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EDITORIAL

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The Editor

Behavior of Ferrocement Material Under Direct Shear

G.J. Al- Sulaimani* and I.A. Basunbul*

The behavior of ferrocement under direct shear was investigated by conducting axial compression tests on Z-shaped specimens reinforced with woven wire mesh producing pure shear on the shear plane. The major study parameters were the volume fraction of wire mesh reinforcement V_f, the shear plane and mortar strength. Test results indicate that ferrocement under direct shear exhibits two stages of behavior (cracked and uncracked) while under flexure it exhibits, a third stage (plastic stage) in addition. The cracking and ultimate shear stresses increase with increasing mortar strength and wire mesh reinforcement. Empirical equations have been developed here using regression analysis to predict the cracking and ultimate shear stresses in terms of the mortar tensile strength f_t and V_f. The test results also indicate that the shear stiffness in the uncracked stage is not significantly affected by the amount of wire mesh; it is mainly affected by the mortar strength. The shear stiffness in the cracked stage is affected by both amount of wire mesh and mortar strength. Ductility of ferrocement material under direct shear increases with increasing wire mesh reinforcement and decreases with higher mortar strength.

INTRODUCTION

Innovative techniques in the use of ferrocement as a construction material have led research on this material to progress at a fast pace in order to develop design and construction guidelines controlling its different behavioral aspects (flexural...etc.). The behavior of ferrocement in flexure has received adequate attention by many researchers and it has been observed to be very similar to that of reinforced concrete members [1-4]. However, ferrocement subjected to shear has not received the same level of attention; little research is reported in the literature on the behavior of ferrocement under shear. This is probably due to the fact that it is mainly used in thin shell elements where shear stresses are not a critical design consideration. But the new developments of ferrocement warrant the study of its shear behavior.

Mansur and Ong [5] have studied the behavior in shear of ferrocement reinforced with welded wire mesh by conducting flexural tests on simply supported rectangular beams under two symmetrical point loads. The major variables of the study were the shear span-to-depth ratio a/h, volume fraction of reinforcement V_f, strength of mortar f_c', and the amount of reinforcement near the compression face. Their test results indicate that the diagonal cracking strength increases as a/h ratio is decreased and V_f, f_c' and reinforcement near compression face are increased. Empirical equations are proposed to predict the diagonal cracking strength of ferrocement. Ferrocement beams are found to be susceptible to shear failure at small a/h ratios when V_f, f'_c are relatively high. In general, however, shear failure is preceded by the attainment of flexural capacity.

The study by Al-Sulaimani, et al. [6] on the flexural strength of flanged beams (I-beams and hollow-box beams) indicates that wire mesh reinforcement in the webs of these beams plays an

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important role in increasing their ultimate flexural capacity and also safeguards against premature shear failure. A study by Saleem [7] on the flexural behavior of ferrocement sandwich ribbed panels has shown that wire mesh reinforcement in the ribs enhances their shear capacity. Panels with no mesh reinforcement in the ribs have shown sudden shear failure. The shear capacity of the panels is increased as the mesh reinforcement in the ribs and number of ribs are increased.

Lua and Wanrioj [8] studied the effect of galvanized welded wire mesh as shear reinforcement when it was used with shotcrete for strengthening of reinforced concrete beams. Test results showed that wire mesh acting as shear reinforcement was fully effective. The failure mechanism of the beams changed from shear failure to flexure when strengthened by ferrocement layer. Chitharanjan, et al [9] studied the effect of adding chicken mesh to reinforced aerocrete beams. Their test results showed that provision of web reinforcement would improve the shear resistivity, provision of chicken mesh induces aggregate interlock force by increasing the tensile strength of aerocrete, and the increase in the number of chicken mesh caging improves the ductility of the member but not the ultimate moment capacity.

The behavior of ferrocement hollow box-beams under transverse shear has been studied [10] by conducting flexural tests on 15 beam specimens. The major parameters used were amounts of wire mesh reinforcement in webs and in flanges of the beam and shear span to depth ratio a/h. Test results indicate that cracking and ultimate shear forces increase as wire mesh in webs is increased; placing wire mesh in flanges also increases shear resistance through arresting the tension cracks and causing them to be finer. Hence, the shear behavior is studied with relation to the total volume fraction of wire mesh reinforcement V_f which includes mesh reinforcement in both webs and flanges. The cracking and ultimate shear strengths also increase as the a/h ratio is decreased. The ACI equation for shear strength of conventional reinforced concrete beams without web reinforcement underestimates the cracking shear strength of ferrocement box-beams. Hence, an empirical equation has been developed using multiple regression analysis to predict the strength of ferrocement box-beams under transverse shear.

In this paper, the behavior of ferrocement under direct shear is investigated as mortar strength and amount of wire mesh reinforcement are varied. Empirical equations are proposed to predict the cracking and ultimate stresses of ferrocement under direct shear.

EXPERIMENTAL PROGRAM

The behavior of ferrocement material under direct shear was investigated by conducting axial load tests on direct shear specimens. This type of test gives an indication of the shear strength of ferrocement under pure shear which is considered as a basic mechanical property as the tensile strength under pure tension. The major variables of the study were amounts of wire mesh reinforcement in the shear plane and mortar strength. The specimens were divided into four groups I to IV, according to the amount of wire mesh reinforcement; each main group is subdivided into three subgroups according to mortar strength (Table 1) with three specimens in each subgroup. Hence, the results presented for each subgroup are really the average of three specimens.

The direct shear specimen used in this study has Z-shape as shown in Fig. 1; it has a width of 300 mm, 100 mm thickness and a height of 600 mm. There is a triangular notch in the middle of each side of the specimen to force failure along the shear plane which has dimensions of 30 mm x 220 mm.

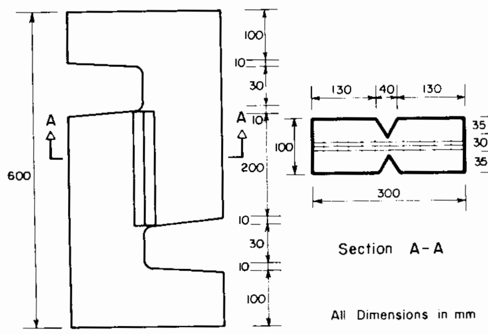

Fig. 1. Direct shear specimen.

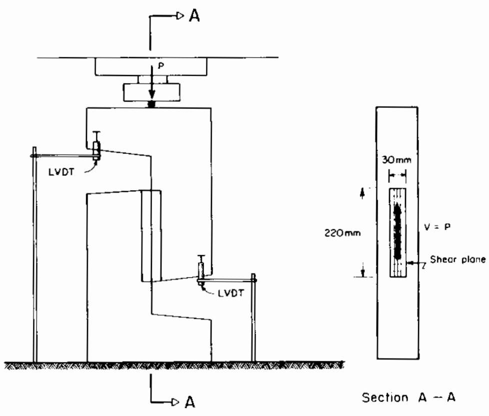

Fig. 2. Schmatic drawing of direct shear test set-up.

Table 1 Details of the Testing Program

Main Group	Number	V_f	Subgroup*	f'_c (MPa)	f_t (MPa)
I	1	0	I - 1	50.9	5.15
			I - 2	43.5	4.30
			I - 3	36.0	3.50
II	1	0.0025	II - 1	52.9	5.10
			II - 2	40.2	4.20
			II - 3	34.8	3.60
III	3	0.0075	III - 1	49.8	5.15
			III - 2	43.7	4.40
			III - 3	33.3	3.05
IV	5	0.0125	IV - 1	52.5	4.90
			IV - 2	42.8	4.00
			IV - 3	36.2	3.45

* Three specimen in each subgroup (Total of 36 specimens).

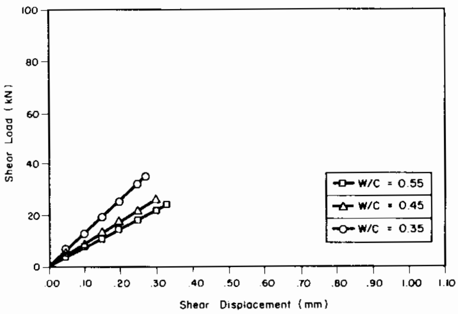

Fig. 3. V- Δ Plots for group I (0 layers).

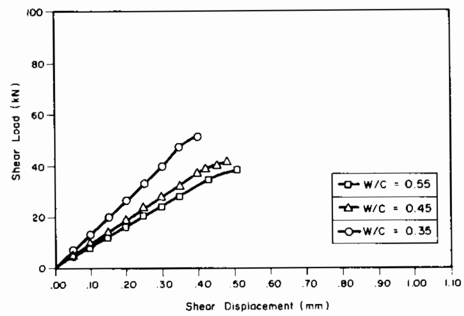

Fig. 4. V-Δ for group II (1 layer).

The wire mesh layers are placed to cross the shear plane. Regular reinforcing bars are placed top and bottom blocks of the specimens to avoid any premature failure of these end blocks.

Ordinary Portland cement Type I with beach dune sand (fineness modulus = 1.5) was used with cement to sand ratio of 1:2. The specimens were cast from concretes with w-c ratios of 0.35, 0.45 and 0.55 giving an average compressive strength f''_c of 51.5 MPa, 42.5 MPa and 35.0 MPa, respectively. For each batch, six 50 mm cubes and six briquettes with cross-section of 25mm x 25 mm were cast to determine the compressive strength f'_c and tensile strength f_t of the mortar, respectively (Table 1). Woven square wire mesh had an opening size D = 8.4 mm, wire diameter d_w = 0.9 mm and average yield strength of 340 MPa. The amounts of wire mesh reinforcement were varied by varying the number of wire mesh layers crossing the shear plane (N = 0, 1, 3 and 5).

The direct shear specimens were tested under axial compression loading to produce direct shear in the shear plane (Fig. 2). For this purpose, an INSTRON 1196 Machine with 250 kN capacity was used. Two Linear Variable Displacement Transducers (LVDT) were positioned on the specimen to measure shear displacements (Δ in mm) versus applied load level (P in kN) which is equal to the shear load (V) applied on the shear plane; the two shear displacement measurements were then averaged and plots of applied shear V versus displacement were obtained.

TEST RESULTS AND DISCUSSION

Plots of shear force acting on the shear plane versus shear displacement (V - Δ) were obtained from the recorded and reduced test data for the different study parameters, with three specimens for each parameter (hence, each V - Δ plot represents an average of three specimens). Figs. 3, 4, 5 and 6 depict V - Δ plots for 0, 1, 3 and 5 wire mesh layers, respectively, with each figure showing three plots for the three w-c ratios used in this study.

Ferrocement, when subjected to flexure, exhibits three stages of behavior: uncracked, cracked and yield or ultimate stage [1-4]. The third stage is an indication of the ductility that ferrocement possesses under flexure. On the other hand, Figs. 3 through 6 indicate the presence of only the first two stages (uncracked and cracked) while the third is absent from the behavior of ferrocement under direct shear within the range of the studied parameters. This substantiates the general statement that shear failure is less ductile than flexure. These figures show that the presence of the cracked stage

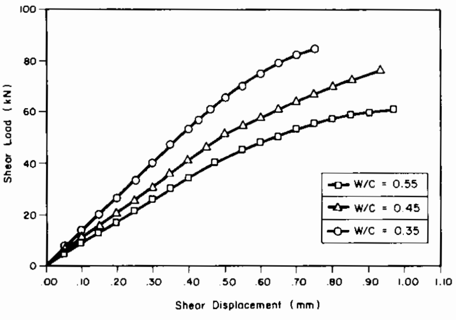

Fig. 5. V- Δ plots for group III (3 layers).

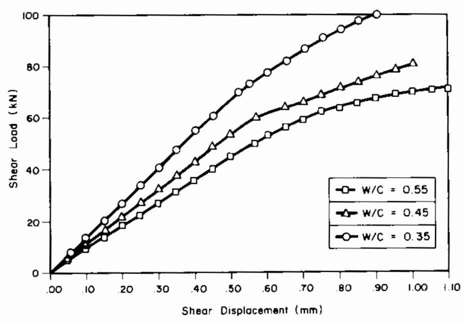

Fig. 6. V- Δ plots for group IV (5 layers).

varies depending on the amount of wire mesh reinforcement; it is completely absent in the case of zero layer (plain concrete), and more present as the number of layers increases.

The values of cracking shear load V_{cr} (shear level at which the V - Δ curve starts deviating from linearity) and the ultimate shear load V_{ult} were obtained from Figs. 3 to 6. These values were then used to calculate the average cracking shear stress τ_{cr} and the ultimate shear stress τ_{ult} by dividing the shear load by the shear plane area (30 mm x 220 mm). The values for τ_{cr} and τ_{ult} are tabulated in Table 2. The area under the V - Δ curve, which is an indication of the material toughness, is also shown in Table 2 for all the investigated direct shear specimens. Table 2 also shows the initial shear stiffness before cracking G_i calculated as τ_{cr} divided by Δ_{cr} (Δ_{cr} is shear displacement at end of uncracked stage), and the reduced shear stiffness G_r obtained by the following equation:

$$G_r = \frac{\tau_{ult} - \tau_{cr}}{\Delta_{ult} - \Delta_{cr}} \tag{1}$$

It is based on idealizing the V - Δ curve to be also linear in the cracked stage as in the uncracked stage, but having lower slope. Δ_{ult} is the ultimate shear displacement corresponding to V_{ult}.

Effect of amount of wire mesh

The test results presented in Figs. 3 to 6 and Table 2 clearly indicate an increase in the cracking and ultimate shear stresses of ferrocement with an increase in the amount of wire mesh reinforcement. As expected, an increase in mesh reinforcement leads to increasing ferrocement ductility and toughness in shear which is also shown from these figures and Table 2. However, the initial shear stiffness G_i does not change significantly with changing the amount of wire reinforcement. Before cracking, shear stiffness (G_i) mainly depends on mortar strength, and the wire mesh plays little role in the stiffness. However, the shear stiffness in the cracked stage (G_r) depends significantly on the amount of wire mesh since it becomes more effective as the mortar cracks. The stiffness in this stage reduces gradually as mortar cracks more and more; however, it is idealized in this study to be constant over the whole stage and calculated using Eq. 1, as mentioned before.

Effect of Mortar Strength

The plots in Figs. 3 to 6 and the results in Table 2 clearly show the effect of mortar strength on

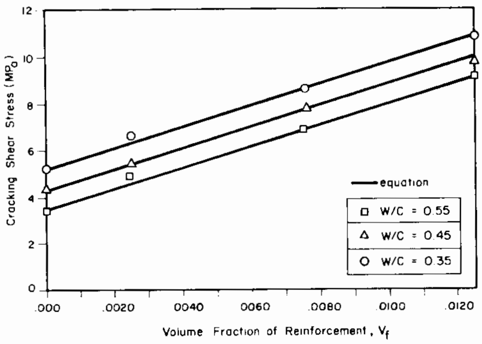

Fig. 7. Cracking shear stress vs. V_f.

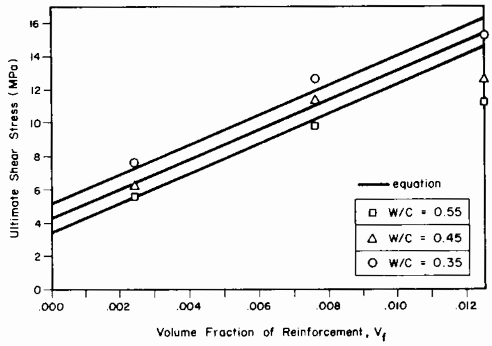

Fig. 8. Ultimate shear stress vs. V_f.

Table 2 Test Results

Group	Subgroup	τ_{cr} (MPa)	τ_{ult} (MPa)	G_i (MPa/mm)	G_r (MPa/mm)	Toughness (kN-mm)
I	I – 1	5.1	–	20.0	–	4.7
	I – 2	4.2	–	15.2	–	4.2
	I – 3	3.4	–	11.0	–	3.5
II	II – 1	7.0	7.7	20.3	12.1	11.1
	II – 2	5.8	6.2	15.3	8.0	10.5
	II – 3	5.2	5.8	12.1	6.5	10.4
III	III – 1	8.6	12.8	20.3	13.6	37.4
	III – 2	7.7	11.6	15.5	9.2	35.6
	III – 3	6.4	9.3	12.9	7.6	34.7
IV	IV - 1	10.5	15.2	20.1	14.9	51.6
	IV - 2	9.5	12.6	15.9	10.5	50.6
	IV - 3	8.7	10.8	13.1	8.5	46.6

* Toughness is represented here by the area under the shear load-shear displacement diagram.

shear behavior. As mortar strength increases, the cracking and ultimate shear stresses, and initial and reduced shear stiffnesses increase. Toughness (represented by the area under the V - Δ curve) seems not to be affected significantly with mortar strength. On the other hand, ultimate shear displacement Δ_{ult} decreases with increasing mortar strength, as shown in Figs. 3 to 6, which is an expected behavior.

Cracking and Ultimate Shear Stresses

From the test results in Table 2, cracking shear stress τ_{cr} and ultimate shear stress τ_{ult} increase as the mortar strength and amount of wire mesh reinforcement increase. An attempt is made here to develop expressions relating τ_{cr} and τ_{ult} to the mortar tensile strength f_t and volume fraction of wire mesh reinforcement V_f. A regression analysis was conducted using the test results of the ferrocement direct shear specimens and the following expressions can closely predict the cracking and ultimate shear stresses for ferrocement under direct shear:

$$\tau_{cr}=f_t+450\,V_f \quad \text{(MPa)} \tag{2}$$

$$\tau_{ult}=f_t+900\,V_f \quad \text{(MPa)} \tag{3}$$

Examining the factors multiplying V_f in Eqs. 2 and 3, it can be stated that the cracking shear stress τ_{cr} is less affected by the amount of wire mesh while its effect is more in τ_{ult}. This is expected because, before cracking, shear behavior of ferrocement depends mainly on mortar strength, while after cracking it depends more on wire mesh than the case before cracking.

Figs. 7 and 8 show plots for τ_{cr} and τ_{ult} versus V_f, respectively; plots shown in each figure are for the different mortar strengths investigated.

From Fig. 8, it looks that the τ_{ult} expression overestimates the experimental values for specimens with five layers of wire mesh. This may be attributed to the premature failure in bond between mortar and wire mesh before achieving the desired shear failure. This bond problem seems to be further aggravated by the absence of a well compacted mortar around the wire mesh due to the large numbers of wire meshes (5 layers). This justification is substantiated by post-test examinations of the test specimens with 5 layers of wire mesh.

CONCLUSIONS

The following conclusions can be drawn from this investigation which studied the behavior of ferrocement under direct shear:

1) Ferrocement under direct shear exhibits two stages of behavior namely cracked and uncracked, while ferrocement under flexure exhibits a third stage (ultimate or plastic stage) in addition to the uncracked and cracked stages. Hence, ferrocement is less ductile under shear than flexure.

2) The presence of the cracked stage in ferrocement behavior under direct shear increases with increasing amount of wire mesh reinforcement.

3) The cracking and ultimate shear stresses of ferrocement increase with increasing mortar strength and wiremesh reinforcement; they can be predicted by the following empirical formulae:

$$\tau_{cr} = f_t + 450\, V_f \quad \text{(MPa)}$$

$$\tau_{u} = f_t + 900\, V_f \quad \text{(MPa)}$$

4) The shear stiffness in the uncracked stage is not significantly affected by the amount of wire mesh while it is significantly affected in the cracked stage. However, the shear stiffness in both stages is affected by the mortar strength.

5) Ductility of ferrocement under shear (represented by the ultimate shear displacement) increases with increasing wire mesh reinforcement and reduces with higher mortar strength.

6) Toughness (represented by the area under the shear load - shear displacement curve) is not significantly affected by the mortar strength. However, it increases with increasing wire mesh reinforcement.

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REFERENCES

1. Logan, D., and Shah, S.P. 1973 Moment capacity and cracking behavior of ferrocement in flexure. *Journal of American Concrete Institute* 70(12): 799-804.

2. Johnston, C.D., and Mowat, D.N. 1974. Ferrocement material behavior in flexure. *Journal of the Structural Division ASCE* 100(ST10): 2053-2069.

3. Balaguru, P.N.; Namaan, A.E.; and Shah, S.P. 1977. Analysis and behavior of ferrocement in flexure. *Journal of the Structural Division ASCE* 103(ST10): 1937-1949

4. Huq, S., and Pama, R.P. 1978. Ferrocement in flexure - Analysis and design. *Journal of Ferrocement* 8(3): 169-193.

5. Mansur, M.A., and Ong, K.C.G. 1987. Shear strength of ferrocement beams. *ACI Journal* 84(1):10-17

6. Al-Sulaimani, G.J.; Ahmad, S.F.; and Basunbul, I.A. 1989. Study of the flexural strength of ferrocement 'flanged' beams. *The Aragian Journal for Science and Engineering* 14(1): 33-46.

7. Saleem, M. 1988. Flexural Behavior of Ferrocement Sandwich Panels. M.Sc. Thesis, Civil Engineering Department, King Fahd University of Petroleum and Minerals at Dhahran, Saudi Arabia.

8. Lua, K.B., and Van Wanrioj, M.C.G. 1988. Strengthening of reinforced concrete beams with shotcrete-ferrocement, In *Proceedings of the Third International Symposium on Ferrocement*. Roorkee: Civil Engineering Department of University of Roorkee.

9. Chitharanjan, N.; Manoharan, P.D.; and Sivaraman, G. 1988. Addition of chicken mesh improves the shear capacity of aerocrete. In *Proceedings of the Third International Symposium. on Ferocement* Roorkee: Civil Engineering Department, University of Roorkee.

10. Al-Sulaimani, G.J.; Basunbul, I. and Mousselhy, E. 19??. Shear behavior of ferrocement box- beams". Paper submitted to *Cement and Concrete Composite Journal.*

Effect of Repeated Loading on Crack Width of Ferrocement

G. Singh * and M. Fong L. Ip **

A ferrocement composite has been studied under repeated loading in flexure. As a part of a large program, development of crack widths due to repeated loading are reported. Reliability of predictive models is discussed and a new model is proposed. Where knowledge of crack width is deemed to be essential it is recommended that the models should be used with due care and not without confirming their applicability through physical tests.

INTRODUCTION

Knowledge of the behavior of a material under static loading is not sufficient for all its applications and must be supplemented by an understanding of the fatigue properties. Ferrocement may sometimes be subjected to a large number of repetitions of fluctuating load, as for example in roof structures and marine applications. Unlike static behavior, fatigue behavior is gradual and progressive, albeit very complex. Most fatigue tests on ferrocement have been performed under load control [1-10] and some [11,12] have been performed under controlled deflection. All these studies have thrown light on the complex interplay between the various extrinsic and intrinsic factors and some have produced predictive models for the designers. Now, one of the limiting criteria of design considered by designers is the crack width. A number of researchers have suggested methods for prediction of crack widths for ferrocement under static loading. Let it be said at the outset that this prediction is very difficult and unreliable [13]. However only Balaguru et al. [6] have suggested that crack widths during fatigue loading can be predicted using the following equation:

$$Y = Ae^{Br}$$

where

Y = average *or* maximum crackwidth

A = value of Y at the end of the first half of the first loading cycle

B = constant (fatigue contribution)

r = cycle ratio (number of cycles/ failure cycles).

The empirical equation for B was given as:

$$B = 0.816 + 0.00445N - 0.495 \times 10^{-5} N^2 \leq 1.67$$

where, N = number of cycles to failure

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A number of researchers have recognized that bond between mortar and wires plays an important role and Balaguru et al. also have taken into consideration the effects of deterioration of bonds. They claim their prediction model to be satisfactory.

SCOPE OF INVESTIGATION

As a part of a continuing program of research into the fatigue characteristics of ferrocement in normal and corrosive environment the authors have studied the effects of repeated loading on the crack development. In this paper the results of the tests are presented and compared with the predictions from the above noted model and discussed. Another model is proposed and shown to be more suitable.

MATERIALS, SPECIMEN PREPARATION AND TESTING

Materials:

Only one type of reinforcement was used for all the specimens. It was galvanized drawn square weldmesh of 6.35 mm x 6.35 mm x 0.71 mm diameter. The ultimate strength of reinforcement was 403 N/mm^2. The yield strength and modulus of elasticity were 345 N/mm^2 and 140 kN/mm^2 respectively.

The mix proportion was 1:2.5:0.5 (cement:sand:water). The grading of the quartzite sand complies with Zone 2 limits of BS 882 (part 2):1973 [14]. Ordinary Portland cement, complying with BS12:1971 [15] was used. The average cube strength was 60 N/mm^2.

Specimen Preparation

The specimen size was 350 mm x 125 mm having a thickness of 30 mm. Six layers of weldmesh, fastened together, were used as reinforcement, thus giving a percentage of reinforcement of about 1.14. No skeletal steel was used and 5 mm spacers were fastened onto the first layer of reinforcement to obtain a cover of 5 mm.

The specimens were cast horizontally in groups of five in a steel mould. For each group of specimens cast, control specimens of mortar were cast at the same time. They consisted of six 100 mm cubes and six 500 mm x 100 mm x 100 mm beams. Immediately after casting, the ferrocement and control specimens were covered with hessian and polythene sheeting for 24 hours at a temperature of about 190°C. The specimens were then demoulded and transferred to the curing room for further curing of 27 days at 20$\pm$ 1°C and relative humidity of 98%. Some of these specimens were tested at the age of 28 days. The rest were divided into two groups. One group was kept in the curing room for various periods prior to testing. The other was preloaded and subjected to accelerated corrosion for various durations before testing.

Corrosive Environment and Preloading

This system [16] was similar to that used by Ravindrarajah and Paramasivam [17]. It provided an accelerated marine weathering condition. Loaded specimens were stored in this system for various durations. Splash zone is the most severe marine condition. It is just above the high tide level where there are build-ups of salt-spray, wetting-drying and freeze-thaw cycles. The main features of this system were the cyclic temperature and moisture environments. The duration of each cycle was 90 minutes, which included a 60 minute dry phase of warm air (70°C) and a 30 minute phase of full immersion (40°C). To simulate sea water and act as a wetting medium in the system, 3.5% NaCl solution was used.

To ensure that the specimens were subjected to severe corrosive conditions, they were preloaded before placing into the storage tanks. The specimens were loaded to the maximum allowable service limit. The *State-of-the-art Report on Ferrocement* [1] gives some guidelines for performance criteria. In this study, the concerning allowable limits were tensile stress in steel reinforcement of 207 MPa and crack width of 0.05 mm.

Testing Rig

The testing rig consisted of a four point arrangement with a span of 300 mm and a constant bending moment zone of 120 mm. An upward jacking force was applied by a 20 kN hydraulic jack through a diaphragm. The whole set up was enclosed in a perspex box. A pump drew the salt solution from the tray at the bottom and supplied it on the top in the form of a spray through a perforated copper pipe.

Strain and deflection measurement were performed with demountable transducers made with spring steel and strain gauges, and were suitably waterproofed.

Deflection was measured by using an ordinary stainless steel linear variable differential transducer, fitted with brass coverings to avoid water ingress.

Data Logging System

The system consisted mainly of a micro-computer, an interface and a bank of amplifiers. Eight channels which comprised of six from strain transducers, one from the LVDT and one from the load cell were used. An interactive computer program was developed to capture, retrieve, amplify and store the results.

TESTING PROGRAM AND PROCEDURES

A total of 60 specimens were tested for fatigue in flexure. They included four groups of fifteen specimens, one for each of the following curing conditions:

1. 28 days of normal curing: no preloading: control specimens.
2. 28 days of normal curing plus one month in the marine environment (450 cycles of exposure).
3. 28 days of normal curing plus three months in the marine environment (1350 cycles of exposure).
4. 28 days of normal curing plus 7 months in marine environment (3150 cycles of exposure).

Flexural fatigue tests were carried out at a frequency of 5 Hz under constant cyclic load. The maximum cyclic load corresponded to the stress induced in the outermost reinforcement expressed as a percentage of its ultimate strength. For earlier groups, five specimens were tested for each maximum stress level (nominal) of 75%, 65% and 55%. The minimum stress level (nominal) of 12.5% was used for all tests. About one-third of the specimens were runouts in each of the two groups. Therefore, higher maximum stress levels of 80%, 70% and 60% were used for latter group. The minimum calculated stress level remained nominally the same. Failure was defined as fracture of the outermost reinforcement. The specimens which did not fail after two million cycles were tested to failure under static loading.

A continuous spray of 3.5% NaCl solution was applied onto the specimens during the flexural fatigue tests. The permanent and cyclic deflection, the load and cyclic strains were measured by the data logging system automatically. Tests ran uninterrupted except when crack and permanent strain measurements were taken. In general, each interruption was about five minutes.

After the specimens were broken either due to fatigue or static failure (of run-outs), the cover to outermost reinforcement and the specimen thickness were measured. The reinforcements exposed at the fractured surface were examined for the evidence of rust.

RESULTS

Typical examples of the changes in average crack width of control specimens with the number of cycles are shown in Fig. 1. Fig. 2 compares the behavior between the control specimens and older specimens stored in the curing room. The corrosive history did not appear to have any adverse effect. This is typically illustrated in Fig. 3. Fig. 4 shows typical relationships between average crack width and the cycle ratio. These plots follow a classical three-stage curve: a sharp rise in the beginning followed by a slow propagation followed in turn by an increased rate near failure.

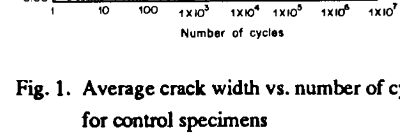

Fig. 1. Average crack width vs. number of cycles for control specimens

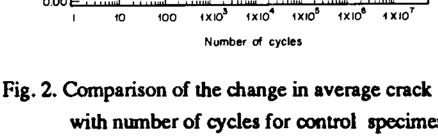

Fig. 2. Comparison of the change in average crack width with number of cycles for control specimens at various ages.

PREDICTION MODEL AND DISCUSSION

The empirical equation proposed by Balaguru et al. [6] was compared with the experimental data obtained by Ip [16]. It gives a gross underestimation of the crack widths as shown on Fig. 4. From the design point of view this can be hazardous. Therefore an improved model was sought through least

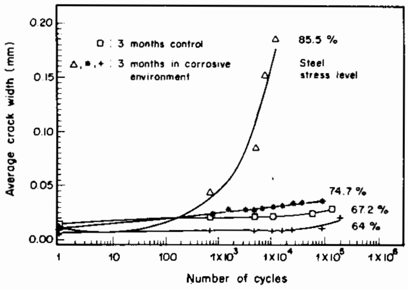

Fig. 3a. Average crack width vs. number of cycles for 3 month old specimen.

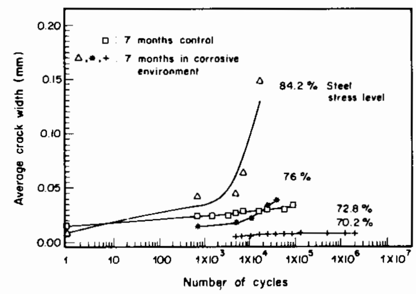

Fig. 3b. Average crack width vs. number of cycles for 7 month old specimem.

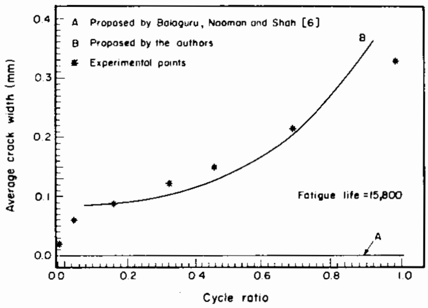

Fig. 4a. Specimen subjected to 5 month corrosive environment and 85% steel stress level.

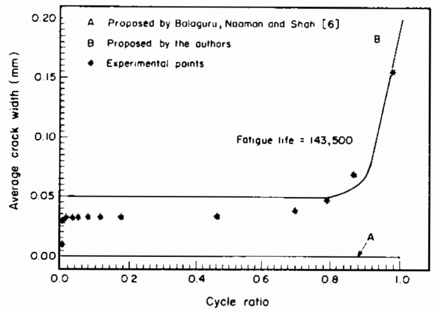

Fig. 4b. Control specimens, 7 months, subjected to 74% steel stress level.

square regression performed on all the specimens, ignoring the data in the initial portion of the tests wherein the crack width prediction was found to be difficult.

The following equation resulted:

$$Y = A^{1} e^{B^{\prime} r C}$$

where Y = average crack width in mm

A^{1}, B^{1} and C are constants

For specimens that failed within 2 million cycles,

$$A^{1} = 0.0486 + 1.88\, C_{1} - 1 \times 10^{-7} N$$

$$B^{1} = 1.772 - 1.28 \times 10^{-6}\, N \geq 0$$

$$C = 0.0199 + 0.000115N$$

where, C_{1} is the value of average crack width at the end of the first half of the first loading cycle.

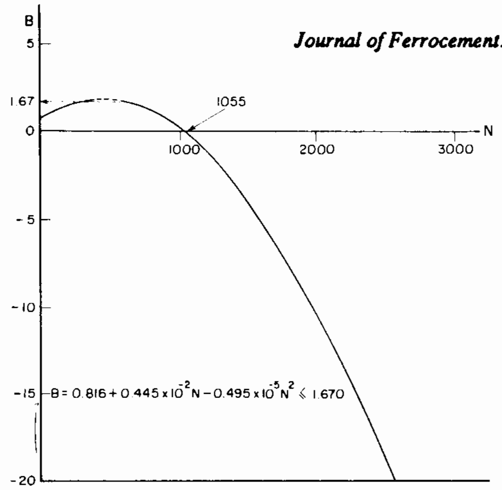

Fig. 5. Variation of coefficient constant B with fatigue cycle N for Reference [6].

For runout specimens,

$$A^{l} = 0.00942 + 0.406\, C_{l}$$

$$B^{l} = 0$$

$$C = 0$$

In practice, the maximum crack width is of greater concern than the average crack width. The expected value of the ratio of the maximum to average width was found to be 2.03 with a standard deviation of 0.46. It should be noted that to avoid excessive time expenditure and too many runout tests all researchers perform fatigue tests in the stress range above a level which would be regarded as allowable steel stress. Below the maximum allowable stress level the crack width was not only small but no increase was observed under load repetitions. This is reflected in the above model for runouts.

Balaguru et al. stated that B in their equation represents the fatigue contribution. However, this B will cause an increase in crack width with increasing cycle ratio only if failure cycle number is less than 1055. This becomes apparent when B is plotted against N using their equation (Fig. 5). Therefore this model is not suitable for predicting crack width.

It has been shown [13] that even under static loading all the available crack-width prediction models are far from reliable. Fortunately the dominating design criterion is not the crack width but the steel stress which can be modelled reasonably reliably. Where knowledge of crack width is deemed to be essential phenomenological study of the composite in question is recommended [18].

For repeated loading the models require knowledge of crack width at the end of the first half of the first real loading cycle. The proposed model in the paper gives satisfactory predictions for the composite tested.

CONCLUSIONS

Crack width and its growth under repeated loading increases with level of steel stress.

For the composite and the testing conditions used in this work the accelerated corrosive environment did not have any adverse effect.

All the crack prediction models are based on phenomenological studies and therefore are applicable only to specific composites and should be used with due care and not without confirming their applicability through tests. Where knowledge of crack width is deemed to be essential the model proposed in this paper should give satisfactory predictions for the composite tested.

REFERENCES

1. ACI Committee 549. 1982, State-of-the-art report on ferrocement. Report No. ACI 549R-82, *Concrete International* 4(8) : 13-38.

2. Bennett, E.W. ; Fakhri, N.A. ; and Singh, G. 1985. Fatigue characacteristics of ferrocement *ACI Journal* : 129-134.

3. Karasudhi, P. ; Mathew, A.G. ; and Nimityongskul, P. 1977. Fatigue of ferrocement in flexure. *Journal of Ferrocement* 7(2): 80-95.

4. Singh, G. ; Bennett, B.W. ; and Fakhri, A. 1986. Influence of reinforcement on fatigue of ferrocement , *The International Journal of Cement Composites and Lightweight Concrete* 8(3): 151-164.

5. Picard, A. , and Lachance, L. 1974. Preliminary fatigue tests on ferrocement plates. *Cement and Concrete Research* 4: 967-978.

6. Balaguru, P.N. ; Naaman, A.E. ; and Shah, S.P. 1979. Fatigue behaviour and design of ferrocement beams. *Journal of the Structural Division* 105(ST7): 1333-1345.

7. McKinnon, E.A. , and Simpson, M.G. 1975. Fatigue of ferrocemnt. *Journal of Testing and Evaluation* 3(5): 359-363.

8. Paramasivam, N.C. ; Das Gupta, N.C. ; and Lee, S.L. 1981. Fatigue behaviour of ferrocment slabs. *Journal of Ferrocement* 11(1): 1-10.

9. Raisinghani, M. , and Sai, A.S.R. 1984. Creep and fatigue characteristics of ferrocement slabs *Journal of Ferrocment* 14(4): 309-322.

10. Singh, G. , and Ip, L. 1988. Influence of a marine environment on flexural fatigue properties of a ferrocement , 525-542. In *International Conference on Performance of Concrete in Marine Environment.*

11 Greenius, A.W. 1975. Behaviour of ferrocement under repeated stresses, *Journal of Structural Engineering* (India) 2(4): 129-136.

12. Singh, G. 1981. Flexural response of a ferrocement to constant deflection repeated loading, In *International Symposium on Ferrocement* 2/1-7. Bergamo: Istituto Sperimentale Modelli e Strutture.

13. Singh, G., and Xiong, G.J. 1991. How reliable and important is the prediction of crack width in ferrocement in direct tension. In print *International Journal of Cement Composites*

14. British Standard Institution. 1973. *Aggregate from Natural Sources for Concrete (Including Granolithic) - metric version, BS 882 (part 2).* London: British Standard Institution.

15. British Standard Institution. 1971. *Portland Cement (Ordinary and Rapid Hardening) - metric version, BS 12.* London: British Standard Institution.

16. Ip, M.F.L. 1989. Fatigue of Ferrocement in a Corrosive Environment, Ph.D. Thesis, University of Leeds.

17. Ravindrarajah, R.S., and Paramasivam, P. 1988 Influence of weathering on ferrocement Properties, 1237-1247 In *Proceedings of the Second International Symposium on Ferrocement, Bangkok: International Ferrocement Information Center.*

The Experimental Behavior Of Ferrocement Flat Plate under Biaxial Flexure

R.P Clarke* and A.K Sharma**

The results of an experimental program taking into account lamination effects are presented and discussed. Twenty-three (23) square, simply-supported ferrocement slabs were tested to failure under biaxial flexure. The program was designed to investigate the effects of certain variables on the strengths, toughnesses, and mid-point deflection characteristics of a slab. Test variables included the through-the-thickness orientation pattern of the meshes; the stacking sequence of the meshes; span-to-thickness ratio and in-plane mesh orientation angle. It was concluded that lamination effects can considerably affect performance and should be considered in experimental work on ferrocement and in the modelling of its behavior.

LIST OF SYMBOLS

$[A]$	= extensional stiffness matrix	h	= slab thickness
$[B]$	= coupling stiffness matrix	a	= slab span
$[D]$	= bending stiffness matrix	p	= load per unit area
E_2	= transverse Young's modulus	$s.s$	= stacking sequence
x	= span-to-thickness ratio	Y	= normalized deflection
N	= number of mesh layers	θ	= mesh orientation angle
o	= through -the-thickness orientation pattern	w	= deflection

INTRODUCTION

The majority of actual and potential applications of ferrocement incorporate plate or shell structural elements. Such applications include storage structures, roofs, wall panels, floor systems, boat hulls, pontoons and other marine structures, etc. There is still an insufficiently clear understanding of the behavior of this novel composite structural material, which implies that much more experimental work is needed. This is evidenced by the fluctuating efficiency ratios (i.e. the ratio of test to theoretical ultimate moment or load) of current analysis approaches especially if mesh orientation angle is a variable [1-5].

To date experimental programs designed to investigate the behavior of ferrocement flat plates have been implicitly based on the premise of homogeneity [2-5]. Nevertheless, ferrocement can be classified as a laminated fiber-reinforced composite material which may have stiffnesses not possessed by homogeneous plates even if anisotropy is presumed [6]. In general, classical laminated plate stiffnesses are represented by the 3 x 3 matrices [A], [B] and [D] viz; the extension, coupling and bending stiffness matrices respectively [6]. The homogeneous plate stiffnesses can be shown to be

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special cases of the [A] and [D] matrices while the [B] matrix is a consequence of lamination hence having no representation in homogeneous plates. The latter matrix basically states that if the laminated plate is subjected to a tensile or compressive load then curvatures and/or twists would also simultaneously occur and vice versa. The existence of this matrix in a laminated plate depends on the symmetry of the properties of the individual layers about the plate's mid-plane. Laminates in the aerospace industry are known to be significantly affected by certain elements of these matrices. According to Jones[7], knowledge of the effect of A16, A26, D16, and D26 on the individual class of problems being considered by the analyst or designer is essential because even a small A16 or D16 might cause significantly different results from cases in which those stiffnesses are exactly zero; and only in the situation where A16, A26, D16, and D26 are exactly zero can they be ignored without further thought or analysis.

Stretching-shearing coupling occurs when the A16 and A26 are non-zero and bending-twisting coupling occurs when the D16 and D26 are non-zero. When B16 and B26 are non-zero twisting-shearing coupling as well as bending-shearing coupling simultaneously occur.

The experimental program forming the basis of this report was therefore designed in consideration of the theoretically possible effects of lamination and this is reflected in the choice of test variables.

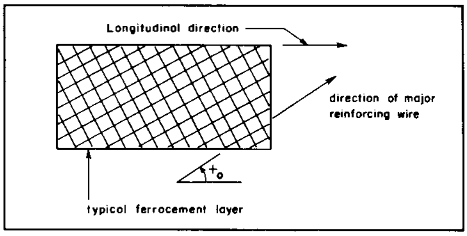

Fig.1. Sign convention for mesh orientation θ.

EXPERIMENTAL PROGRAM

The objective of the experimental program was to investigate the effects of (a) the through-the-thickness orientation pattern of the meshes, (b) the stacking sequence of the meshes, (c) the span-to-thickness ratio, and (d) the in-plane mesh orientation angle, on the strength and toughness of the ferrocement flat plates under biaxial flexure.

The values chosen for the variables and their interpretations are as follows. The through-the-thickness orientation pattern, o, had values of either 'constant' (i.e. c) or 'alternate' (i.e. al). For any mesh angle θ, $o=c$ if for all the meshes the sign of θ remains constant from top to bottom of the slab. $o=al$ if the sign of θ alternates from positive to negative and so on to the bottom of the slab. The sign convention for θ is shown in Fig.1. The stacking sequence, $s.s$, had values of either 'symmetric' or 'anti-symmetric'. This variable refers to the distribution of the properties of the layers about the slab's mid-plane. Since θ is considered as a property, $s.s=asymm$ only if $o=al$ and the number of layers

Table 1 Details of Test Specimens

Group no.	Slab no.	a/h	h mm	f_{cu} MPa	N		o	$s.s$	V_f %	Description (Top to Bottom)
A5	1	34.75	24.12	58.60	5	0	Coral	sym	6.99	00/0/0/0/0
	2	30.77	27.24	58.60	5	60	c	sym	6.20	60/60/60/60/60
	3	21.86	30.08	58.60	5	60	al	sym	5.62	60/-60/60/-60/60
	4	31.93	26.25	58.60	5	30	c	sym	6.43	30/30/30/30/30
	5	33.30	25.17	58.90	5	30	al	sym	6.71	30/-30/30/-30/30
	6	28.27	29.65	58.90	5	45	Coral	sym	5.41	45/45/45/45/45
A6	1	29.59	28.33	54.60	6	0	Coral	sym	7.14	0/0/0/0/0/0
	2	-	-	-	6	60	c	sym	-	60/60/60/60/60/60
	3	30.17	27.78	60.40	6	60	al	asym	7.30	60/-60/60/-60/60/-60
	4	32.78	25.57	60.40	6	30	c	sym	7.93	30/30/30/30/30/30
	5	34.41	24.36	47.50	6	30	al	asym	8.32	30/-30/30/-30/30/-30
	6	29.68	28.24	47.50	6	45	Coral	sym	6.81	45/45/45/45/45/45
A7	1	29.96	27.98	58.40	7	0	Coral	sym	8.44	0/0/0/0/0/0/0
	2	25.67	32.65	58.40	7	60	c	sym	7.24	60/60/60/60/60/60/60
	3	25.34	33.08	58.60	7	60	al	sym	7.15	60/-60/60/-60/60/-60/60
	4	23.52	35.64	58.60	7	30	c	sym	6.64	30/30/30/30/30/30/30
	5	24.44	34.29	58.80	7	30	al	sym	6.90	30/-30/30/-30/30/-30/30
	6	25.10	33.39	58.80	7	45	Coral	sym	6.72	45/45/45/45/45/45/45
B	1	20.76	40.38	58.60	7	0	Coral	sym	5.85	0/0/0/0/0/0/0
	2	21.11	39.70	58.60	7	60	c	sym	5.96	60/60/60/60/60/60/60
	3	19.09	43.90	62.80	7	60	al	sym	5.39	60/-60/60/-60/60/-60/60
	4	21.74	38.56	62.80	7	30	c	sym	6.13	30/30/30/30/30/30/30
	5	21.61	38.79	57.70	7	30	al	sym	6.10	30/-30/30/-30/30/-30/30
	6	19.47	43.04	57.70	7	45	Coral	sym	5.21	45/45/45/45/45/45/45

LEGEND:

a =span of slab

N = number of layers of mesh

asym =anti-symmetric

V_f = volume fraction

θ =in-plane mesh orientation angle

$s.s$ = stacking sequence

sym = symmetrical

h = slab thickness

o = through-the-thickness orientation pattern of the mesh cage

f_{cu} = compressive strength of the mortar

c = constant

al = alternate

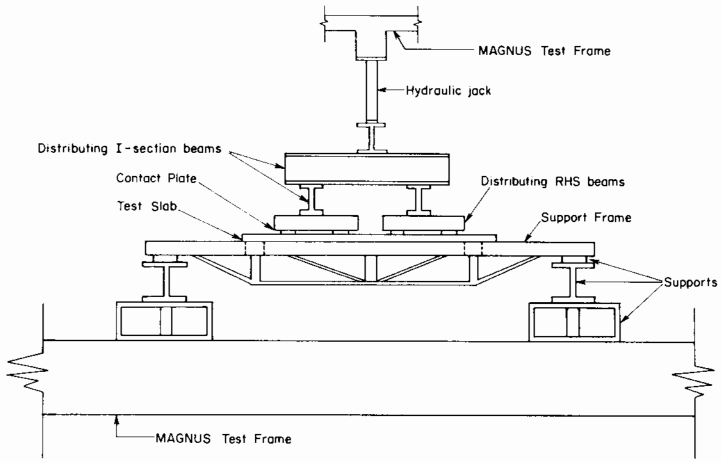

Fig. 2. Biaxial flexure test setup.

of mesh is an even number; otherwise *s.s=symm*. The span-to-thickness ratios (i.e. a/h) varied from approximately 20 to 35. The absolute values of θ were 0, 30, 45, and 60 degrees.

Twenty-three slabs were divided into groups A and B with 17 in group A and 6 in group B. The 17 in A were further sub-divided into groups A5, A6, and A7 of 6 slabs each except for A6 which had 5 slabs. The slabs were of square shape with a span of 838.2 mm (i.e. 33 in.). The test specimens are described in Table 1.

The wire mesh was of 2 mm diameter galvanised mild steel which was square-welded with a spacing of 19 mm (i.e. 3/4 in.). The mesh wire had a Young's modulus of 62.87 GPa (i.e. 9116.15 ksi) and a yield strength of 250 MPa (i.e. 36.25 ksi). The mortar comprised of ordinary portland cement and locally available sand which was capable of passing 100% through a No. 8 sieve. A sand-to-cement ratio of 2:1 and a water-to-cement ratio of 0.45 both proportioned by weight were used. The water contained 300 ppm of chromium trioxide to prevent hydrogen evolution.

A uniform surface load was approximated by using 16 symmetrically placed point loads. The slabs were supported at the edges by resting simply on steel beams in a specially designed test rig. A self-loading test frame of 200 kN (i.e. 20 tons) static capacity was used. The load was read off a calibrated gauge and was applied manually in 2 kN increments until failure. Failure was defined as the point at which the slab took no further load but continued to deflect. The mid-point deflection was measured at each load increment till failure using a dial gauge.

PRINCIPAL TEST RESULTS

The main test results are reported in Table 2 and shows the maximum load recorded in kN and the corresponding mid-point deflection in mm. The first crack load and corresponding mid-point deflection are also reported. The first crack load is defined as the load at which cracks were first observed with the unaided eye.

The descending order of ductility for the groups of slabs were as follows: B, A5, A6, and A7 and the the respective average ratios of first crack to ultimate load were 0.80, 0.82, 0.86, and 0.91.

EFFECTS OF THE TEST PROGRAM VARIABLES

Since span-to-thickness ratio was a variable, this implies that for any pair of slabs being compared there will be at least two variables which do not remain constant with one of them being the slab thickness. The effect of the other variable can be deduced if the effect of the thickness is known beforehand, given that there is a correlation between the observed parameters and the thickness. The parameters of interest were the strength (i.e. load carrying capacity) and the toughness (i.e. the area under the load-deflection curve) though quantitative values were only determined for the former.

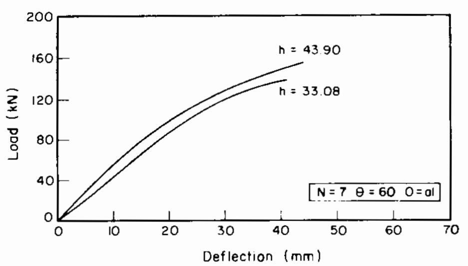

Fig.3. Load-deflection curves showing effect of slab thickness.

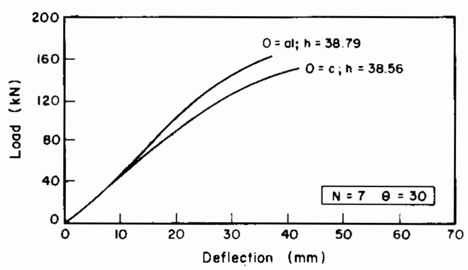

Fig.4. Load- deflection curves showing effect of mesh orientation pattern, o.

Slab Thickness, *h*

A statistical method was used to determine each slab thickness using the t-distribution and was such that the calculated thickness had a 95% confidence of being within 1 mm of the true mean thickness.

An increase in slab thickness resulted in an increase in both strength and toughness. The average increase in thickness was 24% and this resulted in an average strength increase of 11.3%. Therefore quantitatively a 1% increase in slab thickness resulted in a 0.47% increase in strength. This value was used to deduce the effect of the other variables where applicable. The assumed linear variation is valid considering the small differences in thickness of the relevant slabs. Typical load-deflection curves showing the effect of the slab thickness are shown in Fig. 3.

Through-the-Thickness Orientation Pattern, *o*

In general, when *o* changed from 'constant' to 'alternate' there was an average strength increase of 5.3% with a maximum increase of 10.1%. However, there was a general decrease in toughness. Typical load-deflection curves indicating the effect of the orientation pattern are shown in Fig.4.

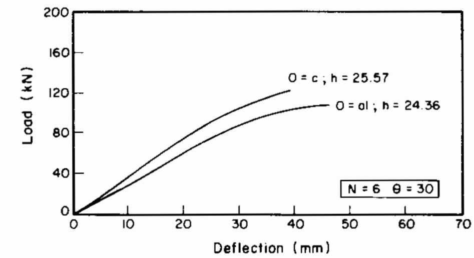

Fig. 5. Load-deflection curves showing effect of stacking sequence.

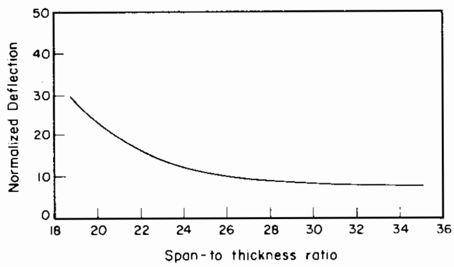

Fig.6. Influence of transverse shear deformation.

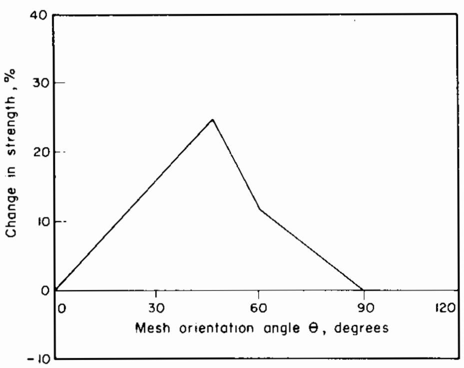

Fig.7. General trends of the effect of θ on the strength of the biaxial felexure slabs.

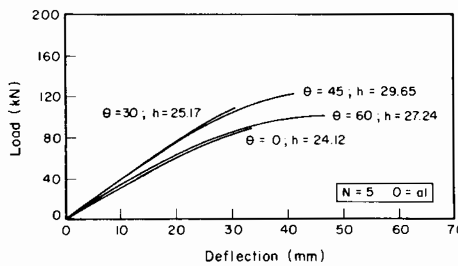

Fig. 8. Load-deflection curves showing effect of mesh-orientation, θ, for biaxial flexure.

Stacking Sequence, *s.s*

A decrease in both strength and toughness was observed when the stacking sequence was changed from 'symmetric' to 'anti-symmetric'. The observed strength decrease was approximately 9.3%. The load-deflection curves showing this effect are shown in Fig.5.

Span-to-Thickness Ratio, *a/h*

The effect of this variable was ascertained by plotting the normalized deflections at failure against the span-to-thickness ratios. The normalized deflection was defined [8] as $w h^3 x 10^4 / p a^4$ where w is the deflection, E_2 is the transverse Young's modulus, p is the load per unit area, and a is the slab's span. The definition of normalized deflection follows from plate solutions which assume that there is negligible contribution to deflection from shear in the thickness direction of the plate (e.g. the Navier solution). Since the terms are dimensionless, if that assumption is valid the normalized deflection would be constant for all values of a/h.

A polynomial regression analysis was performed on the resulting data points and the fitted curve is shown in Fig.6. The equation to the curve given in Eq. (1) is based on single precision floating point arithmetic. The span-to-thickness ratio is reperesented by '*x*', and the normalized deflection by '*Y*'.

$$Y = 701.57 - 67.232x + 1.667x^{2} - 9.032\times10^{-3}x^{3} + 1.9486\times10^{-3}x^{4} - 1.0152\times10^{-4}x^{5} + 1.3119\times10^{-6}x^{6} \quad (1)$$

Fig.6 indicates that for span-to-thickness ratios above about 25 transverse deformation effects are negligible.

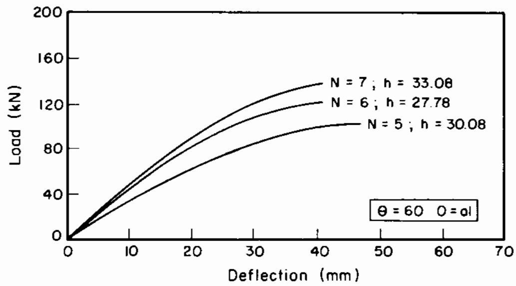

Fig.9. Load-deflection curves showing effect of number of mesh layers, N.

In-plane Mesh Orientation Angle

Fig.7 shows the general trends observed. An increase in θ from 0 to 45 degrees resulted in an average strength increase of 24.5% and an increase in θ from 45 to 90 degrees resulted in an average strength decrease of 24.7%. The effect of θ on toughness was found to be similar to that observed for strength. Typical load-deflection curves are shown in Fig.8.

Number of Layers of Mesh, *N*

Increasing the number of layers of mesh from 5 to 6 resulted in an increase in both strength and toughness. The average strength increase was 15.8%. On increasing the number of layers from 6 to 7, again there was a general increase in both strength and toughness with the average strength increase being 33.4%. Typical load-deflection curves indicating the effect of the number of mesh layers are shown in Fig.9.

DISCUSSION

The behavior of slabs with respect to the variables h, θ and N was as expected [1-5]. However, with respect to variables o and $s.s$, one would not expect changes in strength if interpretation was based on elementary considerations. For the slabs being compared, since each mesh layer has the same component in the direction of loading it is logical to anticipate that in the thickness direction, strength-related properties are the same and hence the idealization of homogeneity is valid. Using Classical Lamination Theory (CLT) it can be shown that as o changes from 'constant' to 'alternate' for those slabs with an odd number of layers of mesh, there is a change in D16 and D26. However, when the number of layers of mesh is an even number D16 and D26 become zero and B16 and B26 changes from zero to non-zero. It can be shown [9] that the strength criterion of the laminate at failure is the determinant of the expression [D] - [B][A]-1[B] is zero, hence the link between the aforementioned changes and the strength changes.

Table 2 Test Results

Slab	Age at test days	Thickness (h) mm	Mortar comp. strength, f_{cu} MPa	Max. load (P_{ult}) kN	Max. deflection (Δ_{ult}) mm	First crack load, P_{cr} kN	First crack deflection (Δ_{cr}) mm
A5-1	28	24.12	58.60	95.19	35.99	76.19	25.65
A5-2	28	27.24	58.60	111.19	41.95	94.19	31.10
A5-3	30	30.08	58.60	101.19	39.70	83.19	29.50
A5-4	30	26.25	58.60	99.19	37.19	78.19	28.88
A5-5	28	25.17	58.90	109.19	31.30	87.19	22.63
A5-6	28	29.65	58.90	123.19	41.10	104.19	30.30
A6-1	31	28.33	54.60	101.19	38.00	84.19	26.00
A6-3	28	27.78	60.40	120.19	41.00	94.19	25.12
A6-4	28	25.57	60.40	121.19	39.00	108.19	32.30
A6-5	28	24.36	47.50	107.19	46.00	94.19	33.13
A6-6	28	28.24	47.50	97.19	33.00	87.19	27.72
A7-1	29	27.89	58.40	119.19	36.40	119.19	37.00
A7-2	29	32.65	58.40	133.19	40.00	127.19	37.10
A7-3	34	33.08	58.60	137.19	41.00	125.19	33.50
A7-4	34	35.64	58.60	153.19	39.00	140.19	32.85
A7-5	30	34.29	58.80	155.19	37.05	148.19	34.75
A7-6	30	33.39	58.80	159.19	40.10	132.19	30.83
B1	31	40.38	58.60	155.19	40.00	116.19	26.25
B2	31	39.70	58.60	145.19	39.50	133.19	33.18
B3	29	43.90	62.80	153.19	44.40	111.19	24.97
B4	29	38.56	62.80	153.19	42.30	129.19	31.95
B5	30	38.79	57.70	163.19	37.30	158.19	35.00
B6	30	43.04	57.70	155.19	48.15	111.19	39.60

The effect of span-to-thickness ratio reflects the influence of transverse shear deformation on the behavior and the limit beyond which the thin plate assumption is invalid. The form of the curve in Fig.6 and the said limit are observed to be quite similar to those of other laminated, though non-cementitious, e.g graphite-epoxy [7]. The cause of the occurance is acknowledged as being the difference between the stiffnesses in its plane and in the thickness direction.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions are as follows:-

1. Changing the orientation pattern of the meshes in the slab from constant to alternate increases

the strength but decreases its toughness if the number of layers of mesh is an odd number.

2. Changing the orientation pattern of the meshes from constant to alternate decreases both the strength and toughness if the number of layers of mesh is an even number.

3. For span-to-thickness ratios about 25 the behavior of ferrocement slabs under biaxial flexure is significantly affected by transverse shear deformation with the degree of significance increasing rapidly as the span-to-thickness ratio decreases.

4. For square ferrocement slabs under biaxial flexure maximum strength is achieved if the angle of orientation of the meshes relative to the edges of the slab is 45 degree.

5. For square ferrocement slabs under biaxial flexure minimum strength is achieved if the angle of orientation of the meshes relative to the edges of the slab is 0 degree.

6. For square ferrocement slabs under biaxial flexure maximum toughness is achieved if the through-the- thickness orientation pattern of the meshes is constant from top to bottom of the slab and the properties of the mesh layers are symmetrically disposed about the mid- plane of the slab.

7. For square ferrocement slabs under biaxial flexure minimum toughness is achieved if the through-the- thickness orientation pattern of the meshes is one which alternates from top to bottom of the slab and the properties of the mesh layers are anti- symmetrically disposed about the mid-plane of the slab.

The reported strength changes of approximately $\pm 10\%$ as effects of lamination are not insignificant given current design philosophy (i.e. ultimate strength). Although the statistics of the program is such as to considerably limit the probability of making meaningful generalizations, it can nevertheless be concluded that the results suggest the need to consider through-the-thickness or lamination variables in experimental work on ferrocement and hence in its modelling as well. This is an established fact in the analysis and design of non-cementitious laminates [7].

The authors recommend that more extensive research on the effects of these variables on ferrocement be made since it appears quite possible that situations can arise in which strength may be overestimated if they are neglected.

REFERENCES

1. ACI Committee 549. 1982. State-of-the-Art- report on ferrocement. *Concrete International* 4(8): 13-38.

2. Austriaco, N.C. ; Lee, S.L. ; and Pama, R.P. 1975. Inelastic behaviour of ferrocement slabs in Bending. *Magazine of Concrete Research* 27(9):193-209.

3. Meek, J.L .1981. Ultimate Strength of simply-supported ferrocement slabs. *Journal of Ferrocement* 11(3):215-228.

4. Prawel, S.P., and Reinhorn, A. 1982. Properties in flexure of under-reinforced panels in two-way bending. *Journal of Ferrocement* 12(3):237-250.

5. Trikha, D.N.; Kaushik, S.K.; and Kotdawala, R.R. 1981. Limit analysis of ferrocement thin slabs. *Journal of Ferrocement* 11(2):111-126.

6. Ashton, J.E., and Whitney, J.M. 1970. *Theory of Laminated Plates*. Westport Connecticut: Technomic Publishing Co.

7. Jones, R.M. 1975. *Mechanics of Composite Materials*. Washington D.C: McGraw-Hill Scripta Book Co.

8. Whitney, J.M. 1969. The effect of transverse shear deformation on the bending of laminated plates. *Journal of Composite Materials* 3: 534-547.

9. Craddock, J.N. 1985. Behaviour of composite laminates after first-ply- failure. *Composite Structures* 3(2):187- 200.

Use of Hard Grass Reeds in Ferrocement

A.M. Waliuddin* and Pervez Brohi*

An experimental pre-cast roofing element has been constructed for low cost roofing system. Hexagonal chicken wire mesh of 12 mm x 24 G, Hard Grass Reeds (HGR) locally known as "Sarkanda" and cement mortar were used in this roofing element. Cross-sectional area of the roofing panel is 457 mm x 64 mm and the span is 915 mm. About 40% of the cementitious materials have been replaced by the HGR. These HGR have also been used to replace the steel reinforcement (skeletal steel) which is a costly material, to provide better thermal and sound insulation and to contribute in reducing dead load of the structure. Pre-cast roofing elements were load tested in accordance with BSI CP-110 Part-1 : 1972 and were found strong enough to carry the required test load.

INTRODUCTION

At the National Building Research Institute, Karachi, Pakistan, Hard Grass Reeds (thatch grass) have been used with ferrocement as a building material. The HGR is available in abundance in the natural vegetation in most part of the country and except for some scattered use in handicrafts and in some temporary structures it otherwise has no significant utilization. The HGR acts as filler, replaces cementitious materials partially and skeletal steel completely. It also reduces the problem of thermal discomfort which occurs in the ferrocement roofing elements due to the relatively small thickness. It creates resistance in the path of heat transmittance and provides better thermal comfort in the low cost roofing system. The HGR contributed about 33% reduction in weight as compared with conventional system. The weight of each roofing element (915 mm x 457 mm x 64 mm) is about 42 kgs only. To construct a full size roof, the above roofing elements may be simply supported on pre-cast reinforced concrete beams or steel beams of small sections to act as one way slab. The load bearing capacity of the roofing panels was checked and found to be adequate in accordance with the Code of practice for the Structural use of concrete BSI CP-110 : Part-1 : 1972.

PROPERTIES OF CONSTRUCTION MATERIALS

The physical properties of the materials indicated were determined.

Cement: OPC Type -I from local market.

Initial setting time : 170 minutes
Final setting time : 250 minutes
Compressive strength (for 28 days) : 37.57 MPa.

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Water: Tap water (fit for drinking purpose) was used.

Aggregate: Fine aggregate locally available

Unit weight : 1794 kg/m^3
Specific gravity : 2.62
Water absorption : 1.20%
Sodium soundness loss : 3.0%

Table 1 Sieve Analysis

Sieve size (mm)	% Passing
10	100
4.75	100
2.36	87
1.18	60
0.60	30
0.30	17
0.15	6
0.075	2

Mix proportioning was so choosen that it can be easily followed by an unskilled person.

Cement = 1 part by volume
Aggregate (fine) = 4 parts by volume
Water-Cement = 0.50

Compressive strength of Mortar:

7 days = 21.68 MPa
28 days = 28.84 MPa
Flexural strength of mortar (for 28 days) = 2.94 MPa.

Wire mesh: Hexagonal, locally available

Tensile strength = 331.09 MPa
Thickness = 24 gage

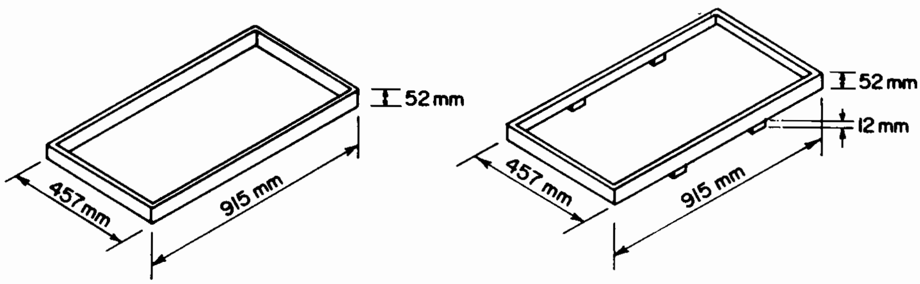
HGR : Hard grass reed - a natural fiber

Tensile strength = 68.96 MPa
Bond strength (HGR - Mortar) = 0.39 MPa
Water absorption = 70%

Density	=	296 kg/m^3
Treatment	=	Bitumen coating was applied

CONSTRUCTION

For casting the slabs a very simple type of wooden mold as shown in the Fig.1 was used. Lubricating oil (mold releasing agent) was applied to the inner side of the mold and the mold was kept on a smooth and hard surface.



a. *b.*

Fig.1. Wooden molds.

The mature and dry HGR, having diameter 10 mm to 12 mm, were cut to the required size and were coated by bitumen for its protection. Three layers of HGR, which equals to about 32 mm to 38 mm thickness, were wrapped by single layer of 12 mm x 24 G hexagonal G.I. wire mesh. The HGR along with wire mesh were placed into the mold leaving 25 mm cover from all the sides. The slabs were cast in two stages. (It could be cast in one operation but two operational casting is preferred to have a stronger bond in between the HGR bundle, wire mesh and bottom layer of mortar). In the first stage the four sides (25 mm cover) were filled and then about 12 mm thick 1:4 cement mortar was applied over the top surface of HGR. It was well compacted and smoothed off by a mechanical trowel (mold shown in Fig.1a was used). In the second stage, the bottom surface was turned up carefully with the help of the mold after 24 hours and following a similar procedure as in the previous case, mortar was applied to the other unplastered side of HGR maintaining 64 mm thickness of the slab.

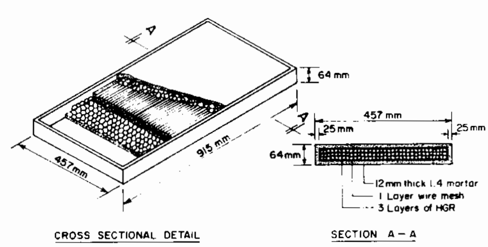


Fig.2.

In this case four small wooden pieces (12 mm thick/high) were simply nailed at the bottom of the same mold to increase the thickness/height from 52 mm to 64 mm (Fig.1b). Cross-sectional details of the slab are shown in Fig.2.

LOAD TEST

Individual test specimens were load tested to be used as a roofing element in accordance with the code of practice for the structural use of concrete CP-110 : Part-1 : 1972. Test load was applied uniformly and incrementally over the surface area of the simply supported test slab. Maximum deflection at the midspan was noted to be 0.07 mm which was within the permissible limit. After removal of the test load, recovery in deflection was also achieved as per code requirements. Later on the test slabs were further loaded by increasing the load to check its safe load bearing capacity. Throughout the loading process the slabs behavior was carefully monitored. Load-deflection observations and curves are shown in Table 1 and Fig 3.

Table 2 Summary of Test Results

Load (kN)	Actual Deflections in mm					Allowable deflection mm
	Slab 1	Slab 2	Slab 3	Slab 4	Slab 5	
1.070	0.0445	0.0445	0.0460	0.0470	0.0450	
2.140	0.0699	0.0826	0.1100	0.0900	0.0800	
3.200	0.0965	0.1270	0.1650	0.1350	0.1200	
4.270	0.1219	0.1651	0.2110	0.1700	0.1600	
5.338	0.1524	0.2159	0.5400	0.2150	0.2000	
6.405	0.1778	0.2540	0.7100	0.2550	0.2400	2.260
7.470	0.2154	0.2921	0.7800	0.2800	0.2650	
8.541	0.7620	0.3302	Cracked	0.3150	0.3000	
9.608	Cracked	0.3886	-	0.3500	0.3400	
10.51	-	Cracked	-	-	0.3850	
11.01	-	-	-	-	0.4100	

DISCUSSION AND CONCLUSION

Using 40% of HGR, the flexural strength of the specimens was 3.73 MPa. Two specimens showed inelastic behavior at an early stage which may be attributed to the local problem e.g. non-uniformity of the diameter of the reeds. Generally roof slabs are designed for a live load of 137.9 kN/m² and these precast panels are supposed to be used as roofing elements. From the Fig.3 and Table. 1 it is obvious that these precast panels could safely be used as roofing elements. The roofing elements are easy to cast. It can be made on selfhelp basis for which they may prove to be more economical. The above type of roofing elements are most suitable for the rural housing because of the easy availability of the HGR. HGR are almost free of cost in the rural areas. This type of roofing will surely be much more

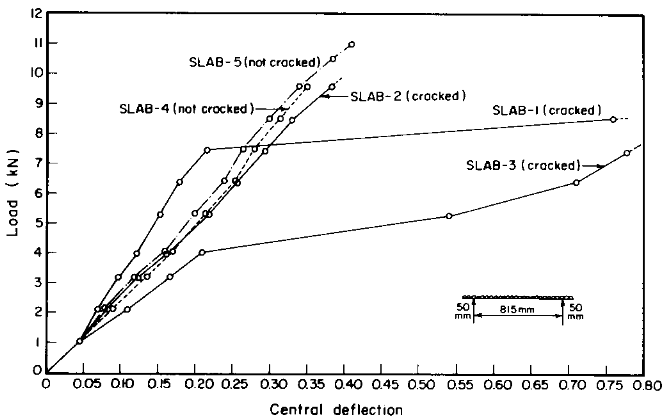


Fig. 3. Load deflection curve.

economical than the conventional system due to the use of HGR.The experimental program shows that further work can be done on HGR for its better utilization in the low cost roofing system.

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REFERENCES

1. British Standard Institution. 1972.*Code of Practice for the Structural use of Concrete, CP 110, Part1*. London: British Standard Institution.

2. American Society for Testing and Materials. 1990. *Concrete and Aggregate (ASTM Vol. 04.02)*, U.S.A. : American Society for Testing and Materials.

BIBLIOGRAPHIC LIST

This list includes a partial bibliography, with keywords, on ferrocement and related topics. Reprints and reproductions, where copyright laws permit, are available at a nominal cost (see page 198) by quoting the accession number and availability given at the top of each reference.

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RESEARCH AND DEVELOPMENT

Material Properties

4074 A:1105

Nimityonskul, P. 1985. Mechanical properties of ferrocement-1. In *Lecture Notes: Short Course on Design and Construction of Ferrocement Structures*, 22-41. Bangkok: International Ferrocement Information Center.

bending / crack arrest / ferrocement / mechanical properties / modulus of elasticity / stress strain curves / tension

4075 A:1105

Raisinghani, M. 1985. Mechanical properties of ferrocement-2. In *Lecture Notes: Short Course on Design and Construction of Ferrocement Structures*, 42-84. Bangkok: International Ferrocement Information Center.

durability / fatigue / ferrocement / impact / mechanical properties / rigidity / shear strength / shrinkage

4084 A:1105

Ellen, P.E. 1985. Concrete mix design- Basic philosophy. In *Lecture Notes: Short Course on Design and Construction of Ferrocement Structures*, 207-241. Bangkok: International Ferrocement Information Center.

concrete / micro cracks / mix design / water cement ratio

4054 A:1099

Farida, P. 1989. *Behaviour of Ferrocement* (in Indonesian). Bandung: Ferrocement Information

Network (Indonesia).

fatigue / ferrocement / impact / materials / properties
Indonesia

4055 A:1099
Farida, P. 1989. *Material Requirements for Ferrocement* (in Indonesian). Bandung: Ferrocement Information Network (Indonesia).

ferrocement / materials / properties / wiremesh
Indonesia

4056 A:1099
Anshori Djausal. 1989. *Mechanical Properties of Ferrocement* (in Indonesian). Ferrocement Information Network (Indonesia).

ferrocement / mechanical properties
Indonesia

4048 A:1094
Hans Rolloos; Anshori Djausal; and Oemar Handojo. 198?. *Ferrocement Technology*. Bandung: Institut Teknologi Bandung (Indonesia).

appropriate technology / bending / ferrocement / fracture strength / impact / mechanical properties / shear
Indonesia

Standards and Specifications

4077 A:1105
Naaman, A. E. 1985. Design criteria for ferrocement. In *Lecture Notes: Short Course on Design and Construction of Ferrocement Structures*, 98-125. Bangkok: International Ferrocement Information Center.

bending / compression loads / design criteria / ferrocement / serviceability / strength / tension

4079 A:1105
Batson, G. B. 1985. Summary of design guide for ferrocement. In *Lecture Notes: Short Course on Design and Construction of Ferrocement Structures*, 85-97. Bangkok: International Ferrocement Information Center.

design / design criteria / fabrication / ferrocement / maintenance / materials

4059 A:1099
Farida, P. 1989. *Standards and Design Procedures for Ferrocement* (in Indonesian). Bandung:

Ferrocement Information Network (Indonesia).

ferrocement / specifications / structural design criteria
Indonesia

4058 A:1099
Anna Roana Gani. 1989. *Mix Design for Ferrocement* (in Indonesian). Bandung: Ferrocement Information Network (Indonesia).

ferrocement / material tests / mix design / mortars (material)
Indonesia

4040 A:1086
____.1989. *Technical Procedures for Ferrocement*, Book 3 (in Indonesian). Bandung: Institut Teknologi Bandung.

applications / ferrocement / materials / mechanical properties
Indonesia

Housing Applications

4042 A:1088
Sukandar, I.H. 1990. *Ferrocement for Structural Elements* (in Indonesian). Bandung: Edisom GMS Meliala Institut Teknologi Bandung.

appropriate technology / ferrocement / materials / roofing / tanks (containers)
Indonesia

Miscellaneous Applications

4038 A:1084
______. 1983. *Technical Procedures for Ferrocement*, Book 1 (in Indonesian). Bandung: Institut Teknologi Bandung.

appropriate technology / ferrocement / materials / tests
Indonesia

4039 A:1085
_____.1983. *Technical Procedures for Ferrocement*, Book 2 (in Indonesian). Bandung: Institut Teknologi Bandung.

appropriate technology / ferrocement / materials / tests
Indonesia

4041 A:1087
_____.1983. *Ferrocement Technologi* (in Indonesian).Bandung: Institut Teknologi Bandung.
applications / appropriate technology / ferrocement
Indonesia

4050 A:1096
____.1983. *Technical Procedures for Ferrocement,* Book 4 (in Indonesian). Bandung: Institut Teknologi Bandung (Indonesia).

ferrocement / housing / materials
Indonesia

4076 A:1105
Wieland, M. 1985. Analysis and design of shell structures. In *Lecture Notes: Short Course on Design and Construction of Ferrocement Structures*, 126-140. Bangkok: International Ferrocement Information Center.

analysis / structural design / ferrocement /flexural strength / membrane theory / shells (structural forms) / static loads

4051 A:1097
____.1990. *Training Program for Ferrocement Technology for Technicians and Contractors*, Book III (in Indonesian). 1-215.Bandung: Ferrocement Information Network (Indonesia).

applications / ferrocement / mechanical properties
Indonesia

4057 A:1099
Anshori, Djausal. 19??. *Analysis and Planning of Ferrocement Structures* (in Indonesian). Bandung: Ferrocement Information Network, (Indonesia).

construction / ferrocement / materials / analysis / planning
Indonesia

General

4037 A:1083
_____. 1979. *Report on Development of Ferrocement Technology in Sulawesi Selatan* (in Indonesian). Ujung Pandang: Development Technology Center-ITB/USAID (Ujung Pandang, Mei, Indonesia), Proyek Kerja Sama Universitas Hasanuddin.

boats / domes (structural forms) / ferrocement / materials / tanks (containers) / tests
Indonesia

4047 A:1093
Anshori, Djausal, and Sosrowinarso. 1979. *Ferrocement Material and its Use in Civil Engineering Construction* (in Indonesian). Bandung: Institut Teknologi Bandung (Indonesia).
applications / ferrocement / materials
Indonesia

4031 A:1077
Miyazawa, S.; Tazawa, Ei-ichi; Kashiwagi, T.; and Shigekawa, K. 1989. Effect of self stress on flexural failure of mortar beams. *Transactions of the Japan Concrete Institute*. 11: 41-48.

bend tests / bending / mortars (material)

4065 A:1099
Anshori, Djausal. 1989. *A Comparison of Ferrocement with Reinforced Concrete and Its Application in Civil Engineering* (in Indonesian). Bandung: Ferrocement Information Network (Indonesia).

ferrocement / materials / reinforced concrete
Indonesia

CONSTITUENT MATERIALS

Mortar Preparation and Plastering

4033 A:1079
Rahman, M.A. 1987. Use of rice husk ash in sancrete blocks for masonry units. *Materials and Structures* 20: 361-366.

rice husk ash / blocks

Substitute Materials for Mortar Preparation

4022 A:1068
Tabata, T.; Takeuchi, K.; and Fukuzawa, T. 1989. Development of special cement and its application. In *Proceedings of 1st Japan International SAMPE Symposium*, 28 Nov. - 1 Dec. 1989, 1599-1605. Tokyo: The Society for the Advancement of Material and Process Engineering (Japan).

bending / cements / mortars (material) / tests / thermal conductivity
Japan

4032 A:1078
Taleno, R. 1990. Qualitative analysis of natural pozzolanas, fly ashes, and blast furnace slags by XRD. *Journal of Materials in Civil Engineering* 2(2): 106-115.

blast furnace slag / fly ash / pozzolans / x - ray analysis
Spain

Admixtures

4019 A:1065
Ohama, Y.; Demura, K.; Satoh, Y.; and Tachibana, K. 1989. Improvement in durability of mortar by effective barrier penetrants. In *Proceedings of Second International Symposium on Cement and Concrete*. 23-30. Beijing: The Chinese Silicate Society (Beijing, China).

chlorides / durability / mortars (material) / tests

4020 A:1066
Demura, K.; Ohama, Y.; Morikawa, M.; and Achiwa, M. 1989. Drying shrinkage of cement mortars treated with shrinkage-reducing agents. *Journal of the Society of Materials Science Japan* 38(431): 926-931.

additives / cracks / drying shrinkage / mortars (material)
Japan

MARINE APPLICATIONS

Construction and Testing

4070 A:1103
____. 1963. Featherstone Ahoy!. *Concrete Construction*: 209-210.

boat / concretes / ferrocement

4053 A:1099
____. 1989. *Lecture notes for Short Course on Offshore Structures Using Ferrocement* (in Indonesian). Bandung: Ferrocement Information Network, (Indonesia).

construction / ferrocement / marine structures
Indonesia

4064 A:1099
Anshori Djausal. 1989. *Application of Ferrocement for Marine Structures* (in Indonesian). Bandung: Ferrocement Information Network (Indonesia).

construction / ferrocement / marine / structures
Indonesia

4066 A:1100
Hans Rolloos; Anshori Djausal; and Oemar Handojo. 19??. *Ferrocement Boat Technology.* 1-148. Bandung: Institut Teknologi Bandung.

ferrocement / hulls (structures) / ships / waves
Indonesia

Feasibility Studies, Rules and Classification

4063 A:1099
Indra Djati Sidi. 1989. *Strength Analysis for Marine Structures* (in Indonesian). Bandung: Ferrocement Information Network (Indonesia).

marine engineering / strength / structural analysis
Indonesia

TERRESTRIAL APPLICATIONS

Housing and Building

4028 A:1075
Stulz, R. 1990. The introduction of FCR and MCR tiles in Peru. *FCR News* (7): 8-12.

fibers / housing / roofing / tiles
Peru

4029 A:1075
De Rivero, M. 1990. The Mateco experience.*FCR News* (7): 2-7.

fibers / housing / roofing / tiles
Peru

Water Resources Structures

4080 A:1105
Wieland, M. 1985. Analysis and design of cylindrical water tanks. 141-159. In *Lecture Notes: Short Course on Design and Construction of Ferrocement Structures,* 141-159. Bangkok: International Ferrocement Information Center.

analysis / crack width / cylindrical tanks / design / ferrocement

4081 A:1105
Kumar, S.K. 1985. FCTANK: An Interactive Microcomputer Program for the Analysis and Design of Ferrocement Storage Tanks. In *Lecture Notes: Short Course on Design and Construction of*

Ferrocement Structures, 160-185. Bangkok: International Ferrocement Information Center.

analysis / design / ferrocement / microcomputers / water tanks / tanks (containers)

4088 A:1128
_____.1990. Ancient and modern rainwater harvesting technologies expand water supplies. *Raindrop, Rain Water Harvesting* Bulletin 4:1.

ferrocement / tanks (containers) / water storage
India

4089 A:1128
_____.1990. Semi-Mechanized Ferrocement Tank Construction. *Raindrop, Rainwater Harvesting* Bulletin 4:3.

ferrocement / mechanization / tanks (containers) / water storage
India

Construction Techniques

4036 A:1082
_____. 1977. *Ferrocement Water Storage Tanks* (in Indonesian). 1-18. Bandung: Kerjasama Dengan Busti Dan Tool. The Negeri Belanda Diterbitkan (Bandung, Indonesia). Pusat informasi Dokumentasi PTP-ITB (Bandung, Indonesia): 1-18.

ferrocement / tanks (containers) / water tanks
Indonesia

General

4061 A:1099
Oemar Handojo. 1989. *Application of Ferrocement in Structures* (in Indonesian). Bandung: Ferrocement Information Network (Indonesia).

construction / ferrocement / materials / structures
Indonesia

PROTECTION AND RELATED TOPICS

Corrosion in Marine Environment

4023 A:1069
Shorobim, K.G.; Tazawa, Ei-ichi; Miyamoto, H.; and Hironaka T. 1989. Influence of construction

defects on corrosion of reinforcement. *Transactions of the Japan Concrete Institute* 11: 171-178.

construction / corrosion / reinforcing steels
Japan

4060 A:1099
Anshori Djausal. 1989. *Corrosion in Ferrocement Construction* (in Indonesian). Bandung: Ferrocement Information Network (Indonesia).

corrosion / ferrocement / marine atmospheres
Indonesia

Coatings and Surface Treatment

4025 A:1071
Hamada, S.; Kaneyuki, K.; and Koyama, H. 1989. On the efficiency of repairment for a structure with alkali-aggregate reaction. *Transactions of the Japan Concrete Institute* 11: 179-184.

aggregates / alkali aggregate reactions / crack width / repairs
Japan

FIBER REINFORCED COMPOSITES

Steel Fiber Composites

4068 A:AIT Thesis 90-8 c.2
Iqbal, H. 1990. Ultimate Flexural Strength of Reinforced Concrete Beams with Large Volumes of Short Randomly Oriented Steel Fibers. 1-117+ix pp. M.Eng; Thesis, Asian Institute of Technology (Bangkok, Thailand).

flexural strength / mechanical properties / models / steel fibers / tests / beams / bending
Thailand

Natural and Organic Fiber Composites

4045 A:1091
Anshori Djausal. 1980. *Fiber Reinforced Pipes* (in Indonesian). 1-22. Bandung: Institut Teknologi Bandung. (Indonesia).

materials / organic fibers / pipes (tubes)
Indonesia

4044 A:1090
Anshori Djausal. 1981. *Fiber Reinforced Roofing Element* (in Indonesian). 1-41. Bandung: Institut Teknologi Bandung.

organic fibers / roofing
Indonesia

Polymer Composites

402 A:1067
Amano, T.; Ohama, Y.; Takemoto, T.; and Takeuchi, Y. 1989. Development of ultrarapid-hardening polymer-modified shotcrete using metal acrylate. In *Proceedings of 1st Japan International SAMPE Symposium.* 1564-1569. Tokyo: The Society for the Advancement of Material and Process Engineering (Japan).

materials / materials tests / polymers / shotcrete
Japan

4026 A:1072
Dean, G.D. 1989. Use of plate bending waves for elastic property determination of polymers. *Composites* 20(6): 575-583.

elastic properties / materials / polymers / reinforced plastics
UK

General

4030 A:1076
Tay, Joo-Hwa. 1990. Ash from oil-palm waste as concrete material. *Journal of Materials in Civil Engineering* 2(2): 94-105.

ashes / concretes / organic materials / wastes
Singapore

GENERAL

Miscellaneous Notes

4052 A:1098
_____. 198?. *Ferrocement Technology Application Training Program for Technicians and Contractors (Book II)*, Report on Participants Assignments Results. (in Indonesian). 1-55.Bandung: Laporan Hasil; Penyelesaian Tugas Peserta. Institut Teknologi Bandung.

construction / ferrocement / materials
Indonesia

4072 A:1105
IFIC. 1985. *Lecture Notes - Short Course on Design and Construction of Ferrocement Structures* 1-346. Bangkok: International Ferrocement Information Center.

4062 A:1099
Widiadnyana Merati. 1989. *Theory of Shell Structures* (in Indonesian). Bandung: Ferrocement Information Network (Indonesia).

analysis / shells (structural forms)
Indonesia

4069 A:1102
____. 1990. *Training Program for Ferrocement Technology for the Technicians and Contractors,* Book 1 (in Indonesian). 1-62. Bandung: Laporan Pelaksanaan. Ferrocement Information Network (Bandung, Indonesia).

ferrocement / technology / trainings
Indonesia

GENERAL

General

4043 A:1089
Anshori Djausal, and D. Kusnadi. 1979. *History and Application of Ferrocement* (in Indonesian). 1-34. Bandung: Institut Teknologi Bandung.

boats / ferrocement / material properties / tanks (containers)
Indonesia

IFIC DATABASE

The INFC database will save your time and effort in finding current information on ferrocement and related construction materials. This database is created and maintained by the International Ferrocement Information Center (IFIC), Asian Institute of Technology, Bangkok, Thailand using UNESCO's Computerized Documentation Service/Integrated Set of Information Systems (CDS/ISIS). It covers ferrocement, the form of reinforced concrete which uses hydraulic cement mortar, and closely spaced layers of continuous and relatively small diameter wire mesh reinforcements; and related construction materials, such as steel fiber composites, bamboo fiber composites, natural and organic fiber composites, and polymer composites.

IFIC regularly reviews over 100 journals, magazines, newsletters, digests and bulletins, in addition to numerous monographs, reports, conference proceedings, theses, and materials supplied directly by ferrocement builders and researchers. From these publications, articles on ferrocement and related construction materials are identified, abstracted, indexed, and entered into the bibliographic database. Each record contains the following primary information: author, title, source, abstract and keywords; and secondary information: availability, date, language and type of publication. INFC database is expanding at the rate of 300 records per year. From these records, IFIC provides computerized bibliographic search services for requests on particular aspects of ferrocement technology and related materials at the following rates:

Subscriber:	US$ 40.00	per contact hour
	US$ 10.00	up to 50 references
	US$ 0.07	for each additional reference above 50
Non-Subscriber:	US$ 60.00	per contact hour
	US$ 15.00	up to 50 references
	US$ 0.10	for each additional reference above 50

Precise description must accompany requests for search service so as to minimize costs. Requests (particularly for letter and telex requests) must include the following: (a) brief but clear summary of the research topic; (b) list of keywords and synonyms; (c) expected number of references; (d) cost limitations; (e) output specifications (date and language restrictions); and (f) degree of urgency of the request. The search print out contains a list of references, which may include abstracts if requested.

Materials listed in the bibliographic search print out are available from IFIC, but subject to copyright restrictions. By quoting the accession number given at the top of each reference, photocopies and/or microfiches of any document can be ordered at the rates given in page 198.

NEWS AND NOTES

THE THIRD FIN COORDINATORS WORKSHOP AND STUDY VISIT

The Third Ferrocement Information Network (FIN) Coordinators Workshop and Study Visit was held 22-28 February 1991 in Auroville, Pondicherry and Madras, India. The host was the FIN (India) based at the University of Roorkee and the Auroville Building Centre (AV-BC), an IFIC Reference Center and node of FIN (India).

The objectives of this workshop and study visit were: to evaluate the end users training program of FIN (India); to develop the methodology for end users training in developing countries and to define the future directions of FIN.

The FIN team include Engr. L. Robles-Austriaco, the FIN international coordinator; Professor Abang Abdullah Abang Ali, national coordinator FIN (Malaysia); Ir. Anshori Djausal, national coordinator FIN (Indonesia); Engr. Edgardo Santibanez, national coordinator FIN

The FIN Coordinators with AV-BC executives, left to right, Engr. Edgardo Santibanez (Philippines), Prof. Abang Abdullah (Malaysia), Mr. P.C. Sharma (SERC, India), Mrs. Lilia R. Austriaco (IFIC), Mr. Tency Baetens (AV-BC) and Mr. Giles Guigan (AV-BC).

The FIN team at the HUDCO Building Technology Exposition and Housing Guidance Center. On display are different appropriate technologies including ferrocement applications in housing.

(Philippines); Professor D.N. Trikha and Professor S. Kaushik, national coordinators FIN (India), Mr. Tency Baetens, and Mr. Giles Guigan of the Auroville Building Centre and Mr. P.C. Sharma of the Structural Engineering Research Centre (SERC), Ghaziabad also participated. The Workshop and Study - Visit was sponsored by the International Development Research Centre (IDRC) of Canada.

The FIN team visited the Auroville Building Centre (AV-BC); the Structural Engineering Research Centre (SERC), Madras; the Indian Institute of Technology (IIT), Madras; and the Housing and Urban Development Coorporation (HUDCO) Southern Zonal Office. The FIN team had a seminar in AV-BC with Mr. Tency Baetens, executive of AV-BC as resource person. The team had a chance to see the manufacturing processes developed in AV-BC and the many existing ferrocement structures in Auroville, an international cultural township.

The FIN coordinators at IIT, Madras, India.

The FIN coordinators at SERC

The many research and development activities in SERC, on ferrocement and related materials and their technology transfer activities were very interesting and educational to the team. The thrust of IIT Madras is to solve local problems through research and development in the Institute. The team was impressed by the on going research at IIT. The HUDCO experience including available appropriate technology and the HUDCO approach on technology transfer was very instructive.

The workshop was conducted in Auroville and Pondicherry. The team evaluated the end users training oganized by FIN (India) and AV-BC. The team has decided on the end users training methodology appropriate for developing countries. This will be the basis for the training manual for FIN to be published by IFIC. Based from their own experiences and through

The FIN coordinators at one of the AV-BC ferrocement housing projects.

the evaluation of the end users training in India and Indonesia the FIN team during the workshop has defined the future direction of FIN Activities.The major thrust will be the establishment of the organizational structure for each country, intensify training activities in three levels:decisionmakers, implementors and end users, and the future financial viability of the members.

AUSTRALIA

Polyurethane Panel

Lewis Lavan Pty Ltd has developed a lightweight building panel which can be made to look like brick. The panel, the company claims can be manufactured at low cost, consists of an encapsulated steel frame with an outer glassfibre reinforced polyurethane skin, a polyurethane core and a plasterboard or fiber-cement inside lining. The density of the polyurethane is varied through the cross section of the panel, with the lower density core providing good insulation.

The outer skin can be molded to simulate a brick or other finish, or even roof tiles.

The company said several buildings using these panels for walls as well as roofs have been built in central Queensland, Brisbane and Victoria, and the panels have performed satisfactorily.

(Engineers Australia, September 21 1990)

FRANCE

Blocks for Building Breakwaters

Armed with the experience it acquired in producing Tetrapode, the world's first artificial building block with an open-ended design, Sogreah of France has begun marketing Accropode (TM) technique, an armour building block that has been designed to be laid in a single layer, instead of the two layer arrangement commonly used with traditional blocks.

Developed by the engineers of the company's Harbours and Coastal Services Department, Accropode (TM) is a uniquely designed artificial unreinforced building block for building maritime breakwaters and similar structures (docks, coastal dykes, etc.) and river levies and dykes.

As the recipient of the prize awarded for innovation by France's Union of Public Works Engineers, Accropode (TM) is unusual in terms of its shape, solid construction and stability.

- its shape (six massive protuberances that have been enlarged at the intersection with its central core) eliminates the need for any form of armoured reinforcement and makes it possible to lay the bricks in a single layer. Its compact shape gives it excellent mechanical resistance.

- the stability of the blocks once they have been laid in a single layer has been tested by 21 internationally renowned laboratories (in systematic tests conducted on small scale models) and in situ (where the results of the previous tests were confirmed).

Accropode (TM) blocks are easy to manufacture (a mould of two symmetrical shells, a frame with an extra-wide upper opening, with removal from the frame in 24 hours time), to handle (using forks or other grips) and to store.

While traditional building blocks have to be laid in two layers, Accropode's shape and sturdy construction make it possible to work with just a single layer, a feature that results in about a 40% savings in terms of the amount of concrete required.

Blocks are available in a wide range of dimensions, from 0.8 m^3 to 21 m^3. It is already in use in various harbours (Calais, France, Bizerte, Tunisia, Damiette, Egypt) and in more than 40 other projects around the world today.

(Scientific News, No.2, September'90)

KENYA

Ferrocement Awareness

The use of ferrocement is gaining increased awareness in Kenya in the recent years. Recently, Youth Polytechnic has conducted a training course for the graduates to build ferrocement water tanks. Ferrocement water tanks are regarded as most suitable in terms of materials and labor for the third world countries. For more information about Youth Polytechnic activities, contac: *Mr. John Ndenga, P.O. Box 1188, Maragoli, Kenya.*

(Information from Mr. Michi Vitz, Resource Coordinator, YTSP, c/o VSO, P.O.Box 284, Kisumu, Kenya.

SWITZERLAND

BASIN

Building Advisory Service and Information Network (BASIN) is a joint advisory service and information network dedicated to the field of building materials and technology. BASIN was primarily established to provide vital advisory services and access to information for individuals, institutions and other organizations involved with housing and building in Third world developing countries.

BASIN comprises of four different agencies namely GATE, SKAT, ITDG, and CRAtenne. Although the four agencies are linked together in a network, each agency caters for specific areas. GATE from Germany provides services in the field of wall building materials and wall construction technologies appropriate for developing countries; SKAT, the Swiss Center for Appropriate Technology is BASIN's specialist for roof construction, ITDG; Intermediate Technology Development Group provides advisory service for cementatious binders; while recently joined member agency CRAtenne, International Center for Earth Construction, will cover all aspects of earth building and will also offer necessary training courses in Production of compressed earth blocks, preservation of earthen architecture, local building materials and construction techniques etc. The joint services of the four network partners are based on Information, i.e. data collection, preparation and dissemination, experience, which includes collection of feedback, analysis, evaluation of tests, projects, research results, etc., and the area of consultancy on specific issues.

BASIN operates a newly developed data bank, which is coordinated between the partner organizations and contains information on documents, technologies/equipment, institutions/consultants/projects in respective subject areas and question and answer statistics. With this constantly increasing and updated information base, together with a fast growing collection of international literature and a pool of recognized subject specialists to refer to, highly qualified answers can be given to technical enquiries on a large number of building issues. BASIN furthermore identifies subject areas in which more specific information or other supporting documentation is needed and arranges the production of necessary publication for dissemination, a primary aim of which is not only to establish a dialogue and an exchange of information between BASIN and the enquirer, but also between building professionals, firms and institutions within the developing countries themselves.

The network is the first attempt to coordinate and monitor, with the support of a data bank, the accumulated know-how in specific subject areas of four appropriate technology institutions for the initiation of free information flow into developing countries with a close coordination of work with resource centers in these countries.

BASIN has been operating now for over a year. The positive reactions from enquiring individuals, firms, organizations and institutions to the services so far offered are justification for its setting-up. With the years to come, BASIN will gradually involve increasing number of resource centers in the Third World.

(BASIN-NEWS, January 1991)

TOGO

Local Networking in Kara, Togo

A small but vital organization in northern Togo is bridging the information gap for rural development activities in the country, and Rainwater harvesting (RWH) technologies are a primary focus of their activities. The Appropriate Technology Center provides linkage between various Togolese technicians involved in program design, technology design, and village based development work. The Center demonstrates effective technologies and provides relevant training, promotes the exchange of ideas and knowledge among projects, and shares relevant research from other countries.

Founded in 1986 by the Government of Togo, with collaboration between UNICEF and the U.S. Peace Corps, the Center has established itself nationally and inter-regionally as a clearing house for innovative technologies and as a facilitator and base for the organization of training sessions and extension campaigns. The Center is staffed by a Togolese director and a Peace Corps volunteer who serves as information coordinator. A small group of support personnel assists in construction of demonstration models and serves as training support staff.

The Center has responded to requests for RWH technical assistance and information from such organizations as UNICEF, World Neighbors, and Peace Corps. It is also in communication with development organizations from several countries to exchange documents and publications for and from its library.

In addition to its RWH interest, the Center also promotes improved clay cooking stoves, hand-dug wells, reforestation, and solar energy. For each of these technologies, the Center's support activities include the collection and dissemination of field-derived and research information, demonstration models and trials, and training for such groups as rural development agents, Peace Corps volunteers, and school teachers.

Training junior and high school teachers has been emphasized, with the intent of integrating the philosophy of appropriate technology into the secondary school curricula. Center personnel also work with farmers, artisans, and women's groups. Trainees learn theory as well as practice. Everyone who studies RWH learns both how to calculate water consumption needs and how to build a cistern and hang gutters.

Currently the Center demonstrates and promotes three cistern models. One is based on the design of a traditional spherical grain bin made with molded clay walls. Once the traditional bin is built on a concrete base, the interior is ferrocemented, resulting in a 3.5 m^3 liter cistern at a materials cost of about CFA 37,500 (US$125). The oldest model has been in use for four years and has needed no repair.

The gutter system developed for this model collects water from a straw roof, which is widely used in Togo, especially in the northern regions. This could be an important innovation in an area where a major problem for RWH is finding an appropriate rain catchment area.

Another cistern model has a capacity of 6 m^3 liters and is made from clay bricks with a ferrocemented interior. It is still undergoing testing, but the initial results seem positive. It is also low cost (US$125) and easy to construct. The Center's 12.8 m^3 liter model is built underground. It is a cement lined spherical pit with a dome-shaped concrete cover. The local soil structure is stable and the pit is also layered initially with a compacted clay. This experimental construction technique using no metal reinforcement has been in use for three years without need for repair. Total materials cost was CFA 172,000 (US$240).

(Raindrop, April 1990)

U.S.A.

ASCE Publishes Design Loads Standard

A new ASCE standard on design loads, published in July 1990, and known as ASCE 7-88, Minimum Design Loads for Buildings and Other Structures is a revision of ANSI A58.1, which was last updated in 1982. The standard gives requirements for dead, live, soil, wind, snow, rain and earthquake loads (and their combinations) that are suitable for inclusion in building codes and other design documents. A major portion of this newly available standard is undergoing yet another revision dealing primarily with recently mandated federal seismic provisions; The publication of the revision is expected some time in 1991.

Structural load requirements provided by the standard are intended for use by architects, structural engineers and those engaged in preparing and administering local building codes.

(ASCE News, September, 1990)

Zero-Porosity Concrete

M. Anthony Tutundjian, president of Concrete Hitech (Holdings) Ltd., developed the new cement modifier, Z-90, for use in large structures exposed to water, salts, toxic chemicals, fungi or algae.

As concrete cures, the escape of internal air creates voids within the sand and aggregate matrix. Unlike voids in other kinds of concrete, Z-90's are few, small, spherical, distinct and enveloped by a mesh of crystals. Since liquids cannot pass through them, that eliminates the possibility of corrosion of embedded reinforcing steel, freeze-thaw deterioration and efflorescence of the surface.

According to a report by Geomaterials Research Services Ltd., Basildon, Essex, Z-90 examined under an electron microscope showed no evidence of interconnected voids.

Z-90 will soon be marketed for use in structures such as basements, tunnels, parking garages and offshore platforms. Z-90 will be distributed in the U.S. by Ceracem East Inc., a licensee in Convington, La.

Z-90 will be available as a concentrate to mix on-site, in a proportion equal to 3% of the weight of cement used. It also will be sold as an already mixed super-cement. Either way, it will create concrete with a compressive strength exceeding 62.06 N/mm^2.

(ENR /August 9, 1990)

ABET Signs 'Washington Accord' for Accreditation

The board of directors of the Accreditation Board for Engineering and Technology, Inc. (ABET) gave final approval to an engineering educational equivalency agreement with the organizations in Ireland, the United Kingdom, New Zealand, Canada, and Australia that are responsible for determining the quality of engineering education in their own country as part of the professional engineering registration process. Known as the "Washington Accord" the agreement recognizes that the accredited courses/programs leading to a degree in engineering of the six countries as being substantially equivalent and satisfying the academic requirements for the practice of engineering at the professional level. ABET is a federation of 25 professional technical societies that represents more than 1.8 million engineers. For more information , Contact: ABET, 345 East 47th St., New York, NY 10017 (212/705-7685).

(ASTM Standardization News, August 1990)

Syndecrete, A New Recipe Concrete

Syndecrete is half the weight of regular concreteat 1200 kg/m^3 and far lighter than granite or marble. Unlike stone or regular concrete, Syndecrete can be shaped or routed with standard carbide-tipped woodworking tools.

Rather than the usual coarse sand or rock aggregate, Syndecrete contains porous volcanic rock, such as pumice, vermiculite, or basalt. In addition, wood or marble chips, brass shavings, or crushed glass can be added to change the appearance.

Finally, polypropylene fibers are added to the batch for reinforcement Because it is cast and not made in sheets, a Syndecrete counter has no seams. After curing, it is sanded and coated with a waterbased sealer. Then, a liquid acrylic wax is applied. The wax makes the surface resistant to oil penetration, water absorption, and stains from food.

Syncrete cast into custom counter tap.

The resulting counter is as rugged as concrete. But some abuse, like splatters of hot oil, can mar the wax but it can be fixed by sanding and reapplying the wax.

Prices range from $556 to $667 per square meter for installation of a 50 mm-thick counter. Tables, chairs, floor and bathroom tiles, showers, sinks, and tubs cast with Syndecrete are also available. Syndesis Studio, 2908 Colorado Ave., Santa Monica, Calif. 90404.

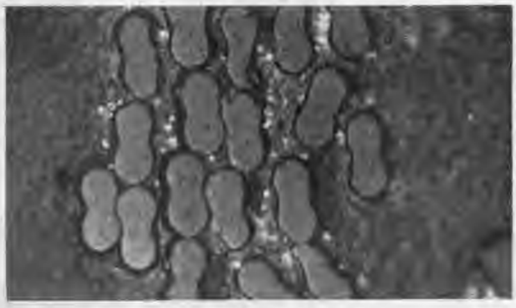
(Popular Science, Oct. 1990. Information sent by Dr. Gary Bowen, Alaska).

Shaped Fibers May Boost Composite Strength

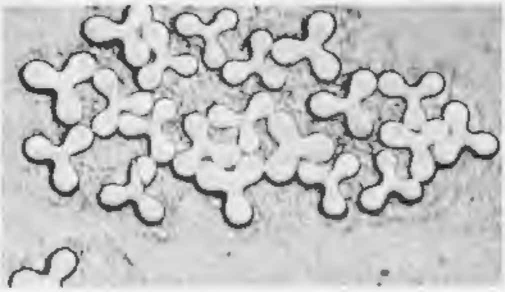
Glass fibers formed into bilobal and trilobal shapes could significantly increase the stiffness and strength of composites. Such fibers are being developed at the Owens-Corning Fiberglas Technical Center, Granville, OH.

Shaped glass fibers have greater surface area per unit weight than standard round fibers. Owens-Corning researchers believe improved composite strength may result because the extra area increases the amount of fiber-to-resin bounding. Shaped fibers could also lead to denser composites with increased stiffness and lower thermal conductivity.

Only experimental quantities of bilobal and trilobal glass fibers have been produced. Re-



Bilobal shaped glass fibers



Trilobal shaped glass fibers having equivalent diameters based on crosssectional area of 6.5 to 25 μm.

search work is now focused on characterizing the properties of the shaped fibers.

(Machine Design, August 1990. Information sent by Dr. G.L. Bowens, Alaska).

Cement Goes High-Tech

National Cement and Ceramics Laboratories, Inc. (NCCL)- Concrete Technology Corporation is now involved in a technology transfer program with the National Science Foundation's Science and Technology Center for Advanced Cement-Based Materials. To aid the flow of research ideas between academia and industry, NCCL inaugurated a $3 million laboratory adjacent to Northwestern University, Evanston, Illinois. Researchers there will apply diagnostic instruments routinely used in metallurgy, but never before in the study of cement, to learn how to manipulate cement's microstructure. They hope to develop new materials to replace expensive or environmentally harmful materials.

(Chemical Engineering, Sept. 1990. Information sent by Dr. G.L. Bowens, Sitka, Alaska).

Concrete Mixing by Heat Pump

Michael K. Andrews, of Union Electric Co., won second place honors in the Industrial Category of the 1990 Marketing Achievement Awards Program sponsored by the Edison Electric Institute. His entry was one of 381 submitted for the annual EEI program.

Andrews worked with Kurtz Concrete Co. in devising a system for the firm to supply concrete at highly competitive prices. This system included the use of a 40 ton, computer controlled heat pump.

(Concrete International, December 1990)

Fiber Research Continues

Direct tensile tests and flexural tests, including crack opening measurements, are among the current activitie of a Concrete Materials Research Council funded study currently in progress.

Approved by the American Concrete Institute agency in 1987, the study also includes more detailed statistical and engineering analyses of large flexural test series results. Proposed modifications and additions to existing testing methods for fibers are expected to result from this project.

The research study recently was the subject of a two day workshop on "Fracture Toughness of Fiber Reinforced Concrete" held in Tempe, Arizona, for a critical review of initial results of the test program and to provide a forum to discuss toughness characterization of fiber concrete and its use in performance evaluation and design. Technical papers reporting project results and findings are now being prepared by participants.

A project of ACI Committee 544, Fiber Reinforced Concrete, the research study involves six universities and industry support, including supplies of fibers from four firms. The schools are the University of Missouri at Columbia, Northwestern University, Clarkson University, Colorado State University, New Jersey Institute of Technology, and South Dakota School of Mines and Technology. The study directors are V.S. Gopalaratnam of Missouri and Surendra P. Shah of Northwestern.

The basic purpose of the study is to determine the influence of specimen size, loading configuration, loading rate, and fiber type on the flexural behavior and fracture toughness of fiber reinforced concrete. The need for a large systematic test program involving interlaboratory studies and data was deemed necessary to provide material characterization and performance evaluation techniques necessary for the material to achieve its potential in design and application.

(Concrete International, December 1990).

Nylon 6 Fiber Improves Properties

Allied-Signal, Inc. has introduced a high-strength nylon 6 fiber engineered for secondary reinforcement of concrete. Nylon 6 fibers, marketed as Caprolan-RC or Nycon Fibers, offer the benefits of fiber technology at a low cost.

When nylon 6 fibers are added to the mix at 0.59 kg/m^3, the fiber bundles open and separate into 34 million individual filaments. These filaments distribute uniformly in the concrete matrix during mixing. The result is a dramatic improvement in concrete performance and durability.

On July 1, 1990, the fibers received approval from the National Evaluation Service Committee of the Council of American Building Officials (CABO) as complying with the requirements of all three model building codes used around the country - ICBO, SBCCI, and BOCA. At 896 MPa tensile strength, they are one of the strongest approved concrete reinforcements in the market.

Independent laboratory tests show that at 0.59 kg fiber/m^3 of concrete, these fibers can reduce plastic cracking by almost 60 % while doubling impact resistance.

The fibers also inhibit plastic settlement, resulting in a more consolidated, homogeneous mix, and reduce concrete permeability. They are corrosion resistant, anti-magnetic, and alkaline resistant. Packaged in 0.45 kg (1 lb), 2.26 kg (5 lb), or 4.5 kg (10 lb) bags, they require minimal work at the batch plant to insure fiber dispersion.

End-uses include slab-on-grade, sidewalks, driveways, elevated slabs, precast units, poured walls, and pools. In all applications, the concrete finishes up with a smooth, non-hairy surface. Concrete reinforced with the fibers can be placed, shot, or pumped and has been successfully used in over 4647531 m^2 (50 million square feet) of installations to date.

(Concrete International, December 1990).

Concrete for Rockwork

Citing not only esthetics, but regional accuracy, realistic scenery, stability, and ease of maintenance, landscape architects and contrators are turning to designs and construction by specialist firms for individualized rockwork to complete their projects. Concrete is the prime material and innovative refinements in design and construction techniques are being used to provide dramatic beauty and compatibility with the surrounding area when creating a new dimension for the environment or masking and enhancing retaining walls. Man-made rock outcroppings can be constructed to appear to be a continuation of the indigenous rock in the area of the site.

Macaire, Inc. individually designs each project, providing greater structural durability than standard molds. The unlimited variety of rock types and colors and the ability to blend plants directly into the rockwork can provide an accuracy and blending with the environment that is rarely possible with standard molds.

(Concrete International, December 1990).

NEW EQUIPMENT

A Brand New Concept

ELE International's Advanced Digital Readout (ADR) is a brand new concept designed primarily for integration into the company's new generation of concrete testing machines.

Also available as a stand-alone instrument, the ADR allows users to retrofit the unit to a wide range of existing equipment enabling this to be updated with 90's technology. Either way users are benefiting from the latest microprocessor controlled technology and the robustness demanded for machines destined to work continually to the highest level of accuracy and reliability in the rugged environment of the concrete testing industry.

A product of many year's research and development by ELE International, the ADR is a technologically advanced microprocessor controlled instrument with facilities for data presentation, stress-calculation and calibration. With its touch button data keys, user friendly-LCD display and menu-driven procedures, all operated and co-ordinated via the front panel, this unit offers all the accuracy, performance, reliability and ease of operation required to meet modern day standards. It has been configured to minimize data input during normal testing procedures and the diagnostic and test routines of the unit help to reduce costly down-time and service charges.

The following are some of the benefits and features included in the ADR:

- Automatic load ranging, for maximum sensitiv ity of readings.
- Indefinite peak load hold until cancelled to reduce operator reading errors.
- Automatic start load pacing with error indicator for accurate control of load rate.
- Switchable load ranges for compression and flexural testing.

- Comprehensive calibration routines to suit a wide range of machines and operating pressures.
- Serial Centronics and RS232 output ports included as standard for connection to printers and computers for hard copy results.

Designed and built at ELE's modern manufacturing facilities, the ADR 1000, 1500, 2000 and 3000 (kN) Concrete Compression Machines with high stability load frames, advanced digital readout and attractive re-styling package can test a comprehensive range of samples.

(New Zealand Concrete Construction, November 1990)

Super Mustang 80

Morgen Manufacturing has introduced the Super Mustang 80 as the most powerful trailer mounted concrete pump in their line up. The Super Mustang delivers 61 m^3 an hour, with a maximum pumping height of 152 m and a maximum pumping distance of 610 m.

The Super Mustang 80 is powered by a turbo-charged, 6-cylinder, water-cooled, 131 kilowatt diesel engine. The engine power and innovative pumping design combine to produce 82 bar pressure on the concrete in the high capacity mode and 114 bar pressure in the high pressure mode.

The heart of the Super Mustang is the cast steel swing valve, designed to provide a nearly straight-line flow of concrete. The flow-through swing valve cylinders provide smooth shifting and positive swing valve location before the main concrete pumping cylinders start to discharge.

Super Mustang Morgan 80

Fast cycling and consistent pump performance are achieved by using the full flow of the main hydraulic pump through the two flow-through cylinders, which enables the swing valve to throw in each direction at the same speed.

The 175 millimeter inlet and 175 millimeter outlet enable the pump to handle difficult mixes. The 175 millimeter outlet means there is no reduction in the pump. Reduction to line size is done in the pipeline, which increases the wear life of the swing valve and all pump components.

The super heavy-duty charging hopper provides greater strength and rigidity for better sealing and longer life of the wear parts. The hopper is designed to withstand the 114 bar pressure that can be attained in the high pressure mode.

The Super Mustang 80 comes equipped with all the standard features of the Mustang line. Among the options included are a water wash system complete with hose and wand, an on-off-reverse remote control with 31 m of cable, an air compressor and hydraulic rear stabilizers.

(News, Paulsen Advertising, Inc. November 1990)

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ABSTRACTS

FP 159 BEHAVIOR OF FERROCEMENT MATERIAL UNDER DIRECT SHEAR

KEY WORDS : ferrocement,shear strength, shear tests, shear failure

ABSTRACT: The behavior of ferrocement under direct shear was investigated by conducting axial compression tests on Z-shaped specimens reinforced with woven wire mesh producing pure shear on the shear plane. The major study parameters were the volume fraction of wire mesh reinforcement Vf. .Th e shear plane and mortar strength. Test results indicate that ferrocement under direct shear exhibits two stages of behavior (cracked and uncracked) while under flexure it exhibits, a third stage (plastic stage) in addition. The cracking and ultimate shear stresses increase with increasing mortar strength and wire mesh reinforcement. Empirical equations have been developed here using regression analysis to predict the cracking and ultimate shear stresses in terms of the mortar tensile strength ft and Vf The test results also indicate that the shear stiffness in the uncracked stage is not significantly affected by the amount of wire mesh; it is mainly affected by the mortar strength. The shear stiffness in the cracked stage is affected by both amount of wire mesh and mortar strength. Ductility of ferrocement material under direct shear increases with increasing wire mesh reinforcement and decreases with higher mortar strength.

REFERENCE : Al-Sulaimani, G.J. and Basumbul, I.A. 1991. Behavior of ferrocement material under direct shear. *Journal of Ferrocement* 21(2): 109-117

FP 160 EFFECT OF REPEATED LOADING ON CRACKWIDTH OF FERROCEMENT

KEY WORDS : ferrocement, bending, flexural strength, repeated stress, crackwidt

ABSTRACT: A ferrocement composite has been studied under repeated loading in flexure. As a part of a large program, development of crack widths due to repeated loading are reported. Reliability of predictive models is discussed and a new model is proposed. Where knowledge of crack width is deemed to be essential it is recommended that the models should be used with due care and not without confirming their applicability through physical tests.

REFERENCE : Singh, G. and M. Fong L. Ip 1991. Effect of repeated loading on crackwidth of Ferrocement. *Journal of Ferrocement* 21(2): 119-126

FP 161 THE EXPERIMENTAL BEHAVIOR OF FERROCEMENT FLAT PLATES UNDER BIAXIAL FLEXURE

KEY WORDS : ferrocement, flexural strength, biaxial loads, bending, plates(structural members)

ABSTRACT: The results of an experimental programme taking into account lamination effects are presented and discussed. Twenty-three (23) square, simply-supported ferrocement slabs were tested to failure under biaxial flexure. The program was designed to investigate the effects of certain variables on the strengths, toughnesses, and mid-point deflection characteristics of a slab. Test variables included the through-the-thickness orientation pattern of the meshes; the stacking sequence of the meshes; span-to-thickness ratio and in-plane mesh orientation angle. It was concluded that lamination effects can considerably affect performance and should be considered in *experimental work on ferrocement and in the modelling of its behavior.*

REFERENCE : Clarke, R.P. and Sharma, A.K. 1991. The experimental behavior of ferrocement flat plates under biaxial flexure. *Journal of Ferrocement* 21(2): 127-136

FP 162 USE OF HARD GRASS REEDS IN FERROCEMENT

KEY WORDS : housing, ferrocement, organic fibers, roofing

ABSTRACT: An experimental pre-cast roofing element has been constructed for low cost roofing system. Hexagonal chicken wire mesh of 12 mm x 24 G, Hard Grass Reeds (HGR) locally known as "Sarkanda" and cement mortar were used in this roofing element. Cross -sectional area of the roofing panel is 457 mm x 64 mm and the span is 915 mm. About 40% of the cementitious materials have been replaced by the HGR. These HGR have also been used to replace the steel reinforcement (skeletal steel) which is a costly material, to provide better thermal and sound insulation and to contribute in reducing dead load of the structure. Pre-cast roofing elements were load tested in accordance with BSI CP-110 Part-1 : 1972 and were found strong enough to carry the required test load.

REFERENCE : Waliuddin,A.M. and Brohi, P. 1991. Use of hard grass reeds in ferrocement. *Journal of Ferrocement* 21(2): 137-141.

INTERNATIONAL MEETINGS

1991: **2nd Regional Conference on Computer Applications in Civil Engineering - RCCACE '91, Johor Bahru, Malaysia.** Contact: Organizing Secretary RCCACE '91, Faculty of Civil Engineering, Universiti Teknologi Malaysia, Karung Berkunci 791, 80990 Johor Bahru, Malaysia.

March 14–15, 1991: **Asia-Pacific Conference on Masonry, Singapore.** Contact: Engr. John S.Y. Tan CI-Premier Pte. Ltd., 150 Orchard Road #07-14, Orchard Plaza, Singapore 0923. Tel: 7332922; Fax: 2353530; Telex: RS 33205.

April 4–5, 1991: **Third International Conference on Structural Failure-ICSF 91, Singapore.** Contact: Dr. K.H. Tan, Department of Civil Engineeering, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511. Tel.: 7722260; Fax: (65) 7791635; Telex: UNISPO RS33943; Telegram: UNIVSPORE.

April 7–11, 1991: **Development and the Environment, Tasmania, Australia.** Contact: The Conference Manager, the Institution of Engineers, Australia, 11 National Circuit, Barton Act, Australia 2600. Tel.: (06)2706549; Fax: (06) 2706530; Telex: AA62758.

April 8–11, 1991: **Conference on Deformation, Yield and Fracture of Polymers, Cambridge, England.** Contact: Plastics and Rubber Institute, Conference Department, 11 Hobart Place, London , England SW1W OHL.

April 14–18, 1991: **Sixth International Symposium: Tunnelling '91, London, U.K.** Contact: The Conference Office, Institution of Mining and Metallurgy, 44 Portland Place, London, U.K. W1N 4BR.

April 21–25, 1991: **International Conference on Computational Engineering Science, Patras, Greece.** Contact: Prof. S.N. Atluri, Computational Mechanics Center, Georgia Tech., Atlanta, GA 30332-0356, U.S.A.

April 23–26, 1991: **The Third East Asia-Pacific Conference on Structural Engineering and Construction (EASEC - 3), Shanghai, China.** Contact:EASEC - 3 Secretariat, Mr. H.F. Xiang/ Mr. D.H. Jiang, Tongji University, 1239 Siping Road, Shanghai 200092, China. Tel.:5455080-3420; Cable:3658; Fax:0086-021-5458965; Telex:33488 TJIDC CN.

June 3–7, 1991: **11th FIP Congress, Hamburg, West Germany.** Contact: FIP Office, The Institution of Structural Engineers, 11 Upper Belgrave Street, GB-London, United Kingdom SWIX 8BH.

June 10–13, 1991: **5th Annual Technical Conference on Composite Materials, Michigan, U.S.A.** Contact: Dr. L.T. Drzal, American Society for Composites, B100 Research Comples, Michigan State University, East Lansing, MI 48824-1326, U.S.A.

June 27–28, 1991: **New Dimensions in Bridges and Flyovers, Singapore.** Contact: Engr. John S.Y. Tan CI-Premier Pte. Ltd., 150 Orchard Road #07-14, Orchard Plaza, Singapore 0923. Tel: 7332922; Fax: 2353530; Telex: RS 33205.

July 29–31, 1991: **Fourth International Conference on Computing in Civil/Building Engineering, Tokyo, Japan.** Contact: Mr. Junichi Yagi, Managing Director, Office of Japan, Society of Civil Engineers, Yotsuya 1-0, Shinjukuku, Tokyo, Japan.

August 4–9, 1991: **International Conference on Durability of Concrete, Montreal, Canada.** Contact: Mr. H.S. Wilson, P.O. Box 3065, Sta. C., Ottawa, Canada K1Y 4J3.

13-14 August 1991: **Piletalk International '91, Kuala Lumpur, Malaysia.** Contact: Conference Director, Engr. John S Y Tan, CI-Premier Pte Ltd, 150 Orchard Plaza, Singapore 0923. Tel: 7332922. Fax: 2353530. Telex: RS 33205 FAIRCO.

August 20–22, 1991: **Computational Structures Technology, Edinburgh, U.K.** Contact: Edinburgh Conference Centre Limited (Forth Rail bridge Centenary Conference), Heriot-Watt University, Riccarton, Edinburgh, U.K. EH14 4AS, Tel.: 031-4495111 Ext.3117; Fax: 031-4513199.

August 25–30, 1991: **Composite Polymeric Material, New York, U.S.A.** Contact: Mr. R.S. Turner, ACS Division of Polymeric Materials, Building 82, Eastman Kodak Co., Rochester, NJ 14650, U.S.A.

26-27 August 1991: **16th Conference on Our World in Concrete and Structures, Singapore.** Contact: Conference Director, Engr. John S Y Tan, 150 Orchard Road, # 07-14, Orchard Plaza, Singapore 0923. Tel: 733 2922. Telex: RS 33205 FAIRCO. Fax: 2353530.

September 3–6, 1991: **Diagnosis of Concrete Structures, Czechoslovakia.** Contact: Doc. Inc. Tibor JAVOR, Dr.Sc. VUIS Lamacska 8, 81714 Bratislava, Czechoslovakia.

8-10 October, 1991: **International Conference on Concrete Engineering and Technology (Current trends and applications), Kuala Lumpur, Malaysia.** Contact: Concet '91 Secretariat, Department of Civil Enigineering, Faculty of Engineering, Universiti Malaya, 59100, Kuala Lumpur, Malaysia. Tel: 03-755-3466 ext. 203 or 351. Telex: MA 39845. Cable: UNIVSEL

October 22–25, 1991: **International Symposium on Modern Application of Prestressed Concrete, Beijing, China.** Contact: Professor Liu Yongyi, China Academy of Building Research (CABR), P.O. Box 752, Beijing 100013, China.

December 4–6, 1991: **ACI International Conference on Evaluation andRehabilitation of Concrete Structures and Innovations in Design, HongKong.** Contact: Mr. William R. Tolley, American Concrete Institute, 22400 W. Seven Mile Road, Detroit, MI 48219-1849, U.S.A.; Fax:(313)532-0655.

7-13 December 1991: **Constro '91, Exhibition of Construction Machinary (Materials and Methods), Pune, India.** Contact: Dr. Neelkanth R. Patwardhan, Chief Co-ordinator Costro '91, Progress House, 54 Wellesley Road, Shivajinager, Pune - 411005, India. Tel: (0212) 58944/57861. Telex: 0146-220 Aqua in. Fax: 0212 - 337985.

9 - 11 December 1991: **First International Seminar on Lime and Other Alternative Cements in Developing Countries, Kenilworth, Warwickshire, U. K.** Contact: Mr. Otto Ruskulis, Intermediate Technology Development Group, Myson House, Railway Terrace, Rugby CV21 3 HT, U.K. Tel: (0788) 560631.

11 - 13 December 1991: **Asian Pacific Conference on Computational Mechanics, Hongkong.** Contact: Dr. J.H.W. Lee c/o Department of Civil & Structural Engineering, University of Hong Kong, Hong Kong. Telex: 71919 CERES HX. Fax: (852)- 559-5337.

May 3–8, 1992: **International Conference on Fly Ash, Silica Fume, Slag and Natural Pozzolans in Concrete, Istanbul, Turkey.** Contact: Mr. H.S. Wilson,P.O. Box 3065, Station C, Ottawa, Canada K1Y 4J3

19 - 21 December 1991: **International Synposium on Fatigue and Fracture in Steel and Concrete Structures, ISSF-91, Madras, India.** Contact: Mr.A.G. Madhava Rao, SERC, Council of Scientific and Industrial Research (CSIR), Madras-600113, Tamil Nadu, India. Tel: 416991. Telex: 041-21067 CSIR IN. Fax: 011-91-44-416508.

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B.K. Paul and R.P. Pama

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(a) Papers on Research and Development
(b) Papers on Applications and Techniques
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