CIVIL ENGINEERING APPLICATION
OF TDA
DIXON LANDING ROAD ON-RAMP
HIGHWAY 880
MILPITAS, CALIFORNIA

June 2, 2007

Prepared for:

California Integrated Waste Management Board
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Sacramento, California 95812

Prepared by:

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IT Project No.: 809931

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1.0 Introduction

This report summarizes the activities associated with the construction of a portion of the south bound on ramp using recycled Tire Derived Aggregate (TDA) material at the recently completed Dixon Landing Road, Highway 880 interchange improvements in Milpitas, California. This project represents the first time the California Department of Transportation (Caltrans) used TDA as a lightweight fill material in highway construction. A location map of the Dixon Landing Road area is provided as Figure 1. The IT Corporation (IT) was contracted by the California Integrated Waste Management Board (CIWMB) to supply TDA for the Project. IT also provided engineering oversight of the delivery and placement of the TDA, and installed temperature and settlement monitoring devices.

The purpose of the project was to demonstrate a civil engineering application of recycled tires. In this case, the tires were used as a relatively lightweight fill material to minimize anticipated settlement within the compressible "bay mud" clays underlying the new southbound on-ramp. It is believed that tires will provide a low cost, partial mitigation for this geotechnical condition. The use of recycled tires will also provide benefits in waste minimization and reduced solid waste disposal.

The project began in 1998 when the CIWMB initiated communications with the Caltrans to identify potential applications and suitable sites for demonstrating shredded tire applications.

The design basis for using shredded tires is detailed in Section 2.0. The interagency coordination, both with Caltrans and regulatory agencies, is summarized in Section 3.0. The CIWMB issued an incentive contract in May, 2000 to provide shredded tire materials for the Dixon Landing Road project. The construction portion of the project began in mid-June 2001, and continued through August of that year. The tire fill demonstration was a relatively small activity within the overall Dixon Landing Road improvements. The location of the TDA embankment within the larger improvements is shown on Figure 2. The specific tasks associated with the TDA project included material acquisition and quality control (Section 4.0), performance monitoring (Section 5.0), and construction oversight (Section 6.0).

Section 7.0 of this report provides recommendations for performing similar projects in the future (based on the experience gained during this first demonstration effort). Section 8.0 provides design considerations for transportation engineers who may wish to explore shredded tire applications for future projects.

2.0 Case history – Dixon Landing, California

The project is located in Milpitas, California at the intersection of I-880 and Dixon Landing Road. The site is underlain by about 30 ft of San Francisco Bay Mud, so lightweight fill was specified for most fill sections to reduce total settlement. The project owner is the California Department of Transportation (Caltrans).

Two sources of lightweight fill were considered: TDA with an in-place unit weight of 50 pcf and lightweight aggregate with a unit weight of about 60 pcf. TDA were chosen for the onramp that will carry traffic from Dixon Landing Road to the southbound lane of I-880. They were chosen because they had a lower unit weight than the lightweight aggregate and because they were expected to be less expensive.

TDA were supplied through an Memorandum Of Understanding (MOU) between the California Integrated Waste Management Board (CIWMB) and the California Department of Transportation (Caltrans). The CIWMB was responsible for procuring the TDA and having it delivered to the site. TDA were required to be delivered at a minimum rate of 300 tons/day. Some of the TDA were delivered in advance and stockpiled at a nearby landfill to facilitate delivery in this traffic congested area. In total, 6627 tons or 662,700 passenger tire equivalents (PTE) of TDA were used for this project

Project design

a. The TDA were placed in two layers, each up to 10 ft thick to meet the guidelines to limit heating of embankment heating. The layers were separated by 3 ft of low permeability soil. A typical embankment cross section is shown in Fig. V-8 and a longitudinal section is shown in Fig. V-9.

b. At station 103+90 the embankment applied a vertical stress of 2250 psf to the foundation soil compared to 3750 psf for an embankment constructed with conventional earth fill. This is a 40% reduction in vertical stress.

c. Conventional lightweight fill was used beneath the bridge abutment as shown in Fig. V-9. This would allow the piles for the bridge abutment to be driven through the volcanic pumice rather than TDA. Moreover, the dynamic properties of the TDA are not fully understood so there were concerns with TDA being required to support the bridge abutment during an earthquake.

. TDA were placed with conventional construction equipment. The construction process is shown in Figs. V-10 through V-17.

.	Unit cost comparison

- Cost for common borrow = $7.48/yd^3$
- Placement costs of shreds (including geotextile) = $3.74/yd^3$
- Purchase & delivery costs of shreds (paid by CIWMB) = $23.66/yd^3$
- In-place cost for shreds = $27.40/yd^3$
- In-place cost for lightweight aggregate = $50.00/yd^3$

1. Cost savings – the cost savings to Caltrans was $477,000 compared to using lightweight aggregate for the project. When the purchase price of the TDA is subtracted, the cost savings is still $230,000. This shows that TDA can be a cost effective alternative to lightweight aggregate.

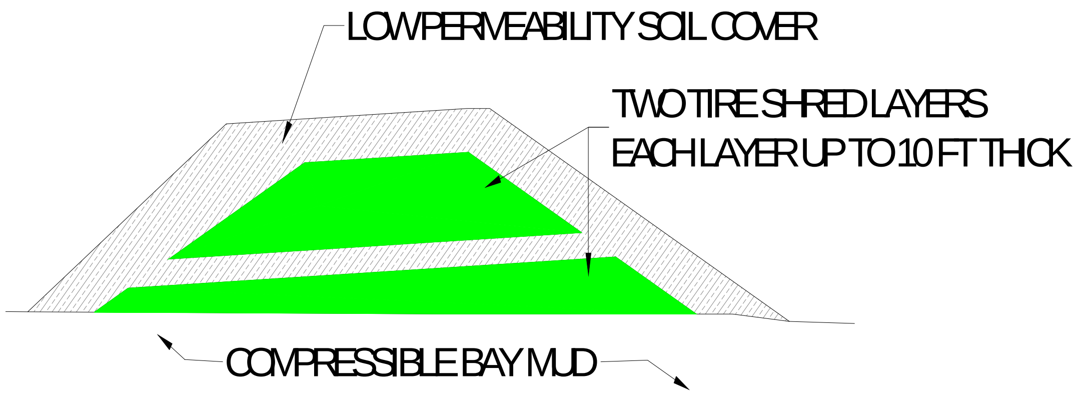

Fig. V-8. Typical cross section, Dixon Landing Interchange.

Fig. V-9. Longitudinal section, Dixon Landing Interchange.

3.0 Interagency Coordination

The Dixon Landing South Bound on-ramp project was constructed through a cooperative agreement between Caltrans and the CIWMB. The two agencies entered into a Memorandum of Understanding (MOU) (Appendix H) which outlined that the CIWMB would supply the Tire Derived Aggregate (TDA) at no charge to Caltrans along with instrumentation and construction over site assistance.

4.0 Material Quality Control

4.1 Material Description

The TDA material selected for use on the project was intended to comply with the criteria identified in the guidance document entitled 'Civil Engineering Applications of TDA' (by Dr. Dana Humphrey, Ph.D., P.E., 1998).

Technical specifications used to select and approve TDA materials for construction defined the materials as follows:

- The TDA shall be made from waste tires that shall be shredded into the sizes specified herein. They shall be produced by a shearing process. TDA produced by a hammer mill will not be allowed. The TDA shall be free of any contaminants such as oil, grease, gasoline, diesel fuel, etc., that could leach into the groundwater or create a fire hazard. In no case shall the TDA contain the remains of tires that have been subjected to a fire. The TDA shall be free from fragments of wood, wood chips, and other fibrous organic matter.

- The TDA shall have less than 1 percent (by weight) of metal fragments that are not at least partially encased in rubber. Metal fragments that are partially encased in rubber shall protrude no more than 25 millimeter (mm) (1-inch) from the cut edge of the TDA on 75 percent of the pieces (by weight) and no more than 50 mm (2-inch) on 100 percent of the pieces (by weight).

- At least one side wall shall be severed from the tread of each tire. A minimum of 90 percent (by weight) of the shreds shall have a maximum dimension, measured in any direction, of 300 mm (12-inch); and 100 percent of the shreds (by weight) shall have a maximum dimension of 450 mm (18-inch).

The TDA shall meet the following grading requirements.

Sieve Sizes	Percentage Passing (by weight)
300-mm (12-inch)	100
200-mm (8-inch)	75 – 100
38.1-mm (1.5-inch)	0 – 25
4.75-mm (No. 4 sieve)	0 – 1

The gradation shall be measured in accordance with the methods for testing the quality of materials and work developed by the California Integrated Waste Management Board (CIWMB).

Due to difficulties by one of the suppliers in achieving full compliance with the above requirements, the material specifications were modified as follows:

- The TDA shall have less than 1 percent (by weight) of metal fragments that are not at least partially encased in rubber. No more than 25 percent of the shreds by weight shall have metal fragments protruding more than 25 mm (1 in.) from the cut edge of the shreds. Shreds retained on a 75-mm (3-in.) square sieve with isolated protrusions of metal fragments greater than 25 mm (1 in.) shall be excepted from meeting the preceding requirement, and shall not be included in the weight of shreds with metal fragments protruding more than 25 mm (1 in.) from the cut edge of the shred. The maximum allowable protrusion of metal fragments from the cut edge of the shreds is 100 mm (4 in.).

A reduced quantity of material was received from that vendor and intermixed with other materials received at the site.

4.2 Procurement of Materials

IT Corporation (IT) was contracted by the CIWMB to provide shredded tire material for the project. As part of this activity IT's staff identified potentially qualified suppliers, in consultation with the CIWMB staff, and contacted the tire recycling vendors to solicit interest in the project.

A detailed scope of work was developed and provided to interested suppliers. A copy of the bid package is contained in Appendix A. IT intended on awarding more than one subcontract to qualified suppliers due to the large quantity of material needed in Caltrans' estimate and to provide flexibility in delivery schedules during construction.

Following vendor discussions at a pre-bid conference and receipt of bids, IT performed a facility inspection at each of the responsive bidders' recycling facilities and collected samples of TDA for prequalification testing.

Based on vendor bids, results of the prequalification tests, and IT's judgement as to the capabilities of the selected vendors to supply adequate quantities of material during the anticipated construction schedule, IT awarded subcontracts to two vendors (Waste Recovery West and Chicago Grade Landfill). Waste Recovery West subsequently identified a second tier supplier (Lakin Tire West) to provide a portion of their contracted volume.

4.3 Pre-Delivery Sampling and Testing

As part of the vendor contracts, IT staff visited each of the three suppliers' facilities prior to initiation of site construction and collected samples of material that was being generated and intended for delivery to the job site. Contract terms identified a sampling frequency of one test per 250 tons of material. A total of 26 samples were collected from the vendors during this phase of the project. Test results are provided in Appendix B.

When possible, the samples were collected by placing baskets directly under the shredder discharge as the material was produced. This ensured a representative sample of the production process, including any miscellaneous fines (i.e. wire, dirt, etc.), would be captured. Where material had already been produced, samples were collected from within the stockpiles at the facility. Both Chicago Grade and Waste Recovery West maintained segregated stockpiles of material intended for use on the project.

Lakin Tire West did not have facilities available to store TDA. The material was placed in transport trailers immediately after shredding for off site delivery. In this case samples were collected from the regular daily production during a facility visit.

Based on the results of these tests, IT informed the CIWMB that the Chicago Grade materials did not meet the original material specifications. In consultation with Dr. Dana Humphry (CIWMB's technical consultant), the modified specification quoted in Section 4.1 was formulated for the Chicago Grade tires.

4.4 Field Sampling

TDA material delivery began in mid-June 2001 and continued through July 31 2001 (reference Section 6.0 - Construction Placement). During delivery, the majority of TDA were placed directly at the road embankment from trucks arriving from the three material supplier facilities. A limited amount of material was temporarily staged at a designated location on property owned by the nearby Newby Island Landfill.

Field sampling of materials arriving at the site was intentionally limited due to the fact that much of the material designated for delivery had already been shredded and sampled at the suppliers' facilities prior to the beginning of construction. A total of 12 samples were collected at the construction site and test results are included in Appendix C.

All deliveries were visually inspected by the IT field engineer to ensure the material was free of soil, litter, or other deleterious materials. Samples were periodically collected from deliveries to the fill embankment by shoveling material into the sample basket immediately after the truck had unloaded on to the fill mat. As the Lakin Tire West facility did not generate a stockpile of material prior to beginning construction, deliveries from this supplier were sampled relatively more frequently in the field.

5.0 Performance Monitoring Devices

5.1 Introduction

As part of the demonstration project, several monitoring technologies have been installed to provided long term data on the performance of the TDA fill material. Monitoring includes temperature sensors to detect thermal effects within the TDA, settling plates to provide measurements of deformation within the TDA fill. A total of 41 monitoring devices were installed during the TDA placement, which consisted of 31 temperature sensors and 10 settlement plates.

5.2 Temperature Sensor Description

Temperature Sensors are vibrating wire temperature sensors supplied by ROCTEST. The actual device is a thermal resistor, attached to wire. Each sensor is calibrated at the factory and checked before installation.

Four control stations are mounted in boxes located at the toe of the embankment slope (see Figure 3). Each station has a set of four to six temperature sensors buried within the TDA fill that are attached through wires. The Control Station consists of two 4 x 4 posts supporting a piece of ¾-inch plywood that has the actual control box mounted on to it (see Figure 4). Each control box is labeled with the corresponding temperature sensors for that particular station. The control box is also attached to a grounding rod. The typical layout and wiring connections of the control boxes are shown on Figure 5. In this way the temperature sensors are protected from possible lightning strikes on the monitoring boxes.

5.3 Settlement Plate Description

The settlement plates are composed of two-foot square, ¾-inch thick plywood with a galvanized pipe flange attached in the center of the upper surface. Two-inch diameter galvanized pipe is then threaded into the flange in 1.2 meters (5 feet) sections. The galvanized pipe is then enclosed with four-inch diameter ABS piping as a protective sleeve (see Figure 6). The bottom 0.6 to 0.9 meters (2 to 3 feet) of galvanized two-inch piping is left uncovered by the ABS pipe. Riser pipes were maintained a minimum of 0.5 meters (1.6 feet) above the embankment surface. The sleeve was added in 4-foot lengths as necessary to keep the sleeve above the elevation of the fill. Additional lengths were attached with standard couplings and glue. The top of the protective sleeve was capped. As the pipe sections are added, the original elevation of each new pipe section is surveyed and recorded. During subsequent surveys deflections of the top of the pipe from the initial elevation will provide evidence of settling and/or deformation of the embankment fill and underlying soils.

5.4 Construction and Placement of Devices

5.4.1 Temperature Sensors

The temperature sensors were installed at the locations (stations) shown on Figures 7 through 10. The lead wires from the sensors were installed in a 0.3-m (1- foot) deep trench. The trench was then back-filled. To protect the wires, wheeled or tracked equipment should not be driven over instrumentation wires until they are covered by a minimum of 0.6 m (2- feet) of material.

5.4.2 Settlement Plates

The Caltrans General Contractor, Desilva Gates (DG), was originally tasked to install ten settlement plates. As the project progressed, the plates were fabricated and installed by the IT field engineer. The as-built locations of the plates are shown on Figures 8 and 10. Settlement platforms were placed directly on the naturally- deposited inorganic subgrade, prior to placement of embankment fill or on previously placed TDA fill.

Initial surveys were obtained from all monitoring devices. DG was required to perform all maintenance and take all necessary precautions to prevent damage, disturbance or movement, other than normal settlement, of any monitoring device once installed.

Immediately prior to final paving, the steel riser pipe will be cut off below the level of the roadway subbase course gravel. A street box will be installed by the contractor to protect the top of each riser pipe.

DG was advised that the Engineer plans to make survey measurements of each settlement platform at the following times:

1. After initial placement of the settlement platform, prior to placement of any fill in the area
2. At least daily during placement of fill and at least monthly during other periods

3. Before and after the settlement platform riser is cut off in preparation for protecting with a valve box cover

4. Any time that the settlement platform is bumped, damaged, vandalized or otherwise altered

5. At any other times deemed necessary by the Engineer

When the construction was finished three temperature sensors were not functional and the settlement plates were repaired three times.

6.0 Construction Placement and Monitoring

6.1 TDA Placement

TDA were delivered to the project site from June 18, 2001 to July 31, 2001. The average delivery rate was 331 tons per day. A total of 6,628 tons were delivered and placed on site in 20 working days (refer to Appendix D for summary table). Progress photographs of the project are contained in Appendix E.

The TDA were predominantly delivered and placed with walking floor trailers. The walking floor trailers were capable of unloading directly onto the final placement areas. The shreds were then moved into place with a D6 dozer equipped with wide tracks and compacted by a vibrating smooth drum roller.

During construction, most of the TDA material was transported directly from the suppliers' facility to the highway embankment. Previous to the actual construction that began on June 18, 2001, a portion of the tire material was temporarily stored at property within the local Newby Island Landfill. The storage was authorized through an agreement between the Newby Island Landfill (Allied Waste Industries, Inc.) and the tire suppliers.

TDA delivery started on June 18, 2001, but was immediately called off due to permit issues associated with DG and Caltrans. Delivery started again on July 2, 2001. On July 11, 2001 and July 16, 2001, TDA delivery was put on hold for the morning at the request of DG. On July 19, 2001 (Thursday), DG requested no delivery for the following Friday and Monday. On July 31, 2001, DG requested no more TDA be delivered. The termination point of delivery was at least 300 tons short of the predicted final tonnage by Caltrans.

Due to the abrupt decision to terminate delivery, a substantial amount of tire material was temporarily stored at the Newby Island Landfill and was subsequently disposed of at that facility.

6.2 .Preliminary Monitoring Data

6.2.1 Temperature Sensors

The temperature sensors return a value associated with the resistance in the end of the sensor, this value is then used along with the initial calibration value to calculate the actual temperature in degrees Celsius. The formula used is located on the temperature calibration sheets, and in the excel spreadsheet used to tabulate the resulting data. See Appendix F for the temperature sensor calculation sheets.

6.2.2 *Settlement Plates*

The original contract called for DG to build and install the settlement plates. During the initial construction phase IT was informed by CIWMB that we were to build and install the settling plates and that Caltrans was to provide the survey data needed. IT performed the construction and installation of the settlement plates. Caltrans performed the initial survey; the grade-checker from DG and Caltrans performed consequent surveys. To date the data from the initial survey by Caltrans has not been found. Data from consequent surveys by DG were conflicting and therefore not useful in gathering settling data desired. During construction both Caltrans and DG were onsite to survey at various times. After the fact it was discovered that some data points gathered by DG were not shot from a known benchmark. The data points were only relevant to others shot that day and could not be used. See Appendix G for the data summary.

In summary, the settling plates were constructed and installed by IT, the survey points were gathered by both Caltrans and DG, the plates have been damaged and repaired several times by DG during construction, data points from Caltrans have not been submitted to date, data from DG had not been shot from a common bench mark and shot with methods that incurred such high tolerances that the data consequently is not useful for determining the immediate settlement that occurred during construction.

7.0 Recommendations

8.0 Design Considerations

FIGURES

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Figure 1
Site Location Map

Figure 2
Site Vicinity Map

Figure 3
Embankment A Control Box Location

Figure 4
Control Box Installation

Figure 5
Instrumentation Connections

Figure 6
Settlement Plate Diagram

Figure 7
Embankment A Sta. 103 + 90 Sensor Locations

Figure 8
Embankment A Sta. 103 + 60 Sensor Locations

Figure 9
Embankment A Sta. 103 + 20 Sensor Locations

Figure 10
Embankment A Sta. 102 + 80 Sensor Locations

APPENDIX A
REQUEST FOR BIDS AND PROPOSALS

APPENDIX B
TDA TEST RESULTS FOR MATERIALS SAMPLED AT PRODUCER FACILITIES

APPENDIX C
TDA TEST RESULTS FOR MATERIALS SAMPLED AT DIXON LANDING ROAD

APPENDIX D
LOAD TRACKING FORM

APPENDIX E
PROGRESS PHOTOGRAPHS

APPENDIX F
TEMPERATURE SENSOR CALIBRATION SHEETS

APPENDIX G
SETTLEMENT PLATE DATA