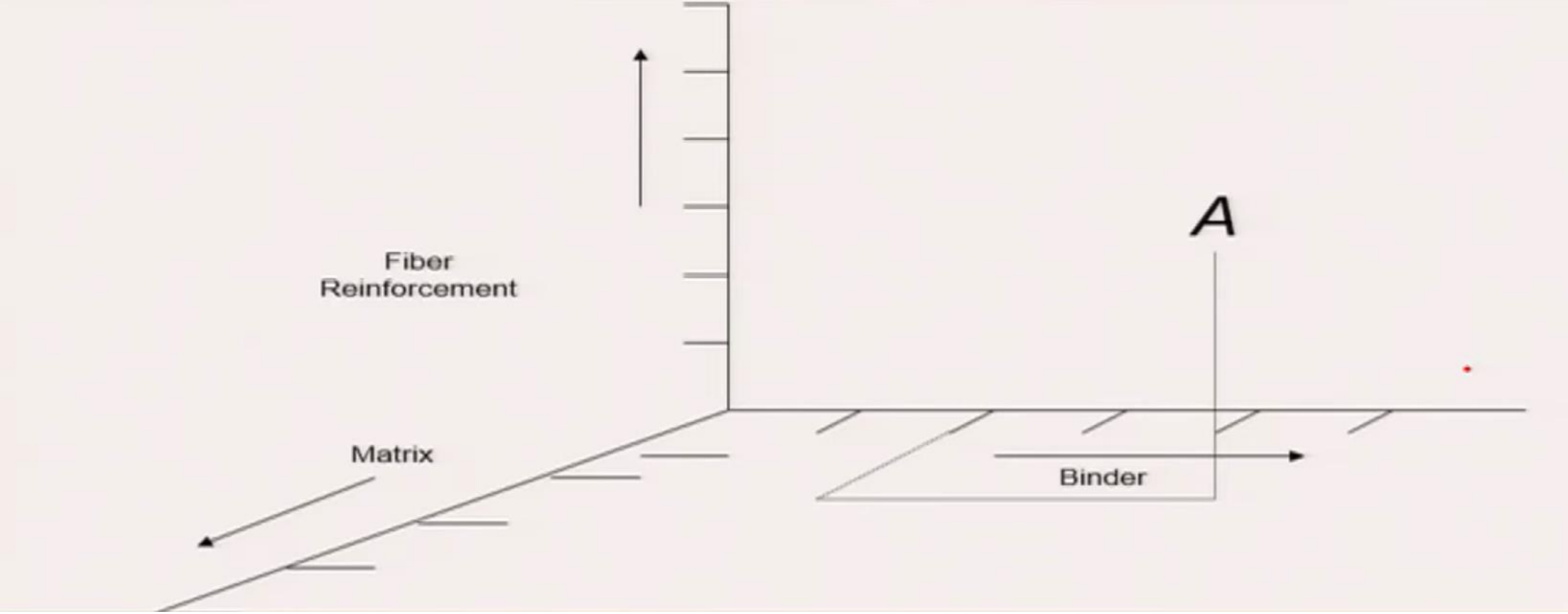
# Modern concrete and composite

- Normal strength Concrete
- High strength/performance concrete
- Ultra high strength concrete
- Fiber Reinforced Concrete.
- Densified with small particle (DSP)
- Macro Defect Free (MDF) Matrix
- Reactive Powder Concrete (RPC)
- Polymer Concrete (PC)
- Polymer cement concrete

# Modern concrete summary

- Geo-polymer concrete
- High volume fly ash concrete
- Roller Compacted Concrete
- Self compacting concrete

# Concrete composite



# High volume fly ash concrete

- Percentage of fly ash 50-60% of cementitious materials.
- Use of super plasticizer.
- Low w/c (0.32 for 60% or 0.45 for 50%)
- Low early strength
- Good long term strength  and durability

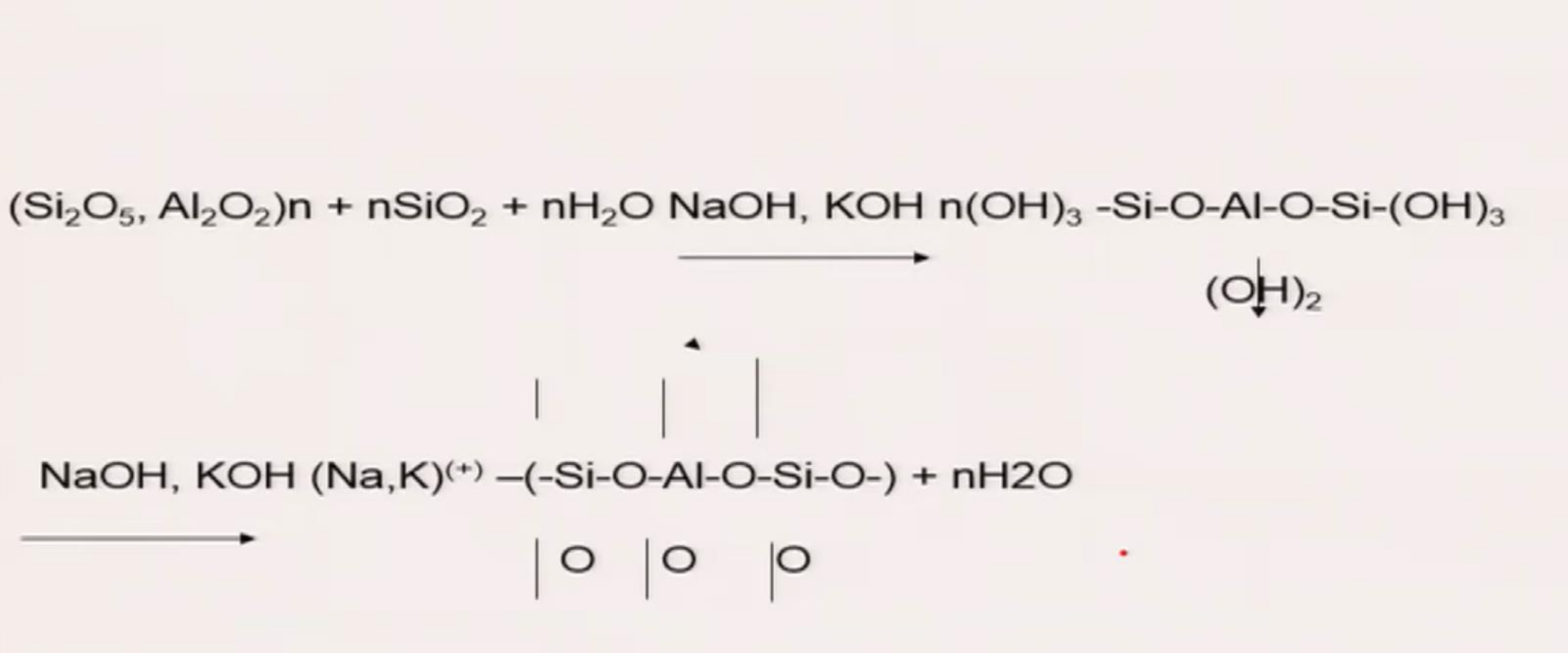
# Roller compacted concrete

- Very low consistency represented by no slump condition
- Compacted earth or rock-fill construction equipment
- Compaction and water content governs strength rather than w/c ratio
- Vibratory roller
- Shall be dry enough to support roller and wet enough to have uniform distribution of paste

# Geo-polymer concrete

- Reaction of alumino silicates with alkali poly silicates.
- Utilizes poly condensation of silica and alumina and high alkali content for strength
- Curing temperature 60°C or so.

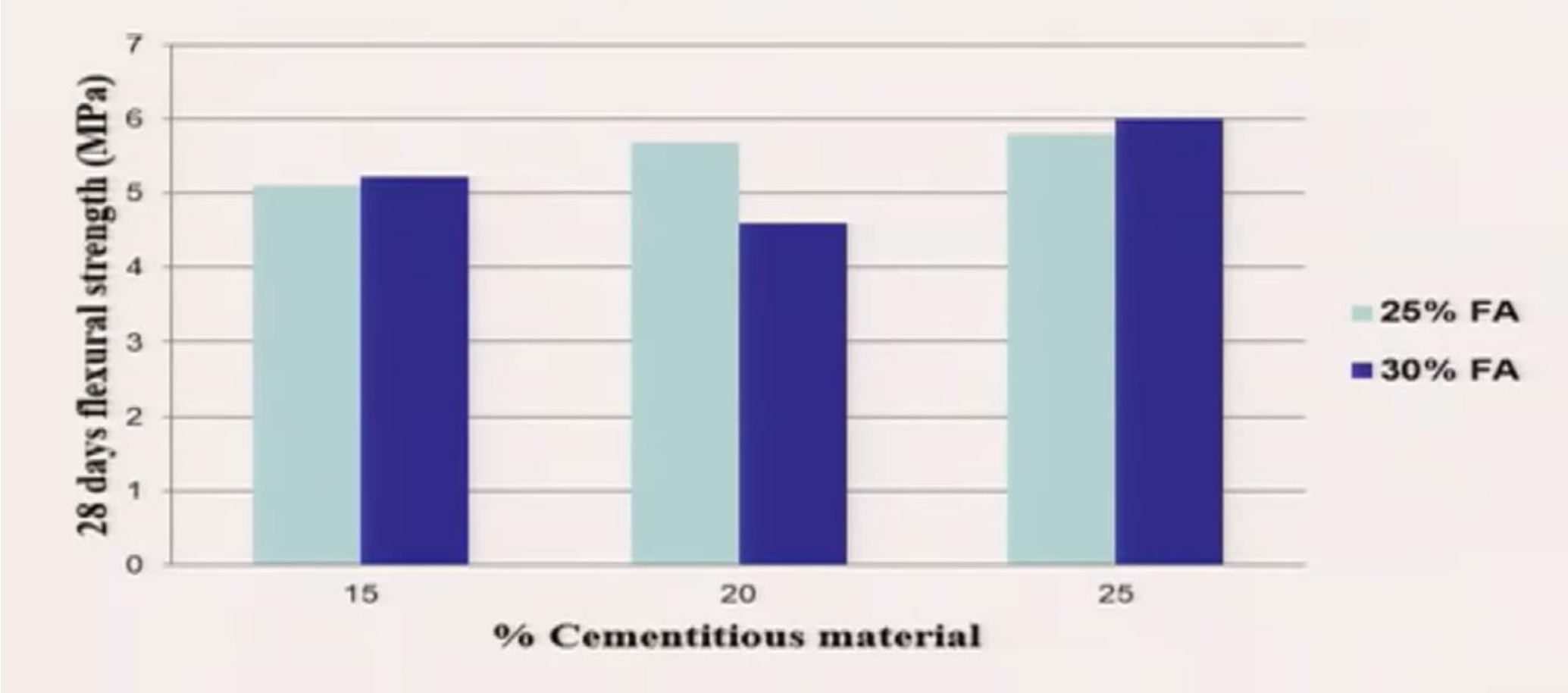
# Geo-polymer concrete



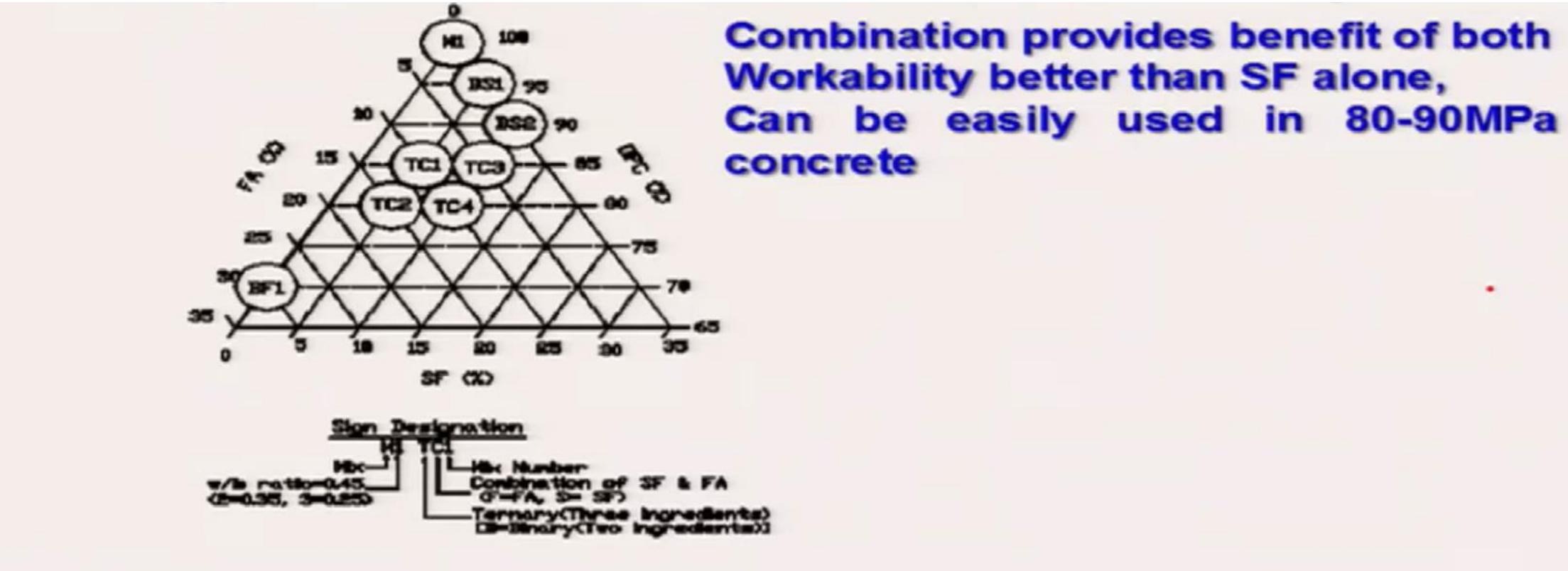
# Geo-polymer concrete

**Materials Mixture-1 20 mm: 277**
**Coarse 14 mm:370**
**aggregates: 7 mm: 647**
**Fine sand: 554**
**Fly ash (low-calcium ASTM Class F) 408**
**Sodium silicate solution( $SiO_2/Na_2O$=2) 103**
**Sodium hydroxide solution 41 (8M) (14M)**
**Super Plasticiser 6 6**
**Extra water 0 22.5**

# Less explored avenue: Pavement(RCC)



# Less explored avenue: SF+FA in High strength Concrete

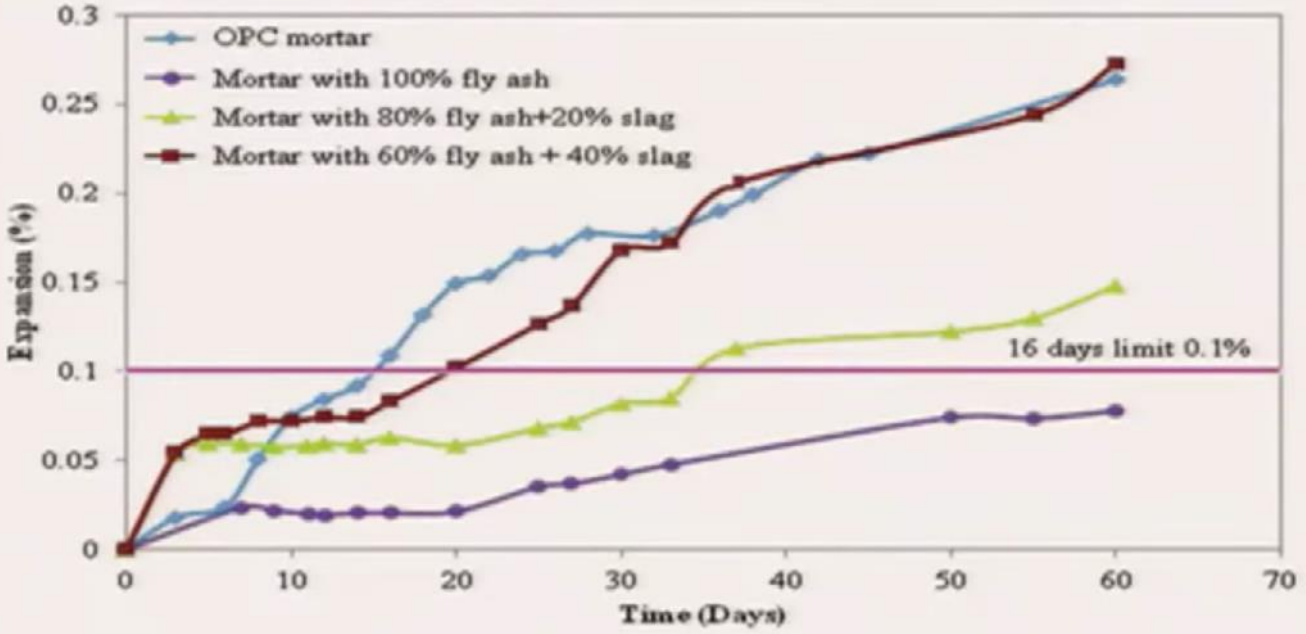


# Less explored avenue: FA+NS

- Nano-Sillica can enhance hydration reaction 2-3% by mass of cementitious/cement inproves several properties
- 1 day, 3 days etc strength improves

# Less explored avenue: FA+GGBFS Geo-Polymer

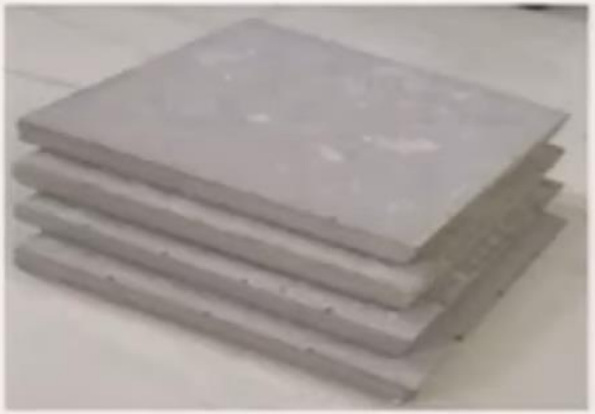
**Nor mal Temperature (up 40 °C) curing.**
**" 100% Clinker replacement**
**" Durable Product**
**AAR results**



# Less explored avenue: Geo-polymer block

Solid bricks

Foamed bricks



Concrete with EPS beads

In-situ Geopolymer foam

# High strength concrete(HSC) & High performance concrete(HPC)

**Paste Strength as high as 276 MPa was obtained in 1930 (w/c=0.08)**

**Max concrete strength: 40 MPa- till 1970**

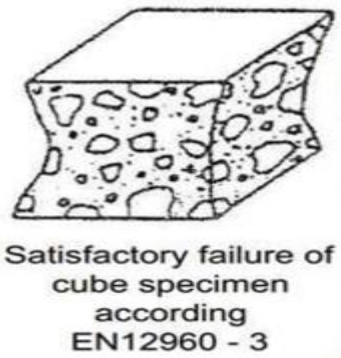
**Present day definitions**

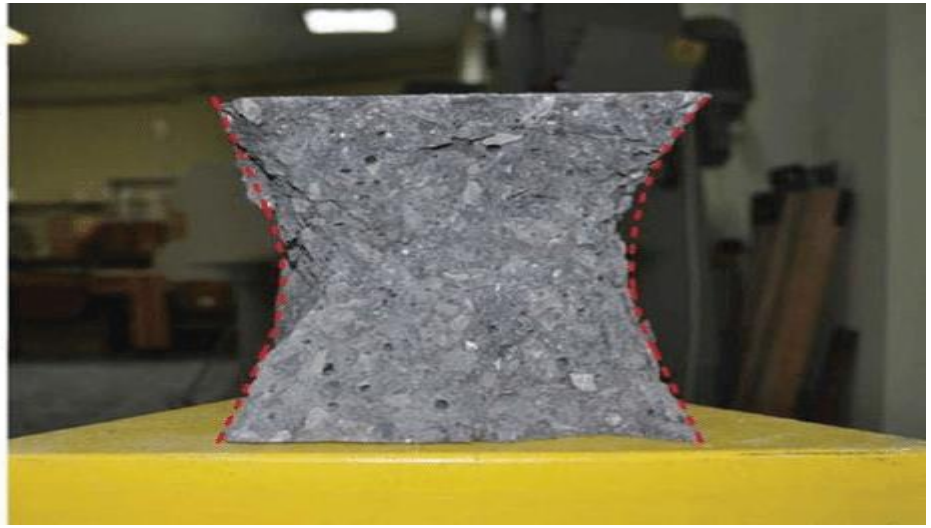
- **$f_{28} \geq$ 60 MPa, M60 $\rightarrow$80MPa HSC**
- **$f_{28} \geq$ 120 MPa, VHSC**
- **HPC – A set of specified requirements to be satisfied, e.g. SCC**

# Recycled aggregates – ITZ and processing

# Uni-axial compression failure of cube

- Failure always occur with the normal strength concrete
- Failure always occur at the aggregate mortar interface



- Failure through aggregate boundry rather than through them multiple visible cracks

# Pores in cement based materials

- Gel pores: micro pores(0.5nm-100nm) (Shrinkage & creep)
- Capillary meso pores(5nm-5000nm)(Mechanical & Durability)
- Macro pores due to air entrainment
- Macro pores due to poor compaction

## In concrete additional Pores at ITZ

- Wall effect
- One sided hydration growth
- Shrinkage
- Trapping of bleeding water

# ITZ porosity

- The strength of concrete is governed by ITZ, up to about 70% of ultimate load cracking is largely due to ITZ crack
- ITZ is extends to about 30 μm from aggregate surface

# Porosity in concrete

- Bulk porosity and pore sizes are governed by w/c
- ITZ porosity is more and pore sizes are larger are governed by w/c
- Hence concrete again follows Abraham’s Law

# Aggregate processing


<Demolition>


<Collection>

<Jaw Crushing>

<Single Jaw Crushing>


<Separation>

<

<Cone Crushing>


<2nd Separating Scree>

<Roll Crushing>

<Fine Particles Oil Separator>

<Air Blow Separator>

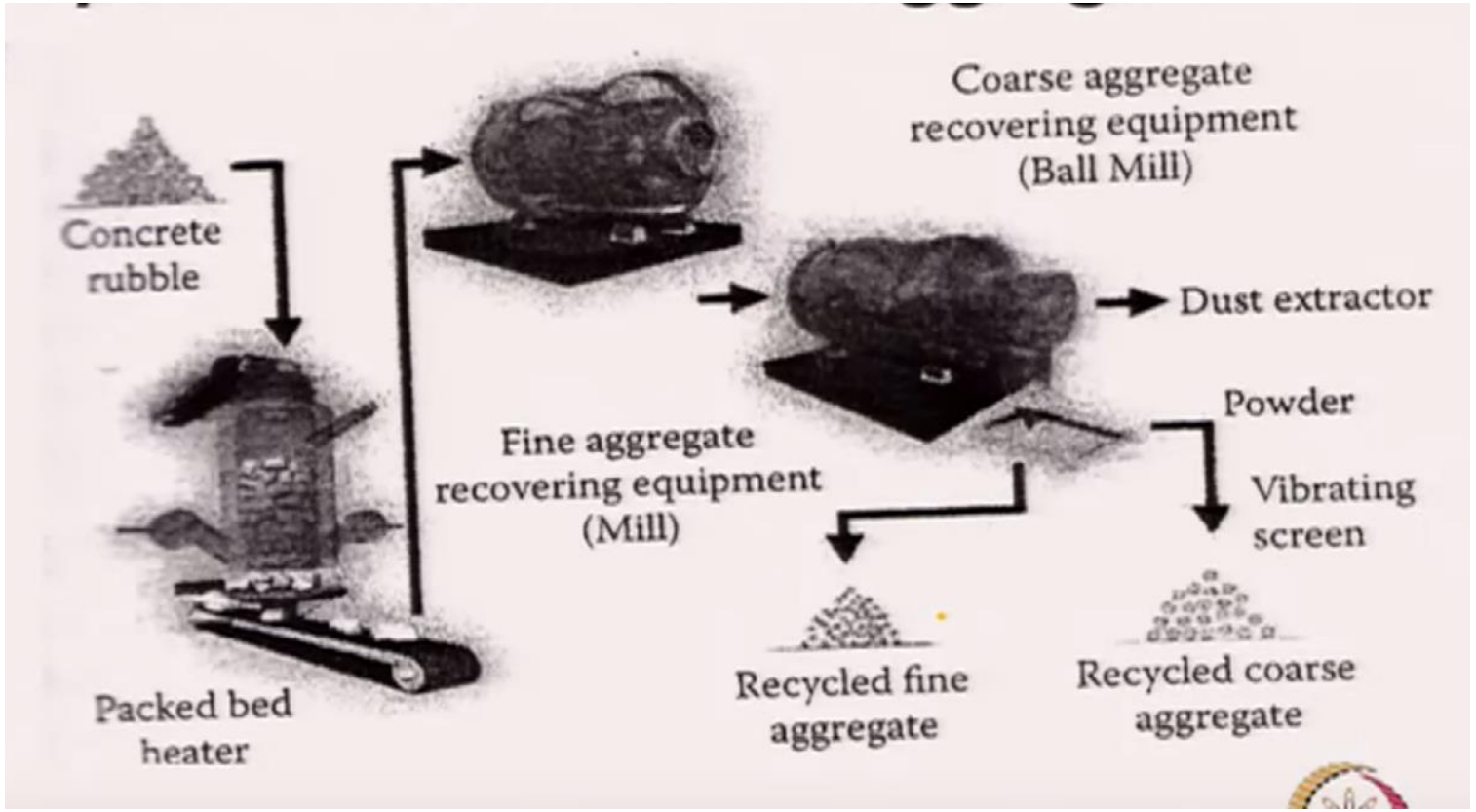
<Magnetic Selector>

<Recycled Aggregate>

# Processing (Japan)

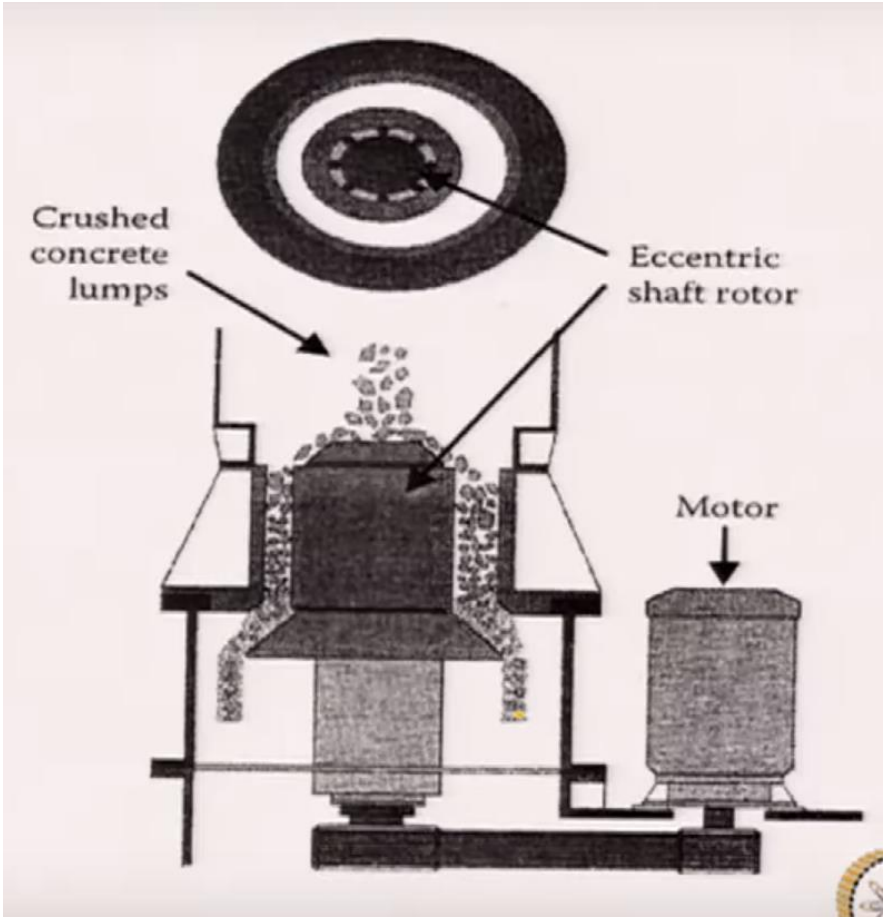
Heating & rubbing: Concrete masses are heated at 300 °C in a Packed bed heater and paste concrete is weakened to remove Mortar and paste adhered to old aggregate.

Ball mill crushing is followed to recover & fine aggregate soil stabilization



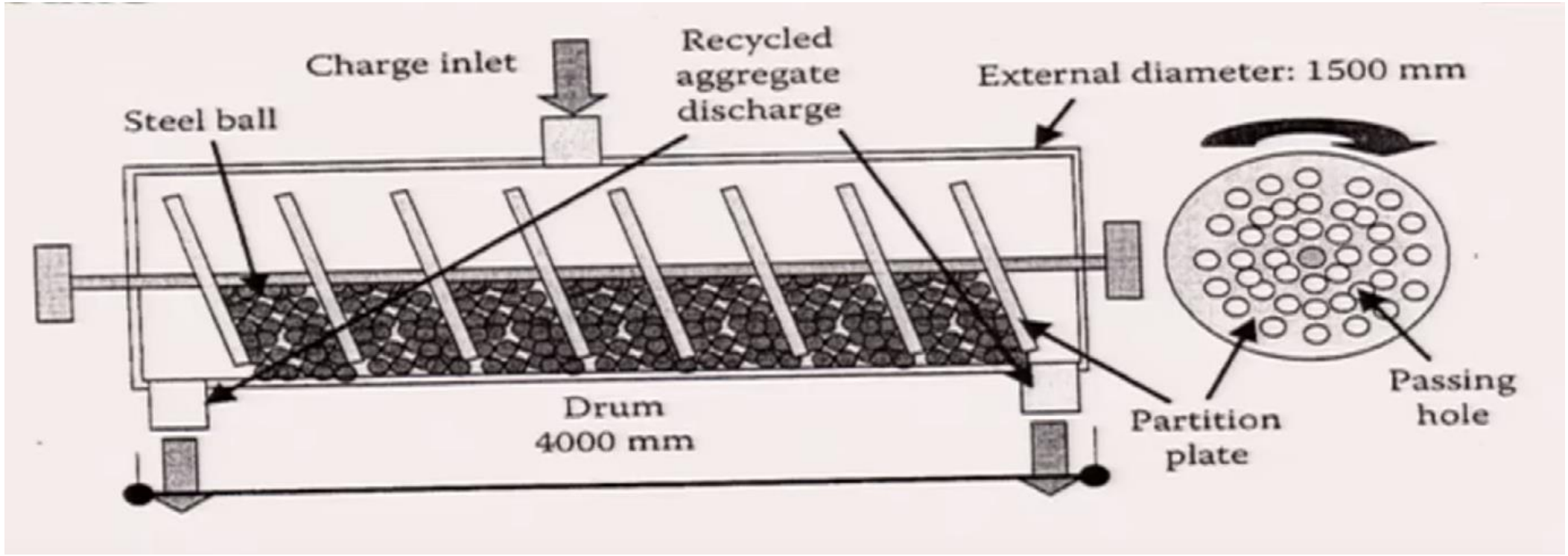
# Processing (Japan)

In the electric shaft rotor method, crushed concrete is passed downward between concentric inner and outer cylinder, the former rotates at high speed to produce a grinding effect to separate mortar from aggregate



# Processing (Japan)

In the mechanical grinding method coarse and fine aggregates are separated by small holes in partition plates placed at an angle with the center shaft in a horizontal rotating drum where grinding is done with steel balls



# Processing

- There is another method of heating up to 700 °C and expected have only 2% paste adhered after disintegration
- Energy required and consequent carbon emission will from process to process
- Heating obviously would mean more energy and carbon emission
- Use of other wastes:

  Road: poor quality concrete debris, asphalt

  wood, metals possible reuse if good.

Construction waste

Stockpiling

Sorting process

Excavation

Primary Crushing

Magnetic Separator

Secondary Crushing

Landfill

Waste includes Wood and paper

Steel Scrap

Manual Removing

Final aggregates (7, 10, 20mm aggregates 75mm rubble)

Screening

Water supply

# Aggregate classification Japan

| Aggregate | Class | Water absorption | Loss in weight | |
|---|---|---|---|---|
| Coarse aggregate | I | <3% | <12% | |
| | II | <3% | And | <40% |
| | II | Or <5% | and | <12% |
| | III | <7% | | - |
| Fine aggregate | I | <5% | | <10% |
| | II | <10% | | - |

# Allowable limits

| Material | % |
|---|---|
| Brick | 2-5 |
| Glass | 0.5-1 |
| Plaster | 0.1% |
| inorganic | 0.1-0.5 |
| plastic | 0.1-0.5 |
| Wood | 0.1-1 |
| Total | 1-6 |

# Aggregate classification EN (CDW)

| Constituent | Description | Category |
|---|---|---|
| $R_C$ | Concrete, and related material | $R_C$90(>90), 70,D, SR |
| $R_U$ +$R_C$ | Natural stone+Conc | $R_{CU}$90, 70,,50,D,SR |
| $R_A$ | Bituminious material | $R_A$ 1, (<1)etc |
| $R_B$ | Brick | < |
| $R_G$ | Glass | < |
| $FL_S$ | Floating stone | < |
| X | Others | < |

# RECYCLED AGGREGATES

# CONTENTS:

- Introduction
- What is RAC all about?
- Why RAC?
- Sources of RAC
- Characteristics
- Classification
- Process
- Application
- Merits
- Demerits
- Conclusion

# INTRODUCTION

- To achieve sustainability in the area of construction, researches and companies focus on using waste concrete as a new construction material. It is called recycled aggregate which can be produced by concrete crusher.

# WHAT IS RAC ABOUT?

- The aggregates that are derived from processing the materials previously used in a construction are called Recycled Aggregate Concrete (RAC).

# RECYCLED AGGREGATES

# Why RAC?

- Due to rapid urbanization and growth in population, the natural resources are depleting.
- The construction industry is facing issues due to the non-availability of good quality aggregates within reasonable distances.
- Good quality crushed aggregates cost more when compared to recycled aggregates.

# Why RAC?

- An enormous increase in the quantity of waste materials and shortage of dumping sites.
- Shortage of dumping sites has resulted in sharp increase in transport and disposal costs.
- High dumping cost for demolished waste, because it has to be dumped away as far as possible from construction site.

# Sources of RAC

- Construction and demolished waste generated due to natural disasters for future development. The old buildings are replaced with the new ones and war inflicted damages.
- Crushing of Portland concrete pavement.
- Tested specimens from laboratory.
- Concrete from ready mix concrete plants and pre casting units.
- Worn out rail ballast.

# Characteristics

- It has low density, elastic modulus, strength and higher water absorption capacity.

- Recycled aggregates have a proportional motor, which is attached to the aggregate. It gives a higher porosity and a lower strength to recycled aggregate concrete than the normal concrete.

# Classification

- Based on material composition RAC is divided into two main types,
- Mixed concrete
- crushed concrete

# Types of Concrete

- Mixed Concrete

- Crushed Concrete

# Process

- Crushing
- Pre sizing
- Sorting
- Screening
- Contaminant Elimination

# Applications

- Concrete sub Structures
- Roads
- Ground Improvement
- Earth work Embankment
- Earth work Cutting

# Applications

- Shallow Foundation
- Deep Foundation
- Utilities
- Concrete Structures
- Building (Residential and industrial)

# Merits

- Reduces the need for virgin aggregates.
- Specification Sized Recycled aggregates.
- Avoid haul off costs and land fill disposal fees.
- Minimal impact on community infra structure by reducing import and export trucking.
- Creates more employment opportunities

# Demerits

- Downgrades the quality of concrete.
- Increase in water absorption capacity.
- Decrease in compressive strength.
- Reduces work ability of concrete.
- Lack of specifications and guidelines.
  Less durability of RAC.

# Conclusion

- Recycling and reusing the building wastes doesn’t merely just solve the problem of construction debris; but also the issue of shortage of natural aggregates can be addressed.