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

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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 (Shafigh et al., 2011)

MANUFACTURED SAND AS FINE AGGREGATE

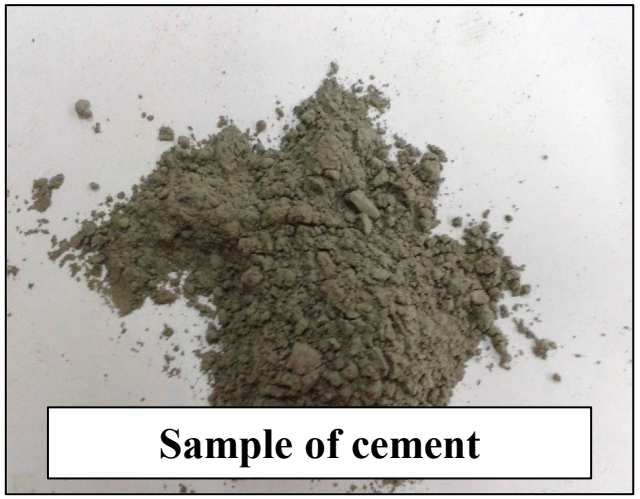


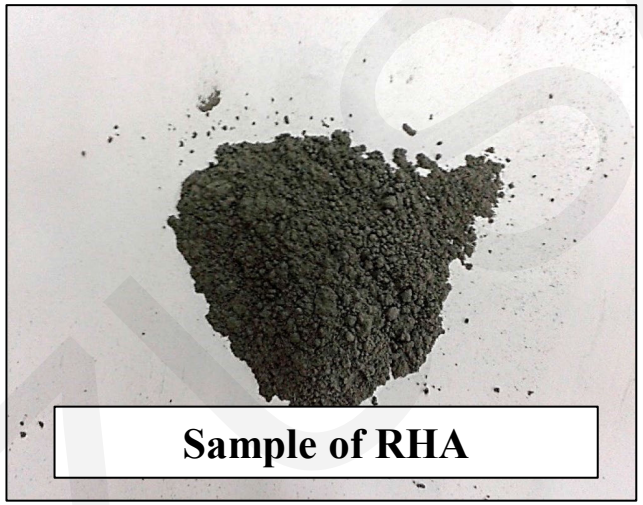


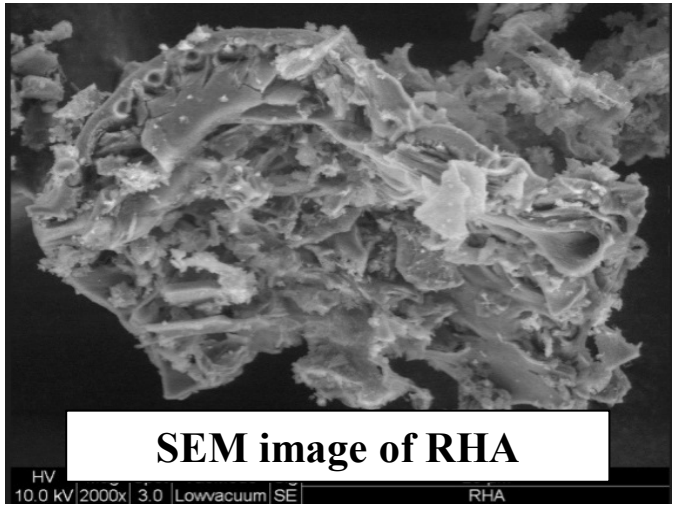


- Manufactured sand (M-sand) is obtained from the processing of quarry dust, which is waste material from the quarrying industry.
- Use of M-sand could reduce dependence on natural mining sand, and hence cut down environmental concerns arising from sand mining, such as soil erosion, flooding etc.

RICE HUSK ASH AS CEMENT REPLACEMENT


Sample of cement


Sample of RHA



SEM image of RHA

- 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 CO_2 emission (Jahren and Sui, 2013).

PRODUCTION OF SUSTAINABLE CONCRETE

OIL PALM SHELL → **FULL COARSE AGGREGATE REPLACEMENT**

Reduce OPS waste & reduce use of granite, which is non-renewable

MANUFACTURED SAND → **PARTIAL/ FULL FINE AGGREGATE REPLACEMENT**

Reduce quarry waste & reduce reliance on mining sand

RICE HUSK ASH → **PARTIAL CEMENT REPLACEMENT**

Reduce rice husk waste, reduce cement consumption & reduce CO_2 emission

→ **SUSTAINABLE LIGHTWEIGHT CONCRETE**

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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)

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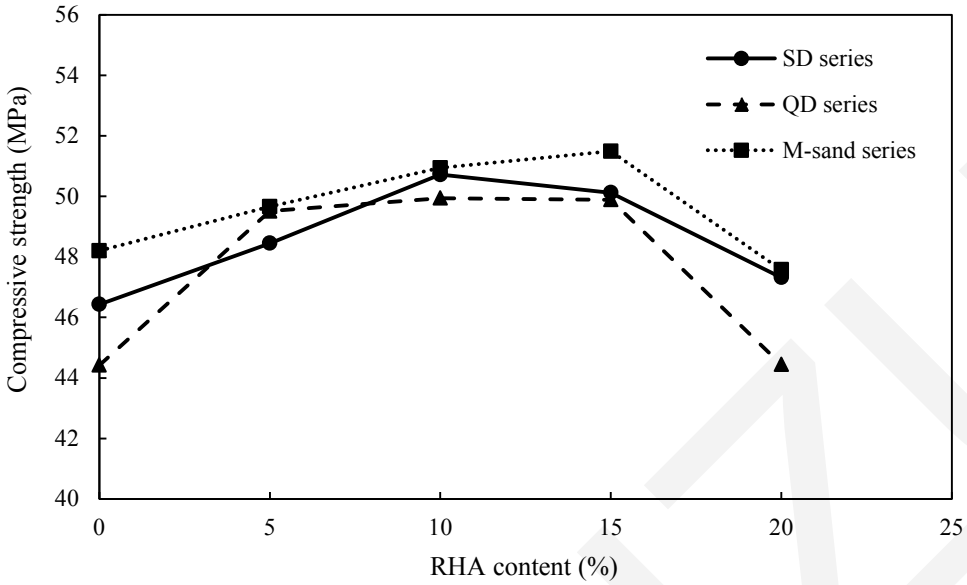
EFFECT OF RHA ON COMPRESIVE STRENGTH



- 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

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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/m^3**.
- 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.

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