FOREWORD

- THIS PRESENTATION GIVES BRIEF VIEW ON SOME MINERAL ADMIXTURES TO OBTAIN MORE WORKABLE & DURABLE CONCRETE

- APPROVED BY IS 456: 2000 BUT NOT COMMONLY USED
DURABLE CONCRETE

- DURABLE CONCRETE MEANS CONCRETE WITH FEWER MICRO-CRACKS (10-100 µm)

- MICRO-CRACKS IN CONCRETE ALLOW INGRESS OF EXTERNAL DETERIORATING AGENTS: WATER, CARBON DIOXIDE, CHLORIDES, SULPHATES & SO ON, LEADING TO DETERIORATION, DISTRESS AND DESTRUCTION OF STRUCTURE

- MICRO-CRACKS IN CONCRETE CAN BE REDUCED USING POZZOLANIC OR CEMENTITIOUS MATERIALS, COLLECTIVELY CALLED MINERAL ADMIXTURES, TO REPLACE CEMENT IN CONCRETE.
MINERAL ADMIXTURES

THE TERM INCLUDES ALL SILICEOUS & ALUMINOUS MATERIALS, WHICH IN FINELY DIVIDED FORM AND IN PRESENCE OF WATER CHEMICALLY REACT WITH CALCIUM HYDROXIDE GENERATED DURING CEMENT HYDRATION TO FORM ADDITIONAL COMPOUNDS POSSESSING CEMENTITIOUS PROPERTIES.

THEY MAY BE NATURALLY OCCURRING MATERIALS, INDUSTRIAL, AGRICULTURAL WASTES OR BYPRODUCTS OR THE ONES REQUIRING LESS ENERGY TO MANUFACTURE.
MINERAL ADMIXURES PERMITTED BY IS 456: 2000

- FLY ASH OR PULVERISED FUEL ASH (IS 3812, GRADE I)
- GGBS OR GROUND GRANULATED BLAST FURNACE SLAG (IS 12089)
- SF OR SILICA FUME (IS 15388: 2003)
- METAKAOLIN (MK)
- RICE HUSK ASH (RHA)
- CARRY SUFFICIENT LAB TESTS WHEN THERE IS NO STANDARD
SILICA FUME (SF)
SILICA FUME (SF)

- BYPRODUCT OF SMELTING PROCESS IN PRODUCTION OF SILICON METAL & FERROSILICON ALLOYS
- MOSTLY COMPOSED OF SUBMICRON PARTICLES OF AMORPHOUS SILICON DIOXIDE (SiO2).
- POZZOLANIC
COMMERCIAL SF

- UNDENSIFIED SF (BULK DENSITY 350 kg/m³):
  - AVAILABLE IN BULK/BAGS NEAR SMELTERS: MAINLY USED IN MAKING PRE-BAGGED PRODUCTS: GROUTS OR REPAIR MORTARS
  - INCONVENIENT TO HANDLE: DUSTY, SELF-AGGLOMERATING & DIFFICULT TO TRANSPORT
COMMERCIAL SF

- DENSIFIED SF (480-720 kg/m³):
  - PARTICLES LOOK LIKE SMALL BEADS, FLOW LIKE WATER & PRODUCE VERY LITTLE DUST
  - CAN BE SHIPPED IN BULK IN PNEUMATIC TRUCKS, JUMBO BAGS, IN SMALL (USUALLY 25 kg) PAPER BAGS
  - HIGH BULK DENSITY REDUCES COST OF TRANSPORTATION
COMMERCIAL SF

- PELLETISED (10-25 mm) SF (about 1000 kg/m³)

- NOT SUITABLE FOR DIRECT USE IN CONCRETE, AS THE HARD PALLETS DO NOT BREAK AND DISPERSE IN A CONCRETE MIXER (. ) CAN BE INTERGROUND WITH PORTLAND CEMENT CLINKER TO PRODUCE BLENDED SF CEMENT
PHYSICAL CHARACTERISTICS

- It is amorphous silica (85-98%) & glassy. Also decides quality.

- Spherical particles with average 0.02-0.25 micron diameter, nearly 100 times smaller than cement particle.

- As a result of agglomeration, actual size: 1-50 micron.

- To make ultra-high strength concrete, ultrasonic dispersivity should be measured & accepted when particle size < 1 micron obtained.

- Well dispersed, superfine SF particles act as filler. Fill void space between the irregular shaped cement particles to bring in refinement of the pore structure in hardened concrete.

- Densified SF sometimes difficult to disperse.

SF QUALITY

- SILICA (> 85%)
- CARBON CONTENT OR LOSS ON IGNITION (< 4 – 6%)
- CONTENT OF CRYSTALLINE & AMORPHOUS SILICA
- SPECIFIC SURFACE AREA (> 15 m²/g)
- POZZOLANICITY OR POZZOLANIC ACTIVITY (ASTM 100 – 105%)
SF IN CONCRETE

- FRESH:
  - LOWER DENSITY (2.2<3.2) INCREASES PASTE VOLUME & MAY SHRINK MORE (.)
  - HIGHER SURFACE AREA (1.5 – 300000 cm²/g) LEADS TO HIGH WATER DEMAND & AEA(.)
    USE HRWRA FOR STRENGTH & DURABILITY
  - CONSTRUCTION WORKER REQUIRES TRAINING
SF IN CONCRETE

- HARDENED:

- IMPROVES DURABILITY & STRENGTH DUE TO INCREASE IN C–S–H WITH LOWER CaO/SiO2 RATIO, (B) REDUCTION IN pH VALUE & (C) DILUTION EFFECT ON C3A

- REDUCED PERMEABILITY
SF ADDITION TO CEMENT

- SF BLENED CEMENT NOT COMMONLY USED
- MOSTLY ADDED TO CONCRETE AS A CONSTITUENT MATERIAL, IN ADDITION TO CEMENT
- RESULTS IN LARGER DOSE OF SUPERPLASTICISER AS WELL AS THE AIR ENTRAINING AGENT TO CONCRETE.
- NEEDS TO BE ADEQUATELY JUSTIFIED ON CONSIDERATIONS OF COST VIS-A-VIS STRENGTH & DURABILITY
- NORMALLY 3-10% SF IS ADDED TO HIGH PERFORMANCE CONCRETE.
SF STANDARD SPECS

INDIAN STANDARD: IS 15388: 2003

EUROPEAN: EN 13263: 2005

AMERICAN STANDARD: ASTM C1240
METAKAOLIN (MK)
METAKAOLIN (MK)

- HIGH REACTIVITY METAKAOLIN OR METAKAOLIN (MK) IS AN ENGINEERED, HIGH STRENGTH, POZZOLANIC MATERIAL
- MANUFACTURED BY CALCINATION OF NATURALLY OCCURING KAOLIN CLAY
- IT IS AN AMORPHOUS ALUMINO-SILICATE (AL2O3.2SiO2)
KAOLIN DEPOSITS: INDIA

- TOTAL ESTIMATED: 2596 MILLION TONNES
- DISTRIBUTED IN ALMOST EVERY STATE IN REASONABLE QUANTITY
- MAJOR: KERALA (24%), RAJ (14%), ORISSA (16%), KARNATAKA (10%)
AVAILABLE IN TWO FORMS:

CLINKER: SIZE 19 – 25 mm (%) GOOD HANDLING ABILITY AND RESISTANCE TO DETERIORATION (%) CAN BE SHIPPED IN BULK & IDEAL FOR INTERGRINDING WITH PORTLAND CEMENT CLINKER FOR THE PRODUCTION OF BLENDED CEMENT (%)

POWDER: PRODUCED BY FINE GRINDING CLINKER (9.5 - 18 m²/g, NITROGEN ADSORPTION) & SOLD IN PACKAGES, BIG SACKS OR IN BULK.
MK FROM WASTE PAPER SLUDGE

- HRM PRODUCED, CALCINING WASTE PAPER SLUDGE WHICH CONTAINS KAOLIN AT 650 – 750 0C

- EFFECTIVE UTILISATION OF WASTE PAPER SLUDGE
POWDER MK

- OFF-WHITE COLOR

- SPECIFIC GRAVITY 2.5 - 2.6 & BULK DENSITY 0.3 – 0.4 t/m³

- SURFACE AREA RANGE: 9.5 - 18 m²/g (NITROGEN ADSORPTION) & AVERAGE PARTICLE SIZE: 1 – 9.5 micron

- ATTRACTIVE IN COLOR MATCHING AND OTHER ARCHITECTURAL APPLICATIONS
STRENGTH & DURABILITY WITH MK

- ENHANCEMENT DUE TO:
  - FILLER EFFECT: IMMEDIATE
  - ACCELERATION OF CEM HYDRATION: FIRST 24 h (. ) TEMP INCREASE
  - POZZOLANIC REACTION: 7 - 14 DAYS
- 10 -25% CEMENT REPLACEMENT FOR IMPROVED STRENGTH & DURABILITY
MK STANDARD SPECS

- INDIAN:
  - INDIAN STANDARD ON MK BEING DRAFTED

- AMERICAN:
  - ASTM C618:
    - STANDARD SPECIFICATION FOR COAL FLY ASH AND RAW OR CALCINED NATURAL POZZOLAN FOR USE IN CONCRETE
RICE HUSK ASH (RHA)
RICE HUSK ASH (RHA)

- Pozzolanic admixture obtained from combustion of rice husk (RH) under controlled temperature & residence time & subsequent size reduction

- Low unburned C & silica mostly amorphous (87 – 94%)

- Specific gravity: 2.15 – 2.16 & bulk density: 0.4 – 0.5 (. ) Surface area: 20 - 40 m2/g (BET), comparable with SF
SUSTAINABILITY OF RHA

- Abundant availability of RH in rice producing countries
- Huge scope to recover heat value to generate power & to use RHA produced in cement & concrete
- World paddy by 2030: 847 – 915 MTPA
- Asia by 2030:
  - Paddy: around 600 – 774 MTPA
  - RH: around 120 – 155 MTPA
  - RHA: 24 – 31 MTPA
RHA FOR CEMENT

- CEMENT REPLACEMENT UP TO 30%
- TO SATISFY ASTM C618, CLASS N:
  - RETENTION 45 MICRON < 34%
  - MOISTURE < 3%
  - LOI < 10%
  - STRENGTH ACTIVITY (CEMENT) > 75%
  - SiO2 + Al2O3 + Fe2O3 > 70%
ADDING ADMIXTURES TO CONCRETE

- IS 456: 2000, CLAUSE 5.2.1 ON POZZOLANS MENTIONS:

  - POZZOLANIC MATERIALS CONFORMING TO RELEVANT INDIAN STANDARDS. PERMISSION OF ENGINEER-IN-CHARGE, PROVIDED UNIFORM BLENDING WITH CEMENT IS ENSURED

- DRY BLENDING REQUIRES SPECIAL CARE DUE TO DIFFERENCE IN DENSITY AND PARTICLE SIZE

- WHEN INDIAN STANDARD NOT AVAILABLE, OTHER INTERNATIONAL STANDARDS WITH PERMISSION OF ENGINEER-IN-CHARGE (.) CONDUCT LAB TESTS
## PERFORMANCE
### 28 DAY COMPRESSIVE (MPA)

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<th>43 G OPC</th>
<th>10% FA 3980 BLAINE</th>
<th>10% SF 19 m2/g</th>
<th>10% MK 14 m2/g</th>
<th>10% RHA &lt; 45 micron</th>
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## COST COMPARISON

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• *Thanks!!*