

RECEIVED

FEB 11 1971

WRG 383

TO: H. A. Brown

DATE: February 8, 1971

FROM: R. C. Ericson
R. E. ChaneySUBJ: Preliminary Report -
Field Performance of MK-4

cc: R. J. Bragg
K. R. Cranker
T. F. Egan
D. G. Powell
R. C. Schneider
W. R. Wright
J. K. Chapin/Travelers Rest
W. R. Payment/Travelers Rest
C. H. Wendel/Los Angeles ZONO
J. H. Huxley/Los Angeles ZONO
T. W. Pickthall/Newark, Calif. ZONO
R. E. Rothfelder/Los Angeles ZONO

3L

INTRODUCTION:

The asbestos free MK-4 formulation has received U.L. ratings which permit Construction Products Division to conduct limited but full scale manufacturing and field application tests. Careful adaptation of the research formulation to the multiple variables encompassed by eighteen (18) manufacturing plants is a necessity prior to any full scale switch from MK-3. Because of pressures to speed the non-asbestos formulation through U.L. Fire Test approval, fire testing was undertaken before any significant amount of field testing could be done.

We are indebted to the Pacific Regional organization for conducting a very thorough field test of two variations (with #3 and #4 vermiculite) of the MK-4 formula (manufactured at Newark, Calif.) at the Hilton Towers in San Francisco on September 3, 1970. R. F. Chaney made the arrangements and performed the test work when the job was on the 40th floor so the results are indicative of what can be done at that height.

Test manufacturing was begun at Trenton, New Jersey, in late October to meet urgent needs for asbestos free product in the Philadelphia market where MK-3 had been banned. After I did some preliminary investigation of vermiculite quality at Trenton and with the concurrence of research, a MK-4 formula was established permitting only #4 vermiculite. With the assistance of John Schroeder from research, I was able to make a meaningful field evaluation on this product at the University High School project in Philadelphia in late November. Operations were in progress on the third floor.

Laboratory testing on samples taken at both job sites and analysis of data is complete. My conclusions and recommendations follow. It is necessary to have a precise way to identify each type of formulation tested, so I am introducing into this report a type designation which I expect to make standard practice in the future for keeping internal records such as Quality Control and production records. To illustrate; an MK-4 product made from Libby #4 ore, expanded on a D-16 furnace will be referred to as MK-4L4D-16.

The summary section of this report is being sent without the complete back-up information in the interest of reporting results as soon as they are available. In the last week of February I will send out the rest of the report which will include a complete write-up of the details of the work and tables containing the detailed back-up data. Exhibits A, B, and C which are currently complete are attached.

CONCLUSIONS:

<u>Manufacturer</u>	<u>Type Product</u>	<u>Packing Wt.</u>	<u>Bd. Ft. Yield/ Bag</u>	<u>Bd. Ft. Yield 45# Bag</u>	<u>Water Gal./ Bag</u>	<u>Water Gal./ 45# Bag</u>
Newark	MK-4L3D-16	45	28.7	28.7	12.5	12.5
Newark	MK-4L4D-16	46	29.4	28.7	13.1	12.8
Trenton	MK-4K4D-16	47	32.4	29.0	12.5	11.3

1. #3 and #4 Libby aggregates expanded on D-16 furnace give essentially the same board foot yields in the finished product.
2. #3 and #4 Libby aggregates give essentially the same water demand in the finished product.
3. Water demand of the product made from #4 Kearney aggregates expanded on a D-16 furnace is significantly lower.
4. Despite this lower water demand (lower water demand usually means lower board foot yield) the Trenton product more than matched the yield of the Newark product.

FORMULATION DATA

<u>Type Product</u>	<u>Vermiculite/Gyp Ratio</u>		<u>Vermiculite</u>	<u>Density</u>
	<u>Cu. Ft./100#</u>	<u>#Verm/100#</u>	<u>Cu. Ft./ Batch</u>	<u>#/Cu. Ft.</u>
MK-4L3D-16	10.7	5.85	32	5.5
MK-4L4D-16	9.3	6.05	28	6.5
MK-4K4D-16	8.8	6.45	26.5	7.3

5. The formulation data supports the basic concept of the MK-4 type of formulation; the ratio by weight of aggregate to gypsum should stay the same. All three test lots are very close in this parameter and this appears to result in a constant yield. The writer believes that the slightly higher aggregate ratio of the Trenton lot did give a potentially higher yielding product since the mixing practice on the job tended to reduce yield. Counter to this is the fact that the San Francisco data is taken 40 floors up while the Philadelphia data is taken at the third floor.
6. The higher density Kearney aggregate appears to be the cause of the significant difference in water demand between the Trenton and Newark product.

TENTATIVE RECOMMENDATIONS:

1. A standard packing weight specification for both East and West Coast MK-4K/L4D-16 of 47# to yield 30 bd. ft.
2. Mixing instructions for West Coast MK-4 should specify 13.0 to 13.5 gal/bag.
3. Mixing instructions for East Coast Mk-4 should specify 12.25 to 12.75 gal/bag.
4. West Coast manufacturing plants with D-16 furnaces can be given the flexibility of using either #3 or #4 vermiculite in MK-4.
5. Until further work has been accomplished East Coast plants will be limited to D-16 #4 vermiculite in MK-4..

FORMULATION SUMMARY MK-4 FIELD TESTS

HILTON TOWERS, SAN FRANCISCO - UNIVERSITY HIGH SCHOOL
PHILADELPHIA

U.L. PROCEDURE - FORMULA LIMITS

	HIGH GYP Limit		NOMINAL		LOW GYP Limit	
	lb	% by wt	lb	% by wt	lb	% by wt
VERMICULITE	181.5	36.5	197.0	38.0	211.0	39.0
GYP SUM	298.0	40.0	300.0	58.0	300.0	56.0
CELIF	17.5	3.5	21.0	4.0	24.0	4.0
AEA	0.75	0.17	0.75	0.17	0.75	0.17
TOTAL	497.75	100.17	518.75	100.17	535.75	100.00

TEST LOTS

	NEWARK MK-4L30-16		NEWARK MK-4L40-16		TRENTON MK-4K40-16	
	lb	% by wt	lb	% by wt	lb	% by wt
VERMICULITE	176.0	35.4	182.0	36.1	193.0	37.6
GYP SUM	300.0	60.4	300.0	59.7	300.0	58.4
CELIF	21.0	4.2	21.0	4.2	20.2	4.0
AEA	0.75	0.15	0.75	0.15	0.92	0.17
TOTAL	497.75	100.15	503.75	100.15	514.12	100.17
VERMICULITE VOL	326 FT @ 5.5		286 FT @ 6.5		245.5 FT @ 7.3	

HILTON TOWERS FIELD TEST PATTERN:

Run #	MATERIAL	dry wt. #	WATER		R (wat/mk)
			gal.	lb	
4	MK-4L30-16	45	11.2	94.0	2.08
3	MK-4L30-16	45	12.5	104.0	2.31
1	MK-4L30-16	45	13.1	109.0	2.43
2	MK-4L30-16	45	14.0	117.0	2.60
6	MK-4L40-16	46	13.1	109.0	2.38
5	MK-4L40-16	46	14.2	118.5	2.60

UNIVERSITY HIGH SCHOOL FIELD TEST PATTERN:

MK-4K40-16	50	12.5	104.0	2.08
------------	----	------	-------	------

MK-4 FIELD TESTS

HILTON TOWERS, SAN FRANCISCO - UNIVERSITY 11011 S. 11th, PHILA.

TEST #	MATERIAL	MIX Ratio	INSTRUMENT APPEARANCE	DENSITY #/cu. ft.		CALCULATED YIELDS BOARD FEET	
				NOZZLE	2" CUBES DRY	NOZZLE DENSITY BASIS	DRY DENSITY BASIS
HT-4	MK-4L30-16	2.08	DRY	43.0	22.50	26.4	26.5
HT-3		(2.31)	O.K.	64.5	20.60	27.6	(28.7)
HT-11		2.43	WET	63.0	19.75	29.2	30.3
HT-2		2.60	WET	64.5	19.45	30.0	30.7
HT-6	MK-4L40-16	(2.10)	O.K.	69.0	20.80	27.0	(29.4)
HT-5		2.38	WET	66.0	20.10	30.0	30.4
UH-1	MK-4K40-16	(2.08)	O.K.	57.0	—	(32.4)	—

DRY DENSITY BASIS YIELD CALCULATIONS

	MK-4L30-16			MK-4L40-16		
	DRY Composition		WET Composition	DRY Composition		WET Composition
	#	% by WT	#	#	% by WT	#
VERMICULITE	176.0	35.4	16.0	182.0	36.1	16.7
CELI F	21.0	4.2	1.9	21.0	4.2	1.9
ZOU	300.0	60.4	27.1	300.0	59.7	27.4
DRY TOTAL	497.0	100.0	45.0	503.0	100.0	46.0
WATER OF HYDRATION (17.8% GYP)			4.8			4.9
IN PLACE TOTAL			49.8			50.9

$$\text{VOLUME OF 2" CUBE} = \frac{2 \times 2 \times 2 \text{ in}^3}{1728 \text{ in}^3/\text{ft}^3} = \frac{1}{216} \text{ cu ft}$$

$$\text{DENSITY OF 2" CUBE} = \frac{\text{WT GMS}}{454 \text{ GMS}/\text{lb}} = \frac{1}{216} \text{ cu ft}$$

$$\text{WEIGHT OF CUBE HT-6} = 20.80 \text{ Gms (SEE EXHIBIT)}$$

$$\text{DENSITY OF HT-6} = \frac{43.7 \times 216}{454} = 20.80$$

$$\text{BOARD FEET YIELD HT-6} = \frac{50.9 \text{ \%}/\text{cu. ft.}}{20.80 \text{ \%}/\text{cu. ft.}} \times \frac{12 \text{ BD. FT.}}{1 \text{ cu ft.}} = 29.4$$

MK-4 DENSITY SAMPLES - HILTON TOWERS

Six (6) test mixers were made and pumped to the 40th floor of the Hilton Towers Building in San Francisco. Material from each of these mixes was sampled by spraying product into the sample containers to that its wet density is representative of the in place material on the steel. After the samples had cured for five (5) weeks (3) 2" cubes were cut from the sample and sent to the A. A. Hanks Laboratory to determine their density. In mid-December the 18 cubes were sent to R. C. Ericson in Cambridge and permitted to cure and dry further until February 3rd. One cube each from the (6) sets of (3) was placed in a 221°F oven for 24 hours and the reweighted results are tabulated below:

Sample #	Density #/cu. ft. (Average of 3)				
	12/2 @ A.A. Hanks		2/3 @ Cambridge		24 hr. Dry @
		Drying Loss		Drying Loss	221°F
1	20.68	.93	19.75	2.57	17.18
2	21.18	1.73	19.45	2.62	17.83
3	22.16	1.56	20.60	2.62	17.98
4	23.92	1.42	22.50	2.93	19.57
5	21.79	1.69	20.10	2.52	17.58
6	22.30	1.50	20.80	2.75	18.05

A check with the U.S. Gypsum Research Lab established their practice of drying gypsum samples at 110° - 115°F because higher temperatures slowly drive off water of hydration. On this basis the samples after 24 hours drying were assumed to have lost some water of hydration. Thus the February 3rd densities measured in Cambridge were selected as having dried close to the point where all water except the water of hydration (17.8% by wt. of gypsum) had left the sample. These densities were felt to give accurate yield data and represent the fully dried in place material on the job.