MICHIGAN
STATE HIGHWAY DEPARTMENT
G. Donald Kennedy
State Highway Commissioner

LIMESTONE DUST IN MORTAR

By

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The gradation of stone* sand greatly influences the workability of concrete made with this material, used as a fine aggregate. If it is too coarse, a "grainy" mix results which is harsh working and which does not hold the mixing water in place. Fine stone dust greatly adds to the plasticity or workability of an otherwise harsh working mixture and from this standpoint "fines" are desirable. But the question arises: What effect does stone dust have on the physical properties of the concrete? Light is thrown on this question through a preliminary series of tests made in the National Crushed Stone Association laboratory.

Mortars were made up in the proportion of 1:2 by weight, using limestone sands having the following gradations:

Total per cent retained on -	Coarse	Medium	Fine
No. 4	0	0	0
8	5	3	0
16	50	38	25
30	70	60	50
50	90	80	70
100	97	93	90
	3.12	2.74	2.35

To the stone sands of the above gradations, limestone dust passing the No. 200 sieve was added to the amounts of 10, 20, and 30 per cent by weight of cement, equivalent to 5, 10, and 15 per cent by weight of sand.

*Effect of Limestone Dust Admixtures on the Strength and Durability of Portland Cement Mortar," Bureau of Engineering, National Crushed Stone Associa tion, U.S.A., 2 Oct., 1937.

All mortars were mixed to approximately the same consistency as determined by the flow table. Finally, after 28 days' storage in the moist room, the specimens (2-in. cubes) were tested for absorption, crushing strength and resistance to freezing and thawing.

It was found that the finer the sand, the higher is the water-ratio required for equal flow or consistency. However, contrary to the general water-cement ratio strength relationship, higher strengths were obtained with the higher water-cement ratios. Likewise the finest sand produced a more resistant mortar in the freezing and thawing test than the coarsest sand, even though the absorption was at the same time higher with the finer gradations.

Ten per cent of dust by weight of cement (5 per cent by weight of stone sand) increased the crushing strength and also the durability with all three sand gradations, but 20 per cent increased the strength and durability only of the coarse and intermediate gradations. Finally, 30 percent of dust (15 per cent by weight of sand) decreased the crushing strength particularly of the intermediate and fine gradations and shows no benefit so far as durability is concerned.

It seems reasonable to conclude from these tests that for 1:2 mortar a small amount of stone dust passing the No. 200 sieve, up to 5 per cent by weight of sand, should improve the mortar-making properties of stone sands within the range of gradation shown, but that more than 10 percent may be harmful, particularly if the sand has a fine gradation.

If the results are further analysed, the indications from these tests point to the desirability of raising the allowable stone dust content above that ordinarily allowed by specifications, perhaps up to 15 percent passing through the No. 100 sieve.

DUST AND PROPERTIES OF MORTARS

Tests were made in U.S.A. to gain additional information on the effect of various quantities of dust in stone sand on the properties of mortar such as might be used in highway concrete. In his article*, Goldbeck stated that the following brief summary of indications from the tests seemed warranted:-

1. To maintain a given consistency in mortars containing dust varying in amount from 4 up to 24 percent, very little increase in water-cement ratio is required.
2. Neither the volume of water released upon settlement of the fresh mortar nor the volumetric shrinkage of the fresh mortar is affected to a significant extent by an increase in dust content up to 24 percent.
3. Crushing strength of mortar is somewhat decreased with increasing percentages of dust. The crushing strength of the 24 percent dust content mortar was 90 percent of that containing only 4 percent dust.
4. The absorption increases with increasing percentages of dust.
5. The durability seems to be affected to a significant degree by high percentages of dust, far more than can be accounted for by the rather slight increase in water-cement ratio required to maintain the same consistency. It would seem inadvisable to use more than 8 to 10 percent of minus No. 100 sieve limestone dust in the stone sand used for concrete to be exposed to the weather.
6. The shrinkage of mortar upon drying out in the air is practically unaffected by the dust content in the sand.

*"The Effect of Dust in Stone Sand on the Properties of Mortars," A.T. Goldbeck, The Crushed Stone Journal, Nov.-Dec., 1938.

Although the above tests were made on mortar, it is to be expected that concrete will be similarly affected, only to a different extent, and hence these tests are applicable qualitatively to concrete also. Finally, it seems safe for concrete containing 1:2 mortar to have at least 8 to 10 percent of stone dust passing the No. 100 sieve. Only one limestone sand and dust was used in these tests, and it is not improbable that other sands and dusts might give results varying somewhat from these.

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Comparative Test Data on Concrete Made From Limestone Aggregate, Limestone Aggregate plus Limestone Dust, Natural Aggregates

MICHIGAN TEST ROAD

Test	Limestone Aggregate	* Limestone Aggregate + Limestone Dust 15.45 lbs/sack cement	Natural Aggregate
Scaling - first year	100% - 22 cycles	100% - 5 cycles	100% - 13 cycles
Scaling - second year	100% - 6 cycles	100% - 6 cycles	100% - 9 cycles
Freezing and Thawing Specimens	In progress 160+	Failure 106 cycles " 108	Failure 76 cycles " 75 cycles
Modulus of Rupture	768 (7) - 585 (28)	578 (7) - 489 (28)	(16) 685
Compression, 6 x 8 cyl.	3069 (7) - 4185 (28)	2694 (7) - 4099 (28)	3411 (7) - 4240 (28)
Cores	5765 p.s.i.	5050 p.s.i.	5750 p.s.i.

* 2.0% fines in aggregate