III−8

AN INSVESTIGATION ON RECTANGULAR SOIL BEAMS WITH TENSION STEEL REINFORCEMENT

By M. Hoshiya[1] , J.N. Mandal[2] and °M. Naruyama [3]

INTORDUCTION

Leonards and Narain(1) developed the procedure to estimate the limiting tensile strain at which a compacted clay will crack. Soil is also weak in tension. Therefore , the aim of this research work described in this present paper is to observe the cracking patterns, mode of failure and the failure stresses and strains of unreinforced and reinforced soil beams. In addition, the principles of reinforced concrete design method were also employed to verify the test results.

DESCRIPTION OF BEAM TESTS

Bending tests were performed in a beam bending machine employing a single concentrated vertical loading at the mid span as shown in Fig.1. Some beam also tested under two point loads. The progress in the understanding of flexural behavior of reinforced soil beam has not been quite as spectacular. A rational theory is essential to reveal the effects of shear and diagonal tension. The principal mechanism of shear resistance , fundamental behavior and mode of failure may be examined with this tests. The component of soil beam section is shown in Fig.2.The shear capacity of reinforced soil beam is generally composed of four principal components:- (1)the shearing stress in the uncracked soil across the compression zone(R_c),(2)the frictional and grains interlock forces that are developed along the line of any crack(R_s), (3)the shear component of longitudinal forces in the reinforcement by dowel action(R_d), and (4)tranverse component of the force F, which results from interlocking of grain particles across a crack (F_g). It is assumed that the resultant of the diagonal crack, dowel forces and the tensile reinforcement meet at a point. The bending moment'M' can be expressed as. $M = R(r_1 + r_2) = RP = T\,jd + (R_s/2 + R_d + F_g)\,r_2$, Again, $M = Rp = T\,jd = C\,jd$, $R = dM/dp = jd\,dT/dp + T\,d(jd)/dp$.

CONSTRUCTION OF SPECIMENS

The soil was mixed to the desired water content one day before compaction are stored in a plastic bag for 24 hours in order to allow the moisture to distribute itself uniformly throughout the soil. The internal surface of beam mold were slightly greased for the easy removal of the compacted beams. The optimum moisture content of clay was 26.4%. The beams of 75 mm width and 90 mm height were formed at a uniform moisture content of about 30 % and 90 % standard proctor compactive effort. Compaction in the beam was in five equal layers, each layer receiving an equal number of blows (60 blows in three passes). If any layer had to be reinforced, it was placed by mild steel net strips (Length = 620 mm, width = 25 mm or 37.5 mm) in the central portion of the beam along the width. The reinforcement strips were bent at either end in opposite direction to get a good grip.

TEST RESULTS AND DISCUSSION

The load - deflection behavior of unreinforced and reinforced beams are shown in Fig. 3. The visual observations of the crack development within the beam as load increases will serve as a stepping - stone for an understanding of the various crack patterns that form, and these patterns may then be compared with the various sections of the load-deformation curve. The mechanics of the reinforcements and their influence on the friction properties of the soil may also help explain some of the contradictory findings. Moreover, it can be observed from the experiments that reinforced soil beam can maintain increase in load even after cracking starts in the beam. The minute cracks are clearly visible on the front or lower surface of the beam. A typical failure modes observed in the bending test are shown in Figs. 4 and 5. The unreinforced sample failed very abruptly (the brittle failure) as can be observed from the crack pattern. The mode of failure was different in the case of reinforced beam (tensile) unlike the case of unreinforced beams where the failure was brittle in nature. Experimental behavior of soil beams were favourably compared with theoretical predictions based on the elastic theory, working stress method, the ultimate load design method and flexure formula. The results of tests are summarized in Tables 1 to 3. The sudden drop in the load are shown in load - deflection curves. The size of the cracks remained approximately similar for the relevant stages of the tests.

CONCLUSIONS

Recent research has led significantly to an improvement in the load carrying capacity and the flexibility of soil beams. The principles of reinforced concrete design may be suitable for the analysis of reinforced soil beam. The addition of a small percentage of reinforcement is sufficient to improve the flexibility of soil beam.

(1)Professor , (2) Post-doctoral Fellow, (3) Asst. Professor , M.I.T., Tokyo, Japan.

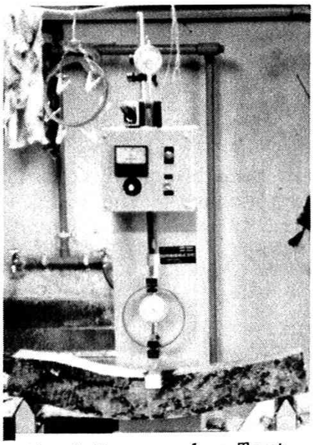

Fig.1.Beam under Test.

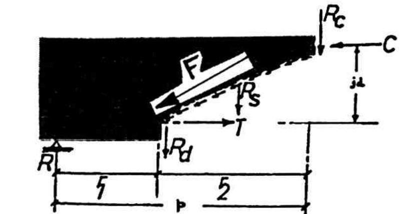

FIG.2.-COMPONENT OF SHEAR STRENGTH IN A SOIL BEAM SECTION

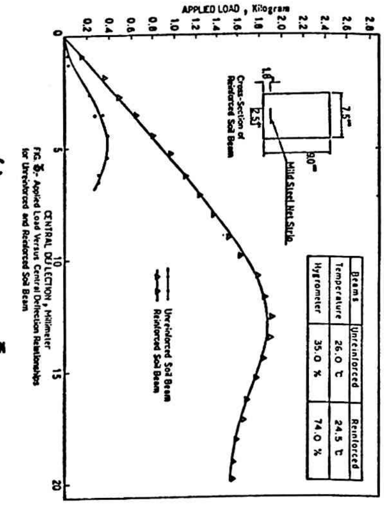

FIG.3.- Applied Load Versus Central Deflection Relationships for Unreinforced and Reinforced Soil Beam

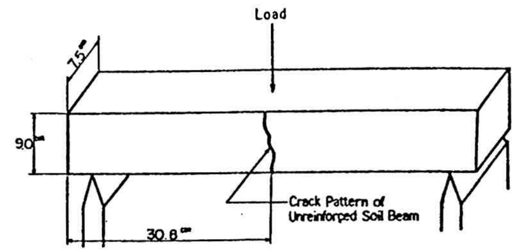

Fig.4. Failure of Unreinforced Soil Beam.

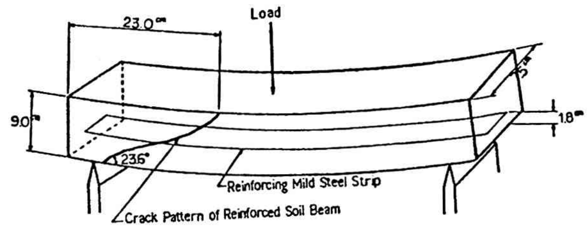

Fig.5. Failure of Reinforced Soil Beam.

TABLE.1.- Rectangular Beam Test Results

Reinforcement Type	Experimental			
	Load at first cracking, Kilogram	Load at failure, Kilogram.	Central deflection at first cracking, Millimeter	Central deflection at failure, Millimeter
Unreinforced	0.392	0.392	4.39	4.39
Reinforced	0.854	1.918	5.02	13.09

TABLE .2.- Rectangular Beam Test Results

Reinforcement type	Flexure Formula			Elastic Theroy	
	Compressive stress at failure, Kilogram per square centimeter.	Tensile stress at failure, Kilogram per square centimeter.	Tensile strain at failure, x 10^{-4}	Tensile stress at failure, Kilogram per square centimeter.	Tensile strain at failure, x 10^{-2}
Unreinforced	0.0527	0.0527	5.547	0.1695	0.839
Reinforced	1.8446	23.8413	0.10818	0.7997	2.503

TABLE.3.- Rectangular Beam Test Results

Reinforcement type	Working Stress Method			Ultimate Load Method	
	Compressive stress at failure, Kilogram per square centimeter.	Tensile stress at failure, Kilogram per square centimeter.	Bond stress, Kilogram per square centimeter.	Tensile stress at failure, Kilogram per square centimeter.	Ultimate Load, Kilogram.
Unreinforced	-	-	-	-	-
Reinforced	0.19467	34.7732	0.0709	166.839	12.61

REFERENCE

(1)Leonards,G.A. and Narain,J.''Flexibility of Clay and Cracking of Earth Dams'' Journal of Soil Mech. and Found. Divs.,ASCE,Vol.89,No SM2,Mar.,1963,pp.47-98.