UNI-GROUP U.S.A.

MANUFACTURERS OF UNI PAVING STONES

PIER IX TERMINAL CASE STUDY

PROJECT:
Pier IX Terminal
(formerly Massey Coal Terminal)
Newport News, Virginia

PROJECT ENGINEERING FIRM:
Daniel Engineering
Greenville, South Carolina

PAVEMENT DESIGN ENGINEER:
Brian Shackel, Ph.D.
Sydney, Australia

GENERAL CONTRACTOR:
McLean Contracting, Co.
Newport News, Virginia

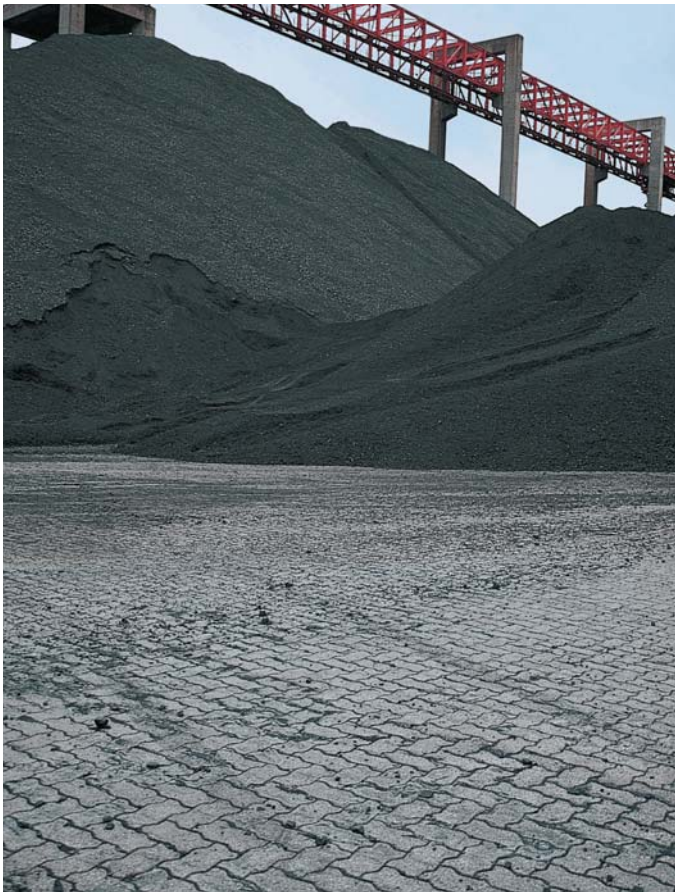
CONCRETE PAVER MANUFACTURERS:
Balcon, Inc.
Crofton, Maryland
Monier, Ltd. (Australia)
Manufactured on site, Newport News, VA

PAVERS:
3 1/8" (80 mm) UNI-Stone® - 610,000 sf

The Pier IX Terminal (formerly Massey Coal Terminal), a computer-controlled trans-shipment facility incorporating ground storage of coal, started construction in April 1981 and began operations in December 1982. Two parallel stacking conveyor systems can place up to 1.4 million short tons of coal in up to 12 separate 100-foot high stockpiles in the 32-acre coal yard. The Pier IX Terminal operates 24 hours a day and is capable of handling 12 million tons of coal per year.

Successful operation of the Pier IX Terminal is dependent on their capability to reclaim essentially all coal from ground storage and their ability to clean out a stockpile containing one type of coal so that another type can be stored without contamination. The ground storage of coal is the most important aspect of Pier IX, thereby allowing railroad and ship operations to function independently.

The decision to build the ground storage facility and use underground reclaim conveyors, as opposed to bucket wheel stacker-reclaimers, resulted in the problem of how to surface the coal yard. A mobile equipment fleet, consisting of tracked dozers for operation primarily on the coal piles and wheeled loaders utilized for cleaning up coal on the yard surface, was needed to move coal. As a result, a surface was required that would not only act as a barrier between the coal and the earth, but also sustain heavy wheel loads and occasional tracked dozer traffic traversing the yard for transferring between stockpiles, refueling, and maintenance.



A summary analysis from the report "Considerations on the Choice of Concrete Block Paving at Massey Coal Terminal, Newport News, Virginia" by former Massey Coal Terminal Vice President and Project Director Gerald R. Brunstrom is shown and highlights the major factors considered in choosing interlocking concrete pavers over eight other pavement types. Mr. Brunstrom maintained that although the analysis was helpful, in the end it was Massey's judgment that pavers would perform best under the harsh conditions.

Out of 1.4 million square feet of yard area, approximately 610,000 square feet is paved with UNI-Stone® interlocking concrete paving stones over a soil cement base, while the remaining area is paved with soil cement only. The pavers were utilized in the northern section of the yard where the highest turnover of the coal stockpiles would occur. UNI-Stone® pavers also were installed in the parking area in front of the firm's offices and in the vehicle maintenance area.

In his report, Mr. Brunstrom revealed that the Pier IX Terminal site is underlain with fine sand, silt and clay deposits with high moisture content and is highly susceptible to large settlements under heavy loads. In order for the coal to be stockpiled to 100 foot heights, this material had to be consolidated with the Dynamic Consolidation method performed by Menard-ECI. Even with the intensive soil consolidation, projections of differential settlement of up to 30 inches in 200 feet were projected under the stockpiles along the central portion of, and at each end of the tunnels. Therefore, it was imperative that the pavement withstand the differential settlement while maintaining structural integrity, as breakup of the pavement would result in contamination of the coal. This was a primary consideration in the selection of the UNI-Stone® interlocking concrete pavers.

SUMMARY ANAYSIS OF PAVEMENT ALTERNATIVES

FACTORS CONSIDERED	TYPE OF PAVEMENT								
	1	2	3	4	5	6	7	8	9
Prevent Contamination	Excel	Excel	Excel	Excel*	Excel	Fair	Poor	Poor	Poor
Allows Cleanup of Coal	Excel	Excel	V. Good	Excel*	Excel	Fair	Poor	Poor	Poor
Ability to Adjust to Differential Settlement	Excel	Excel	Fair	Poor	Fair	Good	Good	Good	Good
Ability to Carry Heavy Wheel Loads	Excel	V. Good	Good	Excel	Good	Good	Good	Fair	Fair
Resistance to Tracks & Dozers	V. Good	Good	Poor	Good	Poor	Good	Good	Good	Good
Resistance to Breaking Up & Coal Contamination	Excel	V. Good	Good	Fair	Fair	Good	Poor	Poor	Poor
Impermeability	Excel	Excel	Good	Excel*	Excel	Poor	Poor	Poor	Poor
Ease of Repair	Excel	Excel	Fair	Poor	Good	Excel	Excel	Excel	Excel
Resistance to Acid Water	V. Good	V. Good	Good	Good	Good	Good	Good	Good	Good
Surface Drainage & Runoff	Excel	V. Good	Excel	Excel	Excel	Fair	Poor	Poor	Poor
Weather Durability	Excel	Excel	V. Good	V. Good	V. Good	Fair	Fair	Fair	Fair
Expected Life (years)	20-25	15-20	10-15	20-25*	10-15	10-15	10-15	10-15	10-15

**If significant differential settlement does not occur. If it does, rating is poor.*

PAVEMENT TYPES
1. Interlocking Concrete Block Pavers over Soil Cement
2. Interlocking Concrete Block Pavers over Crushed Stone
3. Soil Cement Only
4. Reinforced Concrete
5. Bituminous Concrete over Crushed Stone
6. Crushed Limestone
7. Crusher Run Stone
8. Middling Coal
9. Marketable Coal

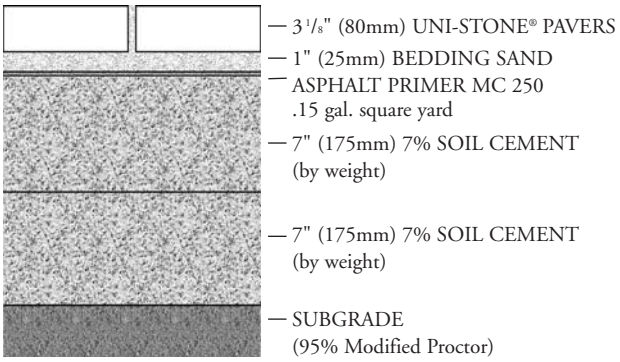
The interlocking concrete pavement at Pier IX was designed by internationally-renowned pavement expert Dr. Brian Shackel, currently department head of the School of Engineering, University of New South Wales, Sydney, Australia and author of the book "Design and Construction of Interlocking Concrete Pavements." The pavement design selected was based on soil conditions at the terminal and a wheel load of 20 short tons with 120 pounds per square inch tire pressure. To accommodate the maximum loading, 3 1/8-inch (80mm) thick UNI-Stone® pavers with a 14-inch thick soil cement base, applied in two 7-inch lifts was specified. For maximum performance and stability, the pavers were installed in a herringbone pattern. Mr. Brunstrom indicated in his report that the soil cement only pavement used over the remainder of the facility was planned for an intermediate period, with the intention of installing interlocking pavers at a later date, based upon performance of the UNI-Stone® pavers.

The UNI-Stone® interlocking concrete pavers specified for the project were manufactured by Balcon, Inc. of Crofton, Maryland, a member of UNI-GROUP U.S.A., and Monier Ltd., an Australian UNI® producer. With over 25 years experience in interlocking concrete pavement design and manufacture, UNI® Paving Stones have built a reputation for unsurpassed quality, durability, and proven performance. Balcon supplied approximately 200,000 square feet of the pavers, with Monier producing the rest at a plant set up on site. Since 1983, Interlock Paving Systems, Inc. of Hampton, Virginia has serviced Pier IX's pavement needs.

UNI® Paving Stones are manufactured to the highest quality standards to meet or exceed ASTM C-936 specifications. When tested in accordance with ASTM method C-140, the UNI-Stone® pavers delivered to the Pier IX Terminal worksite were not permitted to be less than 8000 psi, with no individual unit less than 7,200 psi, and the average absorption was not to be greater than 5%, with no individual unit greater than 7%. The manufacturer had to demonstrate that the units had adequate freeze-thaw resistance for the Newport News area. When tested in accordance with ASTM method C-418, the UNI-Stone® samples were not permitted to have a volume loss greater than 15 cubic centimeters per 50 square centimeters with the average thickness loss not to exceed 3mm.

The installation of the UNI-Stone® interlocking concrete pavers began on October 26, 1982, and was completed in three and one-half months on February 9, 1983, with allowances for winter weather and holidays. Installed manually by a crew of 20 men, the pavement encompasses an area approximately 1,000 feet in length and varying in width from 400 to 700 feet.

CROSS-SECTION PIER IX TERMINAL INTERLOCKING CONCRETE PAVEMENT



Following an early November 1990 visit to inspect the Pier IX facility, Raymond Rollings, Ph.D., P.E., and Marian P. Rollings, Ph.D., P.E., noted U.S. authorities on pavement design, evaluated the UNI-Stone® interlocking concrete pavement in a report prepared for Interlock Paving Systems, Inc. Observing the facility in action, the Rollingses noted severe impact loads from dropping coal and dozers backing down from coal piles onto the paver surface, as well as strong horizontal forces applied to the UNI-Stone® pavers by the blades of the dozers and buckets of the front-end loaders as they move coal.

In addition, the Rollingses found that the pavement in the central drainage swale of the coal storage area was constantly exposed to an aggressive chemical environment due to the necessity of continually spraying the coal piles with water to control dust. They believed that some deterioration due to sulfate and possibly acid attack had apparently occurred, however, they pointed out that all concrete was susceptible to this problem, and the fact that the pavers had resisted the attack for this length of time indicated that they were originally made with high-quality concrete. Furthermore, the Rollingses maintained that the other pavement methods considered also would have been subjected to the chemical attack and/or could not withstand the load, impact, and differential settlement concerns of the project, and that "alternative pavement surfaces probably could not have provided the level of service that blocks have provided at Pier IX."

The Rollingses stated that based on conversations with Pier IX personnel and observations during their visit, the performance of the UNI-Stone® interlocking concrete pavers "has been noteworthy under extremely severe conditions." The Rollingses indicated that although some breakage of the units had occurred due to impact loading of the dozers, they had remained in place and functional. They said that abrasion damage was minimal, except at the maintenance building where concentrated dozer traffic with unpadded grousers resulted in severe abrasion. However, they noted that similar or worse wear would be expected on any concrete thus exposed and that the UNI-Stone® pavers had remained interlocked and still supported current traffic loads. Furthermore, they added that the modular nature of the pavers allowed for easy access and repairs if needed.

Please Note: Pavement design varies with climate, available construction materials, design methods, soil conditions and traffic load. A qualified engineer, architect, and/or landscape architect should be consulted in concrete paver applications to ensure desired results.

In April of 1991, UNI-GROUP U.S.A. manufacturers from across the United States visited the Pier IX Terminal for a tour of the facilities by Roger Doll, Superintendent of Operations and Ed Wolfington, Facility Engineer. In their talk with the group, Mr. Doll and Mr. Wolfington discussed the performance of the UNI-Stone® pavers and the possibility of paving the reminder of the facility with UNI® interlocking pavers. They revealed to the group that the soil cement only pavement had suffered sulfate attack deterioration to a considerable depth and repairs to this area would be difficult. An underground storage tank was under construction at the time, and Mr. Doll pointed out the benefit of being able to lift out the pavers and replace them after work was completed.

After 9 years of severe impact loads and heavy unpadded tracked dozer traffic, the UNI-Stone® pavers still support current traffic

Mr. Doll and Mr. Wolfington expressed interest in working with Interlock Paving Systems on the manufacture of a more sulfate/acid-resistant paver for the conditions existing in the coal storage area, and offered test sites for various mix designs. Mr. Wolfington indicated that physical changes in drainage design or environmental control also might be necessary to alleviate the specific situation in the coal storage area. They acknowledged that the UNI-Stone® pavers had been subjected to extreme abuse and unusual conditions, including some uses that had not originally been intended, and that they have performed exceptionally well under harsh circumstances.

References:

Considerations on the Choice of Concrete Block Paving at Massey Coal Terminal, Newport News, Virginia by Gerald R. Brunstrom, April 1984.

Examination of Pier IX Pavement, Newport News,Virginia by Raymond S. Rollings, Ph.D., P.E. and Marian P. Rollings, Ph.D., P.E., November 1990.

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