Full-Depth Reclamation of Asphalt Roads with Liquid Calcium Chloride

JAMES B. PICKETT

By reusing the asphalt from reconstruction of deteriorating roads and blending it with the gravel base and liquid calcium chloride, states, cities, and towns are able to rebuild their roads at a 50 percent savings. The implementation of a full-depth reclamation program with calcium chloride is a workable, cost-effective solution to the deterioration of roads. Many asphaltic roadways are in advanced stages of deterioration from aging, base problems, and drainage. Some roads have been maintained with the application of a periodic seal coat or an overlay. Because overlays last only a limited time before cracking begins to show through and because of insufficient funding to completely reconstruct the roadways, full-depth reclamation with calcium chloride is helping throughout the country.

Full-depth reclamation is a method that shows what recycling is all about—savings. There are savings in time, savings in materials, and savings in the use of additives.

Full-depth reclamation is a technique in which the full flexible pavement structure and a predetermined portion of the underlying base materials are uniformly crushed, pulverized, blended, or sized to result in a stabilized base course. This method significantly extends the life of the road and the amount of road work done for a budgeted dollar. It is with this objective in mind that calcium chloride is used as a stabilizer by recycling it with asphalt surfaces and base materials from reconstruction. A combination of crushed surface and base material is mixed with calcium chloride to facilitate the road builder's oldest form of stabilization: thorough mix and uniform compaction.

In the field of highway engineering stabilization is recognized as including all procedures for improving the performance of the asphalt, soils, and aggregates used in road construction and maintenance. A highway material may be considered stable if it exhibits a high degree of durability or permanence under traffic, moisture fluctuations, and frost action in colder climates.

The concept of stabilization involves improvement of soil and aggregate material by one or more of the following procedures: drainage corrections, compaction, gradation changes, and use of additives.

The highway superintendent employs any combination of the various stabilization procedures to

1. Improve the bearing capacity of existing subgrade soil,
2. Modify the physical properties of an unsuitable or questionable base course material,
3. Obtain maximum performance from suitable base course material,
4. Reduce the total pavement thickness for a given traffic load, and
5. Provide a satisfactory wearing surface for secondary roads with low traffic volume.

The properties of calcium chloride that make it a particularly useful additive for stabilization are as follows:

1. It has an attraction for moisture;
2. It has low vapor pressure, which enables the chemical to resist evaporation;
3. Its solution has a high surface tension, providing the ability to bind aggregate particles together; and
4. Its solution has a strong moisture film; lubrication of the aggregate particles helps in compaction. The result is greater density through more effective compaction.

Calcium chloride's attraction for moisture and its low vapor pressure maintain uniform moisture content while the recycled material is graded, rolled, and cured. Maintaining the optimum moisture content in the base is the chemical's greatest contribution to the stability of the pulverized material.

Most full-depth reclamation of asphalt roads with calcium chloride is done on roadways in advanced stages of deterioration, with alligator cracks, rutting, frost heaves, potholes, and so on. The work consists of pulverizing the existing surface and blending the crushed surface with its gravel base to a desired depth, adding 0.75 gal of liquid calcium chloride per square yard, repulverizing, grading, rolling, adding 0.25 gal of liquid calcium chloride per square yard to prevent raveling, and letting it cure. Work has been done with Bomag MPH 100 recyclers, and Caterpillar R.R. 250 and Barber Greene RX-40 Dynaplane machines with savings in time, material, additives, and money.

CASE HISTORIES

Niskayuna, New York

In 1978 the highway department of Niskayuna, New York, discovered a solution for one of the town's most serious road maintenance problems. The Niskayuna highway department had always saved and reused old blacktop to create a new aggregate base and had been using calcium chloride for dust control for a number of years. It was a natural next step to combine the two operations, with impressive results.

General Chemical Corporation, 90 East Halsey Road, Parsippany, N.J. 07054.

Niskayuna's biggest budget item was for blacktop, but the budget did not keep pace with the price of blacktop. It was a losing situation until the calcium chloride full-depth reclamation solution. The procedure used was to scarify out blacktop and the gravel base and pass them through a crusher. This homogeneous mass of crushed asphalt and gravel was then redeposited over the subbase. After the homogeneous mass was laid out, 35 percent liquid calcium chloride was applied at the rate of 0.60 gal/yd^2. Three days later liquid calcium chloride was applied again in two passes at a rate of 0.25 gal/yd^2 during each pass. The road was then graded and rolled. Within a few days the road started to harden. A finished surface course of 1½ in. of plant mix topped the road.

In 1979 and 1980, the Niskayuna highway department reconstructed 1 mi each year with similar results. In 1981, 5 mi was reconstructed. By scarifying, combining the blacktop and the gravel base, crushing them, and then adding the liquid calcium chloride to bind the aggregate, Niskayuna was getting reconstructed roads at half the material cost and staying within their budget.

Colonie, New York

In 1983 the town of Colonie, New York, used a Bomag MPH 100 recycler to a depth of 12 in., 6 to 8 in. of which was asphalt that was pulverized with 4 in. of gravel base. On the second pass with the Bomag recycler, workmen were constantly having to stop the operation of the Bomag machine to adjust the amount of emulsion to add. Either too much was added to the recycled material, which made it bleed through, or not enough to bind the recycled aggregate. Because of the success that the neighboring town, Niskayuna, had had with liquid calcium chloride, a decision was made to try this additive.

After the asphalt road had been pulverized to a depth of 12 in., graded, and rolled, liquid calcium chloride was applied to the road through an Etnyre distributor at a rate from 0.60 to 1 gal/yd^2. Within a few days the road started to harden, and 1 month later it looked just like a paved road. Later that summer, the road was paved. The average daily traffic on that road is 1,500 to 2,000 vehicles per day.

East Greenbush, New York

Several towns in the area of Colonie, New York, experimented with liquid calcium chloride. In the town of East Greenbush, New York, liquid calcium chloride was substituted for an emulsion additive. There were assurances when the work began that liquid calcium chloride could do the job and would cost about 60 percent less than the emulsion. During the recycling, the road was kept open and watched carefully. The Director of Public Works was surprised that the road became so hard. After 4 weeks, a double seal of oil and stone was applied.

During the summer of 1983, because of the success of their test road, the town of East Greenbush, New York, reconstructed an additional 3 mi of roads with the Bomag MPH 100 recycler and liquid calcium chloride. Over the last several years the town has reconstructed 20 mi. Some of the roads were not surfaced, and to this day they have still not been surfaced, but remain smooth aggregate roads.

Sempronius, New York

For over 15 years the town of Sempronius, New York, experienced problems with a heavily traveled oil-and-stone road. Every year the town was faced with repairing potholes, alligator cracks, and ruts. The road surface always remained a problem because engineers were not convinced that they had a solid base along the entire length of the road. At first they thought of tearing up the whole road, but the cost was prohibitive. An alternative was to continue filling potholes and washed-away areas. Trueing and leveling would not cure the problem. They would cost more in the long run and the road would still be in bad shape. A cost of $30,000 was estimated to pave the road. This was compared with $18,000 to recycle the road with liquid calcium chloride, including a sealing of oil and stone.

The decision was made to try full-depth reclamation. This included pulverizing with a Barber Greene RX 40, grading, shaping, and rolling, plus two applications of 0.40 gal/yd^2 of 35 percent liquid calcium chloride. Done the old way, reconstruction would have required over 2 weeks of labor.

The Barber Greene RX 40 made passes starting at the edge of an 18-ft-wide road and traveling about 40 ft/min. On each pass the machine pulverized the road to a width of about 6 ft and to a depth of 6 in. The machine ground up the 1 in. of oil-and-stone surface and 5 in. of gravel base. The homogeneous mass of oil and stone, dirt, and gravel was then distributed evenly along the road. A grader reshaped the road, forming a crown with an elevation of 0.25 in./ft. At this point, an asphalt distributor truck applied liquid calcium chloride at a rate of 0.40 gal/yd^2. After the second application of the same amount, the road was then rolled.

It was the town's intention to seal the road with oil and stone; however, the road was so hard and was standing up to traffic so well that it was decided not to apply a wearing course. After a summer of heavy traffic by 10-wheel tractor-trailers, commuters, and service vehicles, plus heavy rains, the road remained hard and dust free. Motorists thought that the road was paved.

PROCEDURES

Stabilization and recycling of existing roadways are not new. There are different procedures, using different types of equipment, such as scarifiers, hammermills, mix pavers, and pulvimixers. The newer reclaimers, such as the Bomag MPH 100, Caterpillar 225, and Barber Greene RX 40, make it economically attractive for in situ full-depth reclamation roads.

Several factors need to be considered when the road is set up for full-depth reclamation. Mix design, which includes chunk sizes and material gradation as well as binder type and amount, must be determined. Laydown requirements must be determined. An economic analysis should be carried out to compare the cost and savings of this method of pavement rehabilitation with alternative pavement maintenance strategies. In every instance, when all the factors were considered, full-depth reclamation of an asphalt road with calcium chloride was tried. The results were successful.

Most in-place asphalt stabilization and recycling projects consist of a series of operations:

1. Ripping or scarification of the existing pavement layers and gravel base,
2. Reduction in size of the asphalt-treated aggregate particles and gravel base,
3. Mixing in of the new asphalt binder with treated aggregate particles and base material,
4. Spreading the recycled material, and
5. Compaction of the recycled material.

The factors in the recycling series of operations, which include the depth of the road to be recycled and the depth of the asphaltic material in the road, include the following:

1. A scarifier, a hammermill, and a grader are needed. A Bomag or a Caterpillar reclaiming machine can do this series of operations in one pass.
2. Mixing in of the new asphalt binder is the most critical operation in the recycling process. What binder? How much binder? How much asphaltic surface is going to blend with the new binder? How will the gravel absorb the binder? According to Scherocman (*1*):

> Any type of asphalt material—asphalt cement, foamed asphalt, cutback asphalt, asphalt emulsion or recycling agent—can be added through the recycler from the tank on an asphalt distributor. In recent years, emulsified asphalt has been the primary binding agent used in most cold in-place recycling projects. The primary decisions to be made during the mixing operation revolve around the type of asphalt binder to be added and the amount to be used. Again, depending on job conditions, one or more passes of the recycler may be required to properly distribute and mix the asphalt binder with the reclaimed material. Because of this multipass operation and because of the variability of this binder addition process, the uniformity of the binder distribution is sometimes poor.

3. Liquid calcium chloride can be mixed into the reclaimed material easily and with less margin for error than with asphalt emulsion. Liquid calcium chloride can be added through a distributor on the surface of the pulverized road material and then repulverized to the desired depth.
4. The spreading or grading of recycled material with calcium chloride is done in the conventional way with a grader.
5. Conventional compaction equipment—a static steel roller, a vibratory roller, or a rubber-tired roller—is used to provide the desired density to the cold-recycled mixture.
6. The amount of 35 percent liquid calcium chloride does not vary and there is less margin for error than with asphalt emulsion. For example, in a desired cut from 6 to 8 in. 0.75 gal/yd^2 is recommended after the first pass and 0.25 gal/yd^2 after rolling. For a depth of 4 to 6 in., the same amounts are recommended.

There are engineers who say that because of unknown factors of mix design that can significantly alter the level of performance of the full-depth reclaimed material, a wearing surface should always be placed over the recycled mixture. This is not the author's experience. Wearing courses can be single- or double-surface treatment, a layer of cold-mix asphalt, a layer of asphalt concrete, or just the full-depth reclaimed material that has just been treated with liquid calcium chloride. Twenty percent of the full-depth reclaimed asphalt roads with calcium chloride remain without a surface course.

There are certain recommendations in recycling with calcium chloride:

1. The asphaltic surface must always be blended with the gravel base course.
2. The gravel base course must be free of 4-in. bones and cobbles, large boulders, rocks, tree stumps, and so on.
3. There must be limitations as far as gradation is concerned with the reclaiming machine. Chunks of asphaltic material may be larger than 2 in. The percentage of −200 mesh is sometimes less than 3 percent. If the depth of cut is 4 in., fines must sometimes be added. It is extremely difficult to achieve 100 percent passing through a 1-in. screen, which is a typical specification for materials on a calcium chloride recycling project.

MATERIALS

The materials should be a mixture of bituminous concrete and existing gravel base course pulverized to conform to the following gradation:

Sieve Designation	*Percent by Weight Passing*
2 in.	100
1 in.	30–65
No. 200	3–12

Allowance must be made in the specifications for the inherent variability of the full-depth reclaimed material. In most projects the above specification is met after the second recycling run, mixing the calcium chloride and the recycled material to the desired depth.

CONCLUSION

Full-depth reclamation of asphalt roads with calcium chloride in lieu of traditional construction methods saves money, natural resources, energy, and time.

1. Money: With a reclaiming machine the cost of pulverization of the road runs from $1.00/yd^2 to $2.00/yd^2, depending on the depth of the cut. The cost of the 35 percent liquid calcium chloride averages $0.75/gal.
2. Natural resources: In situ materials such as asphalt surface courses are pulverized and mixed with the gravel base courses.
3. Energy: No oil used.
4. Time: The average time to reconstruct 1 mi is 2 days.

The concept of calcium chloride as an additive in reclamation has been in use since 1978. Benefits of this additive in reclamation are as follows:

- Uniform Moisture Control: The most important factor in obtaining maximum density in a well-graded mixture is the maintenance of the optimum moisture content. Because of its low vapor pressure, calcium chloride in solution resists evaporation, even in periods of low humidity and high temperature.

- Increased Density: Calcium chloride increases the surface tension. Moisture films of calcium chloride solutions are stronger than those of plain water. The treated aggregate attains a greater density than untreated similar materials.
- Less Compactive Effort Required: Less rolling is required. The accelerated compaction permits earlier completion of work.
- Less Binder Material Required: Because calcium chloride aids soil fines in maintaining a moisture film, it proves an adequate bond for the aggregate.
- Surface Uniformity: The ultimate aim is a smooth riding surface free from long transverse and longitudinal variations, which are detrimental to smooth riding and easy driving. Moisture retained in the road permits the base course to be carried as an open surface without excess wear and deterioration due to traffic for an indefinite period before being primed with bituminous materials.
- Controlled Curing for Increased Stability: The results show that calcium chloride used in the mix ensures a high structural stability by controlling the rate of drying in both the compaction and curing periods.
- Dust-Free Surface.
- Improved Bond: Calcium chloride is an aid to the absorption of bituminous materials. Priming materials are readily absorbed and there is no block of bituminous materials due to dust film.
- Adaptable to Stage Construction: Calcium chloride aids in keeping the aggregate in place. Because of budget problems, engineers have been inclined, especially in rural areas, to recommend building roads in stages to check the grade, drainage, and the selection of the surfaces.
- Extends the Road-Recycling Season: Because of the low freezing point of calcium chloride, recycling work can begin just after the frost is out of the soil and extend into late November.
- Frost Protection: Small percentages of calcium chloride are effective in reducing detrimental frost action. Work done by Floyd Slate of Purdue University concluded that calcium chloride, in a stabilized mixture, prevented detrimental frost heaving (*2*).
- No Threat to Environment: According to George Momberger, a senior engineer technician with the New York State Department of Environmental Conservation, if calcium chloride leaks into a stream, it will carbonate out and leave the water.
- Economy: The average price of 35 percent liquid calcium chloride is $0.75/gal furnished and applied. A total of 1 gal/yd^2 is recommended.

REFERENCES

1. J. A. Scherocman. Cold In-Place Recycling of Low Volume Roads. In *Transportation Research Record 898*, TRB, National Research Council, Washington, D.C., 1983, pp. 308–314.
2. F. O. Slate. Use of Calcium Chloride in Subgrade Soils for Frost Protection. *HRB Proc.*, Vol. 22, 1942, pp. 422–440.