RB 57/100

1/1/5

AMDL Report 297
November, 1963

LIGHTWEIGHT AGGREGATE ROTARY KILN TESTS

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES
Adelaide South Australia

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LIGHTWEIGHT AGGREGATE
Rotary Kiln Tests

by

D. C. Madigan

to

SOUTH AUSTRALIAN GOVERNMENT
DEPARTMENT OF MINES

Investigated by: Metallurgy Section
Officer in Charge: P. K. Hosking

L. Wallace Coffer. Director

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES
Adelaide South Australia

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1. INTRODUCTION

The last report on this project (AMDL Report 191) dealt with the laboratory testing of clays and shales and recommended four samples for pilot tests in a rotary kiln. These samples have now been tested and the results are given in the present report.

2. SUMMARY

Pilot scale rotary kiln tests have been carried out on Tapleys Hill shale, Hallets Cove and Sturtian slates and a recent clay from the Hundred of Port Adelaide.

Continuous bloating of Tapleys Hill Shale was not achieved owing to ring formation in the kiln, but the shale behaved in the pilot kiln in a manner similar to that of Reid's Victorian shale, which is used commercially for the manufacture of lightweight aggregate. It is therefore possible that Tapleys Hill shale could be successfully bloated if sufficiently accurate temperature control or other means could be found to prevent sticking.

The Hallets Cove slate had a narrower bloating range than the Tapleys Hill shale and caused great difficulty with balling and sticking in the kiln. It was the least satsifactory of the samples tested, and does not appear to have any promise as a commercial bloating material.

The bloating characteristics of the Sturtian slate lay between those of the Hallets Cove slate and the Tapleys Hill shale. It appeared to be definitely inferior to the Tapleys Hill shale for the purpose of making a lightweight aggregate. However, if a method were found for the satisfactory continuous bloating of Tapleys Hill shale, the same method might be successful with Sturtian slate, though the prospects of this seem remote.

The clay sample bloated without difficulty and continuous running of the kiln was possible. There is no reason to doubt that this material could be satisfactorily bloated in a commercial kiln. The lightweight aggregate produced was of low bulk density but not particularly great strength. Compression tests of concrete cylinders made with the aggregate indicated that concrete having a compressive strength of about 2000 psi and a bulk density of 95 lb per cubic foot could be expected for a cement content of 6 bags per cubic yard of concrete.

Recommendations are made for a programme of further work.

3. MATERIALS EXAMINED

Samples ranging from 2.5 to 5 tons of each of the following were received:

1. Grey laminated Tapleys Hill shale from Section 79, Hundred of Noarlunga.

2. Recent clay from Section 3070, Hundred of Port Adelaide.

3. Red Marinoan slates and siltstones from Hallets Cove, Section 569, Hundred of Noarlunga.

4. Grey Sturtian slate, Section 1041, Hundred of Adelaide.

The shale and slate samples were reduced to minus $^3/_4$ inch by being passed through a jaw crusher set at $^3/_4$ inch and rolls set at $^9/_{16}$ inch. Screen analyses of the final products are shown in Table 1. Sized fractions for feeding to the kiln were obtained by screening.

TABLE 1: SCREEN ANALYSES OF CRUSHED SAMPLES

Size	Weight, %		
	Tapleys Hill Shale	Hallets Cove Slate	Sturtian Slate
- $^3/_4$ + $^1/_2$ inch	19.0	22.3	21.3
- $^1/_2$ + $^3/_8$ "	31.0	31.3	29.3
- $^3/_8$ + $^1/_4$ "	12.9	15.2	13.0
- $^1/_4$ + $^3/_{16}$ "	9.1	8.1	7.5
- $^3/_{16}$ + 10-mesh	14.3	12.5	13.5
- 10-mesh (BSS)	13.7	10.6	15.4

The clay sample was crushed to minus 10-mesh and fed with water to a rotating drum to produce pellets. The pellets were dried at 100°C and screened to provide a suitable kiln feed.

4. EQUIPMENT

The rotary kiln used was 11 feet long, with a diameter inside the refractory lining of $8^1/_2$ inches. The kiln was rotated by a chain drive and 4 speeds were available as follow:

Gear	rpm
1	3.42
2	4.14
3	6.79
4	10.1

The slope of the kiln could be adjusted by means of a screw jack from 0 to 8 inches in 10 feet (throughout this report figures for the slope of the kiln are given in inches per 10 feet).

Material was fed to the upper end of the kiln by a vibratory feeder at a rate of 10-20 lb per hour. The residence time in the kiln was determined not only by the speed of rotation and the slope of the kiln, but also by the size and shape of the feed particles. By putting about 2 lb of sample into the upper end of the cold kiln and noting the time when the first and last particles were recovered from the lower end, the following average figures were obtained:

Slope in./10 ft	Gear No.	Average Residence Time min.
2.5	4	18
3.75	3	15
3.75	4	12
5.5	2	16
5.5	4	6

The average residence time in the hot kiln was probably longer than these figures indicate, owing to obstruction of passage through the kiln by adhesion of particles to the wall in the hottest zone of the kiln.

In the first experiments (with Tapleys Hill shale only) the kiln was heated with town gas and temperature was measured by a thermocouple contained in a steel probe and attached by leads to a recorder. The probe could be inserted into the kiln from either end. Neither of these arrangements was satisfactory. Fluctuation in the gas pressure made temperature control very difficult, and the gas burner was replaced by an oil burner. Industrial diesel fuel oil was fed to the burner from a gravity tank and air was supplied from a compressed air line through a float-type meter. Consumption of oil was about 1 gallon per hour. The thermocouple probe could not be made sufficiently robust for the purpose and was discarded in favour of an optical pyrometer. Pyrometer readings quoted in this report were made with the burner on and may be somewhat high. Readings taken as soon as possible after turning off the burner were 50-100°C lower than those taken with the burner on, and were certainly too low because the kiln, owing to its small size, cooled very rapidly. The hottest zone (the bloating zone) of the kiln began about 2 feet from the lower end of the kiln, and extended thence about 18 inches towards the upper (feed) end.

5. EXPERIMENTAL PROCEDURE AND RESULTS

5.1 Tapleys Hill Shale

Town gas was used for heating in the following series of tests (1-3) in which temperature was measured with the thermocouple probe.

1. The feed consisted of the crushed sample with the minus 10-mesh material screened out. A slope of 5.5 inches and gear No. 4 were used. When the temperature in the bloating zone reached 900°C the feed was begun, and the temperature was then slowly raised. Bloating began at about 1100°C, but feed soon began to stick to the kiln lining and then broke off to form clinkers which rapidly increased in size, the larger particles being cemented together by the fine material.

2. Six runs were made with the following operating conditions:

Feed	$-\frac{1}{2} + \frac{3}{8}$ in. material
Slope	3.5 and 4.5 inch
Speed	gears No. 3 and 4
Temperature in bloating zone:	1100 - 1200°C

Oxidising, neutral and reducing flames were used. In every case ring formation occurred in the bloating zone after bloating began. Ring formation appeared to take place in the following manner. The sample not being homogeneous, some particles softened more readily than others and adhered to the wall of the kiln. As the kiln rotated and the adhering particles approached the uppermost part of their circular path they dropped off, the gravitational exceeding the adhesive force. In so doing the particles fell through the flame and were thus raised to a higher temperature, which caused them to stick the more readily both to the kiln and to other feed particles. In this way the ring built up at each revolution and the passage of feed through the kiln was stopped. As the thickness of the ring increased the material projected into the flame and was raised to a temperature much higher than the upper limit of the bloating range. At this stage accumulation was very rapid and would soon have closed the kiln had not action been taken to prevent it by reducing the gas supply and breaking up the ring with a length of half inch iron piping. Reduction of the temperature after ring formation had begun caused the ring gradually to fall away and break up into balls or clinkers which were discharged; to achieve this, however, it was necessary to reduce the temperature below the bloating range.
Although the product contained well-bloated particles, conditions were not found under which a steady and continuous yield of successfully bloated material could be obtained.

3. The feed size was increased to minus $^3/_4$ plus $^1/_2$ inch in an attempt to avoid ring formation. The slope was varied from 4 to 7.5 inches with gear No. 4. The results were similar to those described in 2 above. When bloating began it was rapidly followed by ring formation and operating conditions were not found such that bloated material could be continuously obtained from the kiln.

The remaining tests of Tapleys Hill shale were made with the oil burner, and temperatures were measured with the pyrometer. The most successful runs were with feed sized to minus $^3/_4$ plus $^1/_2$ inch, with slope 5.5 inches, gear No. 4, and temperature in the bloating zone of 1240°C. The feed rate was 15-20 lb per hour. Although ringing was not altogether avoided, it was found possible to run the kiln for up to 30 minutes without ringing. About half the product was well-bloated material; the remainder was partially bloated or unbloated material, mostly obtained when the temperature had to be reduced to break up ring formations. Attempts to increase the proportion of well-bloated material by adjustment of the flame to give a lower temperature and more reducing atmosphere, or a higher temperature and more oxidising atmosphere, were unsuccessful, and only resulted in ring formation with the formation of balls or clinkers in the hot zone behind the ring.

The bulk density of the feed was 70 lb per cubic foot. The bulk density of the product was 39 lb per cubic foot. A sample of the well-bloated material, separated from the product by hand picking, had a bulk density of 24 lb per cubic foot and a water absorption of 7.4 per cent after being soaked in water for 48 hours.

This shale tended to break into flakes on crushing, and the flatter pieces showed very imperfect bloating. To overcome inhomogeneities in the feed, the shale was ground to minus 16-mesh in rolls and pelletised in a rotary drum. The pellets, which formed easily, were dried at 80-100°C and screened to give a closely sized feed of minus $^5/_8$ plus $^3/_8$ inch. Results of kiln tests with the pelletised feed were similar to those obtained with the original crushed material. Some well-bloated material was obtained, but ring formation gradually took place and the ring built up until it had to be dislodged (about every 20 minutes). To break up the ring it was necessary to reduce the temperature by cutting back the oil supply, and the product obtained from the kiln was heterogeneous, containing well-bloated, semi-bloated and unbloated material.

5.2 Clay

In the first series of tests pellets screened to minus $^3/_4$ plus $^1/_2$ inch were used for the feed. The slope of the kiln was 4.5 inches and gear No. 4 was used. The temperature in the bloating zone was 1120°C. The feed rate was 15 lb per hour. A well-bloated well-rounded product was obtained. There was no significant adhesion or balling of the particles and no tendency to ring formation in the kiln, so that continuous bloating was achieved. Weak adhesion of the particles did take place in the bloating zone, but the loose clumps so formed readily broke up and fell apart as they moved out of this zone. The bulk density of the feed was 58 lb per cubic foot, of the product 27 lb per cubic foot. The plus 3/4 inch fraction of the product had a bulk density of 16 lb per cubic foot, and the minus 3/4 inch fraction a bulk density of 36 lb per cubic foot.

A run was made with feed sized to minus 5/8 plus 1/2 inch under the same conditions as before. A well-bloated product was obtained, having a bulk density of 30 lb per cubic foot, and a water absorption of 23 per cent after immersion for 24 hours.

The products of the above runs were mixed to give a coarse lightweight aggregate having a bulk density of 27 lb per cubic foot and the following screen analysis:

inch	%
+ 1	3.4
- 1 + 3/4	28.2
- 3/4 + 5/8	33.6
- 5/8 + 1/2	23.1
- 1/2	11.7

This material was reserved for testing in concrete.

Three runs were made with fine material prepared by drying, crushing and screening the clay sample to give feed sized to:

	Mesh
(a)	- 4 + 16
(b)	- 4 + 30
(c)	- 4 + 100

For these runs, a slope of 5.5 inches, with gear No. 4 and a temperature of 1120°C were used. There was no sticking or balling, and the feed flowed evenly and freely through the kiln. The larger particles in the product were evidently bloated. The bulk densities of feed and product were:

Feed Size Mesh	Bulk Density, lb/cu ft Feed	Bulk Density, lb/cu ft Product
- 4 + 16	59.4	49.4
- 4 + 30	61.1	58.0 (combined product)
- 4 + 100	62.1	

The 3 products were combined and screened at 16-mesh. Sixty pounds of the minus 6-mesh fraction were mixed with 73 lb of the plus 16-mesh fraction to give a fine aggregate having the following screen analysis:

Mesh, (Tyler)	%
- 3/8-inch	100
- 4-mesh	96.7
- 16 "	45.1
- 50 "	4.4
- 100 "	0.6

This fine aggregate conformed to the gradation recommended by the ASTM and was retained for use with the coarse aggregate in making concrete cylinders for testing. It had a bulk density of 59 lb per cubic foot.

5.3 Hallets Cove Slate

This material, when introduced to the hot kiln, showed a marked tendency to decrepitation, the particles bursting into small flakes. This was overcome by drying the feed in an air oven at 100°C. The dry material, sized to minus 3/4 plus 1/2 inch, was fed to the oil-fired kiln. Gear No. 4 was used, with a kiln slope of 5.5 inches and temperature in the bloating zone of 1240-1260°C. Ringing and balling caused considerable difficulty, and only a small proportion (less than 10%) of well-bloated material was obtained. The bulk density of the feed was 83 lb per cubic foot, of the product 52 lb per cubic foot, and of selected well-bloated pieces 36 lb per cubic foot. The bloated pieces were well polished, and in fact had almost reached the stage of melting. The water absorption (24 hours) of well-bloated material was 5.7 per cent.

The running conditions given above were the least unsuccessful. Other conditions of slope, speed and temperature were tried, but in no case was bloating without ring formation achieved. The proportion of well-bloated pieces in the products was small, and even these pieces were obtained only by breaking up and dislodging the ring that formed.

5.4 Sturtian Slate

Five kiln runs were made with this material, using the oil burner. The feed was sized to minus 3/4 plus 1/2 inch and had a bulk density of 81 lb per cubic foot. It was necessary to dry the feed at 100°C before introduction into the kiln to prevent decrepitation. The slope of the kiln was varied from 1 to 5.5 inches. Gears No. 3 and 4 were used with temperatures ranging from 1100 to 1340°C in the bloating zone (measured with the optical pyrometer).

Towards the upper end of the temperature range (1250-1300°C) a fairly uniform product, in which most of the pieces showed some degree of bloating, was obtained, but continuous running without ringing followed by some balling was not achieved. The bulk density of this product was 48 lb per cubic foot. The necessity of reducing the temperature from time to time in order to break up ring formations was the chief reason for the presence of unbloated material in the product. When this unbloated material, which amounted to about 25 per cent, was removed, a product of bulk density 42 lb per cubic foot remained, having a water absorption after 48 hours' immersion in water of 4.3 per cent and consisting mostly of well polished pieces.

The runs with Sturtian slate may be summarised by saying that the kiln could be operated so that the greater part of the feed was bloated, but the degree of expansion was not very great. The kiln was worked near the maximum temperature attainable with the oil burner used, but a higher temperature could not have been used since sticking and ringing would have made running impossible.

5.5 Summary of Kiln Tests

A summary of the kiln tests is given in Table 2.

TABLE 2: SUMMARY OF KILN TESTS

	Tapleys Hill Shale	Clay	Hallets Cove Slate	Sturtian Slate
Bloating temp, °C	1240	1160	1250	1280
Bulk density, lb/cu ft				
Feed (-¾ + ½ in.)	70	58	83	81
Run of kiln product	39	27	52	48
Selected product	24	-	36	42
Moisture absorption of product, %	7.4	23.0	5.7	4.3

5.6 Testing of Lightweight Concrete Prepared from Expanded Clay

Samples of coarse and fine lightweight aggregate, prepared from the clay sample as described in 5.2 above, were supplied to the S. A. Institute of Technology for the preparation of standard cylinders to be tested in compression. The composition of the test cylinders is shown in Table 3.

TABLE 3: COMPOSITION OF TEST CYLINDERS

Batch	Cement (by volume)	Fine Aggregate (by volume)	Coarse Aggregate (by volume)	Final water/ cement ratio (by weight)
L1	1	2	4	0.65
L2	1	1.5	3	0.52
L3	1	2	3	0.60
L4	1	2.5	4	0.73

The cylinders were cured in water and tested 28 days after casting. Average results are shown in Table 4. Details of these tests are given in the Appendix.

TABLE 4: TESTS ON CONCRETE CYLINDERS

Batch	Average Bulk Density lb/cu ft	Average Compressive Strength lb/sq in.
L1	90.8	1160
L2	94.6	2200
L3	97.1	2350
L4	95.0	1960

6. DISCUSSION

6.1 Tapleys Hill Shale

Although this is undoubtedly a bloating shale, continuous bloating could not be achieved in the laboratory kiln owing to ring formation and agglomeration (balling) of the feed in the bloating zone. It seemed possible that these difficulties might be caused by non-uniformity in the feed particles. Variation in size, shape and composition might cause some pieces to soften and melt at a lower temperature than others; such pieces would stick to the kiln wall and attach other pieces to themselves and so build up an agglomerate. To exclude such a possibility the shale was ground and pelletised to produce a uniform feed. No advantage however was gained by this means, since the pelletised feed was just as prone to ringing and balling as the original feed, though some excellently bloated and well rounded pellets were obtained.

It is clear that the difficulty found in bloating this shale was due mainly to failure to secure sufficiently accurate temperature control and uniformity of temperature in the bloating zone. Sticking of the feed was caused by overbloating, the result of too high a temperature. But as soon as the temperature was reduced to a level low enough to ensure that no sticking took place, semi-bloated or unbloated material appeared in the product; if the temperature was then raised to ensure proper bloating, ringing soon took place. The bloating range of this sample appears to be somewhat too narrow for bloating to be effectively controlled in a small laboratory kiln, though more accurate temperature control may well be possible in a commercial kiln of diameter 8-12 ft and length 100-120 ft.

The experiment with pelletised feed shows that the difficulties encountered cannot be attributed to non-uniformity in the composition of the feed. The question then arises, why, at a temperature below the sticking point, was an uneven product containing bloated and unbloated material obtained? The explanation may be that each particle did not traverse the same path through the kiln, owing to physical causes such as irregularities in the kiln wall and differences in the shapes and sizes of the particles. Some particles would then be heated to a higher temperature or have a longer residence time in the bloating zone than others. The range of such fluctuation would depend on the design of the kiln, but whatever the extent of this range, it would have to be accommodated within the fixed bloating range of the material for successful bloating to be achieved.

For comparison, a kiln run was made with Reid's Silurian shale from Victoria, which is used in the commercial production of lightweight aggregate. This shale behaved in very much the same way as Tapleys Hill shale. Bloating was uneven, with a tendency to ring formation, and satisfactory continuous bloating was not achieved. The bulk density of the product was 48 lb per cubic foot, that of the feed 78 lb per cubic foot. It seems very probable that in a kiln in which successful continuous bloating of Reid's shale can be achieved, Tapleys Hill Shale could also be satisfactorily bloated.

The bloating ranges established for the preliminary test samples (see AMDL Report 191) were, in °C:

Sample	Atmosphere	
	Reducing	Oxidising
Tapleys Hill shale	50	100
Wingfield clay	115	185
Hallets Cove slate	25	75
Sturtian slate	50	75
Reids shale	75	100

Tapleys Hill shale differs from Reid's in bloating range only in having a somewhat lower range in a reducing atmosphere.

6.2 Clay

This sample has a much wider bloating range than the shale, and no difficulty with ringing and agglomeration in the kiln was found in treating coarse or fine material. The attempt to obtain lightweight fine aggregate by bloating minus 4-mesh material was not very successful because the degree of bloating was slight. In fact, only the larger particles showed appreciable bloating, presumably because the bloating gases escaped from the smaller particles before the pyroplastic condition was reached. It is possible that a more satisfactory lightweight fine aggregate could be made by grinding the lightweight coarse aggregate.

There should be no difficulty in bloating this clay in a commercial kiln, and it would probably not be necessary to pelletise the feed. Air-drying to a suitable moisture content followed by crushing and screening should produce a satisfactory feed. Any material too fine for bloating could be pelletised, or else allowed to consolidate in heaps exposed to the weather until once again ready for crushing, so that there would be no waste. Hamlin and Templin[1] state that raw materials that show satisfactory processing characteristics in a 14-ft test kiln can be readily handled in commercial kilns.

Lightweight aggregate prepared from this clay sample was tested for its suitability for structural lightweight concrete. Standard concrete test cylinders were cast and their 28-day compressive strength was determined. These tests were made in the Civil Engineering Testing Laboratory of the S.A. Institute of Technology, and Mr M. G. Symons, Lecturer in Civil Engineering, made the following observations upon them:

> "The slump test was not a satisfactory criterion in this work. Each mix was prepared dry and water added until an average workability was obtained. The first batch was mixed in a standard concrete mixer, but due to considerable segregation, attributed to the lightness of the coarse aggregate, the subsequent batches were mixed by hand to a satisfactory consistency. The increase in water-cement ratio with increase in proportion of aggregates in the mix is due to the increased surface area to be "wetted".
>
> It appears from these results that the ultimate strength of the lightweight concrete can only be increased by increasing the compressive strength of the coarse aggregate. Also a graded aggregate could produce a concrete with an improved consistency."

In order to assess the results of these tests it is necessary to have some information on the relationship between strength and cement content, and this was found in the American Concrete Institute's Standard ACI 613A-59 (Recommended Practice for Selecting Proportions for Structural Lightweight Concrete). The authors of this standard state that, because of the wide range of cement contents required to produce concrete of the same compressive strength with various lightweight aggregates, they were reluctant to provide any indication of the compressive strength to be associated with a certain cement factor. However, they provide the following approximate relationship:

Compressive Strength psi	Cement Content bags/cu yd (of concrete)
2000	4 to 7
3000	5 to 8
4000	6 to 9
5000	7 to 10

(a bag of cement is taken to be 1 cu ft or 94 lb)

1. Hamlin, H.P., and Templin, G., Evaluating raw materials for rotary-kiln production of lightweight aggregate, U.S. Bur. Min. Information Circular 8122, (1962).

The calculated cement contents of the test cylinders are shown in Table 5.

TABLE 5: CALCULATED CEMENT CONTENT OF TEST CYLINDERS

Batch	Average Compressive Strength psi	Cement Content bags/cu yd of concrete
L1	1160	6.4
L2	2200	8.1
L3	2350	7.4
L4	1960	6.1

A comparison of these results with the figures given by the ACI shows that the cylinders are somewhat weaker than would be expected from their cement content. This is particularly the case with Batch L1, but it should be remarked that this batch was the first using lightweight aggregate ever to be cast at the Institute, and the cylinders showed marked segregation of coarse aggregate, with voids which reduced the effective load-bearing cross section. The inhomogeneity of the mixture is reflected in the wide scatter of results for this batch, 530 to 1980 lb per square inch. Too much weight should therefore not be given to the results for Batch L1. The better results for the subsequent batches perhaps reflect, at least in part, an improved mixing technique. It is possible that, with better graded aggregate, mixtures that would give strengths within the ACI ranges quoted above could be proportioned, but it is clear that the cement content would always be at the top rather than the bottom of the range. Examination of the broken cylinders showed that it was the aggregate, not the mortar or the bonding, that had failed: the particles of coarse aggregate had sheared in every case.

Ordinary heavy-aggregate concrete has a bulk density of 140-160 lb per cubic foot, whereas lightweight concrete made from expanded clay or shale aggregate has a bulk density varying from 70 to 110 lb per cubic foot, depending upon the density of the aggregate and the proportions of the mixture. The test specimens are therefore quite satisfactory in this respect. It is of interest to note that, according to a bulletin of concrete facts published by the Expanded Shale, Clay and Slate Institute (U. S.), the floor of the Willard bridge in Kansas was paved with expanded shale concrete of bulk density 105 lb per cubic foot, and that this resulted in a saving of 4 lb of steel for every cubic foot of floor.

The following rough classification of lightweight concretes, reported by Cole and Zetterstrom[1], may be of interest as a guide to their use:

Class	Strength psi	Use
A (Structural)	3000 to 5000	Structural members, beams etc.
B (Lightweight)	1000 to 3000	Load-bearing walls, slabs, such as found in majority of members in house construction.
C (Insulation-lightweight)	200 to 1000	Non-load-bearing sub-floors, insulation sections of walls and roofs.

With regard to the physical properties of the concrete other than its compressive strength and bulk density, the moduli of elasticity in compression and flexure, the modulus of rupture, and the absorption by weight all appear to be linear functions of the compressive strength, and approximate equations for determining these quantities from the compressive strength are given in Technical Record BS45/25/215 of the Commonwealth Experimental Building Station.

6.3 Hallets Cove Slate

This material was the least satisfactory of the four samples examined. It gave the most difficulty with balling in the kiln and the smallest amount of well bloated material was obtained. The bloating range is evidently too small for bloating to be controlled in the experimental kiln. Well-bloated pieces had a polished and at times almost glazed surface. They were hard and of low water absorption, and could be expected to make a strong concrete. Nevertheless owing to its narrow bloating range this slate does not look promising as a commercial bloating material.

6.4 Sturtian Slate

In its bloating properties this slate lies between Tapleys Hill shale and Hallets Cove slate. The well-bloated pieces were similar to those from the Hallets Cove slate, harder and more polished than those from the Tapleys Hill shale. Commercial bloating of Sturtian slate might however be difficult owing to its restricted bloating range.

1. W.A. Cole and J.D. Zetterstrom, U.S. Bur. Min. R.I. 5065 (1954).

7. RECOMMENDATIONS

The successful bloating in the rotary kiln of the clay sample from Section 3070, Hundred of Port Adelaide, suggests that clay from Section 1012, Hundred of Port Adelaide, and Section 104, Hundred of Yatala, should also be tested in the rotary kiln, since laboratory tests on samples of these clays showed a high bloating index (see AMDL Report 191). A more complete assessment of the clay from Section 3070, Hundred of Port Adelaide, should also be made. Since there is some indication that it may be possible to bloat Tapleys Hill shale in a commercial kiln, further work on this shale may be desirable. The Sturtian and Hallets Cove slates have not shown sufficient promise to warrant further work upon them. The following programme of future work is therefore recommended:

1. Bloating of the clay from Section 3070, Hundred of Port Adelaide, without preliminary pelletising, to check the feasibility of direct bloating of crushed material. Bloating of the crushed feed without pelletising should provide a graded aggregate for testing, capable of producing a concrete of improved consistency. Fine aggregate for incorporation in the concrete to be obtained by grinding the coarse aggregate.

2. Rotary kiln tests on clays from -

   a. Sec. 1012, Hd. Port Adelaide
   b. Sec. 104, Hd. Yatala

3. Preparation of sufficient well-bloated material from Tapleys Hill shale to make standard lightweight concrete cylinders for compression testing.

APPENDIX A

COMPRESSION TESTS ON CONCRETE CYLINDERS

Details of tests carried out on concrete cylinders and summarized in Table 4 are set out in the following table.

TABLE A-1: COMPRESSION TESTS

Cylinder Identification		Dimensions			Weight[a]
Batch	Number	Height in.	Diameter in.	Sectional Area sq in.	lb
L1	1	12.2	5.96	27.9	17.3
	2	12.2	5.97	28.0	18.4
	3	12.1	5.96	27.9	17.2
	4	12.2	5.96	27.9	17.9
	5	12.1	5.97	28.0	16.6
	6	12.2	5.96	27.9	18.3
L2	1	12.2	6.00	28.3	18.2
	2	12.0	5.99	28.2	18.8
	3	12.1	6.01	28.4	18.8
L3	1	12.2	5.97	28.0	18.1
	2	12.1	5.97	28.0	19.3
	3	12.0	5.99	28.2	19.3
L4	1	12.2	5.97	28.0	18.2
	2	12.2	5.97	28.0	18.6
	3	12.2	5.98	28.1	18.6

(a) Excluding caps.

ON CONCRETE CYLINDERS

Volume[b]	Density	Average Density	Compressive Strength	Average Compressive Strength
cu ft	lb/cu ft	lb/cu ft	lb/sq in.	lb/sq in.
0.193	89.2		870	
0.194	94.8		1630	
0.194	88.7		730	
0.194	92.3		1210	
0.194	85.6		530	
0.194	94.3	90.8	1980	1160
0.197	92.4		1530	
0.196	95.9		2740	
0.197	95.4	94.6	2320	2200
0.194	93.3		1690	
0.194	99.5		2750	
0.196	98.5	97.1	2620	2350
0.194	93.8		1930	
0.194	95.9		2100	
0.195	95.4	95.0	1840	1960

(b) Excluding caps.