STRENGTH PROPERTIES OF OIL PALM CLINKER CONCRETE

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Synopsis

The paper summarises the results of a research project on the utilization of oil palm clinker as lightweight aggregate in concrete. Oil palm clinker is a waste by-product in an oil palm processing mill.

The test results indicate that the short-term strength properties of oil palm clinker concrete are about the same as the properties of normal aggregate concrete. The advantage is it's weight reduced by 20%. The disadvantage is oil palm clinker has a high percentage of sulphate content.

Introduction

The objective of the research was to study the possibilty of utilizing 'oil palm clinker' as lightweight aggregate in concrete and also for cement-brick making.

During the palm oil extraction process, as shown in Fig.1, the fibres and shells of the oil palm are used as fuel for firing the mill's furnace to heat up the boiler. After about four hours of burning at a temperature of about 400°C, the shells and fibres are combined, possibly with some other impurities, to form a by-product which is known locally as 'boiler stone'. It is to be called here as oil palm clinker. The clinker which is then withdrawn from the furnace is in lumps of irregular shapes and sizes ranging from about 150-225mm, see Fig.2. It is whitish grey in colour and has a cellular porous structure.

The clinker used in this study was obtained from Felda Trolak processing mill. The clinker, because of it's slab like nature, has to be crushed manually in the laboratory. The crushed clinker was graded into fine and coarse aggregates using British Standard sieves. Particles passing the 5mm sieve, considered as fine aggregate, were separated from those retained on the 5mm sieve. Particles retained on the 5mm sieve were further sieved on a 20 mm sieve and those passing the 20mm sieve were considered as coarse aggregate, see Fig.3 and Fig.4.

Properties of oil palm clinker aggregate

Tests were carried out in accordance with BS 3681: Part 2:1973 (1) to determine grading curve, bulk density, apparent specific gravity and sulphate content of the oil palm clinker aggregate.

Sieve analysis was performed on the fine and coarse clinker aggregates at their air dry condition. A standard procedure of sampling was adopted in taking samples for the analysis. Typical grading curves for the coarse and fine aggregates are shown in Fig. 5. All curves fall within the grading limits permitted by BS 3797:1964 (2).

The bulk densities of oven-dry samples of fine and coarse aggregates were found to be 1075 kg/m3 and 815 kg/m3, respectively. BS 3681(1) defines a lightweight aggregate as one having a bulk density of oven-dry materials not exceeding 1200 kg/m3 for fine aggregate and 960 kg/m3 for coarse aggregate.

Apparent specific gravity of fine and coarse aggregates was found to be in the range of 1.70 to 1.95. Sulphate content of the clinker was found to be in the range of 1.2% to 1.8% which exceeds the value of 1.0% specified by BS 1165:1966(3).

Properties of oil palm clinker concrete

Six types of concrete mixes were investigated. The mixes designated by the volume propotions of cement: fine aggregate: coarse aggregate were 1:2:3C, 1:2:3S, 1:2:4C, 1:2:4S, 1:2:5C and 1:2:5S. The mixes with letter C indicate that the fine aggregate used was the fine clinker, and those with letter S indicate that fine natural sand was used in the mixes.

The fresh concrete mixes were tested for workability after mixing. The tests carried out were slump cone, compacting factor and vebe. The results are summarised in Table 1.

The tests performed on the hardened concrete specimens were cube compressive strength, indirect tensile strength of cylinders and beam flexural strength. Bond test was also carried out on the 1:2:5C mix.

All tests were carried out in accordance with BS 1881:Part 4:1970(4). The number of specimens made for each age of testing were; three for cube tests; two for indirect tensile, beam and bond tests.

The development of strength of the mixes with age are shown in Figures 6, 7 and 8. Fig. 6 shows that the cube strength of 1:2:3S, 1:2:4S and 1:2:4C fall within the range of strength of normal 1:2:4 concrete, the mix which is widely used in reinforced concrete construction. The effect of water-cement ratio on the compressive strength is shown in Fig. 9. The result of push -out 'bond' test is given in Table 2. The densities of the concrete samples were found to be in the range of 1800 to 2000 kg/m3. A normal concrete mix has a density of about 2400 kg/m3.

Table 1: Workability of fresh oil palm clinker concrete

Mix	Water-cement ratio	Slump (mm)	Vebe (s)	Compacting factor
1:2:3S	0.7	1.0	13.0	0.79
	0.8	8.0	6.0	0.86
	0.9	collapse	4.0	0.90
	1.0	15.0	1.0	0.93
1:2:3C	0.7	-	-	0.78
1:2:4S	0.7	2.0	12.0	0.83
	0.8	4.0	10.0	0.86
	0.9	6.0	7.0	0.88
	1.0	10.0	6.0	0.89
1:2:4C	0.7	5.0	18.0	0.82
1:2:5S	0.7	-	13.0	0.83
1:2:5C	0.7	-	-	0.89

Table 2: Push-out 'bond' test results on mix 1:2:5C with water-cement ratio, 0.7

Age (days)	7	14	21	28
Bond strength (N/mm2)	3.8	4.1	4.9	5.6

Conclusions

1. The bulk densities of fine and coarse oil palm clinker aggregates are below the limits specified by BS 3681(1) and their gradings fall within the zone set out by BS 3797(2). As such, oil palm clinker could be used as lightweight aggregate.

2. The short-term strength properties of oil palm clinker concrete are comparable to the strength of normal concrete.

3. Based on the two samples tested, oil palm clinker has a sulphate content of more than 1.0% as permitted by BS 1165(3). Hence, it is not suitable, in it's natural state, for reinforced concrete because it may cause corrosion to the steel reinforcement. However, it may be suitable as lightweight aggregate in blockwork and brickwork. A future paper will discuss the test results on the properties of oil palm clinker bricks.

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5 Jld II/(12). Part of the experimental works was performed by Hassan Ahmad (5) and Ahmad Mahir Makhtar, supervised by Maslin Hassan; and by Mohamed Sabri Mohamed Salleh (6) under the writer's supervision.

References

(1) BS 3681:Part 2:1973, Methods of sampling and testing of lightweight aggregates for concrete.

(2) BS 3797:1964, Specification for lightweight aggregates for concrete.

(3) BS 1165:1966, Specification for clinker aggregate for concrete.

(4) BS 1881:Part 4:1970, Methods of testing concrete for strength.

(5) Hassan Ahmad, Further investigations on the properties of oil palm clinker concrete, B. Eng thesis 1982/83.

(6) Mohamed Sabri Mohamed Salleh, Kajian lanjutan mengenai sifat-sifat konkrit ringan batu hangus kelapa sawit, B.Eng thesis 1984/85.

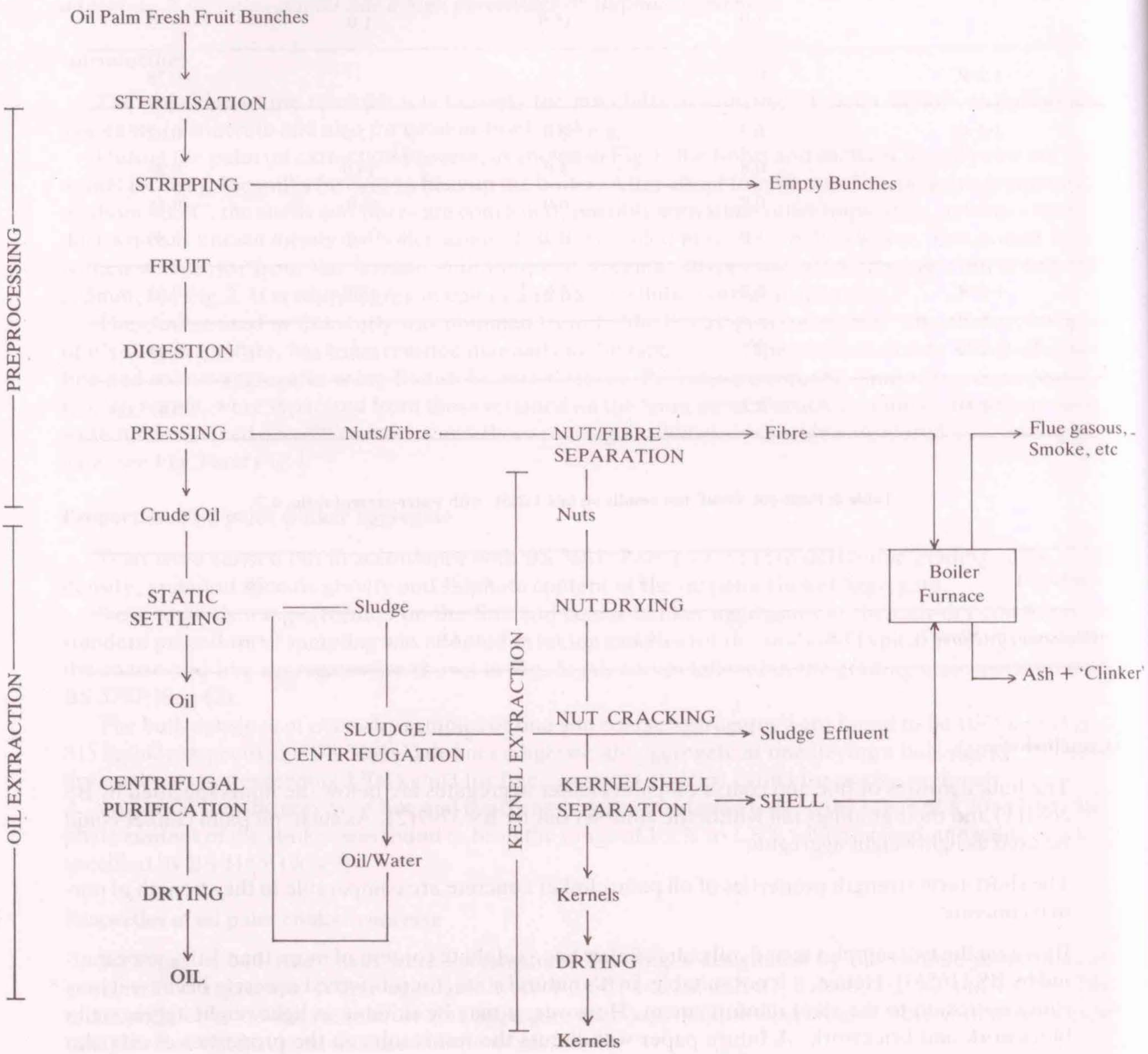

FIG 1: PALM OIL EXTRACTION PROCESS

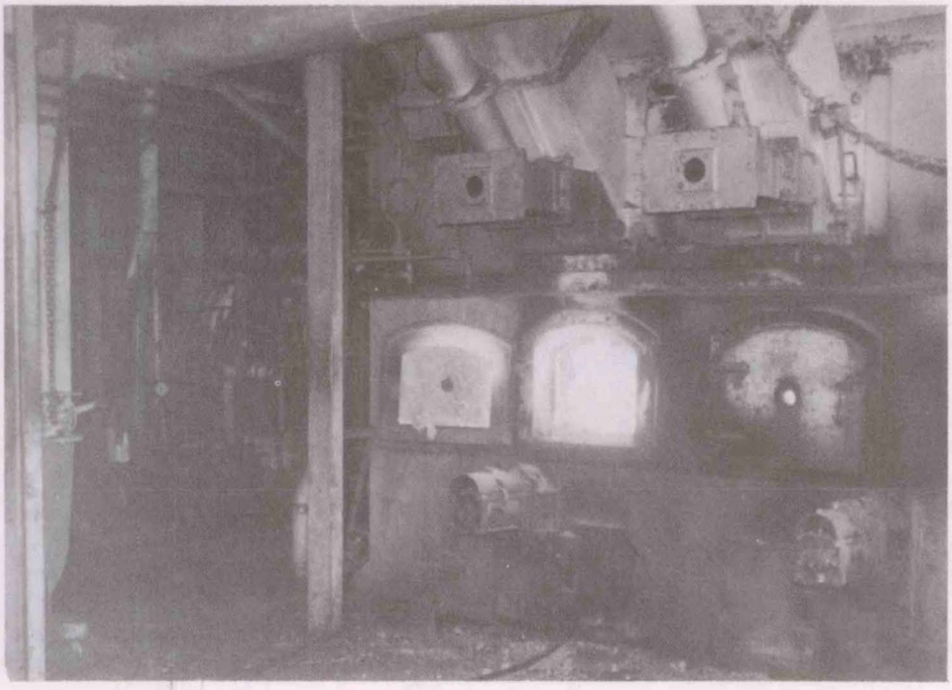

FIG 2(a): THE BOILER FURNACE

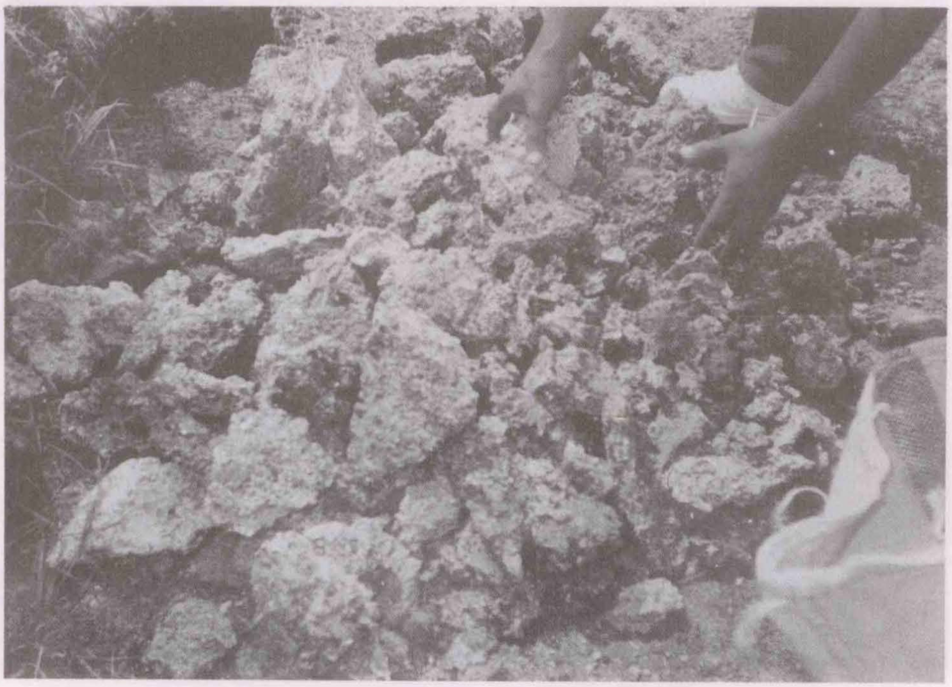

FIG 2(b): OIL PALM CLINKER

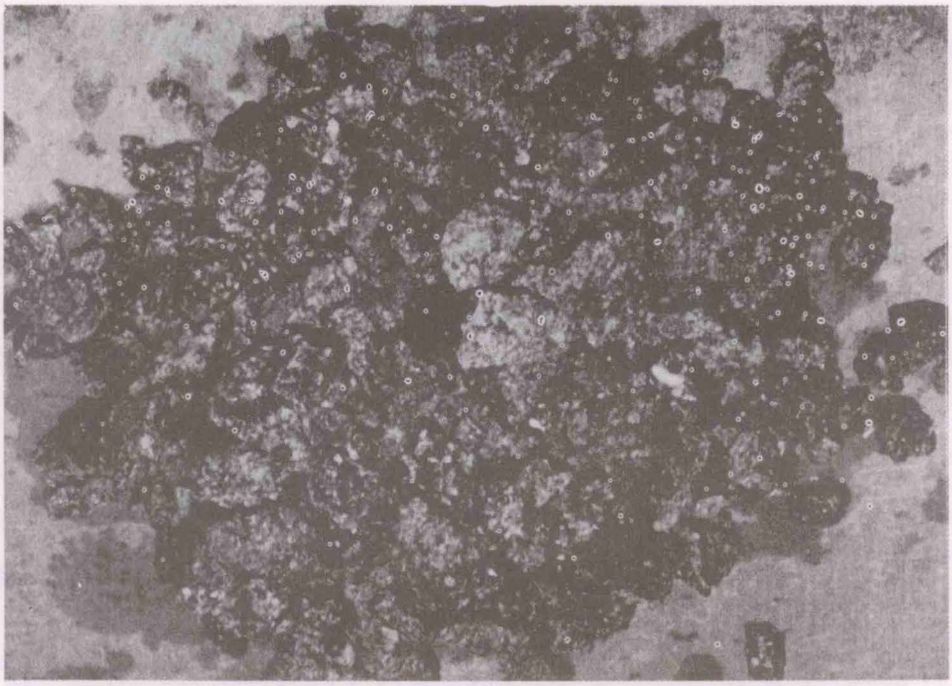

FIG 3: COARSE CRUSHED CLINKER AGGREGATE

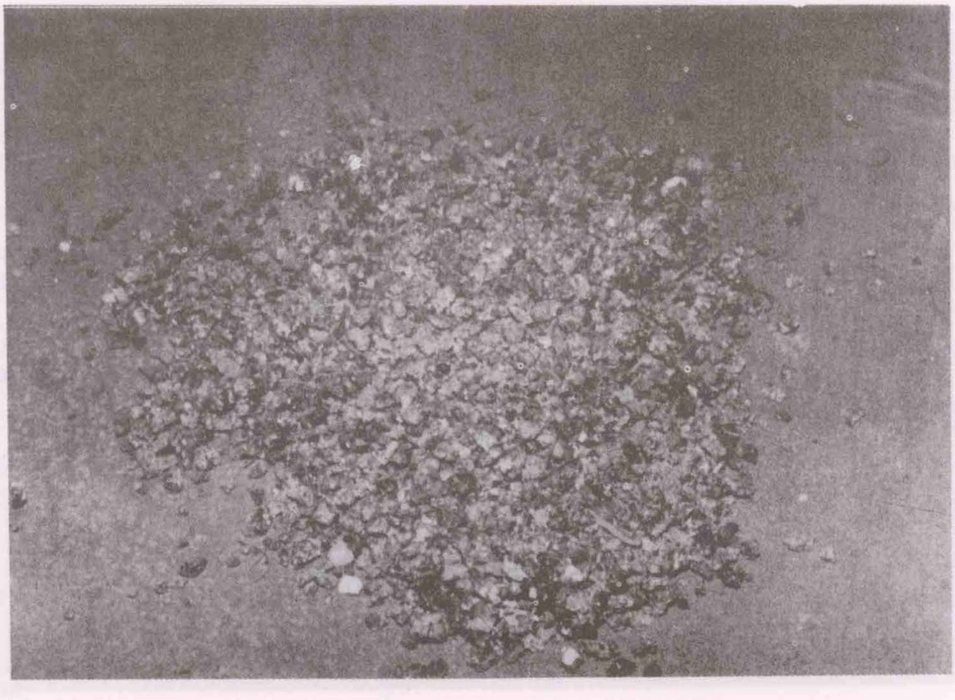

FIG 4: FINE CRUSHED CLINKER AGGREGATE

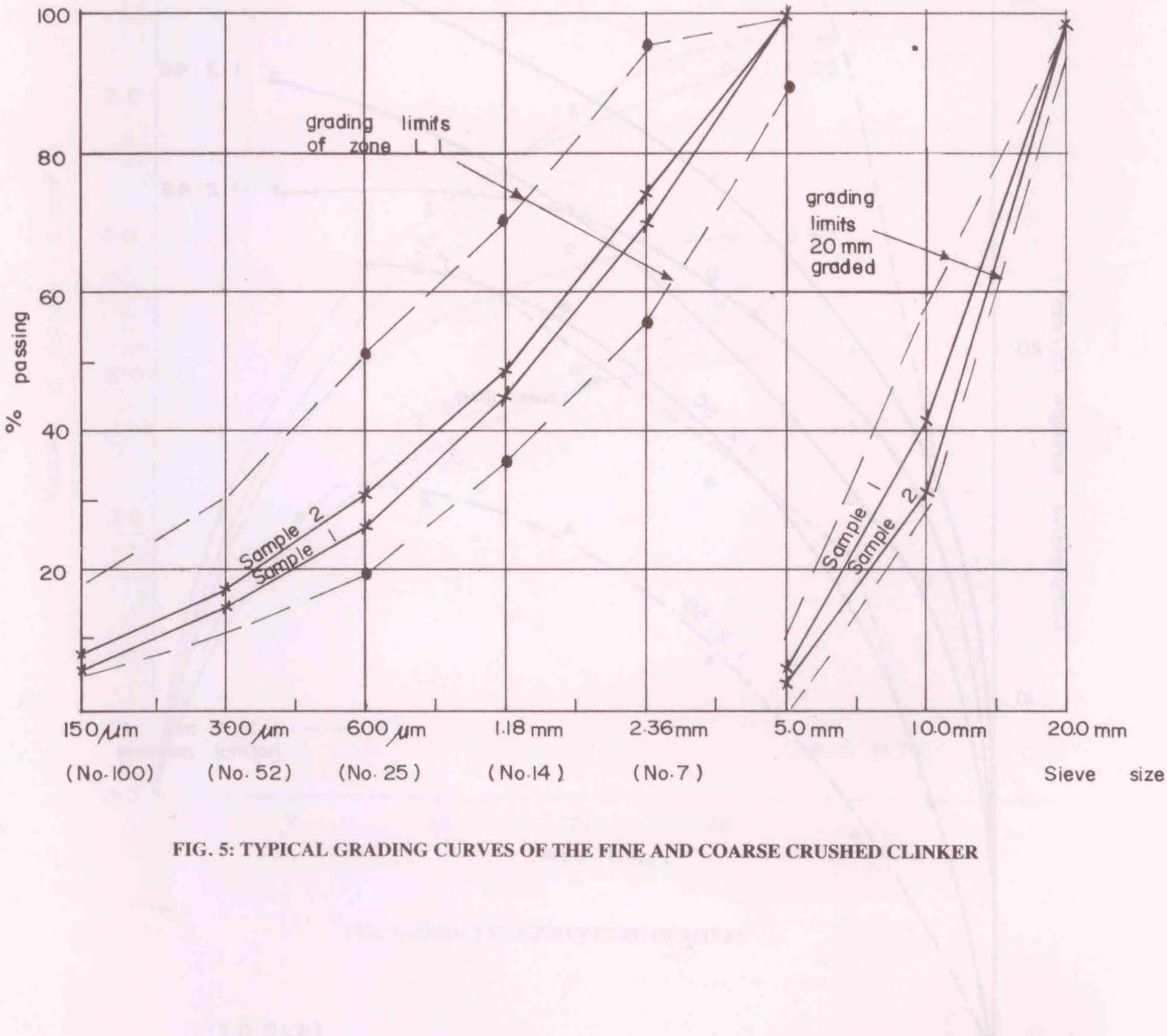

FIG. 5: TYPICAL GRADING CURVES OF THE FINE AND COARSE CRUSHED CLINKER

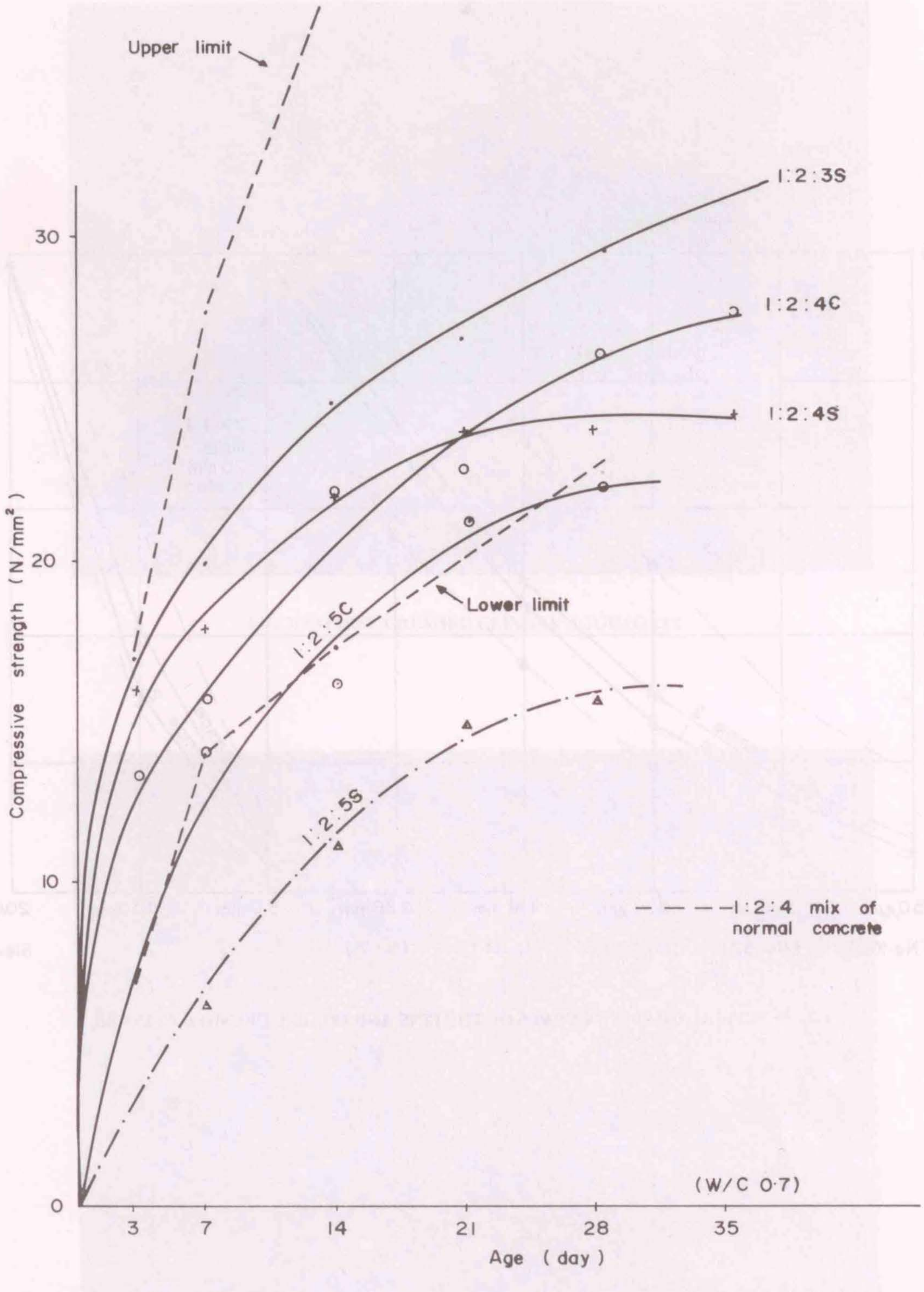

FIG. 6: RELATIONSHIP OF CUBE COMPRESSIVE STRENGTH WITH AGE OF TESTING FOR DIFFERENT TYPES OF MIXES.

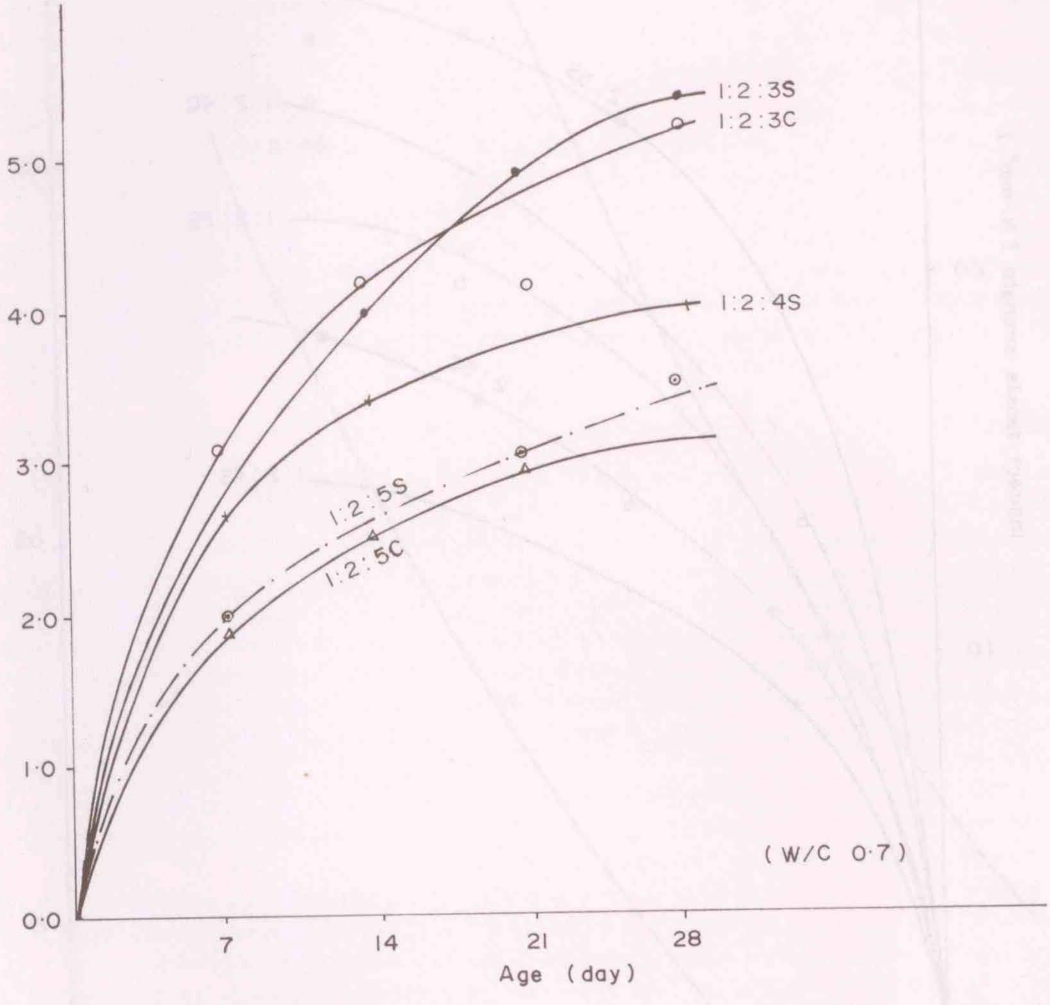

FIG. 7: MODULUS OF RUPTURE OF MIXES

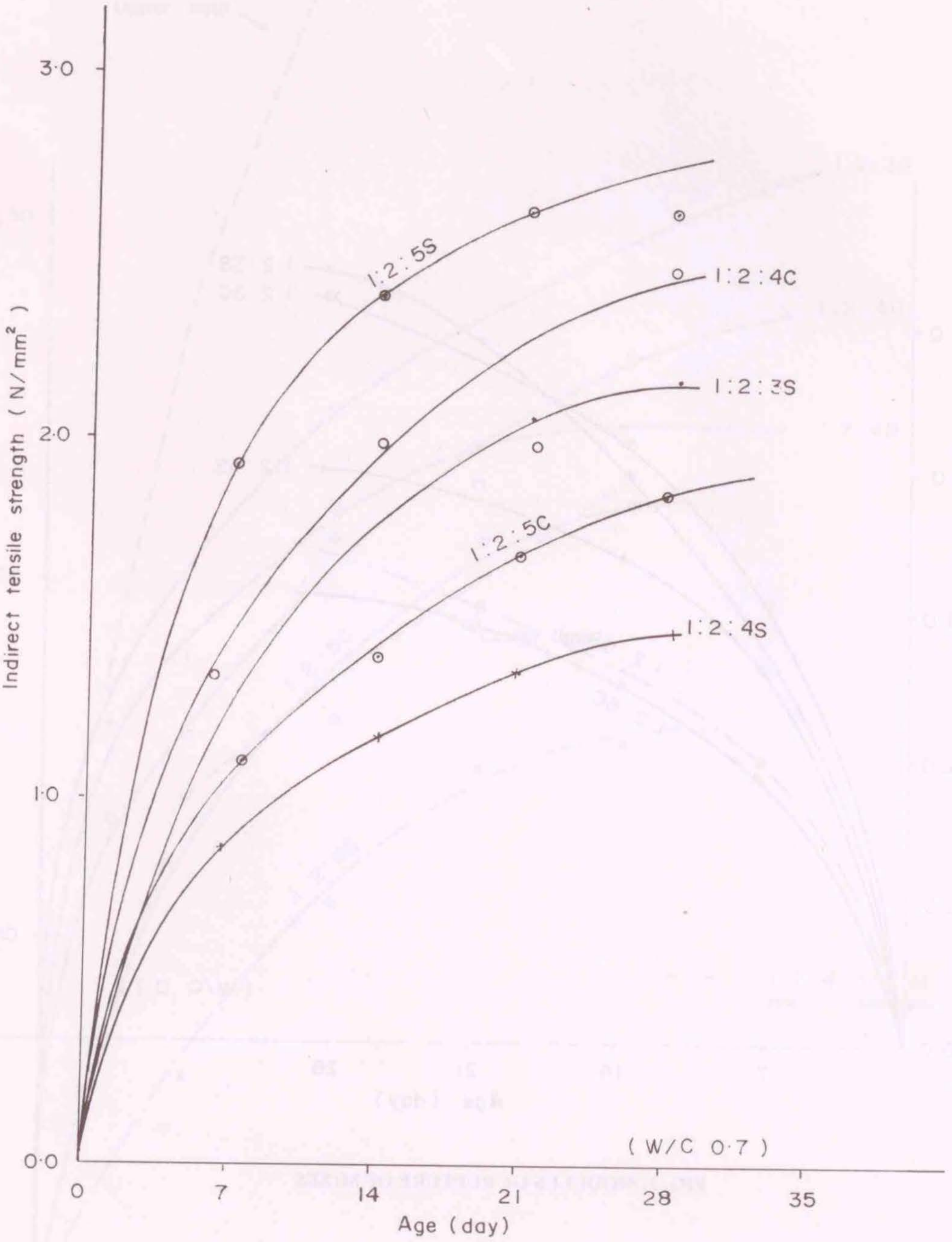

FIG. 8: INDIRECT TENSILE STRENGTH OF MIXES

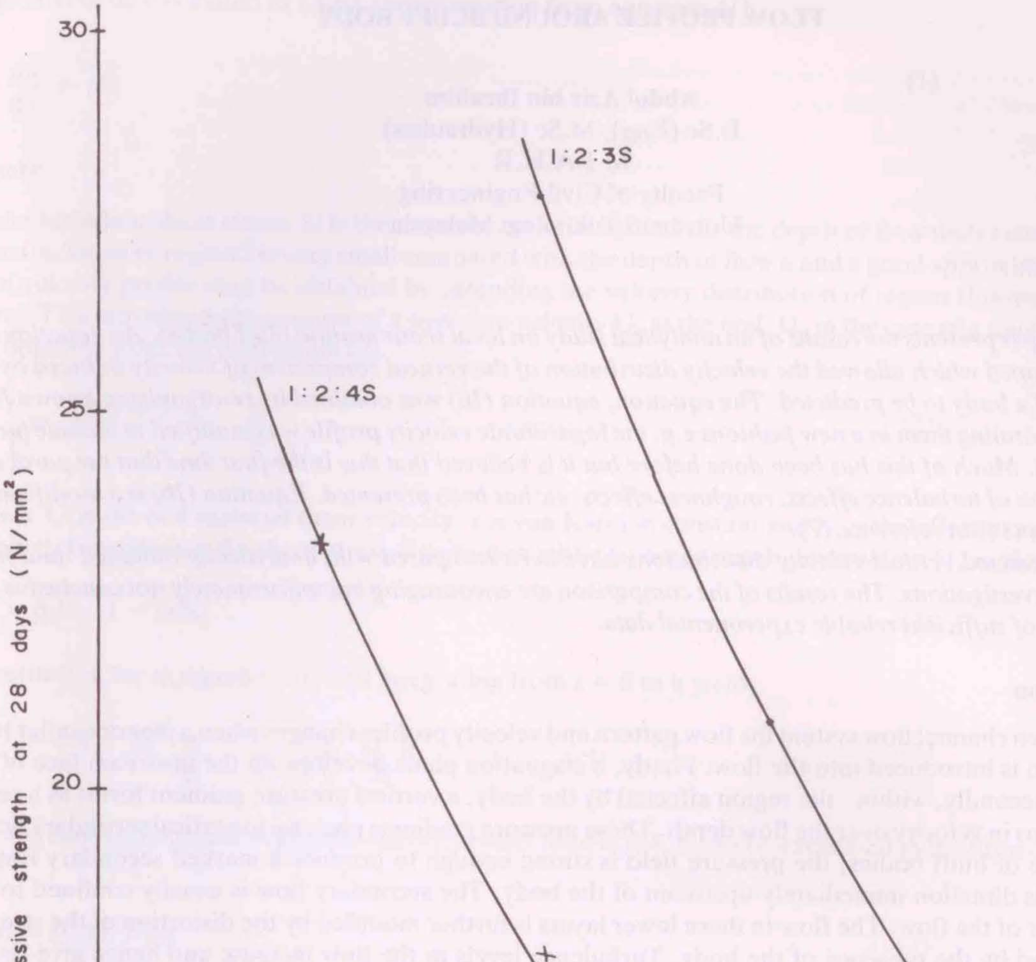

FIG . 9: RELATIONSHIP OF 28 DAYS CUBE STRENGTH WITH WATER-CEMENT RATION OF MIXES 1:2:3S AND 1:2:4S