Experience with Gravel Surface Treatment at Conrail Intermodal Terminals

James P. Carmody
Parsons Brinckerhoff-FG, Inc.
Trenton, New Jersey*

Increased growth in rail intermodalism has created a need for new or upgraded terminals. Construction costs for these terminals are high, and the largest cost item is the paving of the surface. Common practice in pavement design is to use asphaltic concrete or portland cement concrete. Another alternative is the use of an aggregate wearing course, which can reduce capital cost for paving by 40 percent. Conrail has constructed a number of new terminals, which have an aggregate surface, in the last 5 years. Initially there were problems in the terminals because of a lack of proper maintenance procedures. The main problems were the formation of ruts and potholes and dust. They had an adverse effect on the efficiency of terminal operations, and the dust was causing strained relationships with local communities. As solutions to these problems were achieved, standard maintenance procedures were established. These included a periodic application of a dust control agent, preferably calcium chloride, which not only provides effective dust control but also increases the stability of the aggregate. The other procedure is to replenish surface material to maintain a smooth riding surface. In some terminals, this material was a washed pea gravel that served as a surface cover.

The rapid growth in recent years of rail intermodal traffic has created a need for intermodal terminals that can handle increased volumes and provide rapid and efficient transfer. The key to such a terminal is the use of mechanical loaders and a terminal design that minimizes handling of trailers and containers.

Loading intermodal cars by a circus ramp does not require any special construction except a level surface on the track where the ramp is placed. However, a yard in which mechanical loaders (cranes or side loaders) are used is a different situation. These mechanical loaders, when carrying a loaded trailer, produce high ground loadings that require a substantial pavement section.

Common practice for paving in an intermodal terminal is to use asphaltic concrete or portland cement concrete, or both. Pavement design with these materials is expensive, and when the surface area to be paved in a midvolume size terminal (15 to 25 acres) is considered, the construction cost of a new mechanized terminal may not be economically feasible. But there is a another alternative, an aggregate base and wearing course. Such construction can reduce capital costs for paving by as much as 40 percent. This reduction in costs, however, is not achieved without some drawbacks. An aggregate or gravel surface tends to become raveled and form potholes from traffic, water, and frost heave, and will be dusty in dry weather. These are severe problems when their effects on operations and costly maintenance procedures are considered.

If these problems can be overcome, and it has been the position of Conrail in the construction of a number of intermodal terminals that they can be overcome, a gravel surface treatment is a viable alternative. The major objective, therefore, is to maintain a smooth, dust-free surface with cost-effective maintenance procedures.

GRAVEL SURFACE TREATMENT

There are two elements to be considered in the use of gravel surface treatment: (a) an aggregate wearing course placed during initial construction and (b) periodic replenishment of the surface with additional aggregate or gravel. The first element is the aggregate wearing course that is not gravel in the generalized meaning of the word but a well-graded aggregate 100 percent of which passes a 1-in. sieve and 10 to 25 percent of which will pass a No. 200 sieve. The gradation of sizes in between will vary depending on the aggregate source but should provide for maximum density. Each of the Conrail terminals had different aggregate courses due to local availability of materials.

The second element is replenishment of the surface with additional aggregate of the same kind, or a coarse gravel, as a cover for the surface. The choice of replenishment material is a result of availability and individual maintenance procedures in each terminal. These procedures will be outlined later by terminal. It should be noted that the maintenance procedures used in the terminals were initially not engineered solutions, and, as problems arose, more effective and reliable solutions were sought. After testing of materials and observations of successful procedures in these terminals, some generalized maintenance procedures were established. The development of these procedures will be discussed for specific terminals.

There was a quirk in one terminal that had some interesting results. The replenishment material furnished was a washed pea gravel. The gravel was initially applied by contractor, but terminal forces smooth the surface weekly by dragging a piece of scrap rail sideways over the loading area. Although the gravel maintains a loosely bound surface and vehicle tires form ridges, the surface never becomes hard and the ridges flatten under the next passing tire. The loose material only comprises the top 1

*Current affiliation: Greiner Engineering, Inc., Timonium, Md.

in. of surface and does not affect the structural integrity of the aggregate pavement. The loose gravel surface appears to prevent the constant turning of tires in place from gouging out holes in the surface. The weekly grading helps maintain an even distribution of material. Yearly replenishment of this gravel is necessary because some material is carried away by vehicles, some is pulverized, and the rest is imbedded in the aggregate surface.

DUST CONTROL

The biggest problem with an aggregate surface is dust control. In an aggregate wearing surface, there is always fine material that will be raised as dust by vehicle tires unless this material can be bound in the aggregate. Proper levels of moisture in the aggregate will solve this problem by binding all material and will also maximize soil stability. Many approved methods of dust control are used in highway construction and for maintenance of aggregate base roads. These methods are also used in intermodal terminals, but, due to the special nature of the loading areas in these terminals, not all these methods have been successful. These problems and solutions will be highlighted by individual terminal.

Dust will decrease the effectiveness of terminal operation and has a particularly adverse effect on adjacent neighbors. As one local official said, paraphrasing a local environmental statute after the construction of a terminal, "you shall not let dust cross your property line."

EXPERIENCE IN TERMINALS

A synopsis of the experience in each terminal that Conrail has constructed or expanded in the last 5 years follows. All of these terminals had some of the loading and parking areas constructed with an aggregate surface.

Baltimore, Maryland

This terminal has five loading tracks with a total of 60 car spots and an annual volume of 76,000 lifts (information supplied by Pennsylvania Truck Lines, Inc., 1985). The terminal was upgraded to handle additional traffic as a result of the closing of the second terminal in Baltimore at the Dundalk Marine Terminal. This additional traffic was mainly containers, and the upgrading of the terminal reflected the handling of this type of traffic.

The loading areas were paved with asphaltic concrete and the parking areas with aggregate. There were some problems with dust, and the travel lanes in the parking area were sprayed with waste oil (a byproduct of the distillation process and not "used" oil). The oil was marginally effective and created some problems with the state Environmental Protection Agency (EPA). Grading the yard scrapes up the oil-encrusted surface and necessitates reapplication of a dust control agent. Other dust control agents were being considered to replace the oil. Calcium chloride or a similar agent would be ideal for use on this yard surface.

The asphalt paved loading areas were plagued by underground streams that caused structural collapses in many sections, and these sections had to be replaced causing severe disruption of the terminal operation. If this had been an aggregate surface, the collapse of the surface would have been more gradual and remedial measures could have been taken sooner, at less cost, and probably with less disruption to the terminal operation.

East St. Louis, Illinois

This terminal has three loading tracks with 107 car spots and an annual volume of 120,000 lifts (information supplied by Pennsylvania Truck Lines, Inc., 1985). This terminal was built on an existing rail yard adjacent to the circus ramp that it replaced. It has centerline parking between the two main loading tracks and the entire surface is aggregate.

During construction in an extremely dry season, there were severe dust problems particularly in the completed sections where construction traffic moved constantly. The contractor had to water the surface continually during the day and just barely won the battle. Because of the constant watering, the surface become rutted, and the initially constructed sections had to be regraded before the yard was completed.

On completion of construction, the entire yard was sprayed with a calcium chloride solution. This eliminated the watering almost completely and has helped maintain a smooth riding surface. Had the calcium chloride been applied during construction, the additional costs of watering and regrading would have been eliminated.

Harrisburg, Pennsylvania

This terminal has three tracks with 65 car spots and an annual volume of 68,000 lifts (information supplied by Pennsylvania Truck Lines, Inc., 1985). The original yard was expanded to accommodate additional car spots. The terminal was sprayed with waste oil, until that supply was eliminated. The oil controlled the dust, but poor drainage and surface ponding allowed the oil-encrusted surface to spall and form potholes.

The next agent used was emulsified asphalt. This also worked well for a short time but was too expensive to continue repeated applications. The agent being used now is calcium chloride, but its effectiveness has not been investigated yet because of the amount of oil that has built up within the surface of the aggregate. Calcium chloride works best when it leaches into the top 6 in. of aggregate, and an oil-encrusted surface impedes this action.

Morrisville, Pennsylvania

This terminal has two loading tracks with 70 car spots and an annual volume of 78,000 lifts (information supplied by Pennsylvania Truck Lines, Inc., 1985). The terminal was built on an existing rail yard. It has centerline parking between the two loading tracks, and the entire surface is aggregate. A layer of filter fabric was placed under the base to promote drainage and to improve structural integrity.

This terminal also encountered dust problems during construction, and the contractor had to water the surface continually. The filter fabric does an exceptional job of promoting drainage, and the surface dries quite quickly. After completion of construction, the watering was continued. A water truck would operate 8 to 12 hr a day during dry weather just to control the dust. This quickly became an expensive solution. Then a dust control agent, which required a weekly application according to instructions, was used and no additional watering was supposed to have been necessary. However, the effectiveness was marginal and watering was only reduced by 35 percent.

The next control measure tested was placing a layer of washed pea gravel on the surface as a cover. This also worked marginally because the fine material would eventually migrate through the gravel. The last measure was an application of liquid calcium chloride. This still required some watering (2 or 3 times a week) during dry weather. However, after a few seasonal applications of calcium chloride, the need for watering will diminish rapidly because as the calcium chloride leaches into the aggregate it binds the material more effectively. Concurrent with the application of calcium chloride, two sections were cordoned for the testing of other dust control measures. One section had a surface application of MC-30 oil; and the other section had the surface scarified, MC-30 oil applied and mixed into the aggregate, and then was graded and rolled. Both sections controlled dust as well as the calcium chloride, but after a few months these sections became more rutted than the rest of the surface.

Although the pea gravel was ineffective as a dust control agent, it did provide a benefit in the reduction in the formation of potholes. Many of the potholes in the loading area appeared in a straight line parallel to the loading track. The cause of the potholes was the loading machine itself. This yard uses Raygo-Wagner PC-90s that have dual rear tires on one strut and provide the steering. As opposed to turning while moving, these wheels are frequently turned while stationary, and their ribbed tires do a fairly efficient job of drilling holes in the surface. Refitting with smooth tires has reduced this effect. The use of pea gravel further diminishes this effect by absorbing the frictional forces between tires and the surface. Periodic grading maintains an even distribution of gravel and provides a smooth riding surface.

Snow removal produced an unanticipated event. The snow is plowed into piles at regular intervals throughout the terminal in locations where it will not impede the operation. When the snow melts, piles of gravel are left as residue. This gravel can be regraded over the surface.

Portside, New Jersey

This terminal has three loading tracks with 51 car spots and an annual volume of 59,000 lifts (information provided by Pennsylvania Truck Lines, Inc., 1985). This terminal handles mostly containers for transfer to Port Elizabeth and Port Newark. The yard has an aggregate surface but a generally poor subgrade. The entire marine terminal area has been constructed on reclaimed marshland, and it is not uncommon to see undulations in the surrounding roadways because of uneven settlement.

The terminal has no drainage, which causes severe operating problems during wet and cold seasons. Frequently, there are sections that remain underwater for months. This is followed by severe rutting when the surface becomes muddy, and then the surface becomes extremely dusty in dry seasons because any dust control agent has been washed away. This situation is caused by a clogged drainage system and fouled ballast under the loading tracks, which prevents surface runoff. The existing drainage system is a french drain that is partly clogged by the use of oil as a dust control agent. There are plans to resurface the terminal and install a new drainage system. Because of the poor subgrade, an aggregate surface is more practical at this location. When undulations do appear on the surface it can be regraded. A rigid or flexible pavement would require expensive resurfacing.

Springfield, Massachusetts

This terminal has two tracks with 52 car spots and an annual volume of 55,000 lifts (information supplied by Pennsylvania Truck Lines, Inc., 1985). This terminal was built on an existing rail yard adjacent to the existing circus ramps. It has centerline parking between the two loading tracks and the entire surface is aggregate.

Calcium chloride is effectively used for dust control. The yard surface is well consolidated but still requires some replenishment material. There is a grader in the terminal operated by the maintenance personnel, which does periodic grading. In the past, some improper grading was done that allowed some water to pond on the surface. This is a correctable problem.

Worcester, Massachusetts

This terminal has two loading tracks with 48 car spots and an annual volume of 37,000 lifts (information supplied by Pennsylvania Truck Lines, Inc., 1985). The loading area is bounded by the two loading tracks, and the surface is aggregate. Trailer parking is located by the former circus ramp tracks.

Pea gravel is used effectively as a replenishment material in the loading area. The surface is pliable but never ruts. Calcium chloride is used for dust control, but there were problems with the application. The calcium chloride was spread in dry flake form and then sprayed with water. If applied this way, meticulous care is necessary. First the flakes or pellets must be spread evenly or coverage will not be complete, and, second, the water must be sprayed immediately after the calcium chloride is spread. In one instance, the calcium chloride was not sprayed with water until the next day, and the dust that formed between days caused some eye irritations. The best and most effective method is to spray the calcium chloride in liquid solution.

The access roadway from the gate to the loading area also had an aggregate surface and had calcium chloride applied. However, vehicles on this roadway frequently exceed 30 mph. The dust could not be contained under these conditions, and the roadway was paved with asphaltic concrete on a base that was well consolidated as a result of the application of calcium chloride.

LESSONS

The problems discussed have occurred at other Conrail intermodal terminals, and similar solutions have been used to rectify these problems. It may appear that all these problems justify the extra expenditure involved in using asphaltic concrete or portland cement concrete. However, if a regular maintenance schedule is adhered to, there will generally be fewer problems than with other pavement designs.

Portland cement concrete is quite durable, but a deep section (8 to 12 in.) with reinforcement is required to prevent cracking. This can be expensive and construction is generally limited to the trackside loading area where trailers are placed or the traversing strip for the wheels on overhead cranes.

Asphaltic concrete is also durable and requires and 8- to 10-in. depth when placed on a well-compacted base. Because this is a flexible pavement undulations can occur in the surface, and the landing gear on trailers makes impressions in the surface when not gently lowered either by mechanical loaders or tractors. Many of the Conrail terminals that have asphalt pavement require annual repairs of potholes, and some terminals need a complete overlay of 2 to 4 in. (average 10-year life cycle).

Repairs of rigid and flexible pavements are more disruptive to terminal operations than any regular maintenance procedures for an aggregate surface. Rigid and flexible pavements also are allowed to reach higher levels of deterioration before improvements are made because repairs are more costly. Most problems with an aggregate surface can usually be solved with a little grading.

CRITERIA

The following criteria for construction of an aggregate wearing course are beneficial to the maintenance and operation of the terminal:

1. Use of a dust control agent during construction. There are numerous agents available for dust control, and the most common are oil, emulsified asphalt, lignin sulfonate, calcium chloride, and water. The application can be by surface penetration, admix with the aggregate, or surface blanket.

Oil and emulsified asphalts are effective dust control agents because they form a hard crusted surface. These are fine for open roadways but cannot withstand the abuse in a terminal loading area. If the crust is broken potholes will form, and the only effective method of repairing the surface is to scarify the surface, reapply the agent, and grade and roll the aggregate.

Water as an agent is extremely short lived and requires constant applications. Continuous watering in the absence of any other agent will weaken the stability of the surface and allow rutting of the surface. There are also some so-called wetting agents that retain the water on the surface and retard evaporation. These were found to be only marginally better than water.

Calcium chloride and lignin sulfonate are naturally formed agents that have similar characteristics. They both absorb moisture and retain it, leach into the aggregate and provide greater soil stability, and allow the surface to remain pliable. The choice for the Conrail intermodal terminals is calcium chloride because it is readily available in the regions where the terminals are located.

Calcium chloride should be applied in solution by a truck with a spreader spray bar. This ensures even distribution of material and allows penetration of the surface. Surface penetration is the preferred method of application because dust only applies to the top 2 in. of material. Admixing with the aggregate will provide more stability but is also more expensive.

The dust control agent should be applied to sections during construction not applied once at the completion of construction. This will eliminate constant watering and its inherent problems and minimize disruptions during construction.

2. Control of trailer placement in the terminal. The use of an aggregate surface does not allow pavement markings to identify trailer parking spots and loading locations. However, as stated previously, an aggregate surface is best suited for midvolume terminals that generally do not require exact location identification for control of trailer movement. Trailer parking can be identified by sections with signs on poles. In one of Conrail's yards, a double row of trailer parking was separated by a concrete median barrier (as on highways) to provide uniform rows and prevent trailers from being backed into each other. Trailer parking spot numbers can be painted on these barriers.

3. Access roadways should be paved with asphaltic concrete. Speeds in the loading and parking areas are in the range of 5 to 15 mph, but, on access roadway, speeds can exceed 30 or 35 mph and at these speeds even the best dust control agent can lose its effectiveness. It should be noted that paving with asphaltic concrete is also a dust control method.

4. Construction cost differentials. An aggregate wearing course should be 1 1/2 or 2 times the thickness of an asphaltic concrete wearing course depending on the stability of the base course. If the asphaltic concrete wearing course is 8 to 10 in., an aggregate wearing course will be 12 to 20 in. Typical 1984 costs are $2.50 per inch per square yard for asphaltic concrete and $0.80 per inch per square yard for aggregate. Because paving is one of the major construction items, the differential here can account for a 40 percent difference in overall costs.

Optional construction costs for an aggregate course are filter fabric at $2.85 per square yard and dust control agent (calcium chloride) at $0.40 per square yard for an initial application with a 38 percent solution.

Changes and possible downgrading of the drainage system because of reduced runoff were not quantified.

Periodic maintenance of the aggregate surface is also necessary, and the following criteria have been formulated on a trial-and-error basis:

1. Dust control. The preference is for the use of calcium chloride or lignin sulfonate. Two applications should be made yearly: one in the spring and the other in midsummer. These agents will leach into the soil so a periodic application is necessary to cover the surface. Leaching does not mean the loss of the agent but an increase in the penetration of the agent into the aggregate to provide greater soil stability. After repeated applications, the density of agent in solution can be decreased because of the buildup of the agent in the aggregate. During long dry seasons, an occasional watering of the surface may be required to revitalize the properties of these agents. Annual cost for two applications of 34 percent calcium chloride solution is $0.70 per square yard (1984 prices).

2. Periodic grading of the surface. Because the surface of the aggregate will not become completely hard with the use of these dust control agents, some surface material may be shifted and will be manifested in the formation of ruts, potholes, and possibly a washboard effect on the surface. Periodic grading (preferably every 2 or 3 weeks) will prevent problems even if they are not apparent. If these problems persist long enough, the only way to correct them is to scarify the surface and regrade. Annual grading cost is $0.75 per square yard (1984 prices).

Conrail maintains graders, which are operated by terminal personnel, in their intermodal terminals. This is a preferable method because grading can then be done during slack operating periods. Care should be taken to maintain the slope of the surface so the surface runoff will not be impeded or low spots formed that will create puddles.

3. Replenishment of surface material. Small amounts of material will be continually lost for many reasons. Therefore additional material will be

needed to maintain the surface. In general, the same material as was used for the original construction is acceptable. It should be well graded, and, if enough material is applied, it should also be rolled. Annual cost for replenishment of aggregate is $0.40 per square yard (1984 prices).

Another option is the use of pea gravel (about 1/4 in. thick) as a cover material. This has been used in a few terminals as a dust control measure (surface blanket) with limited success. Calcium chloride is used for dust control in these terminals. However, the pea gravel provides a flexible surface. Vehicles leave tracks in the gravel, but the gravel is easily redistributed by the next vehicle. A smooth riding surface is provided because the material conforms to the track of a wheel and will not form hard indentations such as ruts and potholes. An occasional light grading maintains an even distribution of the gravel.

4. Differential in maintenance costs. An aggregate course requires dust control (calcium chloride at $0.70 per square yard), grading ($0.75 per square yard), and replenishment material ($0.40 per square yard) for an annual maintenance cost of $1.85 per square yard (1984 prices). The surface area to be maintained is approximately 70 percent of the terminal area. The 30 percent remaining area is devoted to parking, which requires maintenance about every 3 to 5 years.

An asphalt surface in the terminal generally requires the equivalent of a 2-in. overlay every 10 to 12 years. This is a combination of pothole repair and resurfacing. A 2-in. overlay at 1984 prices cost $5.00 per square yard.

CONCLUSIONS

An aggregate surface for an intermodal terminal is an attractive, cost-effective alternative to other pavement designs. In addition to the cost reduction in material, an aggregate base will absorb some rainfall thereby reducing runoff. This translates into a less costly drainage system and possibly a smaller detention basin. Maintenance procedures may appear to be costly and time consuming, but aggregate is easier to maintain than is an asphalt surface. Maintenance of an asphalt surface usually occurs when surface deterioration has caused a safety hazard and costly repairs are required. Rigid pavements are expensive and used only in limited areas, leaving large areas for other surface paving treatment.

The Conrail terminals, with an aggregate surface, operate efficiently with the proper maintenance procedures and, indeed, are some of the most productive terminals in the Conrail system.