7. The significance of minute fissures compared to those visible to the unaided eye in terms of service of concrete under load and exposure is obscure. Judging by tests made in Germany to determine the durability of reinforcement in concrete beams under load in an atmosphere designed to accelerate rust producing conditions, the very fine checks which accompany an elongation of 0.010 per cent have no signficance in terms of rusting of steel. From the observation of the surface of concrete roads where these checks are undoubtely present, it would not appear that they have much significance in respect to the wear of the surface of the roads. Now if a mesh reinforcement will postpone the appearance of the larger eye visible fissures, then it would seem to be of substantial advantage in maintaining integrity of concrete surfaces.

SUMMARY OF TENSION TESTS OF CONCRETE BRIQUETTES REINFORCED WITH STEEL FABRIC

H. E. Breed
New York University, New York, N. Y.

To all of us there has been apparent the beneficial effects from the use of a small amount of steel well distributed throughout a pavement slab. Observations of actual work over a period of 10 years of pavement built with and without amounts of steel from 21 to 60 pounds per 100 square feet of slab, show definitely the advantage of the reinforced over the plain in giving better condition at less expense for maintenance. The benefit observed shows a greater gain in strength in the concrete in the reinforced sections than the sectional area and the relative moduli of elasticity would indicate. The first question that suggests itself is how great is this benefit and whence does it come?

An observation of the records of a large mileage of concrete pavements from construction to five years of age showed that in the minds of various observers from 20 to 30 per cent of the rupture (cracks) came in the first 28 days of the life of the pavement slab when the tensile strength of the concrete varied from zero to 250 pounds per square inch.

Taking the first month as the most informative period and further limiting the study to the first 7 days when the concrete is weakest and has to resist the greatest contraction, a study of the beneficial effects of a steel fabric was conducted.

In collaboration with Professor E. G. Hooper, of New York University, a preliminary test was conducted as follows:

Test set No. 1, total 24 tension specimens averaging 4⅛ by 5⅞ inches cross-section, divided equally on the basis of *time*, 3 days and 5 days, on the basis of *reinforcement* 0.1 per cent and none, and on the basis of *curing* (after removal from molds) in water to a depth of about ¾ inch and under damp sand. There were then three tension specimens for each combination of time, reinforcement and curing.

The result of these tests indicated a benefit from the use of the steel fabric of 4 per cent where the samples were cured in damp sand, and 19 1 per cent benefit when they were cured with the bottoms wet

To confirm or disprove the benefit shown, additional tests were carried on to the extent of 180 tension tests and 10 compression tests

These tests indicated a benefit in 36 cases showing a range in favor of the single layer of steel fabric from a small percentage up to 42 per cent benefit, and in favor of the double layer from a small percentage up to 82 per cent In four cases, however, negative results were secured from a small percentage to 17 per cent

In a comparison of the plain and the reinforced concrete, taking only the value of the reinforced concrete at the time it cracked, the results indicate

1 Concrete of the dense mix used, treated as described, reinforced with steel fabric $\frac{1}{8}$ to $\frac{1}{4}$ per cent, is benefited in tensile strength far more than the percentage of steel used would indicate

2 The steel fabric tended to maintain the integrity of the unit after rupture, in some cases drawing the parts together to make invisible the plane of the rupture

3 Since safe stresses are normally based upon average ultimate stresses there is possible justification for assuming a proportionately higher safe stress value for the reinforced concrete in spite of the incidental cases where percentage of benefit was negtaive, because permissible variation in values for strength of concrete in any given series of tests is such as to make possible the comparison of a particularly good set of plain concrete with a poor set of the reinforced thereby obtaining negative results fully as large as the largest we obtained

4 *Possible* justification in 3 can become *positive* justification only if the average value as we obtained it is substantiated in a duplication of tests already made, by similar tests on a concrete mix representing the other extreme of density permissible in highway or other work, and test under a lower temperature condition

5 Enough data have been obtained to suggest a few pertinent questions (a) What benefit, if any, would be derived from such reinforcement in a less dense or more absorbed concrete? (b) Did the extreme density of the concrete used prevent greater variation in volume and thereby limit the benefits to be derived from the steel used?

During the course of the experiment there happened one of those accidents that are occasionally illuminating

The test specimens for the two-day period were left out over night just as a road slab would be Rain fell One series of a 3-inch slump consistency absorbed water and expanded When they contracted again in the subsequent drying out, the plain concrete specimens broke, the reinforced ones held together, and where cracks on them appeared, those cracks extended only to the steel, where they stopped. The other series of a 7-inch slump consistency probably expanded less on account of the moisture content already in it. After the drying out one plain specimen was checked and the average strength of the reinforced speci-

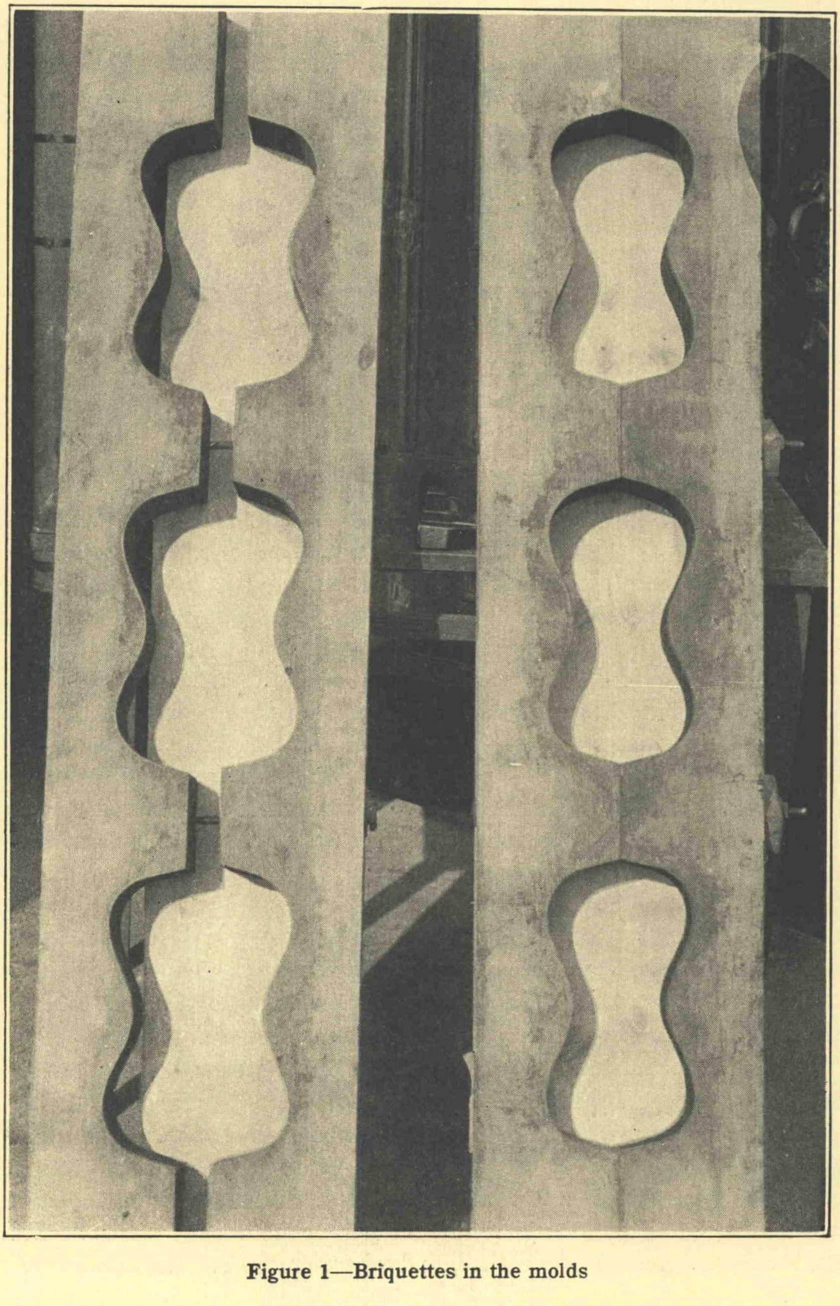

Figure 1—Briquettes in the molds

mens was 20 per cent greater for those with top steel fabric and 82 per cent greater for those with top and bottom steel.

The grand average of all tests in this run exclusive of the two-day results noted above indicated a benefit of over 11 per cent for the ⅛ per cent steel fabric and of over 16 per cent for the ¼ per cent steel fabric.

The tests described were made on concrete briquettes of a 1:1½:3 mix. The shape was that of the cement briquette enlarged four times in all dimensions except that the cross-section area at the center was 3⅝ by 4 inches (Figure 1). Four series of specimens were made containing 0, ⅛, and ¼ per cent of steel fabric as reinforcement, with a slump of 3 inches and 7 inches for each of the following ages: 2, 3, 4, 5, and 7 days. Half of the specimens were cured: after 1 day in the molds, in water about ¾ inch deep and in earth out of doors sprinkled twice daily. There were therefore three tension specimens for each combi-

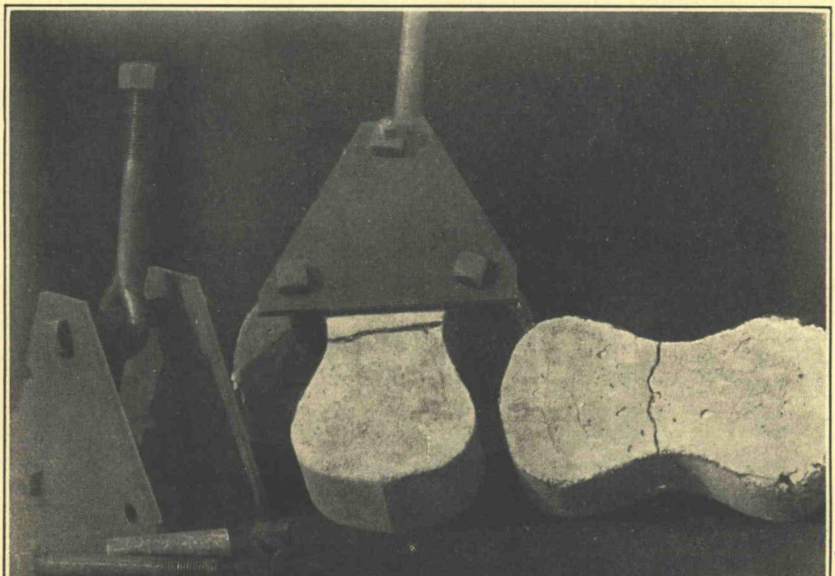

Figure 2—Grip used in testing briquettes

nation of time, slump, reinforcement, and curing. There was one 6 by 12 inch cylinder for each combination of time and slump.

Each step was carried throughout by the same operator so as to reduce as far as possible the personal equation.

Each grip used (Figure 2) was made of two triangular plates of steel separated by 3 bolts encased in pipe. The pipe acted as rollers allowing the grip to adjust itself as the load was applied.

The tension tests were made on a Riehle 100,000-pound machine and the compression tests on a Riehle 200,000-pound machine.