THE LOAD-CARRYING CAPACITY AND DEFORMABILITY OF REINFORCED MASONRY WALLS

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The results of combined loading tests of horizontally reinforced and corresponding unreinforced masonry walls are given and the effect of such reinforcement on masonry wall shear strength and deformability is presented.

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The reinforced walls tested, of height 1.5 m and breadth 1.0 m, were built of expanded-clay aggregate concrete blocks. The results for two walls, built of ceramic perforated brick blocks, of the same dimensions but from a separate series of tests, are included for comparison. All the blocks were 19 cm high. The walls were 29 cm thick (19 cm thick in the case of walls 23 A,B & 24 A,B). The walls were reinforced by placing rectangular mild-steel stirrups 2 ϕ 6 mm or 2 ϕ 8 mm in each horizontal mortar joint (each second joint for walls 23 A,B). The amount of reinforcement in promille was determined by dividing the cross-sectional area of the stirrup by the vertical cross-sectional area of the wall corresponding to it.

The results of the tests are given in Table 1. When investigating the effect of reinforcement it would be appropriate to use a mortar of uniform strength and to maintain a uniform constant vertical loading. As this is difficult to achieve, the measured values of horizontal resistance for the unreinforced walls were recalculated where necessary using experimentally-obtained relations so that the values obtained $H_{comp.}$ were comparable with the reinforced walls. Wall quality can be reproduced with a coefficient of variance of 8 %, so that comparisons between individual reinforced and unreinforced walls are subject to an increased coefficient of variance. Reliable comparisons can thus be obtained only from large-series wall tests. Bearing this in mind, it can nevertheless be seen from Table 1 that the amount of reinforcement may have a certain influence on the horizontal resistance of walls. A smaller amount of reinforcement μ = 0.75 - 1.00 ‰ gave E_H(av.) = H_{max} (reinf.wall)/$H_{comp.}$ (unreinf.wall) = 1.22 (Group I) and a larger amount μ = 1.5 ÷ 1.75 ‰ gave E_H (av.) = 1.25 (Group II). A significantly larger effect E_H = 1.5 was obtained for the brick block walls (Group III), which was influenced by the characteristics and shape of the block and its direction of placing in the wall.

Examples of H-δ diagrams (hysteresis loop envelopes obtained by cyclic horizontal loading at 1 c.p.s. under constant vert.load) for reinforced and comparable unreinforced walls are given in Fig.1. From these diagrams and Table 1 a substantial increase in deformability with reinforcement can be seen. $E_\delta = \delta_{max}$ (reinf.wall)/δ_{max} (unreinf.wall) has an average value of 1.5 for Group I, 2.1 for Group II and 2.9 for Group III. The damage occurring in the reinforced walls was, at essentially greater deformations too, more equally distributed over the wall and the cracks were smaller than in the unreinforced walls (see Figs 2-5).

From the tests it can be concluded that horizontal reinforcing using mild-steel stirrups 2 ϕ 6 mm in each mortar joint is a structural provision which increases the horizontal resistance of concrete-block walls by 25 % and deformability by 50 to 100 %.

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GROUP OF WALLS	REINFORCED WALLS: WALL DESIG-NATION	STIRRUPS	AMOUNT OF REINF. μ (‰)	MORTAR STRGTH. β_m (kp/cm²)	VERT. LOAD V (Mp)	MAX. HOR. LOAD H_{max} (Mp)	MAX. DEF. δ_{max} (mm)	COMPARABLE UNREINFORCED WALLS: WALL DESIG-NATION	MORTAR STRGTH. β_m (kp/cm²)	VERT. LOAD V (Mp)	MAX. HOR. LOAD H_{max} (Mp)	REF. SHEAR STRGTH. τ_k (kp/cm²)	COMP. MAX. HOR. LOAD $H_{comp.}$ (Mp)	MAX. DEF. δ_{max} (mm)	EFFECT OF REINFORCING: ON HOR. LOAD CAPAC. E_H	EFFECT OF REINFORCING: ON MAX. DEF. E_δ
I	23 A	2φ6/40cm	0.75	35	15.0	9.6	6.0	22 A	$\boxed{31}$	15.0	7.7	2.15	7.7	11.0	1.25	1.8
	23 B			45	15.0	9.6		22 B	$\boxed{15}$	15.0	6.0		8.0	8.0	1.20	1.3
	2 A	2φ6/20 cm	1.0	53	21.0	12.5	7.0	1B	49	$\boxed{25.0}$	10.2	1.8	10.0	11.0	1.25	1.6
	2 B			54	18.0	10.9		5B	50	$\boxed{15.0}$	9.3		9.4	10.0	1.16	1.4
	14 A	2φ6/20 cm	1.0	46	36.3	17.1	10.0	13B	$\boxed{68}$	36.3	14.4	2.3	13.4	16.0	1.28	1.6
	14 B			50	44.5	17.2							14.5	15.0	1.19	1.5
II	24 A	2φ6/20cm	1.5	56	21.0	12.5	6.0	22A	$\boxed{31}$	$\boxed{15.0}$	7.7	2.15	9.2	15.0	1.35	2.5
	24 B			22	15.0	8.8		22B	$\boxed{15}$	15.0	6.0		6.8	18.0	1.29	3.0
	3 A	2φ8/20 cm	1.75	52	25.0	12.7	5.0	1B	49	25.0	10.2	1.8	10.0	11.0	1.27	2.2
	3 B			55	25.0	12.1		5B	50	$\boxed{15.0}$	9.3		10.0	10.0	1.21	2.0
	15 A	2φ8/20 cm	1.75	66	37.5	17.2	10.0	13B	68	36.3	14.4	2.3	14.4	15.0	1.19	1.5
	15 B			41	37.1	16.0							13.3	15.0	1.20	1.5
III	12 A	2φ6/20cm	1.0	65	35.7	14.5	5.0	10B	57	$\boxed{25.0}$	7.9	1.1	9.5	15.0	1.53	2.9
	12 B			63	37.4	14.7		11B	66	$\boxed{25.0}$	7.9		9.5	15.0	1.55	2.9

TABLE 1

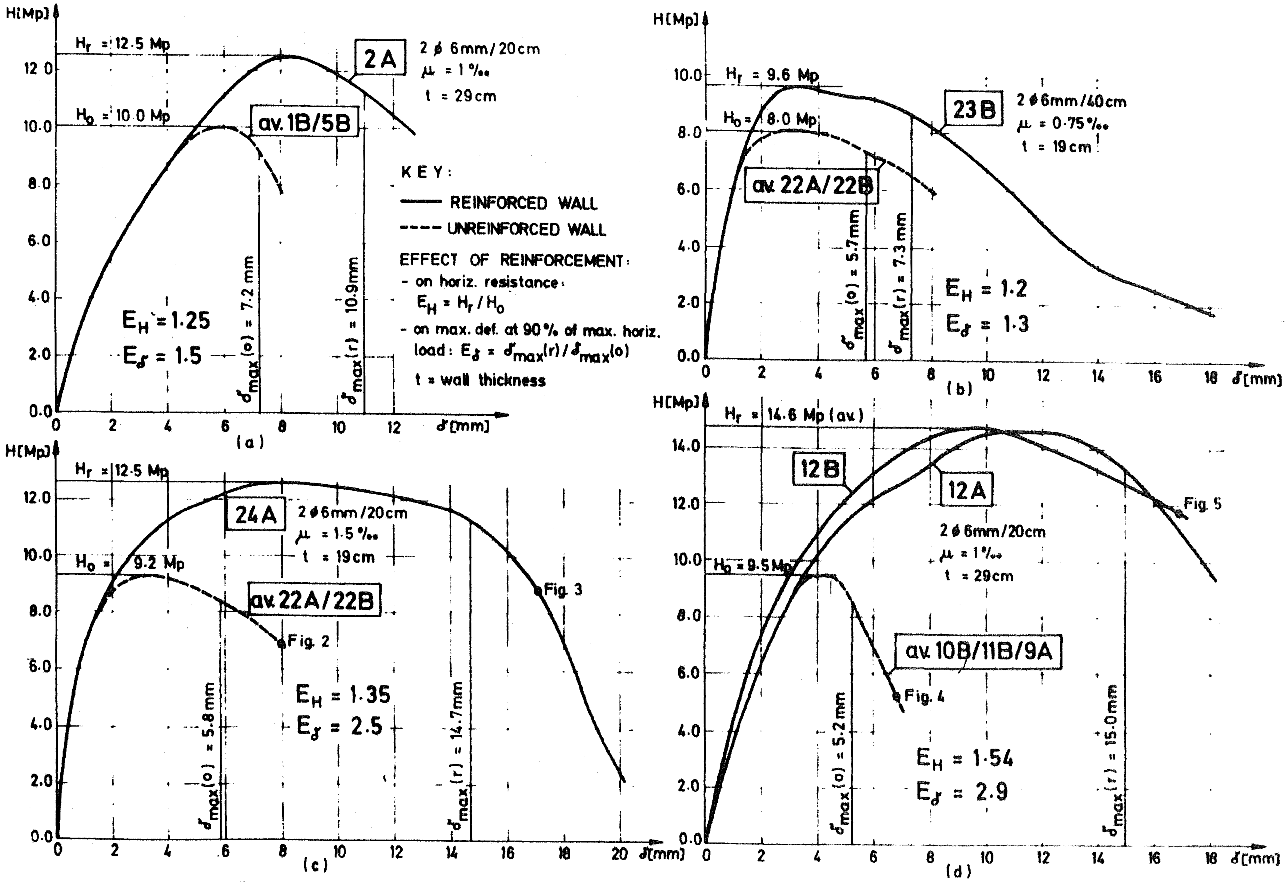

FIG. 1 H - δ DIAGRAMS FOR REINFORCED AND COMPARABLE UNREINFORCED WALLS

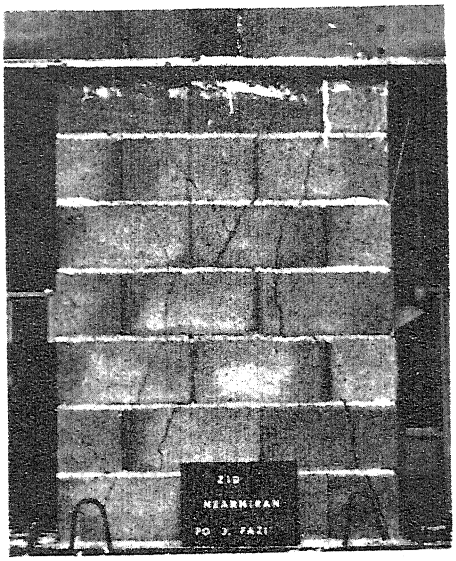

Fig.2 : Unreinforced wall
22 A (δ = 8 mm)

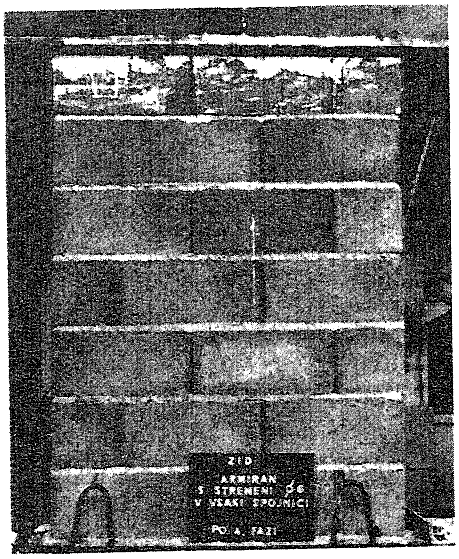

Fig.3 : Reinforced wall
24 A (δ = 17 mm)

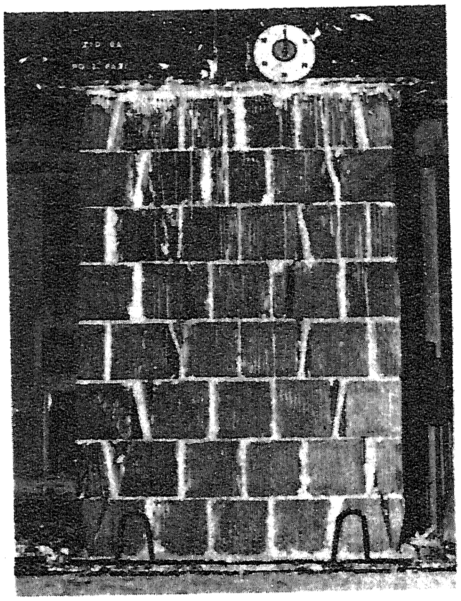

Fig.4 : Unreinforced wall
9 A (δ = 7 mm)

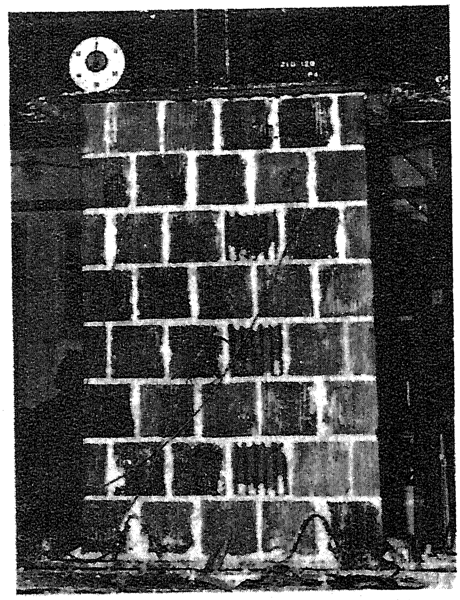

Fig.5 : Reinforced wall
12 B (δ = 17 mm)