THE INFLUENCE OF BRICK AND BRICKWORK PRISM ASPECT RATIO ON THE EVALUATION OF COMPRESSIVE STRENGTH

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ABSTRACT This paper describes a series of uniaxial compression tests on calcium silicate bricks and prims. These tests have been used to study the influence of aspect ratio on the evaluation of compressive strength. A total of 17 types of bricks (some solid and some perforated), with aspect ratios ranging from 0.36 to 3.03, were tested in confined and unconfined compression. From the same batches of units, stack bonded prisms were constructed and tested in confined compression. Differing numbers of units were used in the prisms to produce aspect ratios ranging from 1.71 to 7.76.

From the results, the influence of the testing machine platens on the observed compressive strength of specimens with various aspect ratios has been studied, and a simple relationship for an aspect ratio correction factor derived.

1. INTRODUCTION

The observed strength of a specimen tested in uniaxial compression will depend upon its size and shape. For specimens with low height/width ratios, a significant artificial strengthening is produced by the restraining effects of the platens of the testing machine. Lateral expansion of the specimen is prevented by the friction between the ends of the specimen and the platens, with a resulting increase in the failure load.

The purpose of this investigation was to study the extent to which the confining effect of testing machine platens influenced the measured compressive strength, and to derive correction factors to take account of this effect. Calcium silicate bricks were used for the investigation because of the wide range of sizes available. Bricks with aspect ratios ranging from 0.36 to 3.03 were used. From these bricks stack bonded prisms with aspect ratios ranging from 1.71 to 7.76 were constructed and tested.

By comparing the results for different brick sizes, the influence of aspect ratio on compressive strength was studied, and an aspect ratio correction factor derived. The use of an aspect ratio correction factor allows a true estimate of the compressive strength to be obtained from a confined compression test, regardless of the dimensions of the specimen.

2. FACTORS INFLUENCING THE COMPRESSIVE STRENGTH OF BRITTLE MATERIALS

The factors influencing the compressive strength of brittle materials have been extensively investigated, particularly for materials such as concrete (1). The measured compressive strength of a given material is significantly influenced by the specimen size and shape and end conditions. In this investigation, confined and unconfined compression tests were carried out on sets of identical specimens to avoid the influence of effects other than aspect ratio.

2.1 Influence of Specimen Height

For specimens with the same cross section, the apparent compressive strength decreases as the height of the specimen increases. This apparent strengthening for short specimens is caused by the increased influence of the restraining effects of the testing machine platens. The friction between the platen and specimen can

be minimized by the use of variable stiffness platens and/or capping material, some form of lubricant between the platen and the specimens, or flexible steel brush platens. With the last method the compressive load is applied through a series of closely spaced slender steel filaments which individually possess a very low resistance to lateral movement while still being able to transmit their proportion of the axial load without buckling. This technique has been used successfully for the testing of both concrete (2,3) and masonry (4).

The influence of aspect ratio (height/least width) has important implications in the testing of both masonry units and prisms.

Most masonry codes which incorporate prism tests to determine masonry compressive strength recognise the influence of specimen aspect ratio, and incorporate a correction factor to convert the prism strength to a common base. Close examination of these correction factors reveals that they all appear to originate from a common source (5), (from a series of tests by Krefeld in 1938 (6)). The application of these correction factors to all types of masonry prisms is open to question due to the limited nature of that investigation. Some recent research has been carried out in this area for both clay and concrete masonry (7,8,9,10,11,12) but further clarification is needed.

The effects of specimen aspect ratio are even more significant in the compression testing of brick units. Bricks typically have very low aspect ratios (a standard 230 mm long x 76 mm high x 110 mm thick brick has an aspect ratio of 0.69), and consequently the apparent (confined) compressive strength is significantly greater than the unconfined strength. Thus the standard confined test, although perfectly adequate for comparison of strengths of the same sized units, is not a true indication of the actual compressive strength of the material.

2.2 Other Factors Influencing the Compressive Strength of Masonry Prisms

Apart from the factors already discussed, the compressive strength of masonry is influenced by the properties of its constituents (since it is a composite material). Since mortar and brick have different stiffnesses, the magnitude of the stresses induced in the two materials as the masonry is loaded in compression depends upon the relative proportions and stiffnesses of the brick and joint. As the proportion of brick to joint increases, the strength of the assemblage would be expected to increase due to the decreasing influence of the mortar joints.

The compressive strength of a masonry prism is influenced by the relative proportions of brick and joint, the number of joints in the prism, and end effects induced by the geometry of the prism and the presence of capping or packing.

3. EXPERIMENTAL PROGRAM

3.1 Bricks

A range of calcium silicate bricks (both solid and perforated) was tested. The bricks were selected to minimize the variability of strengths within each type. The types of bricks tested are summarized in Table 1.

In each case sufficient bricks for all projected brick and prism tests were selected at the start of the investigation and stored in the laboratory. Confined and unconfined compression tests were carried out for each brick type.

3.1.1 Confined Compressive Strength of Bricks. For each brick type the compressive strength was determined using the standard procedures set down by A.S. 1653-1974 (13), except that all bricks were tested dry. Bricks were loaded between 5 mm plywood sheets with the load applied at the rate of 250 KPa/s. Sets of 10 bricks were tested in each case. Calculations of compressive strength were performed on the basis of gross area for all units.

3.1.2 Unconfined Compressive Strength of Bricks. For each brick type the unconfined compressive strength was determined using flexible brush platens. Each brush platen consisted of circular filaments, 5.5 mm diameter, 120 mm long located at 6.3 mm centres. A typical testing arrangement is shown in Figure 1.

The testing procedure was similar to that used for the corresponding confined compression tests except that the plywood capping was omitted since the ends of the specimen were plane.

TABLE 1 SUMMARY OF BRICK TYPES

BRICK TYPE *	SIZE (mm) width x height x length	BRICK TESTS (Confined & Unconfined Compression)	PRISM TESTS	REMARKS
SS	210 x 76 x 230	✓	✓	
	145 x 76 x 230	✓	✓	
	110 x 76 x 230	✓	✓	
	90 x 76 x 230	✓	✓	
	76 x 90 x 230	✓	✓	
	76 x 110 x 230	✓	✓	
	76 x 145 x 230		✓	
	76 x 145 x 113	✓		Cut from 145 x 76 x 230
	76 x 212 x 113	✓		Cut from 210 x 76 x 230
	76 x 230 x 110	✓		
S3H	110 x 76 x 230	✓	✓	
	110 x 119 x 230	✓	✓	
S11H	110 x 76 x 230	✓	✓	
	110 x 119 x 230	✓	✓	
M3H	90 x 90 x 290	✓	✓	
	90 x 119 x 290	✓	✓	
M11H	90 x 162 x 290	✓	✓	
W5H	145 x 119 x 230	✓	✓	

* SS - standard solid S3H - standard 3-hole S11H - standard 11-hole
M3H - modular 3-hole M11H - modular 11-hole W5H - wide 5-hole

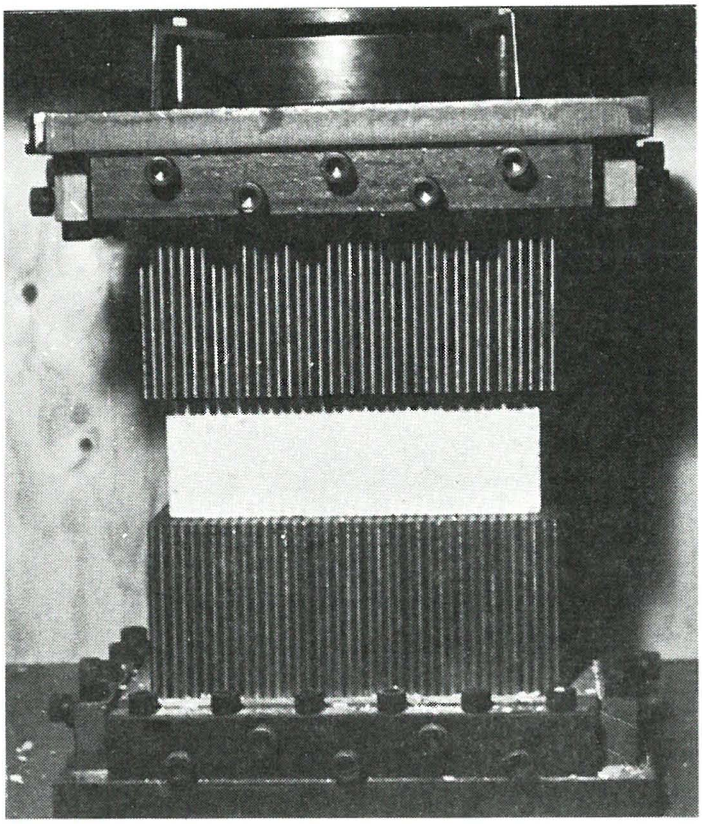

Figure 1

Unconfined Compression Test for Brick Units

3.2 Masonry Prisms

Stack bonded prisms were constructed using the mortar described in Section 3.3. The prisms were constructed and tested in accordance with the SAA Brickwork Code (14). To achieve aspect ratios which varied from 1.71 to 7.76, the number of bricks in the prisms varied from 2 to 6. A summary of the prisms constructed is included with the results in Table 3. Each set of test specimens was constructed as a low stack bonded wall and then separated into 5 prisms. Due to the plane surface of the bricks, the prisms were constructed without mortar caps. Immediately after construction the prisms were wrapped in an impermeable plastic sheet and cured for 7 days.

The prisms were tested in uniaxial compression at 7 days using solid steel platens. Compressive strengths in all cases were calculated on the basis of gross area.

3.3 Mortar

For all prism tests a mortar consisting of 1 part cement: 5 parts beach sand (by volume) plus a water thickener was used. The quantity of water thickener was in accordance with the manufacturer's instructions and sufficient water added to achieve the required workability. For the initial mix, sand and cement were batched by volume and weighed, with all subsequent mixes then being batched by weight for greater consistency.

Sufficient cement and sand were stockpiled at the start of the investigation and the same materials used for all mortar mixes.

4. RESULTS

4.1 Brick Compressive Strength

The confined and unconfined brick compressive strengths obtained from each set of tests are summarized in Table 2. More detailed results are contained in Reference (15). As can be seen from the results, a marked difference in the observed strength between the confined and unconfined tests was observed, particularly for low aspect ratios (due to platen restraint). The failure modes also differed. For the confined test, failure occurred by spalling on the sides of the specimen on the edges of the overlapping cones of influence extending from the ends of the brick in contact with the loading platens. In contrast, lateral expansion of the specimen was unconstrained in the unconfined test, and failure occurred by vertical splitting extending from platen to platen. As is typical for brittle materials, this vertical splitting is the result of lateral tensile failure induced by horizontal brick expansion. For solid units, the vertical splitting was uniformly distributed throughout the brick. For perforated units, the cracking often followed a preferred path due to the influence of the holes which presumably acted as stress concentrations in the induced biaxial tensile stress field.

As can be seen from Table 2, the variation in strengths within each sample of 10 bricks was quite small, with coefficients of variation less than 10% in almost all cases. In addition, the variability of results for each corresponding set of bricks tested in confined and unconfined compression was of the same order.

4.1.1 Influence of Aspect Ratio on Brick Strength. The results of the brick tests in Table 2 have been arranged in increasing order of aspect ratio. In each case,

TABLE 2 Brick Compressive Strength

BRICK TYPE	SIZE (mm) width x height x length	ASPECT RATIO	CONF. STRENGTH Mean (MPa)	Coeffic. of Variation %	UNCONF. STRENGTH Mean (MPa)	Coeffic. of Variation %	$K_c = \frac{\text{Unconfined}}{\text{Confined}}$	REMARKS
SS	210 x 76 x 230	0.36	24.79	10.0	12.37	5.1	0.50	Solid
SS	145 x 76 x 230	0.52	26.47	3.9	14.73	4.0	0.56	Solid
SS	110 x 76 x 230	0.69	36.49	6.5	21.72	2.9	0.60	Batch 1 Solid
SS	110 x 76 x 230	0.69	24.30	9.4	13.84	9.1	0.57	Batch 2 Solid
S3H	110 x 76 x 230	0.69	23.99	4.6	14.83	2.5	0.62	3-Hole
S11H	110 x 76 x 230	0.69	28.96	6.0	18.53	4.2	0.64	11-Hole
W5H	145 x 119 x 230	0.82	23.80	4.6	17.00	5.5	0.71	Wide 5-Hole
W5H	145 x 119 x 230	0.82	23.85	2.0	16.86	5.6	0.71	Wide 5-Hole
SS	90 x 76 x 230	0.84	19.96	10.6	14.97	5.9	0.75	Solid
M3H	90 x 90 x 290	1.00	29.64	4.9	18.46	7.7	0.62	3-Hole
S3H	110 x 119 x 230	1.08	23.08	6.7	18.12	5.9	0.79	3-Hole
S11H	110 x 119 x 230	1.08	21.52	5.6	16.31	3.5	0.76	11-Hole
SS	76 x 90 x 230	1.18	22.39	6.1	16.47	7.5	0.74	Solid
M3H	90 x 119 x 290	1.32	21.61	7.3	15.97	5.9	0.74	3-Hole
SS	76 x 110 x 230	1.45	34.38	5.0	24.27	5.8	0.71	Solid
M11H	90 x 162 x 290	1.80	14.61	4.6	9.60[1]	4.0	0.66	11-Hole
SS	76 x 145 x 113	1.91	21.29	4.6	16.58	5.1	0.78	Solid
SS	76 x 212 x 112	2.79	20.48	8.4[2]	17.40	12.9[2]	0.85	Solid
SS	76 x 230 x 110	3.03	16.37	14.5[2]	16.43	9.3[2]	1.00	Solid

FOOTNOTES: [1] To be accommodated within the brush platens, approximately 20 mm were sawn off each end of the brick. For the unconfined test, premature failure occurred by splitting between these cut faces and the first perforation in each case. The result has therefore been ignored in the analysis.

[2] Note the larger scatter in results for this brick type for both confined and unconfined tests.

* Aspect ratio = $\frac{\text{height}}{\text{least width}}$ of each brick unit.

the aspect ratio correction factor (K_C), defined as the ratio of the unconfined compressive strength to the confined compressive strength, has been calculated. The results reveal that the brick perforation pattern did not seem to significantly influence the correction factor K_C. For the purposes of this study, therefore, all bricks were considered as solid.

4.2 Prism Tests

The results of the prism tests for each prism and brick type are summarized in Table 3. Detailed results are contained in Reference (15).

As can be seen from Table 3, prisms with varying numbers of units (3 to 6) produced a range of aspect ratios (1.71 to 7.76). In all cases, failure occurred by vertical splitting. The variation in strengths within each sample of 5 prisms was quite small, with the coefficient of variation being less than 10% in most cases. This small variation justified the use of the small sample size of 5 prisms for each set of tests.

4.2.1 Influence of Prism Aspect Ratio on Prism Strength. When prisms are loaded in compression, some apparent strengthening will be observed due to the effects of platen restraint. All prism tests were performed with solid steel platens, so that the effects of platen restraint will influence the results. However, since prism aspect ratios are relatively high, (typically in the order of 3), this effect will not be as significant as for the brick units.

The prism results have been plotted separately for solid and perforated units for each brick type in Figures 2 and 3. The decrease in strength with increasing aspect ratio is readily apparent for prisms constructed from solid units, with the effect being less pronounced for prisms constructed from perforated units.

The SAA Brickwork Code (14), incorporates an aspect ratio correction factor for prisms in the evaluation of the brickwork prism compressive strength. These factors have been adjusted so that the aspect ratio correction factor is 1 for a prism whose aspect ratio is 3 (the aspect ratio for a 4-high prism constructed from standard bricks). The validity of this relationship can be checked using the results of this investigation by relation all prism results to the strength of similar prisms with an aspect ratio of 3. In the cases where prisms with aspect ratios of 3 were not tested for a particular brick type, the value was estimated by either interpolation or extrapolation. (See Figures 2 and 3.)

The non-dimensional prism strengths are compared to the A.S. 1640 relationship in Figure 4 for 3, 4, 5 and 6-high prisms, and Figure 5 for 4-high prisms only. It can be seen that the existing Code relationship gives a reasonable estimate of the correction factor for most aspect ratios, particularly when it is remembered that the experimental values cover a wide range of unit sizes and extrusion patterns.

4.3 The Influence of Aspect Ratio on the Compressive Strength of Bricks and Prisms

For purposes of design, the most logical method of allowing for the effects of platen restraint is to convert all confined compressive strengths to an equivalent unconfined value by the application of a suitable correction factor (which will be a function of the aspect ratio of the unit or the prism). Unless the prism mortar joints influence the degree of platen restraint, a common correction factor should apply for both brick units and prisms, with the prisms located at one end of the range (with high aspect ratios), and the bricks at the other (with low aspect ratios). In view of the high aspect ratio of prisms, and the relatively small difference between confined and unconfined strengths, it is reasonable to neglect

TABLE 3 Summary of Prism Tests

BRICK TYPE	SIZE (mm) width x height x length	NO. OF BRICKS IN PRISM	PRISM TYPE	SIZE (mm) width x ht. x length	PRISM ASPECT RATIO[1]	7 DAY PRISM STRENGTH Mean	Coeff. of Variation	95% Char. Strength
						MPa	%	MPa
SS	76 x 90 x 230	3	3B1	76x290x230	3.82	9.91	3.5	9.09
	76 x 90 x 230	4	4B1	76x390x230	5.13	11.51	14.8	7.53
SS	76 x 110 x 230	3	3B2	76x350x230	4.61	17.52	7.2	14.55
	76 x 110 x 230	4	4B2	76x470x230	6.18	15.84	6.5	13.41
	76 x 110 x 230	5	5B1	76x590x230	7.76	13.60	7.4	11.24
SS	76 x 145 x 230	3	3B3	76x455x230	5.99	15.47	2.9	14.42
SS	90 x 76 x 230	3	3B4	90x248x230	2.76	11.64	6.4	9.89
	90 x 76 x 230	4	4B3	90x340x230	3.78	9.31	3.1	8.63
SS	110 x 76 x 230	3	3B5	110x248x230	2.25	15.29	3.8	13.93
	110 x 76 x 230	4	4B4	110x334x230	3.04	12.78	11.5	9.34
	110 x 76 x 230	6	6B1	110x520x230	4.73	10.62	3.7	9.71
SS	145 x 76 x 230	3	3B6	145x248x230	1.71	11.83	6.4	10.08
	145 x 76 x 230	4	4B5	145x350x230	2.41	9.28	3.6	8.51
	145 x 76 x 230	5	5B3	145x440x230	3.03	8.87	11.2	6.55
SS	213 x 76 x 230	6	6B4	213x540x230	2.54	8.09	7.2	6.73
	110 x 76 x 230	6	6B5	230x520x230[2]	2.26	9.82	4.2	8.86
S3H	110 x 76 x 230	3	3B10	110x248x230	2.25	12.53	3.9	11.38
	110 x 76 x 230	4	4B7	110x334x230	3.04	10.61	4.8	9.42
	110 x 76 x 230	6	6B2	110x506x230	4.60	8.57	8.3	6.91
S3H	110 x 119 x 230	3	3B11	110x377x230	3.43	12.78	7.3	10.58
	110 x 119 x 230	4	4B8	110x506x230	4.60	11.49	4.0	10.41
S11H	110 x 76 x 230	3	3B13	110x248x230	2.25	7.95	5.9	6.85
	110 x 76 x 230	4	4B9	110x334x230	3.04	10.51	3.4	9.67
	110 x 76 x 230	6	6B3	110x506x230	4.60	7.55	9.4	5.89
S11H	110 x 119 x 230	3	3B14	110x377x230	3.43	11.48	4.8	10.19
	110 x 119 x 230	4	4B10	110x506x230	4.60	9.61	8.6	7.69
	110 x 119 x 230	5	5B4	110x635x230	5.77	9.66	5.9	8.33
M3H	90 x 90 x 290	3	3B7	90x290x290	3.22	11.27	3.9	10.24
	90 x 90 x 290	4	4B6	90x390x290	4.33	10.64	11.3	7.83
M3H	90 x 119 x 290	3	3B8	90x377x290	4.19	10.67	4.3	9.62
M11H	90 x 162 x 290	3	3B9	90x506x290	5.62	7.90	4.3	7.10
	90 x 162 x 290	4	4B11	90x678x290	7.53	7.77	3.0	7.23
W5H	145 x 119 x 230	3	3B15	145x377x230	2.60	12.92	3.63	11.82
	145 x 119 x 230[3]	3	3B16	145x377x230	2.60	9.59	2.83	8.96
	145 x 119 x 230[3]	4	4B12	145x506x230	3.49	9.09	4.6	8.13
	145 x 119 x 230[3]	6	6B6	145x954x230	6.58	10.09	2.2	9.58

NOTES:
1 Aspect ratio $= \frac{\text{Height}}{\text{least width}}$ of each prism

2 Built as a bonded pier.

3 Batch #2.

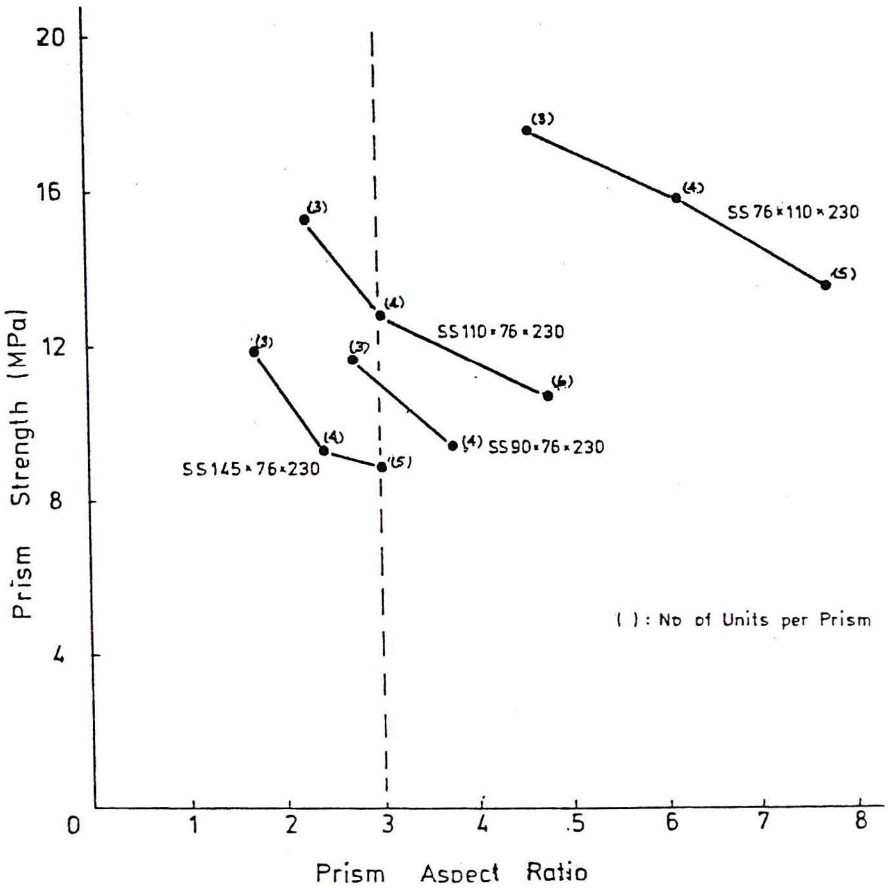

Fig 2 Variation of Prism Strength with Aspect Ratio - Solid Units

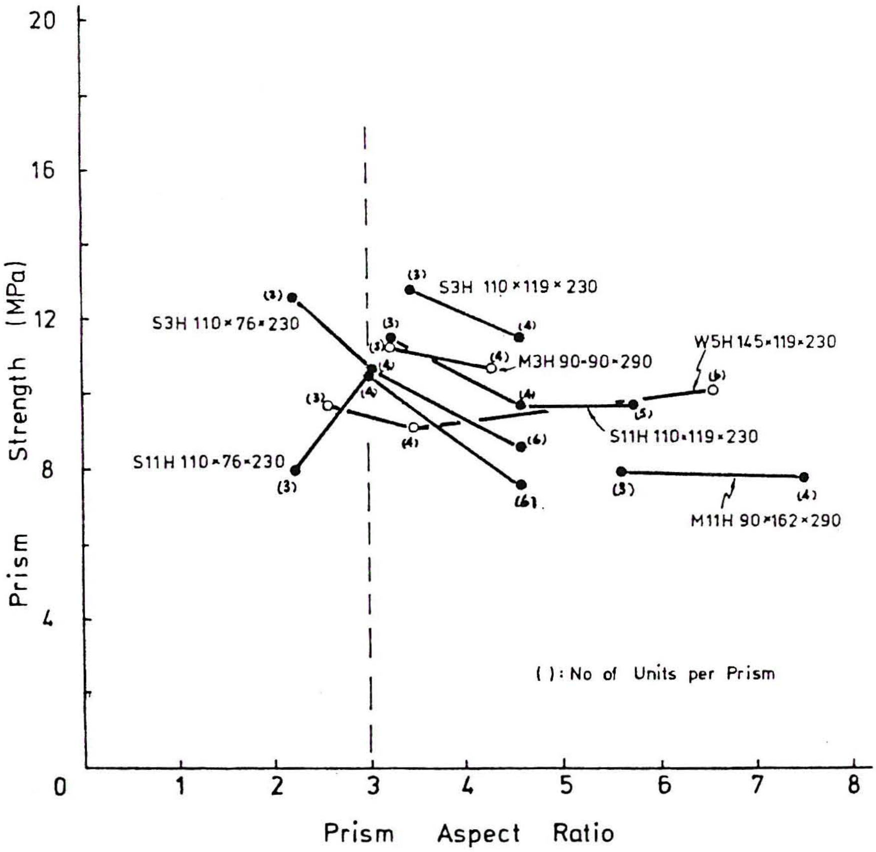

Fig 3 Variation of Prism Strength with Aspect Ratio - Perforated Units

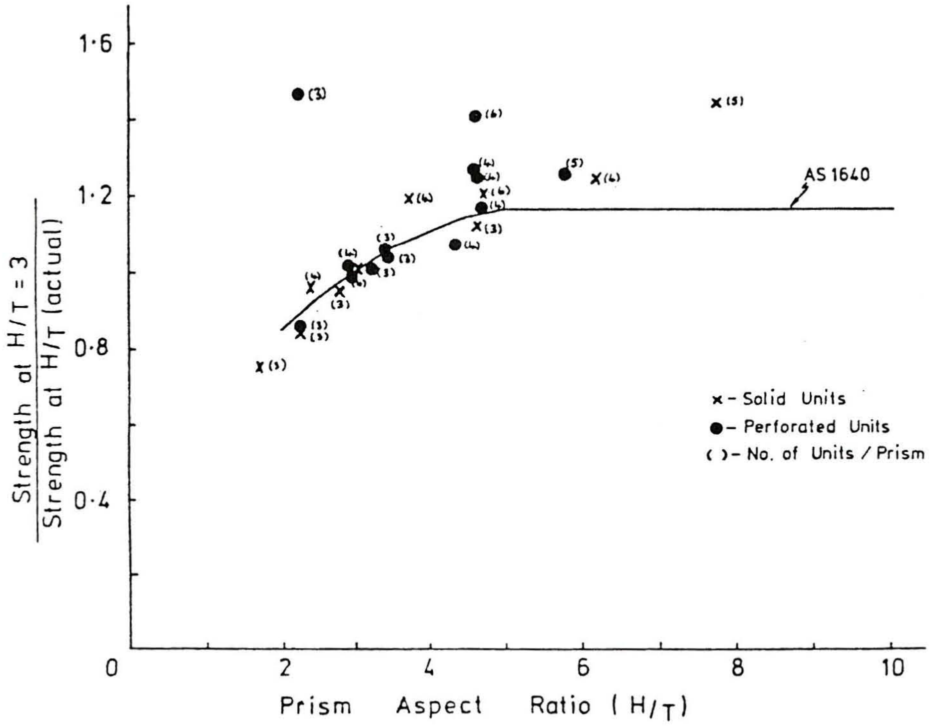

Fig 4 Variation of Prism Strength with Prism Aspect Ratio

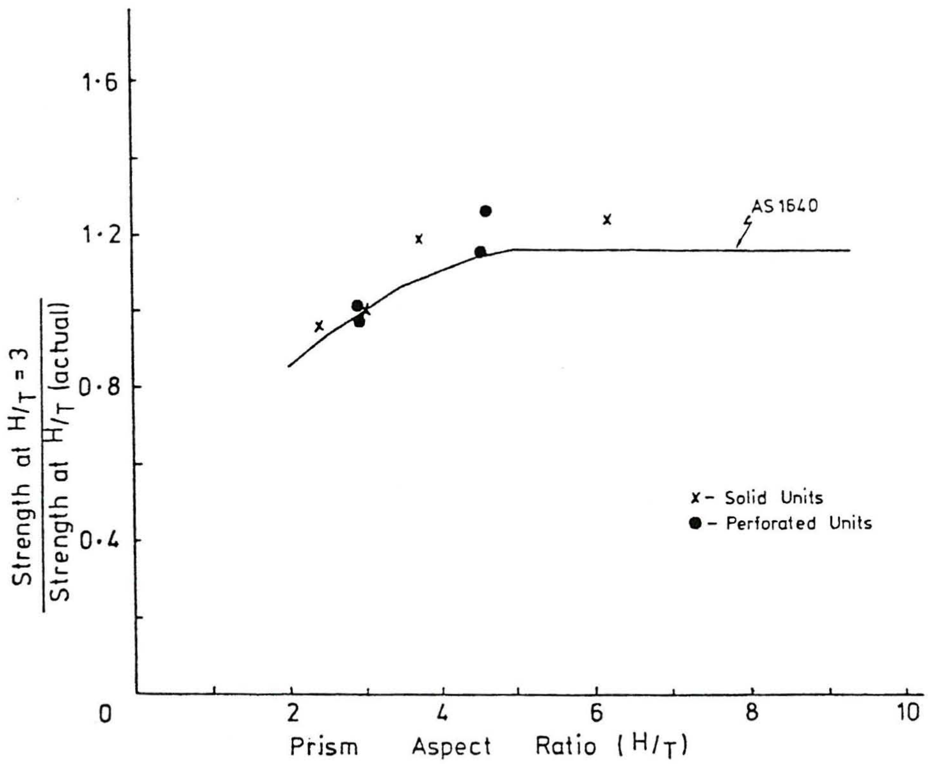

Fig 5 Variation of Prism Strength with Prism Aspect Ratio (4 high prisms only)

the influence of the joint. An analysis of the results confirmed this assumption (15).

4.3.1 Derivation of Aspect Ratio Correction Factors. The aspect ratio correction factors for brick units have been determined experimentally (Table 2). The aspect ratio correction factors for prisms (Table 6.2, A.S. 1640-1974) have been shown to agree with the experimental results (Figures 4 and 5). On the assumption that end effects become negligible at an aspect ratio of 5, the prism correction factors from Table 6.2, A.S. 1640 were adjusted to have a value of 1 for that aspect ratio. If these values are plotted with the correction factors for the brick units, a single relationship can be obtained for all aspect ratios for both bricks and prisms. This linearised relationship is shown in Figure 6 and summarized in Table 4.

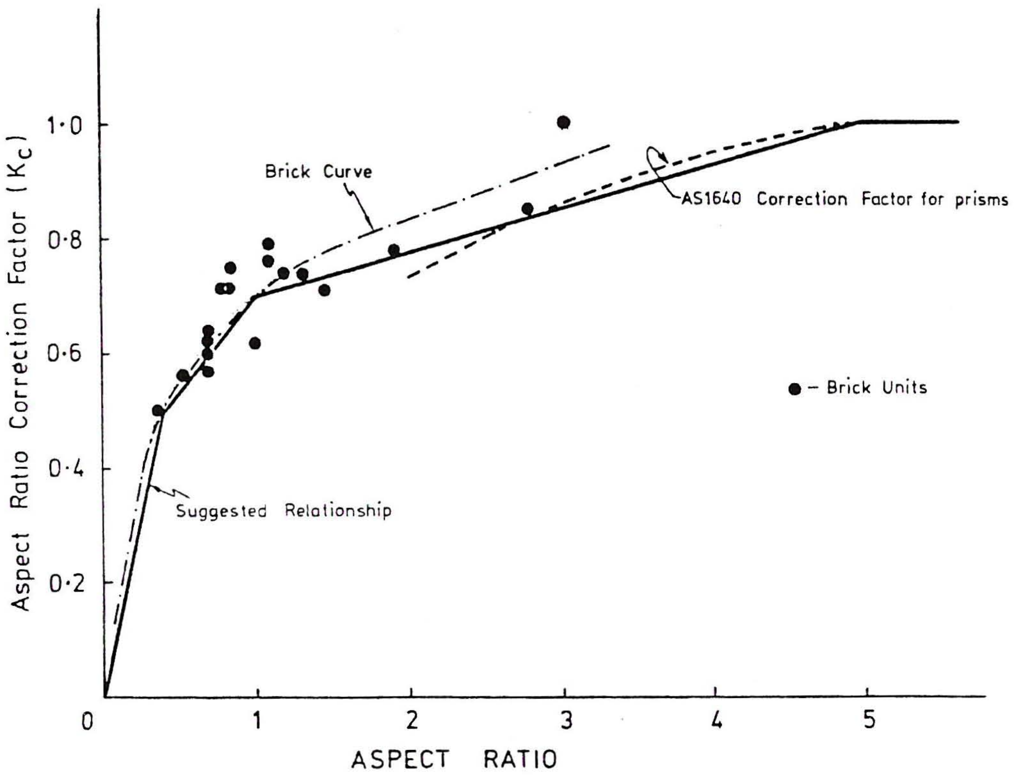

Fig 6 Aspect ratio correction factor for bricks and prisms

It can be seen from the Figure that the proposed relationship is compatible with both the brick and prism results and therefore can be applied to either.

TABLE 4 ASPECT RATIO CORRECTION FACTORS FOR COMPRESSIVE STRENGTH

Aspect Ratio	0	0.4	0.7	1.0	3.0	>5.0
Correction Factor (K_c)	0	0.50	0.60	0.70	0.85	1.00

5. CONCLUSION

This paper has described a series of uniaxial compression tests on calcium silicate bricks and prisms using a mortar consisting of 1 cement : 5 sand + water thickener. For each brick type, the confined and unconfined compressive strengths were determined. Unconfined strengths were obtained using flexible brush platens which minimized the influence of platen restraint on the specimen during loading. By comparing the unconfined and confined compressive strengths of bricks of the same type for a range of aspect ratios, an aspect ratio correction factor was derived. No appreciable difference was observed in this correction factor between solid and perforated units.

Prisms of varying height/width ratio were constructed to study the influence of prism aspect ratio on compressive strength. Differing numbers of units were used in the prisms to produce prism aspect ratios ranging from 1.71 to 7.76. The tests confirmed the validity of the existing relationship in A.S. 1640-1974 for prism aspect ratio correction factors.

A simple relationship for the aspect ratio correction factor applicable to both bricks and prisms has been derived. This can be used to convert the confined compressive strength to an equivalent unconfined value for use in design.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

(1) NEWMAN, K., LACHANCE, L. "The Testing of Brittle Materials Under Uniform Uniaxial Compressive Stress". *Proceedings, American Society Testing of Materials*, 64, pp 1044-1067, 1964.

(2) KUPFER, H., HILSDORF, H., RUSCH, H. "Behaviour of Concrete Under Biaxial Stresses". *Proceedings, American Concrete Institute*, 66, pp 656-666, August 1969.

(3) NELISSEN, L.J.M. "Biaxial Testing of Normal Concrete". Heron (Delft), 18, 1, 1972.

(4) PAGE, A.W. "The Biaxial Compressive Strength of Brick Masonry". *Proceedings, Institution of Civil Engineers*, Part 2, 71, pp 893-906, September 1981.

(5) FOSTER, P.K., BRIDGEMAN, D.D. "Prism Tests for the Design and Control of Brick Masonry". *Proceedings, Institution of Civil Engineers*, Part 2, 55, pp 292, March 1973.

(6) KREFELD, W.J. "Effect of Shape of Specimens on the Apparent Compressive Strength of Brick Masonry". *Proceedings, American Society Testing of Materials*, 38, pp 363-369, 1938.

(7) SHRIVE, N.G. "The Prism Test as a Measure of Masonry Strength". Proceedings of the 8th International Load Bearing Brickwork Symposium, *B.C.R.A.* London 1983.

(8) NOLAND, J.L., HARADA, K.T., FENG, C.C. "The Effect of Slenderness and End Conditions on the Strength of Clay Unit Prisms". *Proceedings, North American Masonry Conference*, Boulder, Colorado, Paper 14, August 1978.

(9) HEGEMIER, G.A., KRISHNAMOORTHY, G., NUNN, R.O., MOORTHY, T.Y. "Prism Tests for the Compressive Strength of Concrete Masonry". *Proceedings, North American Masonry Conference*, Boulder, Colarado, Paper 18, August 1978.

(10) MILLER, D., NOLAND, J., FENG, C.C. "Factors Influencing the Compressive Strength of Hollow Clay Unit Prisms". *Proceedings, 5th International Brick Masonry Conference*, Washington D.C., pp 122-131, October 1979.

(11) KIRTSCHIG, K., CORDES, R. "Zur Einführung Von Formfactoren Bei Der Druckfestigkeitsprüfung Von Kalksandsteinen". Forschungsvereinigung "Kalk-Sand" eV des Bundesverbandes Kalksandsteinindustrie eV Hannover, No. 49, June 1979.

(12) MAURENBRECHER, A.H.P. "Effect of Test Procedures on Compressive Strength of Masonry Prisms". *Proceedings, 2nd Canadian Masonry Symposium*, pp 119-132, 1980.

(13) Australian Standard Specification for Calcium Silicate Bricks (AS1653-1974), *Standards Association of Australia*, Sydney, Australia.

(14) SAA Brickwork Code, (AS1640-1974), *Standards Association of Australia*, Sydney, Australia.

(15) PAGE, A.W. "A Study of the Influence of Brick Size on the Compressive Strength of Calcium Silicate Masonry". *Engineering Bulletin CE13*, The University of Newcastle, N.S.W., Australia, July 1984.