CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

Mines Branch Investigation Report IR 58-88

FURTHER LIGHTWEIGHT AGGREGATE TESTS ON FLY ASH

SUBMITTED BY

THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

by

H.S.Wilson

Industrial Minerals Division

Note: This report relates essentially to the samples as received. It shall not, nor any correspondence connected therewith, be used in part or in full as publicity or advertising matter.

May 16,1958.

FURTHER LIGHTWEIGHT AGGREGATE TESTS ON FLY ASH

SUBMITTED BY

THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

Introduction

Further work has been done on testing fly ash as a raw material for the production of sintered lightweight concrete aggregate. The tests were undertaken to expand on some of the previous work discussed in I.M. Report 492, November 29, 1957. The purposes of these tests are as follows:

(a) to produce a sintered aggregate from a "blended" mix, which is composed of pellets ranging from about 3/4 inch to pin head size.

(b) to produce a heat hardened aggregate from more closely sized pellets.

(c) to find the effect of finer grinding of the fuel used in sintering, than had been used in previous tests.

(d) to eliminate the coating of pellets with fuel as was done in the previous tests.

(e) to investigate the possibility of pelletizing fly ash without the use of a binder and of reducing the concentration of the binder used.

Approximately 500 pounds of fly ash was submitted. It was reported to have been mechanically precipitated at the steam-powered generating plant in Toronto, Ontario.

Procedure

1. Pelletizing

The fuel used in these tests was minus 100 mesh coke. It was mixed with the fly ash in a cement mixer prior to pelletizing. In the first four tests, pelletizing was done in the cement mixer. For the remainder of the tests, it was done in the disc pelletizer. In the tests where a binder was used, it was waste sulphite liquor, containing 8 per cent solid material by weight.

Green strengths of the pellets were determined by dropping individual pellets repeatedly, from both six and twelve inch heights onto a steel plate, until they broke. The average value for 10 pellets in each determination is recorded in the table as the "knock number".

2. Sintering

Sintering tests were carried out in a circular pot, nine inches in diameter at the bottom, ten inches in diameter at the top, and six inches deep. A hearth layer of previously sintered material was placed on the grate to a depth of about one inch, before the charge was placed in the pot. The following sintering conditions were recorded; the time and draft during ignition, the time and draft during the sintering period, and the temperature of the exhaust gases immediately below the grate.

Tests on Aggregates

From the first 13 tests, only the sintered products were of interest, hence only those portions which had formed into a clinker were tested.From the latter eight tests both the sintered and heat hardened products were subjected to physical tests, if there was sufficient recovery.

The products to be tested were crushed and screened to 75 per cent minus 3/8 inch plus 4 mesh, and 25 per cent minus 4 plus 8 mesh. The loose dry unit weight was measured, using the shovelling procedure outlined in American Society for Testing Materials, designation C29. The crushing strength measured was the pressure in pounds per square inch required to give one and two inch compaction to the aggregate placed in a three inch diameter cylinder to a depth of five inches.

SINTERING TESTS

	Pellet Size	Fuel Content (%)	Moisture (%)	Pelletizer	Binder (%)solids)	Knock No 6"	Knock No 12"	Ignition Time	Ignition Draft	Sinter Time	Sinter Draft	Max. Temp.	Recovery (by weight)	Unit Weight (lb./cu.ft.)	Crushing Strength 1"	Crushing Strength 2"	REMARKS
1	-3/8"	5	21.2	cement mixer	1.7	7.5	4.4	1½	2"	10	12"	225°	Sint. 57%	36.8	250	800	
2	-3/8"	5	20.8	cement mixer	1.7	7.1	4.2	1½	2"	6	8	315°	Sint. 56	36.7	220	670	
3	-1"	5	22.4	cement mixer	none	7.8	3.9	2½	3"	12	12"	260	Sint. 61	37.5	240	920	
4	-1½	5	20.2	cement mixer	1.6	7.2	5.2	2½	3"	8	12"	300	Sint. 47	39.0	310	1200	
5	-2"	5	19.8	disc	none	6.8	3.4	2½	3"	15	12"	235	Sint. 50	40.5	310	1060	
6	-2"	5	19.8	disc	none	6.8	3.4	2½	3"	2	8"	120	Sint. 15	-	-	-	most of charge lost th rough grate
7	-2"	5	22.7	disc	none	6.2	3.5	2	5"	11	15"	245	Sint. 52	41.1	220	1060	
8	-2"	5	22.7	disc	none	6.2	3.5	2	5"	13	10"	145	Sint. 35	39.4	240	790	some of charge lost th rough grate
9	-2"	5	22.7	disc	none	6.2	3.5	2	4"	-	15"	-	Sint. 0	-	-	-	pellets disinte grated fire extinguished
10	-2"	7.5	22.5	disc	none	6.7	4.0	2-1/4	3"	-	10"	-	Sint. 0	-	-	-	pellets disintegrated fire extinguished
11	-2"	7.5	19.7	disc	1.6	9.8	5.1	1½	2"	8	12"	415	Sint. 63	40.4	340	1220	
12	-2"	7.5	19.7	disc	1.6	9.3	5.1	1½	2"	5	15"	415	Sint. 65	40.3	370	1200	
13	-2"+4	7.5	18.6	disc	1.5	6.8	4.9	1-1/4	2"	4	8"	660	Sint. 43 H.H. 42	45.0 -	450 -	1550 -	H.H.material used as hearth layer in follow-ing tests.

SINTERING TESTS (cont'd)

	Pellet Size	Fuel Content (%)	Moisture (%)	Pelletizer	Binder (% solids)	Knock No 6"	Knock No 12"	Ignition Time	Ignition Draft	Sinter Time	Sinter Draft	Max. Temp.	Recovery (by weight)	Unit Weight (lb/cu.ft)	Crushing Strength 1"	Crushing Strength 2"	REMARKS
14	-½"+4	7.5	18.6	disc	1.5	6.8	4.9	1	2"	4	10"	775	Sint.33% H.E. 49%	43.1 47.2	470 420	1700 2400	
15	-½"+4	7.5	18.5	disc	1.5	6.8	4.9	1-1/4	2"	4	15"	780	Sint.12 H.E. 66	- 67.5	- 490	- 2780	Fan overheated shut off before sinter complete
16	-⅜"+4	5	17.1	disc	1.4	8.1	9.1	1-1/2	2"	5	8"	440	Sint.31% H.E. 55	21.9 22.7	300 390	990 2110	
17	-⅜"+4	5	17.1	disc	1.4	8.1	9.1	1	2"	6	10"	165	Sint.2 H.E. 14	- 47.6	- 510	- 2980	
18	-⅜"+4	5	17.1	disc	1.4	8.1	9.1	1-1/2	2"	4	6"	400	Sint.33 H.E. 35	51.4 62.5	500 650	910 5090	
19	-½"+4	0	15.4	disc	1.2	8.0	6.0	1½	2"	5	6"	130	Sint. 0 H.E. 13	- -	- -	- -	
20	-½"+4	0	15.4	disc	1.2	8.0	6.0	1½	2"	4	8"	280	Sint. 0 H.E. 21	- -	- -	- -	
21	-½"+4	0	15.4	disc	1.2	8.0	6.0	1-2/3	2"	4	10"	175	Sint. 0 H.E. 13	-	-	-	

Conclusions

A satisfactory blended mix was made in both the cement mixer and the disc pelletizer, for the purpose of producing a sinter cake. It will be noted in the table that the green strengths of pellets using only water are similar to the strengths when waste sulphite liquor was used as a binder. When the pellets made using water only reached the drying stage of the sintering process, the strengths were generally reduced to a point where a considerable percentage of them disintegrated, and were lost through the grate. This is shown in tests 5 to 10. Pellets made with the sulphite liquor were strong enough when heated to remain in place and so result in better sinter recovery. There is inconsistency in the results of the tests using water alone. In tests 3 and 7 a fairly good recovery of sinter was obtained. However, in most others it was low to negligible. In all tests where sulphite liquor was used to produce a blended mix the sinter recovery was good. It appears from these observations that to obtain consistently good results an additive binder such as waste sulphite liquor is necessary.

In the tests previously reported (I.R.No.58-88) the waste sulphite liquor was added in amounts equivalent to 3 per cent solids of the fly ash. In these tests, the concentration of the sulphite liquor was reduced by half with satisfactory results.

In tests 13 to 21, the objective was to produce a heat hardened aggregate. In most of these tests, some sintered material was also obtained. The greatest recovery of sintered and heat hardened materials was obtained in tests 13 and 14 where the pellets

were sized minus 1/2 inch plus 4 mesh, and contained 7.5 per cent coke. The combined recovery of sinter and heat hardened pellets from each of these tests was about 85 per cent.

It appears that finer grinding of the coke had a beneficial effect on sinter recovery. In the work reported previously, ten per cent of minus 10 mesh coke was required to give sinter recoveries of 60 per cent or greater. Seven and a half per cent was intimately mixed with the fly ash, and 2.5 per cent as coating on the pellets. In these tests, using minus 100 mesh coke, 7.5 per cent coke mixed with the fly ash gave sinter recoveries of over 60 per cent. Thus the necessity of coating the pellets with coke was eliminated.

Within limits, the higher the draft during the sintering period, the shorter the time required for sintering to be completed. The lower limit is the minimum volume of air which will support combustion of the charge. The upper limit is the maximum amount of air to support combustion but not an excess, which will cause a cooling effect on the charge, thus increasing the sintering time. The more porous the bed of pellets the lower the draft required. In tests 16, 17, and 18 it will be noted in the table that an increase in draft resulted in longer sintering periods. This would indicate the drafts used are around the upper limit of the draft required.

The unit weights of all the products measured are below the maximum of 55 pounds per cubic foot as specified by the American Society for Testing Materials. The heat hardened aggregates are naturally heavier than the sintered aggregates. The crushing strengths of the heat hardened aggregates are also higher than of the sintered aggregate. The crushing strength of a commercial expanded slag is

approximately 200 and 1100 pounds per square inch for one and two inch compaction. The crushing strength of an expanded shale produced in a rotary kiln is approximately 300 and 2000 pounds per square inch for one and two inch compaction. Although the crushing strength of this fly ash aggregate is lower than the shale aggregate, a satisfactory concrete could no doubt be made from it.

H.S. Wilson

May 16,1958.

H.S.Wilson,
Engineer,
Industrial Minerals Division.