APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND

RESEARCH PROGRAMME NO. 21
MATERIALS FOR CONCRETE

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FERROCEMENT REINFORCED WITH SHORT WIRES

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BY
SMITH KAMPEMPOOL
PREECHA DISATHIEN
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By Smith Kampempool* and Preecha Disathien*

SUMMARY

This investigation was performed in two stages. The first stage is to determine the optimum wire length based on the strength of the slab. The second stage is to establish the wire size to yield the maximum strength of the test piece.

A set of impact test and bending test have been applied to the slabs. A conclusion can be drawn that No. 19 gauge wire of 5 cm in length gives the highest impact resistance and bending strength.

I. INTRODUCTION

Ferrocement reinforced with steel rods and wire-mesh was sucessfully used in the construction of fishing vessels, barges and grain storage bins. However the method of construction is very tedious and time-consuming. This complication could be simplified by employing the fibre reinforcement method which sometimes is called a short wire reinforcement.

The object of this investigation is, therefore, to apply the short wire reinforcement to determine the optimum length and size of reinforcing wire based on impact and flexural strength of the test pieces.

II. MATERIALS AND METHODS

(i) Cement

Throughout this investigation, Portland cement type I (ASTM C150-63), Elephant brand, produced by the Siam Cement Co. was used. An amount of 12 bags of cement were received and stored in sealed steel drums. About three months thereafter the casting of ferrocement slabs was completed.

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*Building Materials Unit, Minerals and Metals Group, Technological Research Institute, ASRCT.

(ii) Sand

Fine sand used in this project was from Ban Klum. They were screened through No. 20 US sieve and established grain size distributions were found and shown in Figure 1. As a reference, the Ban Klum sand was taken from the same source of that used by the Construction Material Marketing Co. in the construction of 350 tonnes ferrocement barge, the first of its kind built in Thailand.

(iii) Iron wires

The ungalvanized wire undoubtedly possesses superior quality in bonding to the cement mortar and costs less than the galvanized wire. But special order must be made directly to the manufacturer. Therefore, galvanized iron wires of gauge Nos. 24, 22 and 19 were selected for this investigation.

(iv) Mixing proportion of cement mortar

The mixing proportion of cement mortar was adopted from the mixing designation M-6 in Report no. 1 of Research Project no. 21/14 "Ferrocement for construction of fishing vessels", using cement/sand ratio of 1:1.5 without admixture and water/cement ratio of 0.5 by weight. The wire reinforcement is 12 per cent by weight of cement content.

(v) Storage of test specimens

The slab specimens were removed from the moulds after aging of 24 hours and were immediately covered with damp clothes for curing purpose.

(vi) Physical tests

All specimens were tested immediately after 28 days of curing.

Impact test. Specimens for impact test were cast in the form of 100 x 100 x 2.5 cm slabs. The test was conducted by dropping a sand bag weighing 9 kg from various heights upon the test pieces until the first crack was observed.

Flexural test. The specimens for flexural test were made to 53 x 36 x 2.5 cm size. The arrangement of equipment for flexural test is shown in Figure 2, indicating that the test slab is placed on two supported steel bar spacing at 40 cm apart. The transverse load is pro-

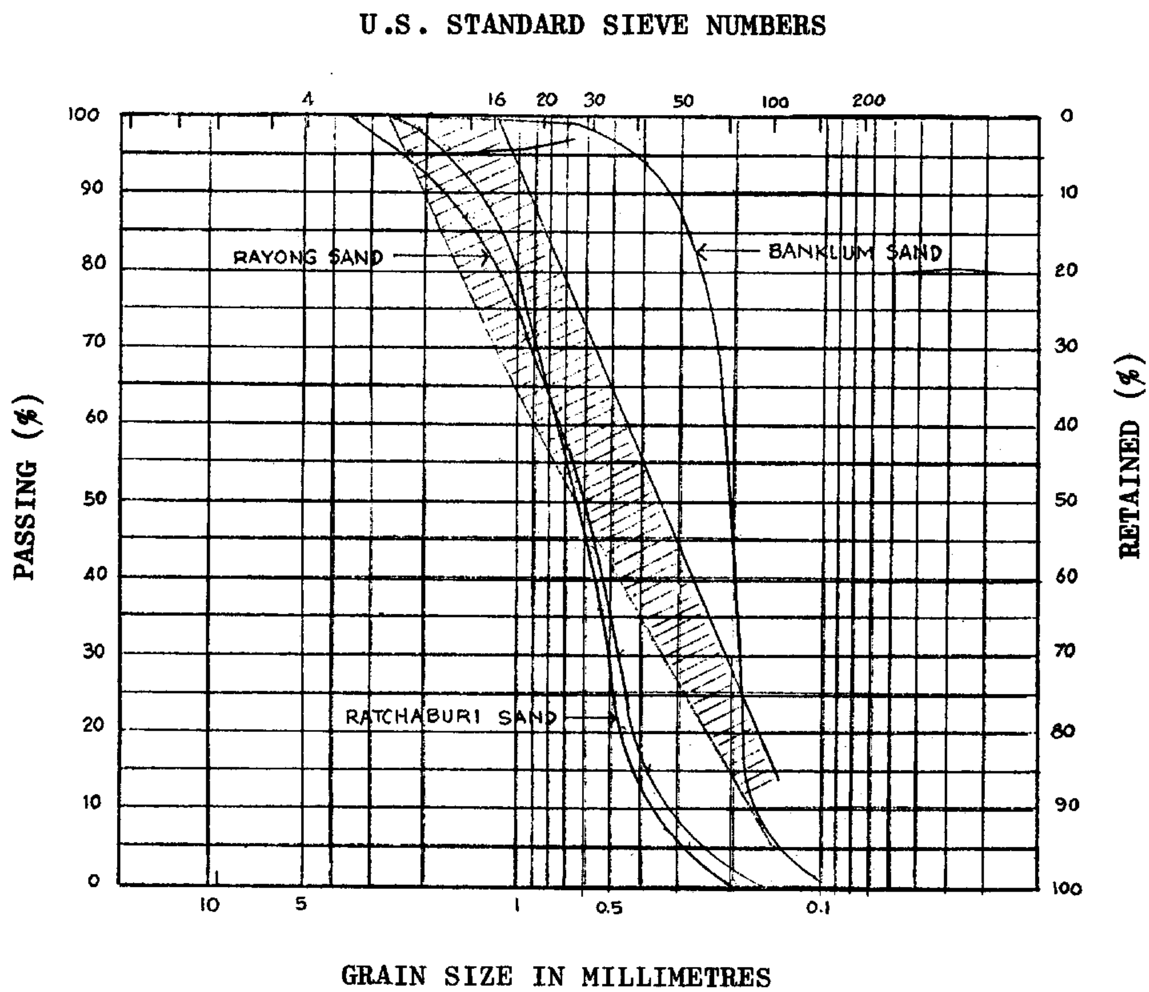

Figure 1. Grain size distribution curves of Rayong sand and Ban Klum sand. Well-graded sand should lie in between the shaded envelope.

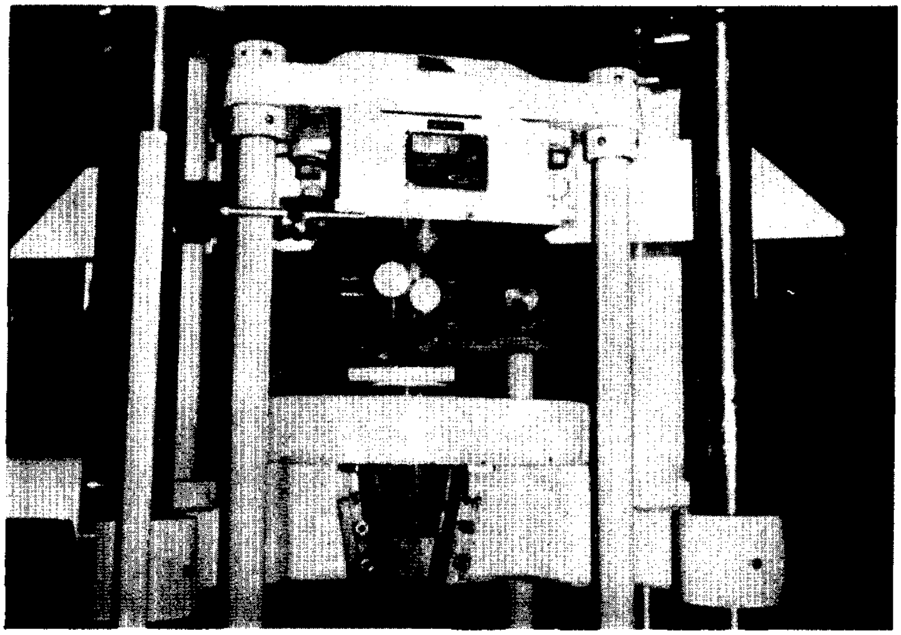

Figure 2. The arrangement of flexural test equipment.

duced by the third bar which is located in the middle of the slab. The deflection dial gauge was set under the slab at the middle point.

(vii) Selection of wire length

In determining the wire length to produce the maximum strength of slab, the wires of gauge no. 24 were selected as the reinforcement and the various lengths of 3, 4, 5 and 6 cm were specified.

(viii) Investigation of wire size

The wires of gauge Nos. 24, 22, and 19 were cut into the most suitable length obtained from (vii). The slabs reinforced with these wires were made and tested for their physical properties.

III. RESULTS AND DISCUSSION

(i) Wire length

The optimum length of wire was determined by comparison of the strength of the specimens under both impact and flexural tests. The results shown in Table 1 reveal that the impact strength increases with the increase of wire length. However, the upper limit of wire length is governed by the workability of the mixture. Should the wire be too long the thorough mixing will be next to impossible. Convinced by this fact, it was decided that the maximum wire length of 6 cm is suitable for this investigation.

The bending test results in Table 2 indicate that there was insignificant difference in bending strength. The load deflection curves in Figures 3, 4, 5 and 6 show that the bending strength of the test slabs are comparatively much lower than those reinforced with wire-mesh. Anyhow their yield strength as determined by the 0.2 per cent offset cannot be determined.

But the results (Table 2) indicate that test specimens using 5 cm wires yield the maximum flexural strength; also their load deflection curves (Figure 6) show consistent results for the five test specimens.

It is, therefore, recommended that the wire of 5 cm long to be used in the next stage of investigation.

(ii) Wire size

A series of impact and bending tests of test specimens of fixed length but variable diameters were undertaken. The results of impact test in Table 3 and those of bending test in Table 4 reveal that the impact resistance and bending strength were at maximum when wires of larger diameter were employed.

It is, therefore, established that the No. 19 gauge wire is most favourable.

TABLE 1. IMPACT TEST RESULTS OF SLABS WITH VARIOUS LENGTH OF WIRE GAUGE NO. 24

Slab no.	Length of reinforcing wire (cm)	Weight of slab (kg)	At initiation of crack		
			Impact load (kg)	Dropping height (m)	Impact energy (kg-m)
24I-5-1	3	53.0	9	1.50	13.5
24I-3-2	3	53.6	9	1.50	13.5
24I-3-3	3	52.9	9	1.50	13.5
24I-4-1	4	53.8	9	2.00	18.0
24I-4-2	4	54.7	9	2.20	19.8
24I-4-3	4	55.4	9	2.25	20.25
24I-5-1	5	54.5	9	3.50	31.5
24I-5-2	5	55.6	9	3.50	31.5
24I-5-3	5	55.8	9	3.50	31.5
24I-6-1	6	53.6	9	4.50	40.5
24I-6-2	6	55.6	9	4.50	40.5
24I-6-3	6	56.0	9	4.50	40.5

TABLE 2. BENDING TEST RESULTS OF SLABS REINFORCED WITH VARIOUS LENGTHS OF WIRE GAUGE NO. 24

Slab no.	Length of reinforcing wire (cm)	Weight of slab (kg)	At initiation of crack	
			Flexural load (kg)	Flexural strength $kg\text{-}cm^2$
24F-3	3	10.53	180	1.33
24F-4	4	11.28	215	1.59
24F-5	5	11.05	218	1.62
24F-6	6	11.04	202	1.49

Note. The values are the average of 5 specimens.

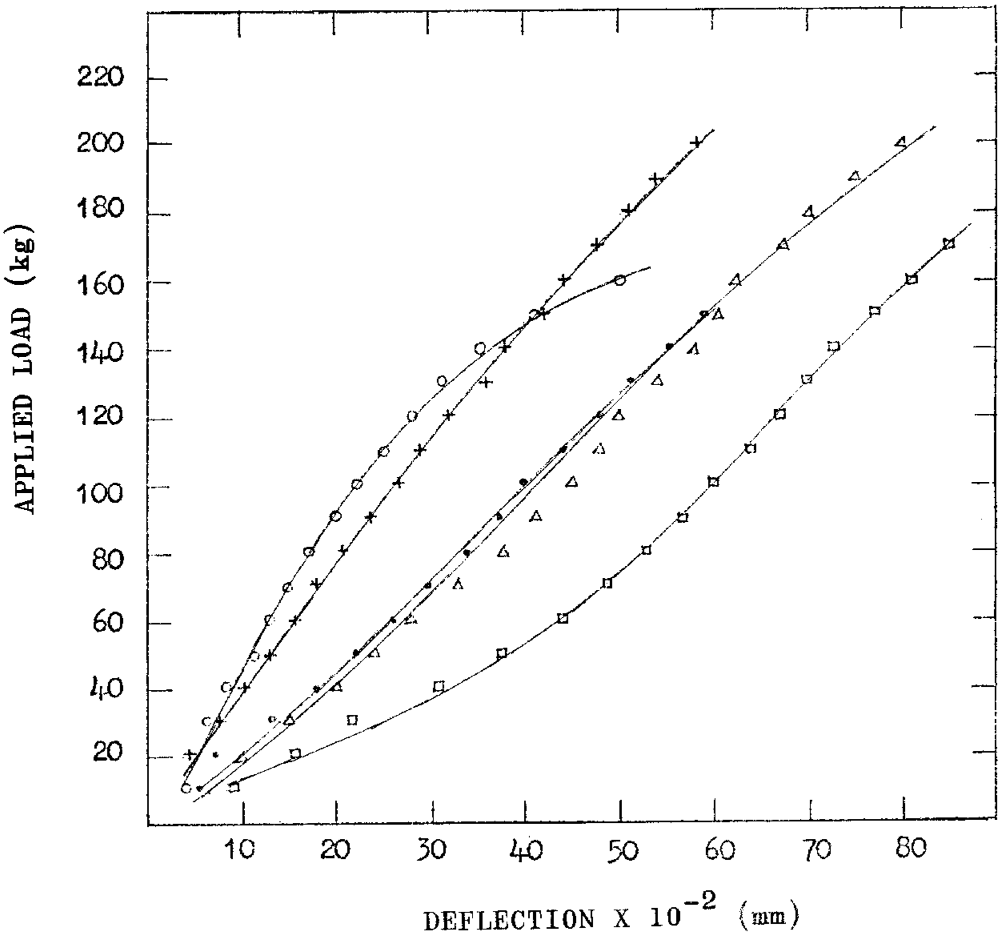

Figure 3. Load-deflection curves of 5 slabs reinforced with 3 cm wires of gauge No. 24.

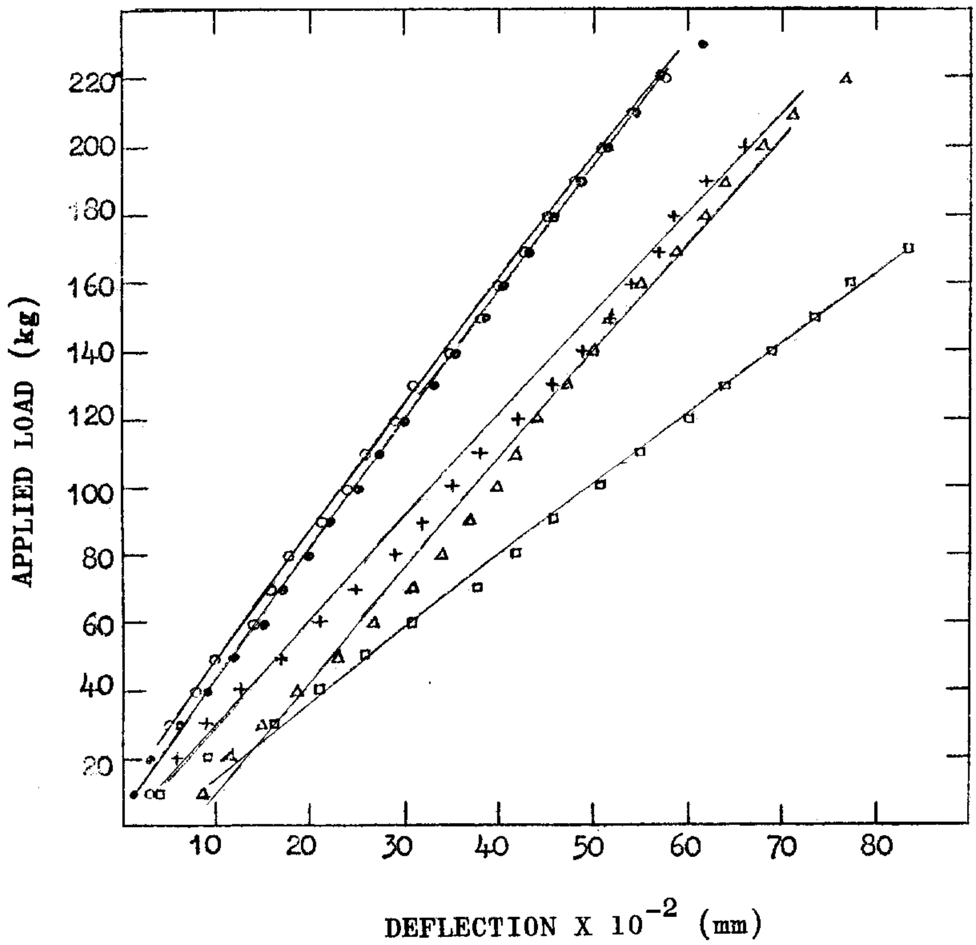

Figure 4. Load-deflection curves of 5 slabs reinforced with 4 cm wires of gauge No. 24.

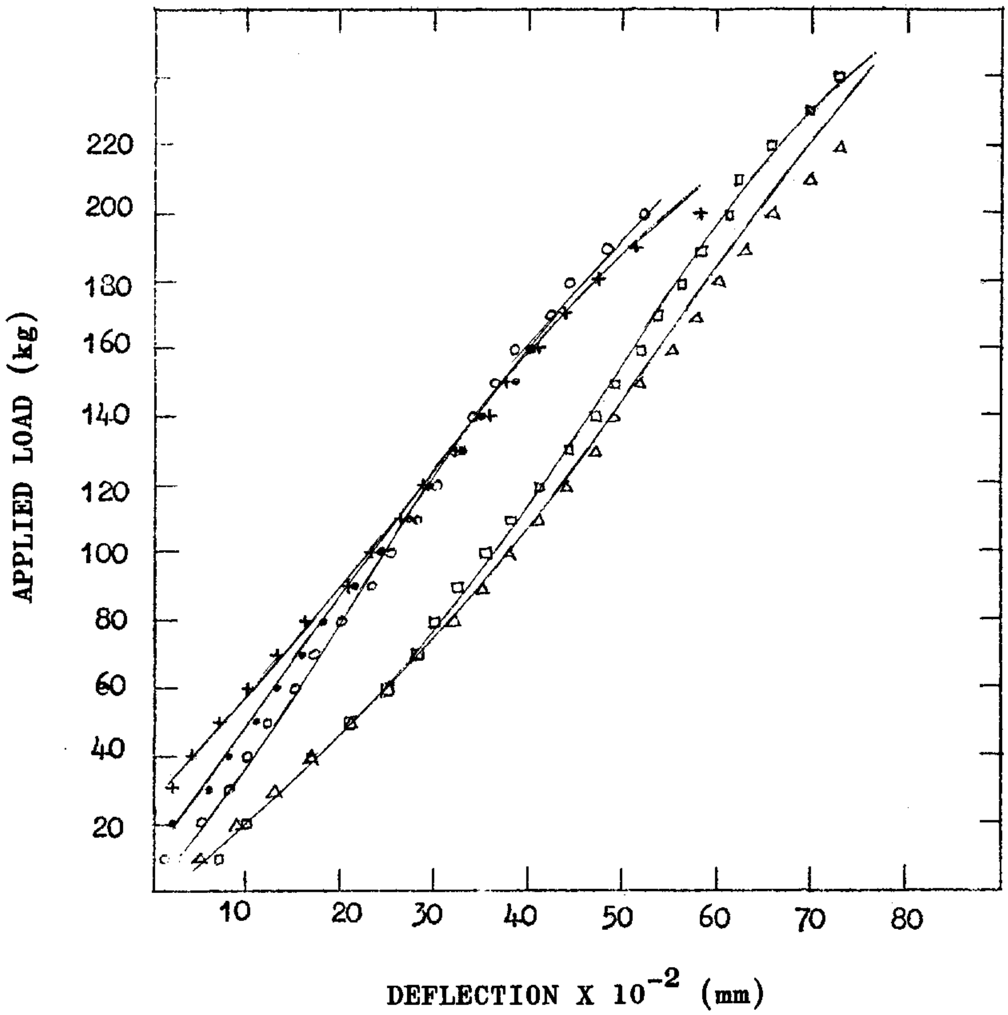

Figure 5. Load-deflection curves of 5 slabs reinforced with 5 cm wires gauge No. 24.

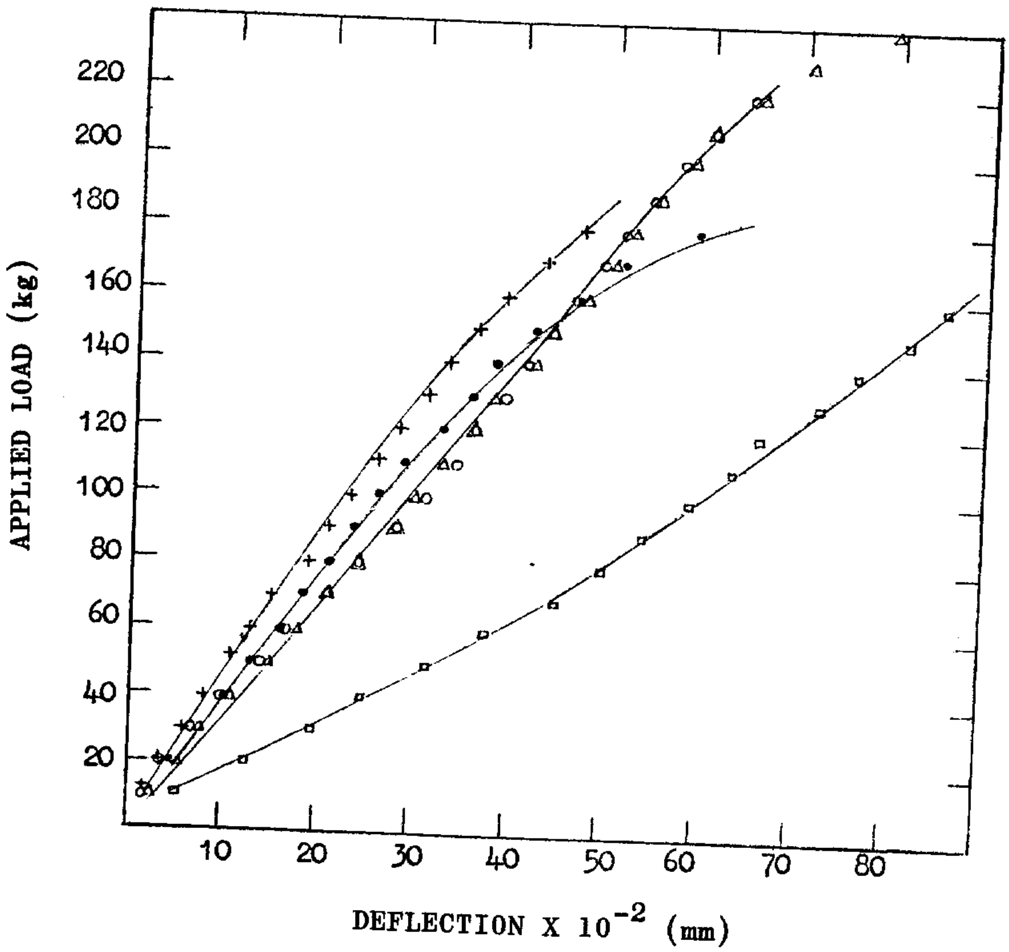

Figure 6. Load-deflection curves of slabs reinforced with 6 cm wires of gauge No. 24.

TABLE 3. IMPACT TEST RESULTS OF SLABS WITH VARIOUS SIZES OF WIRE REINFORCEMENT

Slab no.	Length of reinforcing wire (cm)	Weight of slab (kg)	At initiation of crack		
			Impact load (kg)	Dropping height (m)	Impact energy (kg-m)
24I-5-4	5	54.5	9	2.0	18.0
24I-5-5	5	54.0	9	2.5	22.5
24I-5-6	5	53.5	9	2.5	22.5
22I-5-1	5	54.5	9	3.0	27.0
22I-5-2	5	52.5	9	2.5	22.5
22I-5-3	5	53.0	9	2.5	22.5
19I-5-1	5	54.5	9	3.25	29.25
19I-5-2	5	55.0	9	3.50	31.5
19I-5-3	5	53.5	9	3.50	31.5

TABLE 4. THE FLEXURAL TEST RESULTS OF SLABS REINFORCED WITH VARIOUS SIZES OF WIRE

Slab no.	Gauge no. of reinforcing wire	Length of wire (cm)	Weight of slab (kg)	At initiation of crack	
				Applied load (kg)	Bending strength (kg/cm^2)
24F-5-2	24	5	11.02	223	1.65
22F-5-1	22	5	11.08	203	1.51
19F-5-1	19	5	11.04	278	2.06

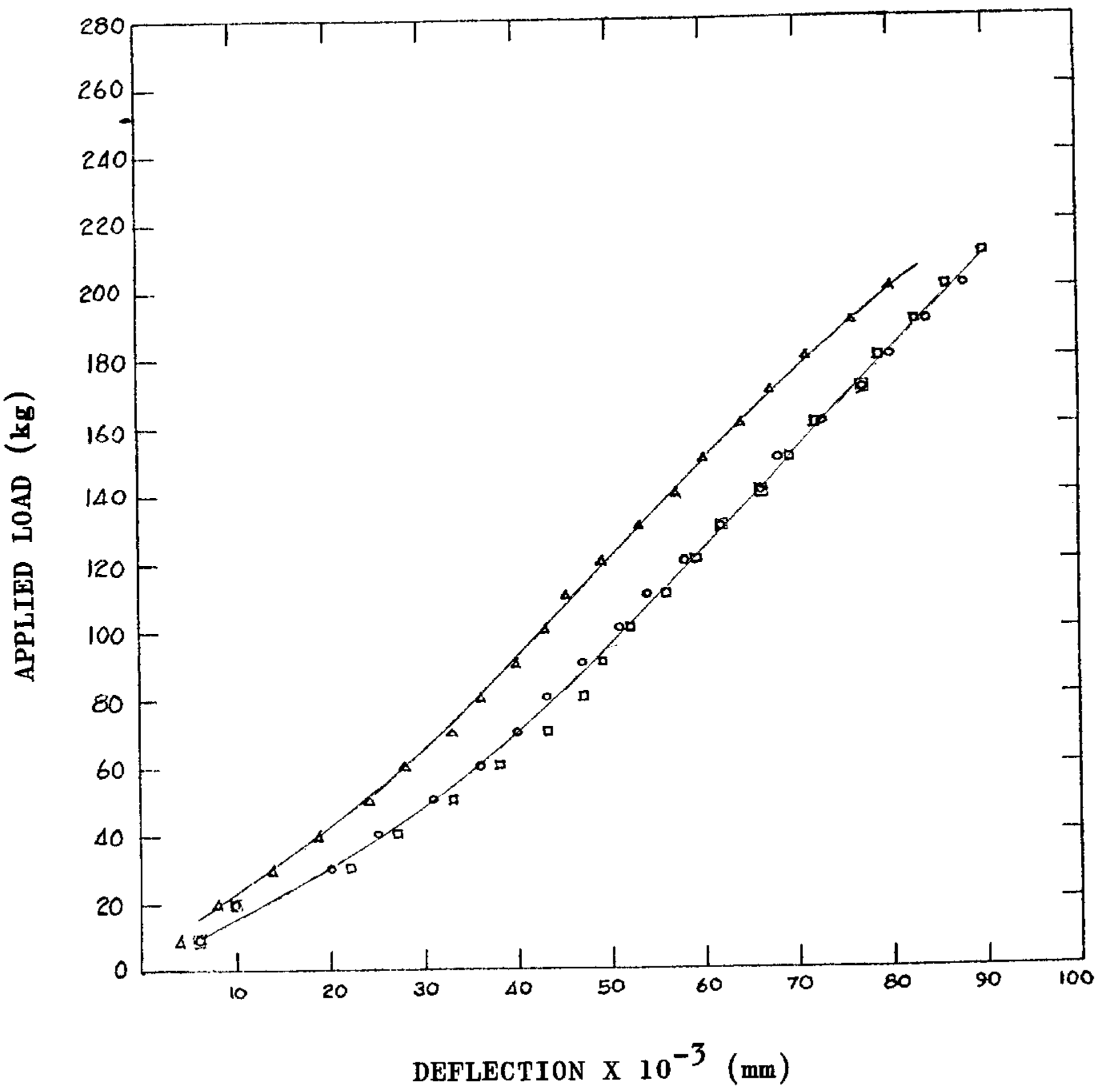

Figure 6. Load-deflection curves of slabs reinforced with wire of gauge No. 22 of 5 cm length.

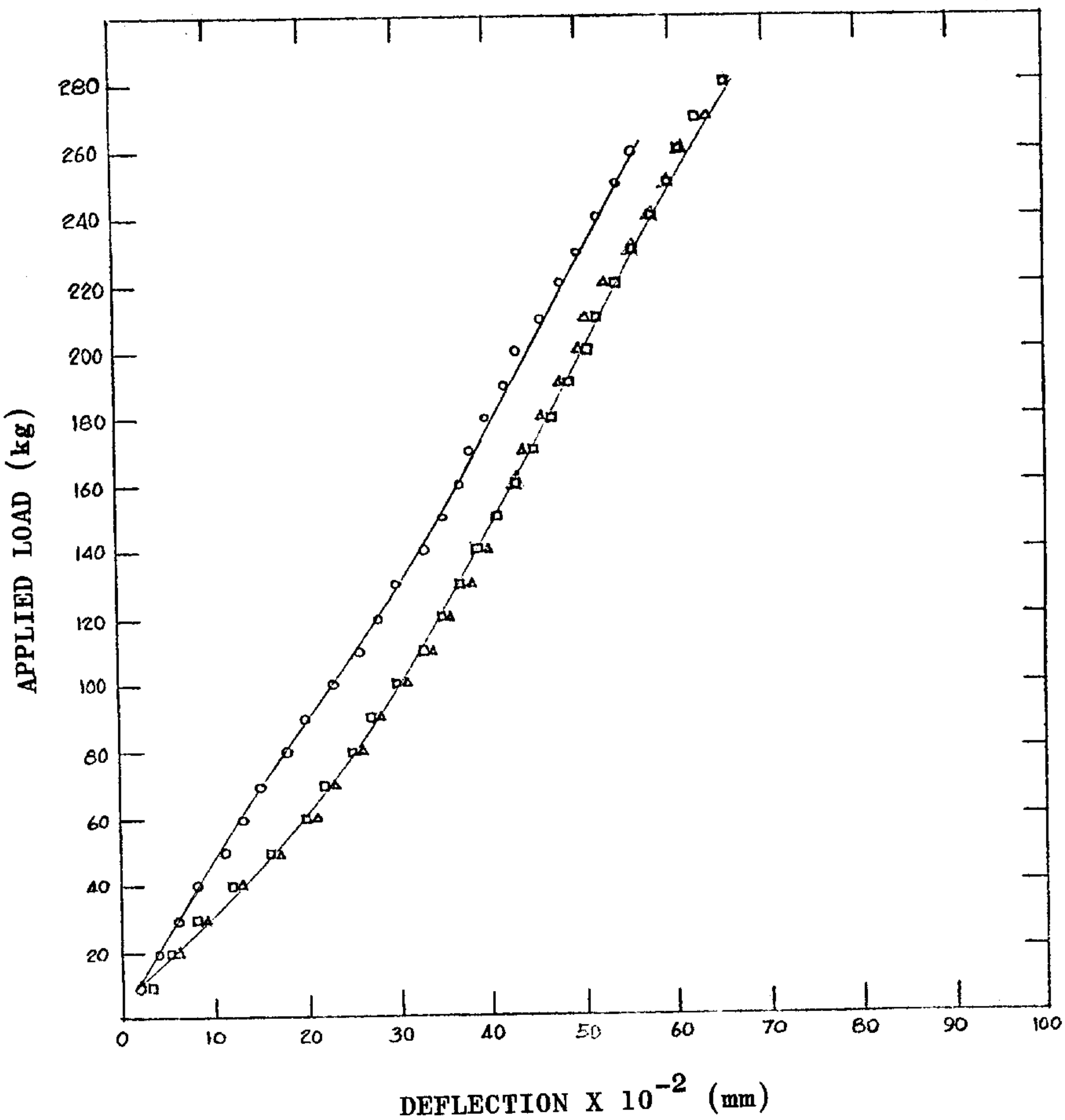

Figure 8. Load-deflection curves of slabs reinforced with wire of gauge No. 19 of 5 cm length.

IV. CONCLUSION AND RECOMMENDATION

From this investigation, the following conclusions and recommendations can be drawn:

1. Slabs made with No. 19 gauge wire of 5 cm in length establish the highest strength.

2. Both impact and bending strengths are comparatively much lower than those obtained from the ordinary ferrocement test specimens.

3. Because of the poor flexural test result, the yield strength at 0.2% offset cannot be determined.

4. Should the non-galvanized wires were used, the bond strength is expected to be improved.

5. The impact resistance increases with longer wire reinforcement.

V. REFERENCES

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