

Enhancement of the mechanical properties of lightweight oil palm shell concrete using rice husk ash and manufactured sand

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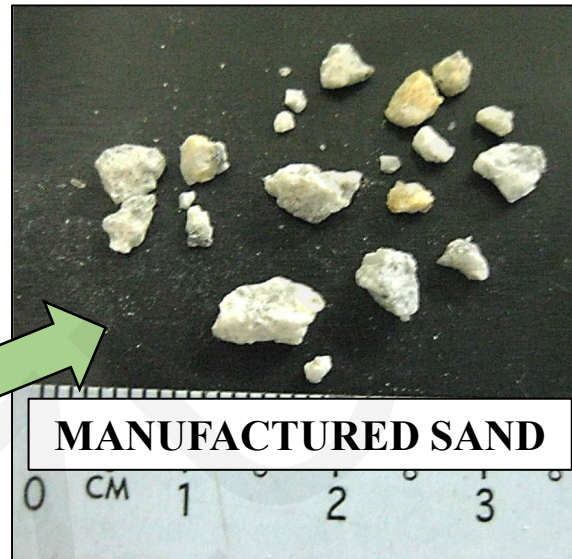
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OIL PALM SHELL AS COARSE AGGREGATE



- Waste oil palm shells (OPS), a waste material from the palm oil industry, has been successfully used as lightweight aggregate to produce lightweight concrete.
- A low-cost house has been built in Sabah, Malaysia using OPS concrete for monitoring purpose (Teo et al., 2006).
- High-strength OPS concrete with compressive strength up to 46 MPa was developed recently (Shafiq et al., 2011)

MANUFACTURED SAND AS FINE AGGREGATE



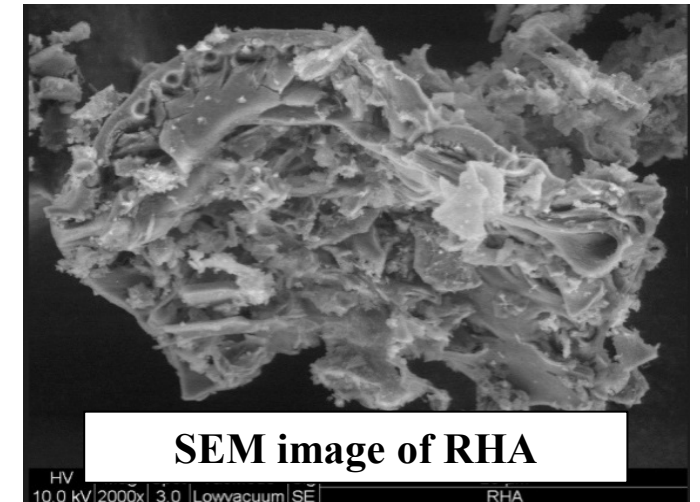
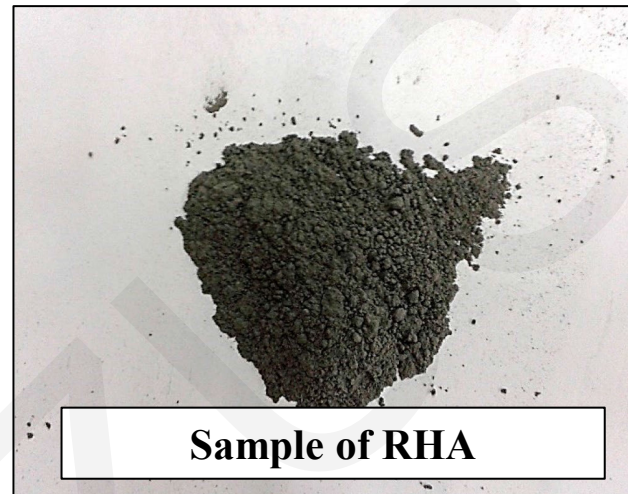
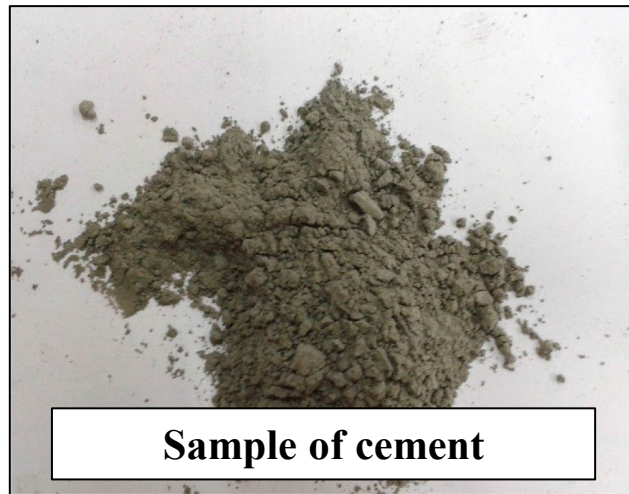
MANUFACTURED SAND



NORMAL SAND

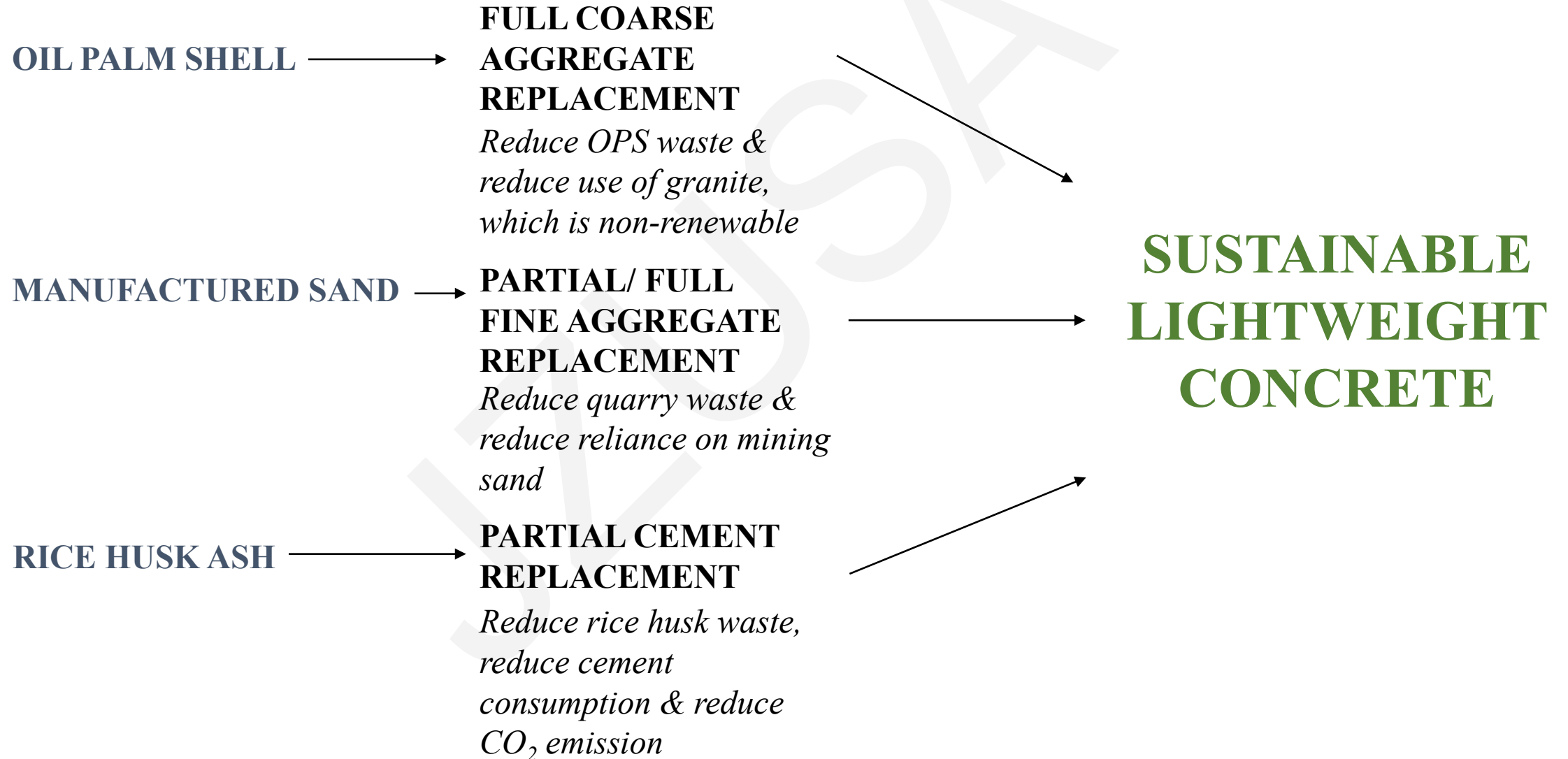
- Manufactured sand (M-sand) is obtained from the processing of quarry dust, which is waste material from the quarrying industry.
- Use of M-sand could reduce dependence on natural mining sand, and hence cut down environmental concerns arising from sand mining, such as soil erosion, flooding etc.

RICE HUSK ASH AS CEMENT REPLACEMENT



- Rice husk ash (RHA) is obtained from the processing and burning rice husk waste.
- RHA has excellent pozzolanic activity due to its high silica content and fine particles.
- Use of RHA as partial cement replacement was reported to reduce up to 3 million tonnes of CO₂ emission (Jahren and Sui, 2013).

PRODUCTION OF SUSTAINABLE CONCRETE



METHODOLOGY

Trial Mix variables

- ✓ RHA content (0%, 5%, 10%, 15%, 20%)
- ✓ Type of sand (*normal sand, M-sand, quarry dust*)



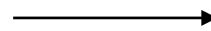
Testing

- ✓ Cube compressive strength (BS EN 12390-3)



Mix variables

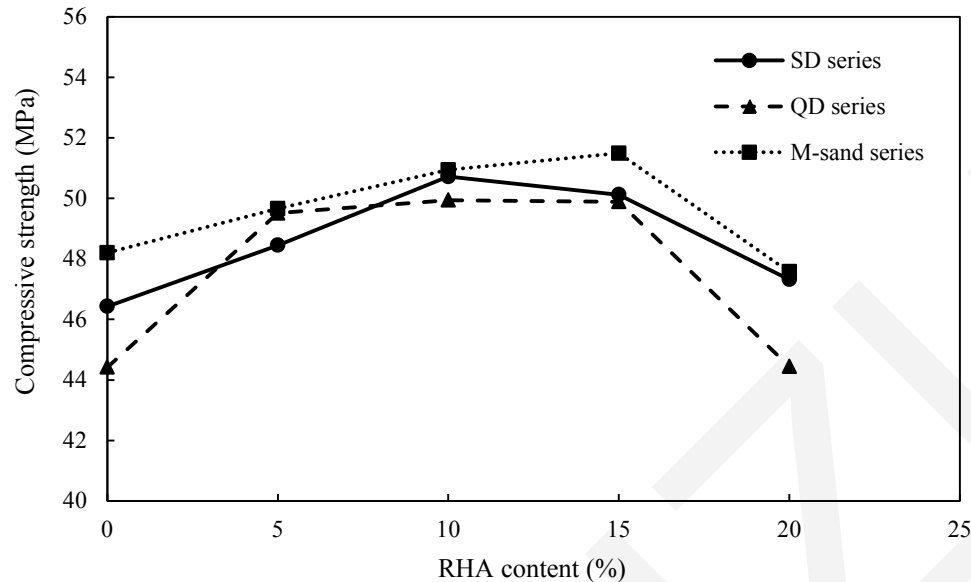
- ✓ RHA content (0%, 15%)
- ✓ Type of sand (*normal sand, M-sand*)
- ✓ Sand content (0%, 50%, 100%)



Testing

- ✓ Slump (BS EN 12350-2)
- ✓ Cube compressive strength (BS EN 12390-3)
- ✓ UPV (ASTM C597)
- ✓ Splitting tensile strength (BS EN 12390-6)
- ✓ Flexural strength (BS EN 12390-5)
- ✓ Modulus of elasticity (ASTM C469)

EFFECT OF RHA ON COMPRESIVE STRENGTH



- Best performance in terms of compressive strength obtained through **the use of M-sand & 15% RHA**
- M-sand – more cubical shape, less flaky particles

- RHA act as filler in early ages and pozzolanic reaction at later ages
- CSH produced from pozzolanic reaction reduced porosity of concrete

WORKABILITY, DENSITY & UPV

- **Slump reduced by 30 – 50%** when **RHA** was used due to higher viscosity of the fresh OPS concrete.
- Use of **M-sand** exhibited slight improvement in the workability; **slump** was **increased by 8 – 15%** as M-sand has better aggregate shape (cubical and less flaky).
- **Density reduction of 3 – 6%** with the use of RHA (lower specific gravity than cement); use of **M-sand did not affect density** due to similar specific gravity of M-sand and normal sand.
- OPS concrete produced had oven dry densities between **1766 – 1933 kg/m³**.
- After 28 days, UPV of all OPS concrete were **3.8 – 4.0 km/s** and hence the concrete may be classified as having ‘**good quality**’.

MECHANICAL PROPERTIES

- Highest **compressive strength** for OPS concrete utilizing **M-sand and 15% RHA** as cement replacement.
- M-sand + 15% RHA improved **splitting tensile strength** by **28%** to 3.45 MPa – stronger bond at interfacial transition zone (ITZ).
- Use of RHA improved **flexural strength** by **6 – 15%** - packing ability of fine RHA particles.
- Modulus of elasticity (MOE) for OPS concrete ranged between 14 – 17 GPa, and within the range for lightweight concrete; **RHA improved MOE** due to filling of pores and improvement of the ITZ.

CONCLUSION

- ✓ Production of sustainable high strength lightweight concrete incorporating OPS, M-sand and RHA.
- ✓ Improvement in mechanical properties such as compressive strength, splitting tensile strength, flexural strength and MOE.
- ✓ Best OPS concrete performance incorporating 100% M-sand and 15% RHA as fine aggregate and cement replacement, respectively.