



# EVALUATION OF VARIOUS LIME PRODUCTS FOR DRYING & MODIFYING SOILS

Omni Materials, Inc. (Omni) recently worked in conjunction with a Soil Stabilization Contractor, **Mt. Carmel Stabilization Group, Inc. (MTCSG)**, performing field trials with a few lime-based products to determine their effectiveness as drying agents for placing and compacting embankments.

LKD is a co-product of quicklime production that is collected from the rotary kiln at about 10-20% of quicklime produced. LKD contains calcium oxide (CaO) and magnesium oxide (MgO), but at varying amounts less than quicklime. LKD also contains available pozzolanic minerals in the form of aluminates and silicates, which are absent in quicklime. When compared to quicklime, the presence of these pozzolans allow LKD to be more effective at developing long-term strength in a larger range of soil types than just highly plastic soil.

Typically, when using LKD or quicklime to remove excessive moisture from the existing ground or newly placed fill, the chemical is spread, then immediately mixed with the soil without the addition of water, and then compacted. The goal of this process is solely to remove the excess moisture to achieve the desired compaction. By adding lime-based products, it increases the soil's optimum moisture content, thus narrowing the moisture content difference needed to facilitate compaction.

Secondly, by adding lime-based products for drying, there are immediate benefits (modification of the clay soil particles), and long-term benefits (increase in strength). Recently, Omni completed several field studies to evaluate the drying effectiveness of three different chemicals (LKD, LKD II, quicklime) on three different projects - one in central Ohio and two outside Indianapolis. We also performed field trials on a new lime-based product called OmniMax™ that was used on the two Indianapolis projects.

# FIELD AND LABORATORY TESTING PROCEDURES

The fill soils on all of these projects generally consisted of silty clay soils. For the field trials, the labs took moisture contents and bulk samples of the engineered fill prior to any chemical being spread. Then MTCSG spread and mixed each chemical following the National Lime Association's procedure for drying engineered fill soil (i.e. mixing the chemical without adding water and with no mellowing period and remixing). After the soil and the chemicals were mixed, moisture samples were taken and exposed to ambient conditions for 1 hour or 2 hours and then sealed for moisture content testing.



The labs also performed untreated and treated Proctors with bulk samples taken in the field and with the chemicals used on site to establish what the untreated and treated optimum moisture contents were. Field strength specimens were also molded at each location for each chemical treatment to estimate how much strength would be gained by modifying the soil. The labs did a variety of field-molded strength specimens for testing at various curing periods.

The charts provided demonstrate how effective each chemical is at removing excess moisture when compared to quicklime during the timeframe while the treated fill is compacted. While all four products demonstrated capability to dry the soil and increase the optimum moisture content, adding quicklime in amounts needed to dry the soil to achieve compaction and stability averaged in lower unconfined compressive strengths when compared to using LKD and OmniMax™.

The theory that quicklime is twice as effective as LKD in drying soils has not revealed itself in any of our data to date. The economics of the use of co-products and blends such as LKD, LKD II and OmniMax™ vs. quicklime for drying soils has been the driving factor in the use of these lower cost chemicals for many years. The data does support that quicklime is effective at drying soils, but the costs of using quicklime in lieu of these lower-cost lime-based chemicals does not provide the value to the project that may be anticipated, as well as sacrificing potential strength gains. The use of LKD and OmniMax™ at lower application rates in most cases, resulted in better drying effectiveness than quicklime. Omni Materials will continue to perform field trials throughout 2023 and 2024 and plan to publish the results.

Update 2023 – two additional field trials were completed in the spring months of 2023 – one in the greater Indianapolis area (Indianapolis Project No. 3) and one in Columbus (Columbus Project No. 2). The results showed again that LKD was nearly as effective, if not better at reducing the moisture content of the untreated soil as well as increasing the optimum moisture content. The results also demonstrated that the LKD-treated soil developed higher unconfined compressive strength than the quicklime-treated soil.

## INDIANAPOLIS PROJECT NO. 1

Sample ID	Chemical	Application (%)	Untreated MC (%)	Untreated OMC (%)	Percent Above Untreated OMC (%)	Treated OMC (%)	Treated MC After 1 hour (%)	Treated MC After 2 hours (%)	Total Moisture Reduction (%)	Final Moisture Content vs Treated OMC (%)	Net Effect of Moisture Content (%)*	2-day Average UCS (psi)
BS-1	LKD II (L)	4.8	18.6	12.4	6.2	14.9	11	10.4	-8.2	-4.5	10.7	80
BS-2	Quicklime	4.1	17.8	11.8	6.0	14.8	14.1	13	-4.8	-1.8	7.8	70
BS-3	LKD	4.6	17.8	14.9	2.9	17.4	11.3	10.5	-7.3	-6.9	9.8	50
BS-4	OmniMax	4.6	17.9	9.8	8.1	12.0	14.1	11.9	-6	-0.1	8.2	40

\*Decrease in Moisture Content at 2 hours + Increase in OMC

## COLUMBUS PROJECT NO. 1

Sample ID	Chemical	Application (%)	Untreated MC (%)	Untreated OMC (%)	Percent Above Untreated OMC (%)	Treated OMC (%)	Treated MC After 1 hour (%)	Treated MC After 2 hours (%)	Total Moisture Reduction (%)	Final Moisture Content vs Treated OMC (%)	Net Effect of Moisture Content (%)*	7-day UCS (psi)
BS-8	Quicklime	6.6	20.2	12.7	7.5	14.8	15.4	14.3	-5.9	-0.5	2.6	0**
BS-9	LKD II	6.7	17.5	13.3	4.2	14.2	12.4	10.4	-7.1	-3.8	4.7	140
BS-10	LKD	6.3	17.7	9.7	8.0	10.4	11.1	9	-8.7	-1.4	2.1	130

\*Decrease in Moisture Content at 2 hours + Increase in OMC

\*\*Field-molded strength specimens could not maintain geometry and broke apart during removal from the split-spoon mold.

## INDIANAPOLIS PROJECT NO. 2

Sample ID	Chemical	Application (%)	Untreated MC (%)	Untreated OMC (%)	Percent Above Untreated OMC (%)	Treated OMC (%)	Treated MC After 1 hour (%)	Treated MC after 2 hours (%)	Field Total Moisture Reduction (%)	Field Final Moisture Content vs Treated OMC (%)	Net Effect of Moisture Content (%)*	48-hr UCS (psi)	5-day UCS (psi)	7-day UCS (psi)
1	LKD	4.0	20.1	12.7	7.4	13.5	16	15.2	-4.9	1.7	5.7	50	77	72
2	OmniMax	4.8	20.3	12.6	7.7	14.6	15.9	15.1	-5.2	0.5	7.2	81	126	108
3	Quicklime	4.8	23.7	13.4	10.3	16.9	16.4	15.7	-8	-1.2	11.5	68	46**	39

\*Decrease in Moisture Content at 2 hours + Increase in OMC

\*\*Field-molded strength specimens could not maintain geometry and broke apart during removal from the split mold. They were remolded and compacted in the lab upon arrival.

## INDIANAPOLIS PROJECT NO. 3 (UPDATED APRIL 2023)

Sample ID	Chemical	Application (%)	Untreated MC (%)	Untreated OMC (%)	Percent Above Untreated OMC (%)	Untreated In-Situ DD (pcf)	Treated OMC (%)	Treated MC After 1 hour (%)	Treated MC after 2 hours (%)	Field Total Moisture Reduction (%)	Field Final Moisture Content vs Treated OMC (%)	Net Effect of Moisture Content (%)*	48-hr UCS (psi)	5-day UCS (psi)	7-day UCS (psi)	14-day UCS (psi)
2	LKD	5.8	23.4	15.0	8.4	88.7	16.9	21.6	20.0	-3.4	3.1	5.3	36.0	48.5	51.3	54.2
3	Quicklime	5.1	18.0	11.8	6.2	101.2	12.9	15.1	14.4	-3.6	1.5	4.7	4.2	3.3	5.5	7.9

\*Decrease in Moisture Content at 2 hours + Increase in OMC

## COLUMBUS PROJECT NO. 2 (UPDATED JUNE 2023)

Sample ID	Chemical	Application (%)	Untreated MC (%)	Untreated OMC (%)	Percent Above Untreated OMC (%)	Untreated In-Situ DD (pcf)	Treated OMC (%)	Treated MC After 1 hour (%)	Treated MC after 2 hours (%)	Field Total Moisture Reduction (%)	Field Final Moisture Content vs Treated OMC (%)	Net Effect of Moisture Content (%)*	48-hr UCS (psi)	5-day UCS (psi)	7-day UCS (psi)	28-day UCS (psi)
BS-3	LKD	3.0	14.4	9.1	5.3	108.0	10.3	11.1	10.2	-4.2	-0.1	5.4	115	120	125	165
BS-5	Quicklime	2.5	12.8	9.6	3.2	110.0	10.6	9.4	9.0	-3.8	-1.6	4.8	60	75	80	110

\*Decrease in Moisture Content at 2 hours + Increase in OMC