**Report No. CDOT-DTD-R-2005-2**
**Final Report**

# APPENDICES

# TIRE BALES IN HIGHWAY APPLICATIONS: FEASIBILITY AND PROPERTIES EVALUATION

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**March 2005**

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**RESEARCH BRANCH**

## APPENDIX A. TIRE BALE APPLICATIONS FOR CIVIL ENGINEERING PROJECTS

Although the use of tire bales in civil engineering applications has been relatively limited to date, they have been used in some other applications. For example, tire bales have been extensively used as wind breaks for livestock on farms. In such applications, tire bales are generally stacked to the desired height, usually 1.2 m to 1.8 m (4 to 6 ft), and are not treated with any particular facing or reinforcing material. Tire bales are frequently used in a similar manner to construct non-structural walls.

The use of tire bales for erosion control has offered good results. However, little published information has been reported on the design criteria for such application. A large project in which tire bales were implemented as erosion control is the restoration project along Lake Carlsbad in New Mexico. A 1,220 m (4000 ft) long section of the shoreline was protected against erosion by the use of tire bales. The bales were laid in a wet concrete leveling pad, and then covered in shotcrete. Backfill material was then placed behind and on top of the treated bales, upon which a pedestrian sidewalk was ultimately constructed. According to reports based on visual inspections of the project, the tire bales have performed extremely well, and plans for use of tire bales in future erosion-control projects along the lake are being undertaken. A view of the tire bales during the construction process is shown in Figure A1.

Another civil engineering application in which tire bales have been used is for the construction of earth dams. For example, tire bales were used as lightweight fill on both the upper and lower sides of the clay-core dam in Mountain Home, Arkansas (Biocycle, 2001). Tire bales were placed in lifts one bale deep; each lift was covered with compacted clay and granular soil. When the desired height was reached, the tire bales were ultimately capped with a layer of compacted soil. Initial reports based on visual inspections of the dam indicate that the bales are performing extremely well.

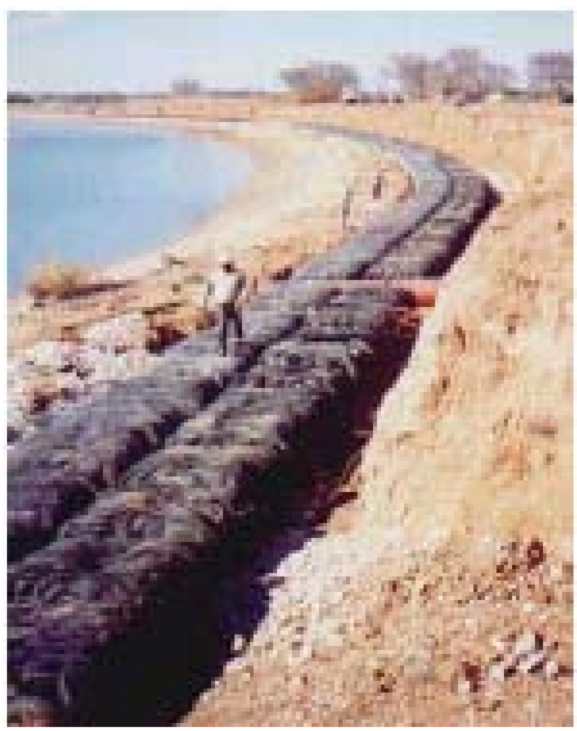

**Figure A1. Tire Bales as Erosion Control (during construction)**

# APPENDIX B. CASE STUDIES OF TIRE BALE APPLICATIONS FOR TRANSPORTATION PROJECTS

## *CASE STUDY 1: SLOPE REPAIR TEXAS*

Tire bales have been reportedly used for remediation of a slope failure in Texas (Richard Williammee, 2002, email communication). Specifications for tire bale embankments are currently under development by the Texas Department of Transportation (See Appendix D). Construction recommendations include placement of a 12 in granular base drainage layer at the bottom of the embankment before placing the tire bales as shown on the typical sections. The granular base layer should be extended sufficiently to allow water to freely drain away from the embankment structure. The specifications also called for embankment construction to minimize infiltration of water and air into the tire bale fill. Use of restraining straps in the longitudinal direction of the roadway is recommended. In addition, the proposed specifications require placement of an 8 inch compacted soil layer between each tire bale layer. Use a soil with a PI less than 35 is required to provide a cushioning layer between successive layers of tire bales. Use of a geomembrane is required over the final layer of the tire bales in order to provide longterm durability to the embankment. Finally, an 18 inch minimum thick mineral soil layer free of organic matter should be placed on the side slopes.

## *CASE STUDY 2: CONDIN ROAD, CHAUTAUQUA COUNTY, NEW YORK*

Condin Road, located in Chautauqua County, NY was originally constructed over wet clay soils in the late 1800s. Ever since, the gravel road has experienced significant problems associated to freeze/thaw cycles each winter. In addition, growing concerns have been reported in Chautauqua County regarding the size of stockpiles of scrap tires. Specifically, many illegal tire dumps within the county had posed a threat to the environment as well as health related problems to the local population. Consequently, action was then taken by the county to use scrap tires productively. Specifically, a research development and demonstration project was permitted by the New York State Division of Environmental Conservation in which tire bales were to be used as replacement sub-grade fill for a portion of the road in 1999 (Scrap Tire News, 2002). A Beneficial Use Determination was issued by the New York DEP in January 2003 (See Appendix 8.5).

The project involved the excavation of 1000 feet of the existing road subgrade, and replacing it with tire bales. After the excavation, a nonwoven geotextile was placed over the in-situ soil. On top of this geotextile, tire bales were placed in a brick-like fashion to form the core of the roadbed structure. Voids within the tire bales were filled with coarse sand, which was compacted using traditional methods (a vibratory roller was used). Finally, three 6-inch gravel lifts were placed on top of the tire bales, with each lift compacted also using vibratory methods. A view of the construction process is shown in Figure B1.

After the first winter following completion of construction of the test section of the road, the results indicated that the test section performed much better than the rest of the road. Significant damage was observed at several locations along the rest of the road, while no damage was observed along the tire bale test section.

According to the Chautauqua County Public Works Director, the section of road that utilized the tire bales performed better through the rain, snow, and heavy traffic than ever before. Although the test embankment was not outfitted with instrumentation, the success of the project has been attributed to three main factors (Encore Systems, Inc.).

> First, while the bearing capacity of the tire bale layers was not quantified, its magnitude is certainly well above that of the subgrade soils.
>
> Second, the good drainage characteristics of the tire bales, which facilitate flow of infiltrating liquids through the tire bales, promoting drainage into lateral trench drains.
>
> Finally, the insulation of the tire bales, which were reported to protect the sub-base from frost-damage.

More than 250,000 waste tires were used in this project. Following this successful application, permits have been granted to implement similar county projects.

Chautauqua County prepared the the following summary “ Utilization of Scrap Tires in Baled Form Used in Roadbed Construction in Conjunction with the Tire Amnesty Program” to describe their experience detail the cost savings associated with their application of baled tires on the sections of roadways completed from 1999 to 2002..

**Figure B2. Construction of a Road Embankment Using Tire Bales as Subgrade**

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**DEPARTMENT OF PUBLIC FACILITIES**
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# Utilization of Scrap Tires in Baled Form Used in Roadbed Construction in Conjunction with the Tire Amnesty Program

## SCOPE AND DESCRIPTION OF PROJECT

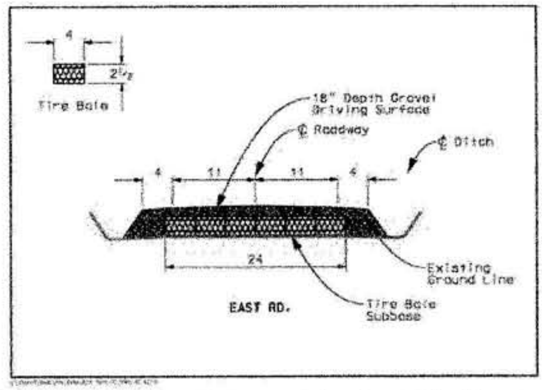
*Clearing Chautauqua County's of scrap tires through a "tire amnesty" program, while beneficially reusing the tires in baled form in roadbed construction as a cost-effective alternative to a typical stone drainage layer when used in areas of marginal (wet) soils.*

## HISTORY OF THE PROGRAM

On April 23, 1995, Chautauqua County faced environmental disaster as millions of tires burned on a rural hillside in the Town of Charlotte. Over the next 72 hours, hundreds of firefighters and highway personnel risked their lives to contain the inferno, operating with near zero visibility because of the dense black smoke. That fire nearly bankrupted several local fire departments and cost the Chautauqua County Department of Public Facilities more than $62,000.

Even before the smoke cleared, County officials made a commitment to never expose the environment, residents or employees to such a risk again. With approximately 10 million tires dumped in the County, a mechanism was needed to clean them up.

Chautauqua County researched the entire scrap tire "industry" including markets such as commercial rubber products, civil engineering applications and fuel substitute/supplements. Tire shredding was investigated and it was determined that the entire investment, not including maintenance, would cost between $3-5 million. The Rubber Manufacturers Association indicated that the market for tire-derived crumb rubber was poor, and the supply exceeded any demand.




Chautauqua County was introduced to the concept of baling whole tires in a visit to a 40 million tire dump in southern Ohio. The operators had purchased a portable baler which hydraulically compressed 100 light truck or passenger tires into a one-ton block. The baler manufacturer, Encore Systems, was contacted and it was learned that tire bales were being used in many civil engineering applications in the United States including streambank stabilization, retaining walls, and erosion control. Encore Systems then introduced the idea of using whole baled tires in road subgrade. In wet soils the tire bales can be used to effectively float over marginal areas. The tire bale road base would be engineered to work as efficiently as gravel subgrades at less financial and environmental cost.

In 1998, discussions began with the New York State Department of Transportation (NYSDOT) and the New York State Department of Environmental Conservation (NYSDEC) regarding permitting of the use of whole baled tires in two road demonstration projects. On September 28, 1998, the Research, Development and Demonstration permit was granted.

## PROGRAM ACHIEVEMENTS

### Initial Clean up of a Large Tire Dump

Chautauqua County began baling whole scrap passenger and light truck tires on October 28, 1998 at a site in the Town of Poland referred to as the Levant Tire Dump. This initiative was spearheaded by the County Department of Public Facilities and the County Department of Environmental Health as a means to eliminate the threat of a tire fire at this location. The dump was adjacent to residences, a recharge area for the Cassadaga Valley Aquifer, two major State highways and a church and school complex. In addition, the site's soggy soils and limited access would have made mobilization of fire fighting equipment nearly impossible. Manual labor for transporting the tires to the baler was provided by inmates of the Chautauqua County Jail. County employees, as well as employees of our partner town and villages, operated the baler, the trackhoe to dislodge the muddy and wet tires and the loader to catch the tires from the baler and place on the lowboy for transport to the County Landfill in Ellery, the location specified in our permit adjacent to one of the road demonstration projects.

In making this project a reality, Chautauqua County, the New York State DOT and the New York State DEC worked together and were able to implement an unprecedented use of scrap tires in a relatively quick period of time. The Sheriff's Department provided between 4 and 6 inmates daily who had the unenviable task of manually lifting thousands of tires per day and hand loading them into the baler. On September 17, 1999, the last of the 154,000 tires at Levant were baled and by September 28, 1999 the site was graded and seeded.

### Cleaning up Smaller Stockpiles from Municipalities and Residents

### Tire Amnesty Program

Due to the high cost of scrap tire disposal, most of Chautauqua County's rural towns and villages had their own small stockpiles of tires at their highway barns. In addition, many towns also had the problem of tires dumped illegally along their roadsides and stored in residents' yards. Using the County Landfill as a centralized tire collection site, the County offers a Tire Amnesty program, now in its third year, for these towns, villages, and cities. The scrap tires are brought to the Landfill by each municipality, free of charge, where they are baled and stored for use in the roadbed construction projects. Working at a steady pace, two operators can bale four to six hundred tires an hour. As done at the Levant clean-up, the Chautauqua County Department of Public Facilities working in conjunction with the Sheriff's Department, uses low-risk prison inmates as labor. In addition to the towns and villages participation, in 2001 and 2002, the County allowed tires from small tire dumps (5,000 tires or less) to be brought to the Tire Amnesty collection point, thus eliminating most of Chautauqua County's remaining tire dumps.

### Tire Bales in Roadbed Construction

Four roads have been built using the bales.

- ✓ **Condin Road, Town of Ellery**
- ✓ **Kabob Road, Town of Stockton**
- ✓ **East Road, Town of Charlotte**
- ✓ **Sanford Road, Town of Cherry Creek**

#### Condin Road, Town of Ellery

The tires baled from the clean-up of the Levant Tire Dump were used in our first demonstration project in the summer of 1999. Condin Road is a gravel road that is used by large trucks accessing the leachate ponds on the County Landfill's property. This road had always been troublesome. Due to its location on a hillside, the poor drainage of the soils below, and the heavy truck traffic, a section of this road would continually erode and needed to be graded often. 120,000 tires or 1,200 bales were used in the replacement of the subgrade in a 928′ section. The road surface was excavated 2′ below finished grade, geofabric laid, and the 1,200 bales were placed 6 bales wide by 200 bales long on top of the fabric. Covering the bales was 2,500 tons of sand to fill the voids as much as possible. This process not only serves as a free draining system, it also locks each bale into place forming a non-shifting layer. A vibratory roller was used to compact the sand, then three, 6″ lifts of gravel were laid again being compacted by the vibratory roller. The adjacent land was seeded and mulched for erosion protection and stabilization purposes. Condin Road, the first road in Chautauqua County to be built over a base of tire bales has proven itself to not only be durable, but a significant improvement from the problem road it had been in the past.

**Kabob Road, Town of Stockton**

Kabob Road is a well-used paved county road with a daily traffic count of 740 as recorded by the Chautauqua County Department of Public Facilities Engineering personnel. It is used very often as an alternative route to busy NYS Route 60, which is the major north-south artery through Chautauqua County linking I-90 and I-86. In October of 2000, the Kabob Road was scheduled to be blacktopped. It had a 200 foot banked curve which had been a perennial trouble spot...it just couldn't hold the pavement on that stretch. The sub-base of the road was very poor. The road was originally built on a marsh and the roadbed consisted of marginal wet clay-type soils. The freeze/thaw cycle would heave and break the pavement. Before the County spent the money on blacktop, the sub-base needed to be drastically improved. The tire bales were the perfect solution as the material for sub-base because of their free-draining characteristics, load handling capabilities and size. It was determined that the entire 200 foot section of the Kabob Road needed to be completely rebuilt. The roadbed was prepared similarly to that of Condin Road with the addition of a drainage pipe. 30,000 tires or 300 bales were placed side by side on the geotextile covered roadbed, sanded, rolled, and graveled. Unlike Condin Road which was left graveled, Kabob Road received 9 inches of blacktop. Kabob Road, the second road in Chautauqua County to be built over a base of tire bales and the first to be paved has proven itself to be very durable. In addition, the solving of its drainage problem has kept this section of road free from potholes and provides a safe surface for driving.

**East Road, Town of Charlotte**

East Road is a rural gravel road own by the Town of Charlotte bordered by State-owned lands with traffic counts averaging 100 vehicles daily, East Road was constructed years ago over very marginal soils. In spring, this road is very soft making travel difficult. A 1000' demonstration project using 120,000 tires or 1,200 bales to effectively bridge over this very poor base of marginal soils was completed in June 2001. The severe drainage problem and marshy soils of East Road have been conquered by rebuilding its base using tires bales and raising its surface. Although East Road has just made it through only one Chautauqua County winter, we are pleased to report that East Road is not only be passable, but now provides a safe and smooth ride through the picturesque town of Charlotte.

**Sanford Road, Town of Cherry Creek**

Reconstruction of the roadbed in an 1500′ section of Sanford Road was completed in the summer of 2002. Sanford Road is a rural gravel road in the Town of Cherry Creek running through the Boutwell Hill State Forest. This road is frequently impassable during wet weather due to poor drainage, marginal soils and low lying sections. Sanford Road, originally a farm-to-market road was built over extremely poor soils. In the winter, water trapped in the soft soils freezes. During the spring thaw, the melted ice turns the road into a rutted, potholed mess as the base cannot support the weights of the vehicles traveling over it. The existing roadbed of Sanford Road was excavated down 24″, geotextile fabric installed and underdrain where necessary. Baled tires were placed 5 across due to the narrower than usual road right of way and totally encapsulated within the road fill and covered with 18″ of gravel. Approximately 150,000 tires in baled form were used for the 1,500′ road project. Periodic maintenance of the gravel surface by the Town of Cherry Creek will ensure future long term road integrity.

## THE NUMBERS

### Tires Cleaned Up

| | | |
|---|---|---|
| 1999 | Levant Tire Dump | 154,000 |
| 2000 | Tire Amnesty I | 145,200 |
| | Tires from private collection site | 17,500 |
| 2001 | Tire Amnesty II | 52,000 |
| | Tires from small tire dumps | 50,000 |
| 2002 | Tire Amnesty III | 61,000 |
| | Tires from small tire dumps | 32,282 |
| | **TOTAL TIRES CLEANED UP TO DATE** | **511,982** |

### Tires Used in Roadbed Construction

| | | |
|---|---|---|
| 1999 | Condin Road | 120,000 |
| 2000 | Kabob Road | 30,000 |
| 2001 | East Road | 120,000 |
| 2002 | Sanford Road | 150,000 |
| | **TOTAL TIRES USED IN ROADBED CONSTRUCTION** | **420,000** |

### Program Costs and Savings

Taxpayer Disposal Costs per Tire

| | |
|---|---|
| Normal cost for disposal at landfill | $2.00 each |
| Cost during program (includes costs for prison guard, baler operating costs, baling wires) | $0.40 each |
| **TOTAL TAXPAYER SAVINGS PER TIRE** | **$1.60 EACH** |

Taxpayer Disposal Costs for Entire Tire Amnesty Program

| | |
|---|---|
| Normal cost for disposal at landfill | $1,023,964.00 |
| Cost during program (includes costs for prison guard, baler operating costs, baling wires) | $204,792.80 |
| **TOTAL TAXPAYER SAVINGS FOR ENTIRE TIRE AMNESTY PROGRAM** | **$819,176.00** |

Using Baled Tires in Roadbed vs. Stone

| | |
|---|---|
| Cost of stone for 1000′ of roadbed construction | $24,050.00 |
| Cost of tires for 1000′ of roadbed construction | $21,000.00 |
| **TOTAL TAXPAYER SAVINGS FOR 1000′ ROADBED CONSTRUCTION** | **$3,050.00** |

Using Baled Tires in Roadbed vs. Stone in 4 Completed Road Projects

| | |
|---|---|
| Condin Road (928′) | $2,830.40 |
| Kabob Road (200′) | $610.00 |
| East Road (1000′) | $3,050.00 |
| Sanford Road (1500′) | $4,575.00 |
| **TOTAL TAXPAYER SAVINGS FOR ALL ROADBED CONSTRUCTION PROJECTS** | **$11,065.40** |

## PARTICIPATION

Chautauqua County now has the enviable reputation of being one of the few counties in New York State that has an excellent working relationship with the towns and villages located within its boundaries. Sharing services between the counties and its municipalities and between municipalities is commonplace and offers the taxpayers services that otherwise would not be available to them, with accompanying cost savings. The entire Tire Baling and Tire Amnesty programs would not have been possible without their cooperation.

During the Levant Tire Dump clean-up, each municipality sent one worker for a one week stint of operating the baler. Some municipalities even offered trucks and additional personnel to help, even though the tire dump had no impact on their communities. In return, the county offered the Tire Amnesty program to the municipalities. Each municipality offered their residents an important benefit at minimal cost to the municipality. There was not one town, village or city that did not participate.

Chautauqua County's tire program broke the boundaries between the municipalities and the county and unearthed the spirit of cooperation and communication that was buried deep within the heart of Chautauqua County.

## APPLICABILITY IN OTHER MUNICIPALITIES and EXPECTED LIFE OF PROJECT

In October of 2001, Chautauqua County applied for a Beneficial Use Determination from the New York State Department of Transportation. When approved, this technology will be available for use without obtaining a separate permit for each planned project. Permitting, while a necessary safeguard for the environment, becomes a long drawn-out expensive process. We feel that we have proven this technology to be a safe, cost-effective and excellent method of reducing the numbers of scrap tires in New York State, which in turn will help curb the spread of the West Nile Virus and would prevent the environmental disaster of a large tire fire. When approved, Chautauqua County plans to continue to offer the Tire Amnesty Program to county residents and will reconstruct roadbeds in other trouble spots within the county's highway system as long as scrap tires are available within our borders. In addition, we have offered to share our expertise with other municipalities that desire a cost-effective and beneficial method of scrap tire management.

## BENEFITS

**Taxpayers' Benefit**
In addition to the obvious benefit of elimination of a health hazard and eyesore, Chautauqua County's scrap tire management program actually saved the taxpayers over $830,241.00 during its first four years.

**Environment and Health Benefit**
Because of the density of the bales, the decreased surface area, and lack of air, the danger of another environmentally damaging tire fire was greatly reduced. In addition, tires in baled form do not hold water, thus the risk for the spread of the West Nile Virus was reduced as places for the mosquitoes to breed were eliminated.

**Towns, Villages & Cities' Benefit**
The Tire Amnesty Program was a chance for the municipalities to offer their residents an important benefit at no cost to the resident and minimal cost to the municipality.

**County's Benefit**
The success of this program proves that cooperation between the County and communities benefits everyone.

**Department of Public Facilities Benefit**
By using the tire bales instead of the traditional method of rock and gravel, we are conserving our natural resources and saving money. In addition, drainage in perpetually troublesome road sections has been greatly improved thus extending the life of the road, reducing the need for constant patching and maintenance, and ensuring a safe ride for the traveling public.

**Sheriff's Department**
The inmates who participated in the tire baling work program became model prisoners. They came back to the jail with a sense of pride and accomplishment. Incidents of fights, illnesses, and complaints dropped drastically within this group.

## CONCLUSION

Chautauqua County Department of Public Facilities, Division of Transportation has successfully devised and implemented an innovative program to clear the landscape of scrap tires at no cost to county residents through the Tire Amnesty Program and to transform these tires into viable road construction materials through baling resulting in substantial savings to the taxpayers of Chautauqua County, safer roadways for the traveling public, and at the same time lessened the risk of the spread of the West Nile Virus by eliminating many potential mosquito breeding areas.

## FOR MORE INFORMATION

Please contact:

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Comprehensive information package and video available.

### *Case Study 3: Front Range Tire Recycle, Inc., Sedalia, Colorado*

Front Range Tire Recycle, Inc. is a tire recycling facility located in Sedalia, southwest of Denver, Colorado. This facility is located on a property adjacent to a set of railroad tracks. Part of the property that lies nearest the railroad tracks is located on a relatively steep slope. Maximizing the use of the property has always been difficult due to the sloping terrain of the property.

When Front Range Tire Recycle, Inc. opened for business, the method of storing the tires involve simple stockpiling of large quantities of tires. This approach was later deemed unsafe because of the fire hazard posed by the tires as well as because of the breeding ground for infectious mosquitoes. Consequently, Front Range Tire Recycle, Inc. initiated tire shredding operations. Among other reasons, tire shredding decreases the volume of tire stockpiles. However, problems associated with fire hazard are still of concern. In addition to safety issues, the commercial demand for shredded tires was not significant. Recently, the owner of the company decided to manufacture tire bales.

According to the owner of the company, Mr. Rick Welle, more tires can be stored when using tire baling approaches. Also, there seems to be a "good market" for the bales. In addition, Mr. Welle has been utilizing tire bales for road construction within his facility. The road construction activities that took place at this facility are reported herein.

The portion of the property at Front Range Tire Recycle, Inc. that lies adjacent to the railroad tracks was essentially unusable due to the steep grade of the slope. Consequently, in an effort to maximize land usage, the company decided in 2000 to construct a road on top of the slope using tire bales. Such a road would route the truck traffic across the facility.

Construction of the road involved an initial excavation into the slope (i.e. a "cut" excavation), which was conducted to define a relatively flat surface in order to place the tire bales. Next, the tire bales were stacked in a "brick-like" fashion using a forklift. Once the stacked bales reached the desired height for the roadway, the bales were compacted using a front-end loader. In addition to soil, tire shreds were spread over the surface of the tire bale layers in an effort to level the roadway. Finally, soil was placed in uniform layers above the final layer of tire bales and compacted. A view of the road at this Sedalia facility is shown in Figure B3.

Visual inspection of the road indicates that the structure has performed very well so far, with little need for maintenance. The only reported maintenance need involved the repair of some small sinkholes that developed near the edges of the roadway. Figure B4 shows a typical sinkhole. The mechanism for sinkhole generation is attributed to incomplete filling the voids of the tire bales with soil. The sinkholes developed because tire shreds were not initially spread in their vicinity after stacking the bales. Maintenance operations involved filling and compacting the sinkholes with soil (Welle, 2003, personal communication). In spite of the development of few sinkholes, the road has performed extremely well even though it is subjected to daily heavy truck traffic (e.g. semi with trailers) and occasionally large construction equipment (e.g. front-end loaders and scrapers).


**Figure B3. Road built from stacked tire bales.**

Recent Colorado state laws required that the company divide some of the existing tire and tire shred piles in case of an emergency fire situation. As a result of this regulation, the company has begun to divide a few of his large piles with roadways wide enough for a fire engine to circulate. Because of the successful performance of the first tire bale road, additional roads with tire bales are in the process of being constructed. One of these roads is shown in Figure B5. However, it should be noted that the tire bales that are being placed are on top of compacted soil that is underlain by another layer of tire bales.

Even though there have been experimental tire bale applications for civil engineering applications, similar to the case studies described above, there exists a need for additional research. Nearly all of the civil engineering projects that have utilized tire bales have been completed on a “trial-and-error” basis. This method has proven itself to be very successful in most cases. However, to fully utilize tire bales and make them available on a large scale for civil engineering applications, research will need to be conducted to further the knowledge of the properties and capabilities of tire bales.

**Figure B4. Typical sinkhole.**


**Figure B5. Roadway construction using tire bales.**

## APPENDIX C.  General Properties of Tires and Results of March 2000 Tire Bale Lab Tests

**Materials Composition, Rubber Manufacturer's Association Fact Sheet**

**Creep and Load Test on Tire Bale, Twin City Testing /Encore Systems March 2000**

1. Typical Materials Composition of a Tire
2. Typical Composition by Weight
3. Densities of Shredded and Whole Tires
4. Rubber weight by tire component.
5. Steel Tire Cord Analysis

### 1. Typical Materials Composition of a Tire

| This table lists the typical types of materials used to manufacture tires. |
|---|
| Typical Composition of a Tire |
| Synthetic Rubber |
| Natural Rubber |
| Sulfur and sulfur compounds |
| Silica |
| Phenolic resin |
| Oil: aromatic, naphthenic, paraffinic |
| Fabric: Polyester, Nylon, Etc. |
| Petroleum waxes |
| Pigments: zinc oxide, titanium dioxide, etc. |
| Carbon black |
| Fatty acids |
| Inert materials |
| Steel Wire |

### 2. Typical Composition by Weight

This lists the major classes of materials used to manufacture tires by the percentage of the total weight of the finished tire that material class represents.

**Passenger Tire**

| | |
|---|---|
| Natural rubber | 14 % |
| Synthetic rubber | 27% |
| Carbon black | 28% |
| Steel | 14 - 15% |
| Fabric, fillers, accelerators, antiozonants, etc. | 16 - 17% |
| Average weight: | New 25 lbs, Scrap 20 lbs. |

**Truck Tire**

| | |
|---|---|
| Natural rubber | 27 % |
| Synthetic rubber | 14% |
| Carbon black | 28% |
| Steel | 14 - 15% |
| Fabric, fillers, accelerators, antiozonants, etc. | 16 - 17% |
| Average weight: | New 120 lbs., Scrap 100 lbs. |

**3. Densities of Shredded and Whole Tires**

| LOOSELY PACKED | APPROXIMATE DENSITIES | DENSELY PACKED |
|---|---|---|
| 550-600 lbs/yd$^3$ | single pass | 1220-1,300 lbs/yd$^3$ |
| 850-950 lbs/yd$^3$ | 2" shred | 1,350-1,450 lbs/yd$^3$ |
| 1,000-1,100 lbs/yd$^3$ | 1 1/2" shred | 1,500-1,600 lbs/yd$^3$ |
| 100/10Yd$^3$ | WHOLE TIRES (PASSENGER/LIGHT TRUCK) | 500/10Yd$^3$ |
| | 10 MESH- 29 lbs/ft$^3$ | |
| | 20 MESH- 28 lbs/ft$^3$ | |
| | 30 MESH- 28 lbs/ft$^3$ | |
| | 40 MESH- 27 lbs/ft$^3$ | |
| | 80 MESH- 25-26 lbs/ft$^3$ | |

**4. Rubber weight by tire component.**

A tire is manufactured from several separate components, such as tread, innerliner, beads, belts, etc. This table shows which cc account for the rubber used to make the tire.

**RUBBER PERCENT BY WEIGHT IN A NEW RADIAL PASSENGER TIRE**

| | |
|---|---|
| TREAD | 32.6% |
| **BASE** | 1.7% |
| SIDEWALL | 21.9% |
| BEAD APEX | 5.0% |
| BEAD INSULATION | 1.2% |
| FABRIC INSULATION | 11.8% |
| INSULATION OF STEEL CORD | 9.5% |
| INNERLINER | 12.4% |
| UNDERCUSHION | 3.9% |
| | 100.0% |

**5. Steel Tire Cord Analysis**

The tire industry uses ASTM 1070 and above tire cord quality wire rod in the manufacture of new tires. There are approximately pounds of steel belts and bead wire in a passenger car tire.

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(651) 645-3601, Fax: (651) 659-7348

**TO:** Mr. Ed Drews
Encore Systems, Inc.
585 Northwest 3rd
Cohasset, MN 55721

**DATE:** March 24, 2000

**PROJECT NO:** 030066

**PROJECT:** MNDOT TEST OF TIRE BAIL

## CREEP AND LOAD TEST ON TIRE BAIL

### INTRODUCTION:

This report presents the results of load testing performed by Stork Twin City Testing Corporation (TCT), on one tire bail submitted by the Encore Systems of Cohasset, Minnesota. The scope of our work was limited to:

1. Performing a creep test on the tire bail.
2. Performing a load deflection test on the tire bail.
3. Presenting a report of our test results.

Our work was requested and authorized by Mr. Ed Drews of the Encore Systems on March 2, and March 7, 2000, respectfully.

### SUMMARY OF TEST RESULTS:

| Type of Test | Maximum Load | Avg. Ultimate Deflection, inch. | Time of ultimate Deflection, If applicable |
|---|---|---|---|
| Creep | 88,000 Lbs. | 8.06 | 4320 min (72 hours) |
| Load Deflection | 338,850 Lbs. | 11.45 | N/A |

### SAMPLE DESCRIPTION:

On March 15, 2000, one tire bail was submitted to TCT for load testing. The test bail was approximately 60 inches in length by 50 inches in width and 30 inches in height. The test bail consisted of tires compacted with steel wire. The bail came with a steel plate on top that measured 60 inches in length by 50 inches in width and 1 inch thick.

### TEST PROCEDURES:

Laboratory testing was performed March 17, 2000 and subsequent dates. A summary of test procedures is as follows:

1. The test bail, with the steel plate on top, was placed under a stationary reaction frame within our laboratory on a steel plate. We then placed a number of beams across the steel test plate to distribute the load during testing.

## CREEP AND LOAD TEST ON TIRE BAIL

**TEST PROCEDURES:** (cont.)

2. A hydraulic ram, connected to a hand (creep test) or electric (load deflection test) pump, was placed on the steel beams and below the reaction frame. A hydraulic gauge was used to monitor the load during test. The hydraulic pump and ram system calibration was traceable to the National Institute of Standards and Technology.

3. The creep test was performed first. A load of 88,000 pounds was applied to the bail and held.

4. Deflection readings were the obtained using a tape measure. The measurements were taken from the floor to the top plate at all four corners. The load was held until no noticeable deflection increase was observed. The load was then released.

5. The load deflection test was then performed using the same test configuration.

6. The sample was loaded in equal increments, to a load of approximately 335,000 pounds. At each load increment deflection readings were obtained in a similar fashion as the creep test.

7. Upon loading 335,000 pounds, the load was released and the sample was inspected for distress.

**TEST RESULTS:**

**Creep Test**

| Time (min.) | Average Deflection (inches) |
|---|---|
| 0 | 0 |
| 5 | 6.02 |
| 10 | 5.98 |
| 15 | 6.64 |
| 20 | 6.78 |
| 25 | 6.78 |
| 30 | 6.94 |
| 35 | 7.00 |
| 40 | 7.05 |
| 45 | 7.03 |
| 50 | 7.03 |
| 55 | 7.05 |
| 60 | 7.22 |
| 120 | 7.22 |
| 180 | 7.30 |
| 240 | 7.44 |
| 300 | 7.55 |

## CREEP AND LOAD TEST ON TIRE BAIL

**TEST RESULTS:** (Cont.)

**Creep Test** (Cont.)

| Time (min.) | Average Deflection (inches) |
|---|---|
| 1620 | 7.55 |
| 2820 | 8.02 |
| 4320 | 8.06 |

The load remained constant at 88,000 pounds.

**Load Deflection Test**

| Load (Lbs.) | Average Deflections (inches) |
|---|---|
| 0 | 0 |
| 55,450 | 4.25 |
| 103,600 | 6.95 |
| 150,800* | 8.95 |
| 199,250 | 9.70 |
| 246,450 | 10.70 |
| 292,250 | 11.20 |
| 338,950 | 11.45 |

*A bundle strap failed at approximately 175,000 pounds.

Please see the attached photographs and graphs.

**REMARKS:**

Unless further notice is received, the sample will be retain for a period of two weeks and then discarded. If you have any questions regarding this report, or if we may be of further assistance, please feel free to contact us at (651) 659-7340.

**STORK TWIN CITY TESTING CORPORATION**

Thaddeaus L. Harnois
Staff Engineer
Construction Materials Department

John D. Lee, P.E.
Senior Staff Engineer
Construction Materials Department

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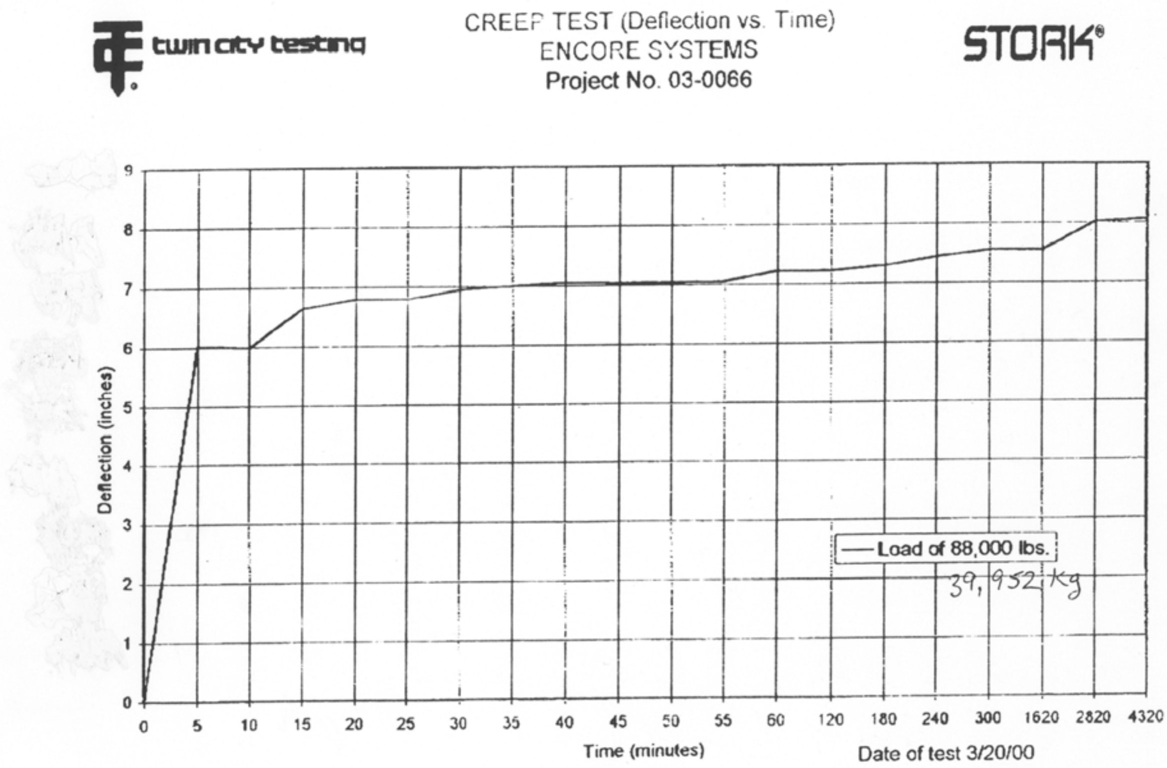
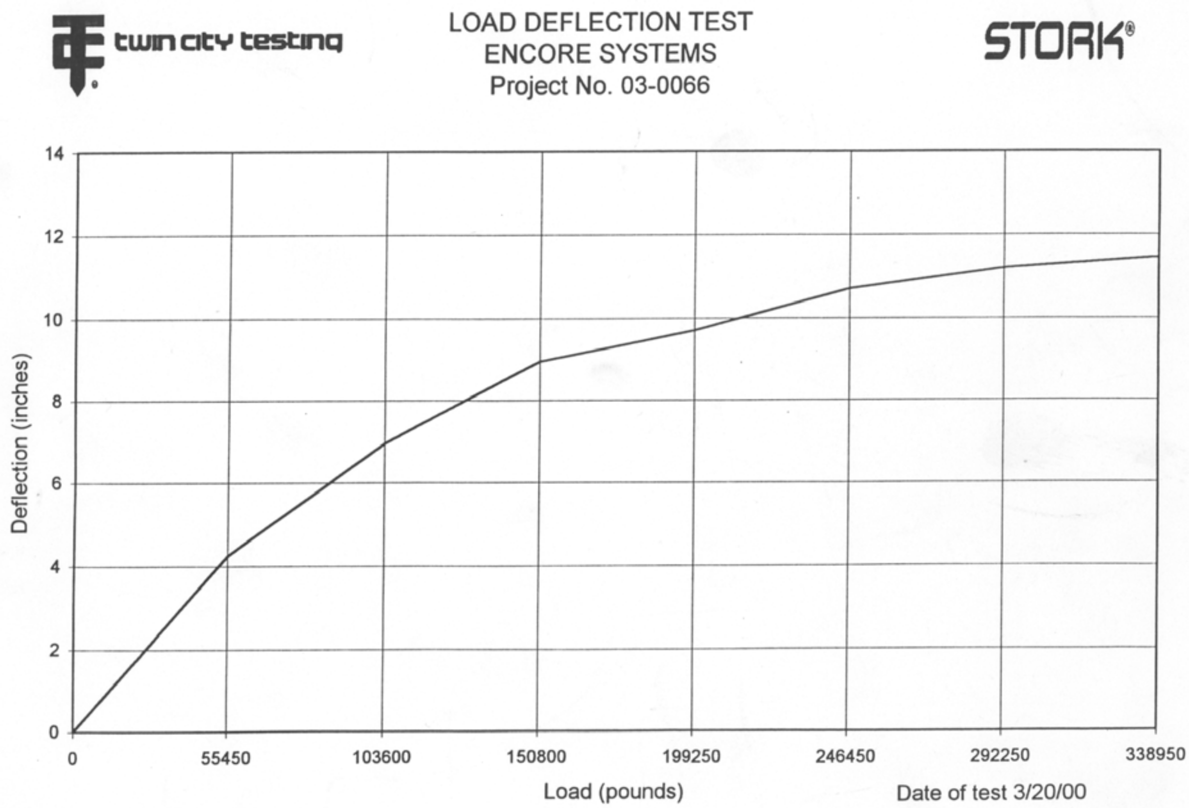


twin city testing
CREEP TEST (Deflection vs. Time)
ENCORE SYSTEMS
Project No. 03-0066
STORK®
Deflection (inches)
9
8
7
6
5
4
3
2
1
0
0 5 10 15 20 25 30 35 40 45 50 55 60 120 180 240 300 1620 2820 4320
Time (minutes)
Date of test 3/20/00
Load of 88,000 lbs.
39,952 Kg


twin city testing
LOAD DEFLECTION TEST
ENCORE SYSTEMS
Project No. 03-0066
STORK
Deflection (inches)
14
12
10
8
6
4
2
0
0
55450
103600
150800
199250
246450
292250
338950
Load (pounds)
Date of test 3/20/00

# APPENDIX D. 2004 Lab Test Data on Tire Bales (performed for this study)

GeoTesting Express, Inc.
2662 Holcomb Bridge Road, Suite 310
Alpharetta, GA 30022

www.GeoTest.com
phone: 770-645-6575
fax: 770-645-6570
email: info@geotest.com

Subject: **Summary of the Laboratory Tests Performed for the Tire Bale Study**
**GTX Project No.: G0581**
**December 16, 2004**

GeoTesting Express, Inc. (GTX) has completed the laboratory tests on tire bales received in accordance with the scope of work and GTX proposal No. 0050197. The following sections briefly describe the test performed including any modifications made during the performance of the test program as was previously discussed in our interim reports. The test results from all tests performed follow the description of the test program.

## TIRE BALE LABORATORY TEST PROGRAM

The following laboratory test program was performed on the (9) tire bales that were received at the GeoTesting Express, Inc. laboratory in Alpharetta, GA. All tests were performed on the entire bale. The tire bales will have a rough estimated size of 2.5 ft x 4.5 ft x 5 ft and weigh approximately 1 ton. The sequence and procedures listed below were followed to allow for reuse of bales where possible.

- **Dry, wet and submerged unit weight of as received tire bales.**

  Unit weigh tests were made on all samples received. The procedure consisted of volumetric measurements and weight of the sample as received noting any presence of moisture in the bale. The volume was measured by taking dimensional measurements. For dimensional measurements, a significant number of measurements were taken to obtain unit weight measurements within a 1 % accuracy and repeatability. Digital image analysis was used to confirm the measurements with two digital photos (front and side view) taken of each bale along with a visible reference scale mounted on the bale using a level camera located vertically at the mid height of the bale. Representative images are shown included with this report. At least two bales were stored in a dry environment for a sufficient period of time (i.e., no weight change within a 1 day period of time) in order to obtain an air dry unit weight for these two samples. These two samples were then also used to obtain the submerged and wet unit weight of the tire bales.

Submerged unit weight measurements were obtained by submerging the entire bale in a tank of water for a sufficient period of time to allow all free air to escape and obtain the weight below water. Prior to placement in the tank, the water in the tank was maintained at room temperature for at least 24 hours to reduce the amount and equilibrate the dissolved oxygen in the water. After obtaining the submerged weight, each sample was extracted from the water, allowed to freely drain, and weighed immediately after drainage to obtain the wet unit weight.

– **Vertical Permeability of tire bales.**

- The vertical permeability of two (2) tire bales was evaluated by rapidly extracting the bale which had been submerged in water and monitoring the time it takes for water to completely drain from the sample under gravity flow. The horizontal sides of the tire bale were wrapped with shrink wrap to prevent lateral flow out of the sides of the bale. The time of extraction was sufficiently rapid to maintain a visible and measurable differential head differential (e.g., with piezometers) between the water in the reservoir and in the sample.

– **Unconfined compressibility with both vertical and horizontal deformation measurements**.

- Unconfined compression tests were performed generally following the ASTM D2166 Standard Test Method for Unconfined Compressive Strength of Cohesive Soil. These test were performed at the Georgia Institute of Technology structural laboratory in Atlanta, Georgia and a separate report is attached on this phase of the testing program. In summary, the top and bottom loading platens consisted of large concrete blocks, which had surface area that was than the compressed loaded tire bale surface area and extended beyond the dimensions of the sample in all directions when fully loaded. The load platens were also sufficiently stiff so as not to bend or deform during testing and distribute the load uniformly across the sample. A minimum of three vertical deformation measurements (to an accuracy of 0.1 inches) was made with gages located equal distances around the sample (e.g., 3 gages located at the third points around the sample). Lateral movement was also be measured in at least three equally spaced (from top to bottom) vertical locations by measuring the circumference with a tape measure. A calibrated load cell was used to measure the applied load. A peak strength was not reached for the tire bales and tests were performed to maximum loads of 300 to 600 kips, based on equipment compatibility and safety. Both continuous monitoring using data acquisition methods and manual readings to perform a check were made, with vertical and horizontal deformation shall be taken at a minimum of every 10 kips up to 100 kips and at every 25 kips up to the full load condition. An unload – reload test was performed on one of the bales.

- **Unconfined and confined compressibility of tire bales (i.e., without and with in fill materials) at working loads, including static and cyclic modulus evaluation.**

  These tests were performed in the GeoTesting Express, Inc. laboratory in a similar manner as the unconfined tests except that the maximum load was 20 kips, steel platens with an area greater than the compressed tire bale were used to apply the load, and the cyclic load was performed at 9 kips with a one foot circular plate (to simulate a vehicle load at the tire surface). Two tests were performed on two separate tire bale samples, one unconfined and one confined with a minimum of six inches of dry, concrete sand (ASTM C-33) completely surrounding the sides of the tire bale. For the confined test, the samples were contained in a rigid box, the sand placed in the annulus between the sides of the box and the sample, and the surface sand was compacted with a vibratory plate compactor a minimum of five passes. Sand that subsided during compaction was replaced to form a level surface. For the cyclic load test a level bearing surface was provided beneath the circular plate using a non shink mortar mix. Prior to performing the static compression test on either of the unconfined or confined tire bale, the cyclic load test was performed using a 1 ± 0.5 hertz frequency for a minimum of 1000 cycles. Vertical deformation measurements (to an accuracy of 0.001 inches) were made using LVDT's and a data acquisition system. Following the cyclic load test, the static load deformation test was performed to 20 kips.

- **Time-dependent deformations of tire bales under sustained load (i.e. creep).**

  Creep test consisted of placing a constant load on a single unconfined tire bale and monitoring the deformation response for a period of 1000 hrs at a constant room temperature. Three tests were performed fresh bales (previously not used in the test program), one with an applied load of 8 kips and the other two with an applied load of 20 kips. In this case, metal plates with an area greater than the compressed tire bale were used for the load platens and an air bag was used to sustain the required load. Twin air bags were used to sustain the required load. A second steel plate was placed above the air bags, and a load cell was placed between the upper steel plate and a reaction beam to monitor the applied stress. The vertical deformation measurements were made using three gages, with an accuracy of 0.0254 mm (0.001 in.) placed evenly (at the third points) around the sample. The first 90 kN (20 kips) test experienced accelerated movement on one corner after approximately 190 hrs and the test had to be terminated. There is a tendency for tires to shift laterally in their unconfined condition. The second 90 kN (20 kips) did not experience this problem and the test was performed to the required 1000 hrs of time.

- **Shear strength between adjacent vertically stacked tire bales.**

  In this test, a direct shear test was performed by vertically stacking two tire bales, restraining the upper bale from moving laterally, and measuring the force to pull out the bottom bale, which was supported by low friction rollers. The air bag system used in the creep tests was used to apply the normal load. Tests were conducted at normal loads of 9 kN (2 kips) (i.e., the dead weight of the upper bale), 18 kN (4 kips), and 27 kN (6 kips).

During application of shear force the bales tended to roll due to interlocking at undulations on the interface surfaces, rather than slide along the interface. This resulted in eccentric loading on the load cell used to monitor the normal stress and the test had to be stopped before a peak shear stress could be reached.

– **Rebound and potential expansive pressure.**

In order to evaluate uplift potential, two tests were performed, one to evaluate swell pressure plus free swell and the other to evaluate free swell alone. The first test was conducted on a sample that had been manufactured and stored for a period of 1 year. In this test, a rigid piston with a load cell was placed on the sample using a wooden pallet as a platen to facilitate cutting of the wires. The five vertical tie wires were then cut and the load required to prevent any upward vertical movement was measured. The load to prevent uplift was relatively small and stabilized within an hour at 1.6 kN (356 lbs). However, after cutting of the wires, significant lateral movement was observed and continued after the load had stabilized. After no increase in upward pressure was observed, the load was released and the upward vertical movement was monitored until no additional movement occurred. A relatively small average vertical movement of 21.4 mm (1 in.) was measured. The lateral movement was significant with almost 600 mm (2 ft) of movement observed in the band width direction [300 mm (1 ft) on each side], until the bale was restrained by the sides of the 2 m wide (6.6 ft) container.

Due to the significant lateral movement observed during the first test, the second test was performed by restraining the lateral movement with several lifting straps, simulating confinement by adjacent tire bales. All five vertical tie wires on a tire bale were cut and the upward vertical movement monitored.

The following test matrix was used in order to maximize the number of test that could be performed on the nine (9) tire bales.

**Table 1. Tire Bale Test Matrix**

| Sample Number | Unit Weight | k | UC-ult | UC-conf. & cyclic | Shear (τ) | Swell rebound & Press. | Creep |
|---|---|---|---|---|---|---|---|
| 1 | X | X | | X | X | | X |
| 2 | X | X | | X | X | | X |
| 3 | X | | | | X | X | |
| 4 | X | | | | | X | |
| 5 | X | | X | | | | |
| 6 | X | | X | | | | |
| 7 | X | | X | | | | |
| 8 | X | | X | | | | |
| 9 - Old | X | | | | | X | |

# Representative Photos of Tire Bales used for Lab Tests

Tire Bale 0, Side 1


Tire Bale 0, Side 2


Tire Bale 5, Side 1


Tire Bale 5, Side 2

GeoTesting express

# GEOMETRY, DRY, WET AND SUBMERGED UNIT WEIGHT

**Project No. :** GTX G0581 **Project Name:** Tire Bale Study
**Tested By:** SD **Reviewed By:** JW
**Test Date:** 4/5/2004 **Review Date:** 4/9/2004

| | |
|---|---|
| Tare Weight, lbs: | 23 |

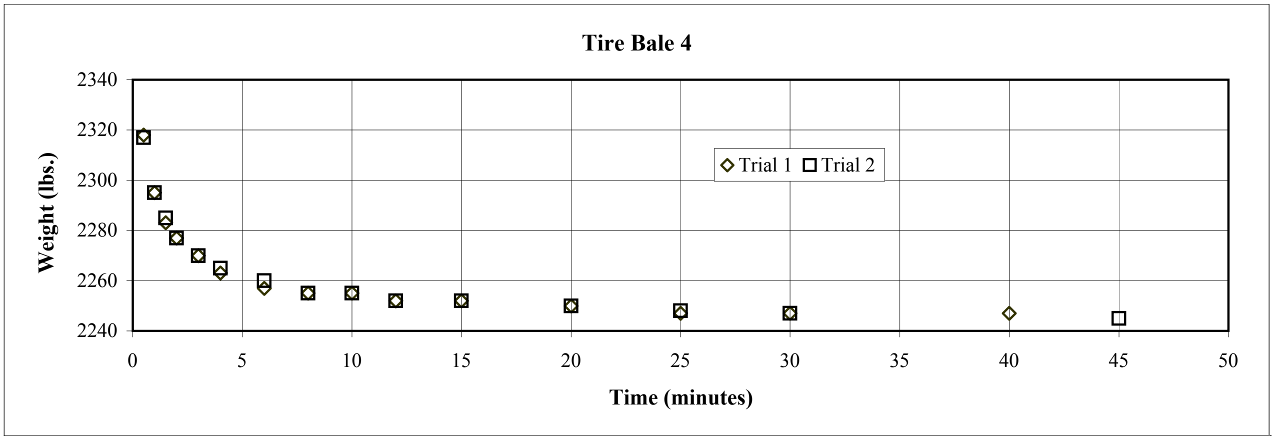
| Tire Baled No. | 0 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| As Received + Tare Weight, lbs | 2185 | 1933 | 2073 | 2026 | 1998 |
| As Received Weight, lbs | 2162 | 1910 | 2050 | 2003 | 1975 |
| Dry Weight, lbs | 2161 | 1910 | 2049 | | |
| Submerged Weight, lbs | 293 | 189 | 238 | | |
| Wet(Drained) Weight, lbs | 2288 | 2098 | 2205 | | |
| Thickness, ft | 2.4 | 2.3 | 2.3 | 2.2 | 2.4 |
| Width (band direction), ft | 4.7 | 4.7 | 4.8 | 4.8 | 4.8 |
| Width (cross-band direction), ft | 5.2 | 5.0 | 5.0 | 5.2 | 5.3 |
| Volume, $ft^3$ | 59.0 | 54.1 | 54.4 | 54.4 | 59.2 |
| As received Unit Weight, $lbs/ft^3$ | 36.6 | 35.3 | 37.7 | 36.8 | 33.4 |
| Dry Unit Weight: | 36.6 | 35.3 | 37.7 | | |
| Submerged Unit Weight: | 5.0 | 3.5 | 4.4 | | |
| Wet Unit Weight: | 38.8 | 38.8 | 40.5 | | |

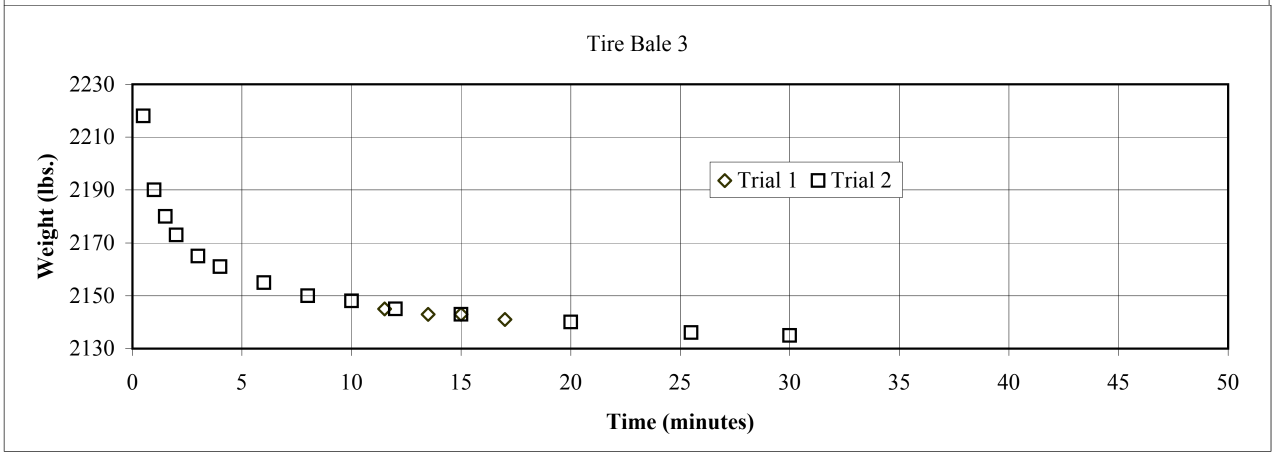
GeoTesting express

# VERTICAL PERMEABILITY OF TIRE BALES

**Project No. :** GTX G0581
**Tested By:** SD
**Test Date:** 4/12/2004
**Project Name:** Tire Bale Study
**Reviewed By:** JW
**Review Date:** 4/16/2004

| Tire Bale 4 | | | | Tire Bale 3 | | | |
|---|---|---|---|---|---|---|---|
| **Trial 1** | | **Trial 2** | | **Trial 1** | | **Trial 2** | |
| **Time (minutes)** | **Weight of Tire Bale (lbs)** | **Time (minutes)** | **Weight of Tire Bale (lbs)** | **Time (minutes)** | **Weight of Tire Bale (lbs)** | **Time (minutes)** | **Weight of Tire Bale (lbs)** |
| 0.5 | 2318 | 0.5 | 2317 | 11.5 | 2145 | 0.5 | 2218 |
| 1 | 2295 | 1 | 2295 | 13.5 | 2143 | 1 | 2190 |
| 1.5 | 2283 | 1.5 | 2285 | 15 | 2143 | 1.5 | 2180 |
| 2 | 2277 | 2 | 2277 | 17 | 2141 | 2 | 2173 |
| 3 | 2270 | 3 | 2270 | | | 3 | 2165 |
| 4 | 2263 | 4 | 2265 | | | 4 | 2161 |
| 6 | 2257 | 6 | 2260 | | | 6 | 2155 |
| 8 | 2255 | 8 | 2255 | | | 8 | 2150 |
| 10 | 2255 | 10 | 2255 | | | 10 | 2148 |
| 12 | 2252 | 12 | 2252 | | | 12 | 2145 |
| 15 | 2252 | 15 | 2252 | | | 15 | 2143 |
| 20 | 2250 | 20 | 2250 | | | 20 | 2140 |
| 25 | 2247 | 25 | 2248 | | | 25.5 | 2136 |
| 30 | 2247 | 30 | 2247 | | | 30 | 2135 |
| 40 | 2247 | 45 | 2245 | | | | |



## Tire Bale 4 - Unconfined Under a Cyclic Load of 9 kips
## Peak Values
## Representative Data

**Up to row 1310** **Up to column CF**

| Cycle # | Cen. Def. | LC (kPa) | LC (psi) | LC (lbf) | SD3 (mm) | SD4 (mm) | SD5 (mm) |
|---|---|---|---|---|---|---|---|
| 1 | 23.78689667 | 527.483 | 76.502 | 8652.200 | 23.65999 | 24.30027 | 23.40043 |
| 2 | 24.21059667 | 526.822 | 76.406 | 8641.358 | 24.10309 | 24.71157 | 23.81713 |
| 3 | 24.29583 | 522.19 | 75.735 | 8565.380 | 24.18019 | 24.81437 | 23.89293 |
| 4 | 24.34129667 | 520.205 | 75.447 | 8532.821 | 24.21869 | 24.85547 | 23.94973 |
| 5 | 24.34129667 | 517.558 | 75.063 | 8489.403 | 24.21869 | 24.85547 | 23.94973 |
| 6 | 24.44563 | 518.22 | 75.159 | 8500.261 | 24.31509 | 24.95837 | 24.06343 |
| 7 | 24.24336333 | 510.941 | 74.103 | 8380.865 | 24.12239 | 24.75267 | 23.85503 |
| 8 | 24.25613 | 508.295 | 73.719 | 8337.463 | 24.14169 | 24.75267 | 23.87403 |
| 9 | 24.21693 | 504.986 | 73.239 | 8283.187 | 24.10309 | 24.71157 | 23.83613 |
| 10 | 24.14543 | 502.34 | 72.856 | 8239.785 | 24.02609 | 24.64987 | 23.76033 |
| 11 | 24.06019667 | 499.031 | 72.376 | 8185.508 | 23.94899 | 24.54707 | 23.68453 |
| 12 | 24.10623 | 497.046 | 72.088 | 8152.948 | 23.98749 | 24.60877 | 23.72243 |
| 13 | 24.11209667 | 494.4 | 71.704 | 8109.546 | 24.00679 | 24.58817 | 23.74133 |
| 14 | 24.07296333 | 491.091 | 71.224 | 8055.270 | 23.96829 | 24.54707 | 23.70353 |
| 15 | 24.02013 | 487.783 | 70.744 | 8001.009 | 23.94899 | 24.46477 | 23.64663 |
| 16 | 24.04606333 | 485.136 | 70.361 | 7957.591 | 23.96829 | 24.48537 | 23.68453 |
| 17 | 24.00686333 | 483.151 | 70.073 | 7925.031 | 23.92969 | 24.44427 | 23.64663 |
| 18 | 23.95396333 | 480.505 | 69.689 | 7881.629 | 23.89119 | 24.36197 | 23.60873 |
| 19 | 23.88876333 | 477.858 | 69.305 | 7838.211 | 23.81409 | 24.30027 | 23.55193 |
| 20 | 23.92169667 | 476.535 | 69.113 | 7816.510 | 23.85269 | 24.34147 | 23.57093 |
| 21 | 23.69343 | 473.888 | 68.729 | 7773.092 | 23.62149 | 24.11527 | 23.34353 |
| 22 | 23.69983 | 471.903 | 68.441 | 7740.533 | 23.64069 | 24.11527 | 23.34353 |
| 23 | 23.70606333 | 471.241 | 68.345 | 7729.674 | 23.62149 | 24.11527 | 23.38143 |
| 24 | 23.50379667 | 467.933 | 67.866 | 7675.413 | 23.42879 | 23.90957 | 23.17303 |
| 25 | 23.41226333 | 465.948 | 67.578 | 7642.854 | 23.35169 | 23.80677 | 23.07833 |
| 26 | 23.41913 | 465.286 | 67.482 | 7631.995 | 23.35169 | 23.82737 | 23.07833 |
| 27 | 23.21639667 | 461.316 | 66.906 | 7566.876 | 23.15909 | 23.60117 | 22.88893 |
| 28 | 23.17719667 | 460.655 | 66.810 | 7556.034 | 23.12049 | 23.56007 | 22.85103 |
| 29 | 23.10566333 | 458.67 | 66.522 | 7523.474 | 23.04339 | 23.49837 | 22.77523 |
| 30 | 22.96209667 | 456.685 | 66.234 | 7490.915 | 22.88929 | 23.35437 | 22.64263 |
| 31 | 22.89016333 | 455.361 | 66.042 | 7469.197 | 22.83149 | 23.27217 | 22.56683 |
| 32 | 22.81866333 | 453.376 | 65.754 | 7436.638 | 22.75439 | 23.21047 | 22.49113 |
| 33 | 22.74029667 | 452.053 | 65.562 | 7414.937 | 22.67739 | 23.12817 | 22.41533 |
| 34 | 22.64233 | 450.73 | 65.371 | 7393.236 | 22.58099 | 23.02537 | 22.32063 |
| 35 | 22.54479667 | 448.745 | 65.083 | 7360.676 | 22.46539 | 22.94317 | 22.22583 |
| 36 | 22.49879667 | 447.421 | 64.891 | 7338.959 | 22.42689 | 22.88147 | 22.18803 |
| 37 | 22.40083 | 445.436 | 64.603 | 7306.400 | 22.33059 | 22.77867 | 22.09323 |
| 38 | 22.36163 | 444.113 | 64.411 | 7284.699 | 22.29199 | 22.73757 | 22.05533 |
| 39 | 22.29016333 | 443.451 | 64.315 | 7273.840 | 22.21499 | 22.67587 | 21.97963 |
| 40 | 22.42039667 | 444.775 | 64.507 | 7295.557 | 22.34979 | 22.79917 | 22.11223 |
| 41 | 22.59673 | 449.406 | 65.179 | 7371.519 | 22.52319 | 22.98427 | 22.28273 |
| 42 | 22.66823 | 451.391 | 65.466 | 7404.078 | 22.60029 | 23.04597 | 22.35843 |
| 43 | 22.80539667 | 454.038 | 65.850 | 7447.496 | 22.73519 | 23.18987 | 22.49113 |
| 44 | 22.94253 | 456.023 | 66.138 | 7480.056 | 22.86999 | 23.33387 | 22.62373 |
| 45 | 23.09926333 | 459.331 | 66.618 | 7534.316 | 23.02419 | 23.49837 | 22.77523 |
| 46 | 23.17076333 | 461.316 | 66.906 | 7566.876 | 23.10119 | 23.56007 | 22.85103 |
| 47 | 23.26229667 | 462.64 | 67.098 | 7588.593 | 23.17829 | 23.66287 | 22.94573 |
| 48 | 23.52973 | 465.948 | 67.578 | 7642.854 | 23.44809 | 23.93017 | 23.21093 |
| 49 | 23.60809667 | 468.595 | 67.962 | 7686.272 | 23.52509 | 24.01247 | 23.28673 |
| 50 | 23.76483 | 469.918 | 68.153 | 7707.973 | 23.67929 | 24.17697 | 23.43823 |
| 51 | 23.84316333 | 471.903 | 68.441 | 7740.533 | 23.75629 | 24.25917 | 23.51403 |
| 52 | 24.03226333 | 475.211 | 68.921 | 7794.793 | 23.94899 | 24.44427 | 23.70353 |
| 53 | 24.12333 | 476.535 | 69.113 | 7816.510 | 24.04529 | 24.52647 | 23.79823 |
| 954 | 28.20746333 | 466.61 | 67.674 | 7653.713 | 28.22629 | 28.39237 | 28.00373 |
| 955 | 28.10323 | 465.286 | 67.482 | 7631.995 | 28.12999 | 28.28957 | 27.89013 |
| 956 | 27.97923 | 462.64 | 67.098 | 7588.593 | 27.99509 | 28.16617 | 27.77643 |
| 957 | 27.91359667 | 460.655 | 66.810 | 7556.034 | 27.93729 | 28.08387 | 27.71963 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 958 | 27.79606333 | 458.67 | 66.522 | 7523.474 | 27.82169 | 27.96057 | 27.60593 |
| 959 | 27.69853 | 456.023 | 66.138 | 7480.056 | 27.70609 | 27.87827 | 27.51123 |
| 960 | 27.58736333 | 454.7 | 65.946 | 7458.355 | 27.60969 | 27.75487 | 27.39753 |
| 961 | 27.51536333 | 452.715 | 65.658 | 7425.796 | 27.53269 | 27.67267 | 27.34073 |
| 962 | 27.42423 | 451.391 | 65.466 | 7404.078 | 27.43629 | 27.59037 | 27.24603 |
| 963 | 27.30036333 | 448.083 | 64.987 | 7349.818 | 27.32069 | 27.46697 | 27.11343 |
| 964 | 27.20239667 | 446.76 | 64.795 | 7328.117 | 27.22439 | 27.36417 | 27.01863 |
| 965 | 27.05886333 | 444.113 | 64.411 | 7284.699 | 27.07029 | 27.22027 | 26.88603 |
| 966 | 26.98059667 | 442.128 | 64.123 | 7252.139 | 27.01249 | 27.13797 | 26.79133 |
| 967 | 26.88893 | 440.143 | 63.835 | 7219.579 | 26.91609 | 27.03517 | 26.71553 |
| 968 | 26.81063 | 438.819 | 63.643 | 7197.862 | 26.83909 | 26.95297 | 26.63983 |
| 969 | 26.58236333 | 432.864 | 62.779 | 7100.183 | 26.60789 | 26.72677 | 26.41243 |
| 970 | 26.60193 | 434.849 | 63.067 | 7132.743 | 26.62709 | 26.74727 | 26.43143 |
| 971 | 26.39329667 | 429.556 | 62.300 | 7045.923 | 26.41519 | 26.54167 | 26.22303 |
| 972 | 26.47809667 | 432.864 | 62.779 | 7100.183 | 26.51149 | 26.62397 | 26.29883 |
| 973 | 26.52359667 | 434.188 | 62.971 | 7121.901 | 26.55009 | 26.66507 | 26.35563 |
| 974 | 26.58876333 | 435.511 | 63.163 | 7143.602 | 26.62709 | 26.72677 | 26.41243 |
| 975 | 26.77826333 | 440.804 | 63.931 | 7230.422 | 26.80049 | 26.93237 | 26.60193 |
| 976 | 26.88263 | 442.789 | 64.219 | 7262.981 | 26.91609 | 27.03517 | 26.69663 |
| 977 | 26.92813 | 444.113 | 64.411 | 7284.699 | 26.95469 | 27.07627 | 26.75343 |
| 978 | 26.98693 | 444.775 | 64.507 | 7295.557 | 27.01249 | 27.13797 | 26.81033 |
| 979 | 27.12406333 | 448.745 | 65.083 | 7360.676 | 27.14729 | 27.28197 | 26.94293 |
| 980 | 27.23473 | 450.73 | 65.371 | 7393.236 | 27.26289 | 27.38477 | 27.05653 |
| 981 | 27.33269667 | 452.715 | 65.658 | 7425.796 | 27.35929 | 27.48757 | 27.15123 |
| 982 | 27.43709667 | 455.361 | 66.042 | 7469.197 | 27.47489 | 27.59037 | 27.24603 |
| 983 | 27.56139667 | 458.008 | 66.426 | 7512.616 | 27.57119 | 27.73437 | 27.37863 |
| 984 | 27.63926333 | 459.331 | 66.618 | 7534.316 | 27.66749 | 27.79597 | 27.45433 |
| 985 | 27.75686333 | 462.64 | 67.098 | 7588.593 | 27.78319 | 27.91937 | 27.56803 |
| 986 | 27.82883 | 464.625 | 67.386 | 7621.153 | 27.84099 | 28.00167 | 27.64383 |
| 987 | 27.93319667 | 465.948 | 67.578 | 7642.854 | 27.95659 | 28.10447 | 27.73853 |
| 988 | 28.01796333 | 468.595 | 67.962 | 7686.272 | 28.05289 | 28.18667 | 27.81433 |
| 989 | 28.12276333 | 469.918 | 68.153 | 7707.973 | 28.14919 | 28.31007 | 27.90903 |
| 990 | 28.22706333 | 473.226 | 68.633 | 7762.233 | 28.24559 | 28.41287 | 28.02273 |
| 991 | 28.21429667 | 472.565 | 68.537 | 7751.391 | 28.22629 | 28.41287 | 28.00373 |
| 992 | 28.35099667 | 475.873 | 69.017 | 7805.652 | 28.38039 | 28.53627 | 28.13633 |
| 993 | 28.41666333 | 476.535 | 69.113 | 7816.510 | 28.43819 | 28.61857 | 28.19323 |
| 994 | 28.56716333 | 480.505 | 69.689 | 7881.629 | 28.61159 | 28.78307 | 28.30683 |
| 995 | 28.56029667 | 479.843 | 69.593 | 7870.771 | 28.61159 | 28.76247 | 28.30683 |
| 996 | 28.59373 | 481.166 | 69.785 | 7892.472 | 28.65019 | 28.82417 | 28.30683 |
| 997 | 28.66653 | 483.813 | 70.169 | 7935.890 | 28.76579 | 28.92697 | 28.30683 |
| 998 | 28.73289667 | 486.46 | 70.553 | 7979.308 | 28.86209 | 29.02977 | 28.30683 |
| 999 | 28.77273 | 487.121 | 70.648 | 7990.150 | 28.91989 | 29.09147 | 28.30683 |
| 1000 | 28.78603 | 487.121 | 70.648 | 7990.150 | 28.93919 | 29.11207 | 28.30683 |
| 1001 | 28.87893 | 490.43 | 71.128 | 8044.427 | 29.07399 | 29.25597 | 28.30683 |
| 1002 | 28.92519667 | 492.415 | 71.416 | 8076.987 | 29.15109 | 29.31767 | 28.30683 |
| 1003 | 28.96503 | 493.076 | 71.512 | 8087.829 | 29.20889 | 29.37937 | 28.30683 |
| 1004 | 29.01119667 | 494.4 | 71.704 | 8109.546 | 29.26669 | 29.44107 | 28.32583 |
| 1005 | 29.09779667 | 497.708 | 72.184 | 8163.807 | 29.40159 | 29.58497 | 28.30683 |
| 1006 | 29.14449667 | 499.031 | 72.376 | 8185.508 | 29.45939 | 29.66727 | 28.30683 |
| 1007 | 29.19076333 | 500.355 | 72.568 | 8207.225 | 29.53649 | 29.72897 | 28.30683 |
| 1008 | 29.23699667 | 501.678 | 72.760 | 8228.926 | 29.61349 | 29.79067 | 28.30683 |
| 1009 | 29.30339667 | 503.663 | 73.048 | 8261.486 | 29.70989 | 29.89347 | 28.30683 |
| 1010 | 29.26356333 | 502.34 | 72.856 | 8239.785 | 29.65209 | 29.83177 | 28.30683 |

## Tire Bale 4 - Unconfined
## Minimum Values

## Under a Cyclic Load of 9 kips

### Representative Data

| Cycle # | Cen. Def. | LC (kPa) | LC (psi) | LC (lbf) | SD3 (mm) | SD4 (mm) | SD5 (mm) |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 10.5536 | 1.531 | 173.109 | 0 | 0 | 0 |
| 2 | 0.917206667 | 10.0574 | 1.459 | 164.970 | 0.90074 | 0.95104 | 0.89984 |
| 3 | 1.20604 | 10.0574 | 1.459 | 164.970 | 1.18493 | 1.2492 | 1.18399 |
| 4 | 1.373873333 | 9.89196 | 1.435 | 162.256 | 1.3487 | 1.4137 | 1.35922 |
| 5 | 1.497816667 | 10.0574 | 1.459 | 164.970 | 1.47875 | 1.53708 | 1.47762 |
| 6 | 1.594223333 | 10.2228 | 1.483 | 167.683 | 1.5799 | 1.6399 | 1.56287 |
| 7 | 1.665953333 | 9.89196 | 1.435 | 162.256 | 1.64734 | 1.71187 | 1.63865 |
| 8 | 1.72459 | 10.0574 | 1.459 | 164.970 | 1.70514 | 1.76842 | 1.70021 |
| 9 | 1.783363333 | 9.89196 | 1.435 | 162.256 | 1.76294 | 1.83011 | 1.75704 |
| 10 | 1.830653333 | 9.72655 | 1.411 | 159.543 | 1.81592 | 1.87637 | 1.79967 |
| 11 | 1.861596667 | 9.56113 | 1.387 | 156.829 | 1.84001 | 1.90722 | 1.83756 |
| 12 | 1.920286667 | 9.72655 | 1.411 | 159.543 | 1.90744 | 1.96377 | 1.88965 |
| 13 | 1.962733333 | 9.89196 | 1.435 | 162.256 | 1.94116 | 2.01003 | 1.93701 |
| 14 | 1.998623333 | 9.56113 | 1.387 | 156.829 | 1.97969 | 2.04602 | 1.97016 |
| 15 | 2.034353333 | 9.56113 | 1.387 | 156.829 | 2.01341 | 2.07686 | 2.01279 |
| 16 | 2.0734 | 9.56113 | 1.387 | 156.829 | 2.05194 | 2.11285 | 2.05541 |
| 17 | 2.094596667 | 9.72655 | 1.411 | 159.543 | 2.07603 | 2.13341 | 2.07435 |
| 18 | 2.120773333 | 9.72655 | 1.411 | 159.543 | 2.0953 | 2.16425 | 2.10277 |
| 19 | 2.143576667 | 9.56113 | 1.387 | 156.829 | 2.1242 | 2.18482 | 2.12171 |
| 20 | 2.169643333 | 9.56113 | 1.387 | 156.829 | 2.14828 | 2.21052 | 2.15013 |
| 21 | 2.1891 | 9.56113 | 1.387 | 156.829 | 2.16755 | 2.22594 | 2.17381 |
| 22 | 2.20869 | 9.72655 | 1.411 | 159.543 | 2.18681 | 2.24651 | 2.19275 |
| 23 | 2.22325 | 9.72655 | 1.411 | 159.543 | 2.20126 | 2.25679 | 2.2117 |
| 24 | 2.23952 | 9.56113 | 1.387 | 156.829 | 2.21571 | 2.27221 | 2.23064 |
| 25 | 2.250976667 | 9.39571 | 1.363 | 154.116 | 2.2398 | 2.28249 | 2.23064 |
| 26 | 2.26559 | 9.56113 | 1.387 | 156.829 | 2.2398 | 2.29791 | 2.25906 |
| 27 | 2.283493333 | 9.56113 | 1.387 | 156.829 | 2.26388 | 2.31334 | 2.27326 |
| 28 | 2.284966667 | 9.56113 | 1.387 | 156.829 | 2.2687 | 2.3082 | 2.278 |
| 29 | 2.29155 | 9.39571 | 1.363 | 154.116 | 2.2687 | 2.31848 | 2.28747 |
| 30 | 2.306216667 | 9.56113 | 1.387 | 156.829 | 2.27833 | 2.3339 | 2.30642 |
| 31 | 2.312746667 | 9.56113 | 1.387 | 156.829 | 2.29278 | 2.33904 | 2.30642 |
| 32 | 2.322513333 | 9.39571 | 1.363 | 154.116 | 2.2976 | 2.34932 | 2.32062 |
| 33 | 2.327413333 | 9.72655 | 1.411 | 159.543 | 2.30242 | 2.35446 | 2.32536 |
| 34 | 2.334023333 | 9.39571 | 1.363 | 154.116 | 2.30723 | 2.36474 | 2.3301 |
| 35 | 2.3405 | 9.39571 | 1.363 | 154.116 | 2.31205 | 2.36988 | 2.33957 |
| 36 | 2.343573333 | 9.2303 | 1.339 | 151.403 | 2.32168 | 2.36474 | 2.3443 |
| 37 | 2.350186667 | 9.2303 | 1.339 | 151.403 | 2.3265 | 2.37502 | 2.34904 |
| 38 | 2.353483333 | 9.56113 | 1.387 | 156.829 | 2.3265 | 2.38017 | 2.35378 |
| 39 | 2.361696667 | 9.2303 | 1.339 | 151.403 | 2.33613 | 2.39045 | 2.35851 |
| 40 | 2.366433333 | 9.39571 | 1.363 | 154.116 | 2.33613 | 2.39045 | 2.37272 |
| 41 | 2.3777 | 9.2303 | 1.339 | 151.403 | 2.35058 | 2.39559 | 2.38693 |
| 42 | 2.39084 | 9.39571 | 1.363 | 154.116 | 2.36985 | 2.41101 | 2.39166 |
| 43 | 2.40722 | 9.39571 | 1.363 | 154.116 | 2.37948 | 2.43157 | 2.41061 |
| 44 | 2.423603333 | 9.72655 | 1.411 | 159.543 | 2.38912 | 2.45214 | 2.42955 |
| 45 | 2.43819 | 9.39571 | 1.363 | 154.116 | 2.40839 | 2.46242 | 2.44376 |
| 46 | 2.45767 | 9.56113 | 1.387 | 156.829 | 2.43247 | 2.47784 | 2.4627 |
| 47 | 2.46771 | 9.56113 | 1.387 | 156.829 | 2.43729 | 2.4984 | 2.46744 |
| 48 | 2.48224 | 9.72655 | 1.411 | 159.543 | 2.44692 | 2.50868 | 2.49112 |
| 49 | 2.50515 | 9.56113 | 1.387 | 156.829 | 2.471 | 2.53439 | 2.51006 |
| 50 | 2.519843333 | 9.39571 | 1.363 | 154.116 | 2.48545 | 2.54981 | 2.52427 |
| 51 | 2.5344 | 9.89196 | 1.435 | 162.256 | 2.4999 | 2.56009 | 2.54321 |
| 52 | 2.5556 | 9.56113 | 1.387 | 156.829 | 2.52399 | 2.58065 | 2.56216 |
| 53 | 2.586566667 | 9.56113 | 1.387 | 156.829 | 2.55289 | 2.6115 | 2.59531 |
| 54 | 2.606156667 | 9.72655 | 1.411 | 159.543 | 2.57216 | 2.63206 | 2.61425 |
| 55 | 2.620716667 | 9.56113 | 1.387 | 156.829 | 2.58661 | 2.64234 | 2.6332 |
| 56 | 2.645313333 | 9.56113 | 1.387 | 156.829 | 2.60587 | 2.67319 | 2.65688 |
| 57 | 2.664796667 | 9.72655 | 1.411 | 159.543 | 2.62996 | 2.68861 | 2.67582 |
| 58 | 2.684496667 | 9.56113 | 1.387 | 156.829 | 2.64441 | 2.71431 | 2.69477 |
| 59 | 2.70727 | 9.72655 | 1.411 | 159.543 | 2.66849 | 2.73488 | 2.71844 |
| 60 | 2.731626667 | 9.72655 | 1.411 | 159.543 | 2.69258 | 2.75544 | 2.74686 |
| 61 | 2.754236667 | 9.72655 | 1.411 | 159.543 | 2.71184 | 2.77086 | 2.78001 |
| 62 | 2.772386667 | 9.72655 | 1.411 | 159.543 | 2.73111 | 2.79657 | 2.78948 |
| 63 | 2.808386667 | 9.72655 | 1.411 | 159.543 | 2.76483 | 2.83769 | 2.82264 |
| 64 | 2.824656667 | 9.72655 | 1.411 | 159.543 | 2.77928 | 2.85311 | 2.84158 |
| 65 | 2.853936667 | 9.89196 | 1.435 | 162.256 | 2.81299 | 2.87882 | 2.87 |
| 66 | 2.866863333 | 9.72655 | 1.411 | 159.543 | 2.81781 | 2.8891 | 2.89368 |
| 67 | 2.892956667 | 9.72655 | 1.411 | 159.543 | 2.84671 | 2.9148 | 2.91736 |
| 68 | 2.920873333 | 9.89196 | 1.435 | 162.256 | 2.8708 | 2.95079 | 2.94103 |
| 69 | 2.950126667 | 9.89196 | 1.435 | 162.256 | 2.8997 | 2.97649 | 2.97419 |
| 70 | 2.97132 | 9.72655 | 1.411 | 159.543 | 2.92378 | 2.99705 | 2.99313 |
| 71 | 3.005473333 | 9.89196 | 1.435 | 162.256 | 2.9575 | 3.0279 | 3.03102 |
| 72 | 3.033116667 | 9.89196 | 1.435 | 162.256 | 2.98158 | 3.0536 | 3.06417 |
| 73 | 3.06596 | 9.72655 | 1.411 | 159.543 | 3.0153 | 3.09473 | 3.08785 |
| 74 | 3.091783333 | 9.72655 | 1.411 | 159.543 | 3.0442 | 3.11015 | 3.121 |
| 75 | 3.109906667 | 9.89196 | 1.435 | 162.256 | 3.05865 | 3.13586 | 3.13521 |
| 76 | 3.147236667 | 9.89196 | 1.435 | 162.256 | 3.09718 | 3.1667 | 3.17783 |
| 77 | 3.179943333 | 9.89196 | 1.435 | 162.256 | 3.1309 | 3.20268 | 3.20625 |
| 78 | 3.212623333 | 9.89196 | 1.435 | 162.256 | 3.1598 | 3.23867 | 3.2394 |
| 79 | 3.245223333 | 9.72655 | 1.411 | 159.543 | 3.19834 | 3.26951 | 3.26782 |
| 80 | 3.273003333 | 10.0574 | 1.459 | 164.970 | 3.22242 | 3.30036 | 3.29623 |
| 81 | 3.298963333 | 9.89196 | 1.435 | 162.256 | 3.25132 | 3.32092 | 3.32465 |
| 82 | 3.336543333 | 9.89196 | 1.435 | 162.256 | 3.28504 | 3.36205 | 3.36254 |
| 83 | 3.359236667 | 9.89196 | 1.435 | 162.256 | 3.31876 | 3.37747 | 3.38148 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 84 | 3.393603333 | 10.0574 | 1.459 | 164.970 | 3.34284 | 3.4186 | 3.41937 |
| 85 | 3.42446 | 9.89196 | 1.435 | 162.256 | 3.37656 | 3.4443 | 3.45252 |
| 86 | 3.452266667 | 9.89196 | 1.435 | 162.256 | 3.40546 | 3.47514 | 3.4762 |
| 87 | 3.48152 | 9.89196 | 1.435 | 162.256 | 3.43436 | 3.50085 | 3.50935 |
| 88 | 3.520456667 | 9.89196 | 1.435 | 162.256 | 3.47771 | 3.53169 | 3.55197 |
| 89 | 3.54013 | 9.72655 | 1.411 | 159.543 | 3.48734 | 3.5574 | 3.57565 |
| 90 | 3.587446667 | 10.0574 | 1.459 | 164.970 | 3.54514 | 3.60366 | 3.61354 |
| 91 | 3.61349 | 9.72655 | 1.411 | 159.543 | 3.56441 | 3.62937 | 3.64669 |
| 92 | 3.639583333 | 9.89196 | 1.435 | 162.256 | 3.59331 | 3.65507 | 3.67037 |
| 93 | 3.68024 | 10.2228 | 1.483 | 167.683 | 3.63666 | 3.69106 | 3.713 |
| 94 | 3.70655 | 10.0574 | 1.459 | 164.970 | 3.65593 | 3.72704 | 3.73668 |
| 95 | 3.730823333 | 9.72655 | 1.411 | 159.543 | 3.68965 | 3.74246 | 3.76036 |
| 96 | 3.768263333 | 9.89196 | 1.435 | 162.256 | 3.72336 | 3.77845 | 3.80298 |
| 97 | 3.797676667 | 9.89196 | 1.435 | 162.256 | 3.75708 | 3.80929 | 3.82666 |
| 98 | 3.82375 | 9.89196 | 1.435 | 162.256 | 3.78117 | 3.835 | 3.85508 |
| 99 | 3.83697 | 9.72655 | 1.411 | 159.543 | 3.7908 | 3.85556 | 3.86455 |
| 100 | 3.84505 | 9.72655 | 1.411 | 159.543 | 3.80043 | 3.8607 | 3.87402 |
| 950 | 6.311586667 | 10.7191 | 1.555 | 175.823 | 6.44966 | 6.14837 | 6.33673 |
| 951 | 6.309853333 | 10.5536 | 1.531 | 173.109 | 6.44966 | 6.14317 | 6.33673 |
| 952 | 6.30164 | 10.5536 | 1.531 | 173.109 | 6.44002 | 6.13287 | 6.33203 |
| 953 | 6.29343 | 10.5536 | 1.531 | 173.109 | 6.43039 | 6.12267 | 6.32723 |
| 954 | 6.278873333 | 10.7191 | 1.555 | 175.823 | 6.41594 | 6.11235 | 6.30833 |
| 955 | 6.27224 | 10.7191 | 1.555 | 175.823 | 6.41112 | 6.10207 | 6.30353 |
| 956 | 6.27082 | 10.5536 | 1.531 | 173.109 | 6.41112 | 6.10721 | 6.29413 |
| 957 | 6.26086 | 10.5536 | 1.531 | 173.109 | 6.39667 | 6.09178 | 6.29413 |
| 958 | 6.24457 | 10.5536 | 1.531 | 173.109 | 6.38222 | 6.07636 | 6.27513 |
| 959 | 6.239833333 | 10.5536 | 1.531 | 173.109 | 6.37741 | 6.07636 | 6.26573 |
| 960 | 6.23808 | 10.5536 | 1.531 | 173.109 | 6.37259 | 6.07122 | 6.27043 |
| 961 | 6.224996667 | 10.5536 | 1.531 | 173.109 | 6.36296 | 6.0558 | 6.25623 |
| 962 | 6.220183333 | 10.5536 | 1.531 | 173.109 | 6.35332 | 6.0558 | 6.25143 |
| 963 | 6.215043333 | 10.5536 | 1.531 | 173.109 | 6.35332 | 6.04038 | 6.25143 |
| 964 | 6.210306667 | 10.5536 | 1.531 | 173.109 | 6.34851 | 6.04038 | 6.24203 |
| 965 | 6.192186667 | 10.5536 | 1.531 | 173.109 | 6.33406 | 6.01467 | 6.22783 |
| 966 | 6.1842 | 10.5536 | 1.531 | 173.109 | 6.3196 | 6.01467 | 6.21833 |
| 967 | 6.177603333 | 10.3882 | 1.507 | 170.396 | 6.31479 | 6.00439 | 6.21363 |
| 968 | 6.171116667 | 10.3882 | 1.507 | 170.396 | 6.30997 | 5.99925 | 6.20413 |
| 969 | 6.159706667 | 10.3882 | 1.507 | 170.396 | 6.29552 | 5.98897 | 6.19463 |
| 970 | 6.151503333 | 10.7191 | 1.555 | 175.823 | 6.28589 | 5.97869 | 6.18993 |
| 971 | 6.14491 | 10.3882 | 1.507 | 170.396 | 6.28589 | 5.96841 | 6.18043 |
| 972 | 6.1335 | 10.5536 | 1.531 | 173.109 | 6.27144 | 5.95813 | 6.17093 |
| 973 | 6.130366667 | 10.3882 | 1.507 | 170.396 | 6.27144 | 5.95813 | 6.16153 |
| 974 | 6.12227 | 10.3882 | 1.507 | 170.396 | 6.2618 | 5.95298 | 6.15203 |
| 975 | 6.12865 | 10.3882 | 1.507 | 170.396 | 6.27144 | 5.95298 | 6.16153 |
| 976 | 6.135213333 | 10.5536 | 1.531 | 173.109 | 6.27144 | 5.96327 | 6.17093 |
| 977 | 6.13853 | 10.5536 | 1.531 | 173.109 | 6.27625 | 5.96841 | 6.17093 |
| 978 | 6.145123333 | 10.5536 | 1.531 | 173.109 | 6.27625 | 5.97869 | 6.18043 |
| 979 | 6.143303333 | 10.5536 | 1.531 | 173.109 | 6.28107 | 5.96841 | 6.18043 |
| 980 | 6.14819 | 10.7191 | 1.555 | 175.823 | 6.28589 | 5.97355 | 6.18513 |
| 981 | 6.153 | 10.5536 | 1.531 | 173.109 | 6.29552 | 5.97355 | 6.18993 |
| 982 | 6.166083333 | 10.3882 | 1.507 | 170.396 | 6.30515 | 5.98897 | 6.20413 |
| 983 | 6.16951 | 10.2228 | 1.483 | 167.683 | 6.30515 | 5.99925 | 6.20413 |
| 984 | 6.17932 | 10.5536 | 1.531 | 173.109 | 6.3196 | 6.00953 | 6.20883 |
| 985 | 6.182526667 | 10.3882 | 1.507 | 170.396 | 6.32442 | 6.00953 | 6.21363 |
| 986 | 6.190586667 | 10.3882 | 1.507 | 170.396 | 6.33406 | 6.01467 | 6.22303 |
| 987 | 6.196923333 | 10.5536 | 1.531 | 173.109 | 6.33887 | 6.01467 | 6.23723 |
| 988 | 6.2005 | 10.7191 | 1.555 | 175.823 | 6.33887 | 6.0301 | 6.23253 |
| 989 | 6.213586667 | 10.5536 | 1.531 | 173.109 | 6.34851 | 6.04552 | 6.24673 |
| 990 | 6.215083333 | 10.5536 | 1.531 | 173.109 | 6.35814 | 6.04038 | 6.24673 |
| 991 | 6.223283333 | 10.5536 | 1.531 | 173.109 | 6.36296 | 6.05066 | 6.25623 |
| 992 | 6.226346667 | 10.5536 | 1.531 | 173.109 | 6.37259 | 6.04552 | 6.26093 |
| 993 | 6.231373333 | 10.5536 | 1.531 | 173.109 | 6.37259 | 6.0558 | 6.26573 |
| 994 | 6.237826667 | 10.3882 | 1.507 | 170.396 | 6.37741 | 6.06094 | 6.27513 |
| 995 | 6.25095 | 10.3882 | 1.507 | 170.396 | 6.39186 | 6.07636 | 6.28463 |
| 996 | 6.259153333 | 10.7191 | 1.555 | 175.823 | 6.40149 | 6.08664 | 6.28933 |
| 997 | 6.26575 | 10.5536 | 1.531 | 173.109 | 6.40149 | 6.09693 | 6.29883 |
| 998 | 6.27534 | 10.5536 | 1.531 | 173.109 | 6.42076 | 6.09693 | 6.30833 |
| 999 | 6.280263333 | 10.5536 | 1.531 | 173.109 | 6.43039 | 6.10207 | 6.30833 |
| 1000 | 6.285216667 | 10.7191 | 1.555 | 175.823 | 6.42557 | 6.11235 | 6.31773 |
| 1001 | 6.288466667 | 10.5536 | 1.531 | 173.109 | 6.44002 | 6.11235 | 6.31303 |
| 1002 | 6.303246667 | 10.5536 | 1.531 | 173.109 | 6.44484 | 6.13287 | 6.33203 |
| 1003 | 6.30642 | 10.7191 | 1.555 | 175.823 | 6.44966 | 6.13287 | 6.33673 |
| 1004 | 6.316096667 | 10.7191 | 1.555 | 175.823 | 6.45929 | 6.13807 | 6.35093 |
| 1005 | 6.31953 | 10.7191 | 1.555 | 175.823 | 6.45929 | 6.14837 | 6.35093 |
| 1006 | 6.33248 | 10.7191 | 1.555 | 175.823 | 6.47374 | 6.15857 | 6.36513 |
| 1007 | 6.343896667 | 10.5536 | 1.531 | 173.109 | 6.48819 | 6.16887 | 6.37463 |
| 1008 | 6.35537 | 10.5536 | 1.531 | 173.109 | 6.49301 | 6.18427 | 6.38883 |
| 1009 | 6.36192 | 10.7191 | 1.555 | 175.823 | 6.50746 | 6.18947 | 6.38883 |
| 1010 | 6.36852 | 10.5536 | 1.531 | 173.109 | 6.50746 | 6.19977 | 6.39833 |

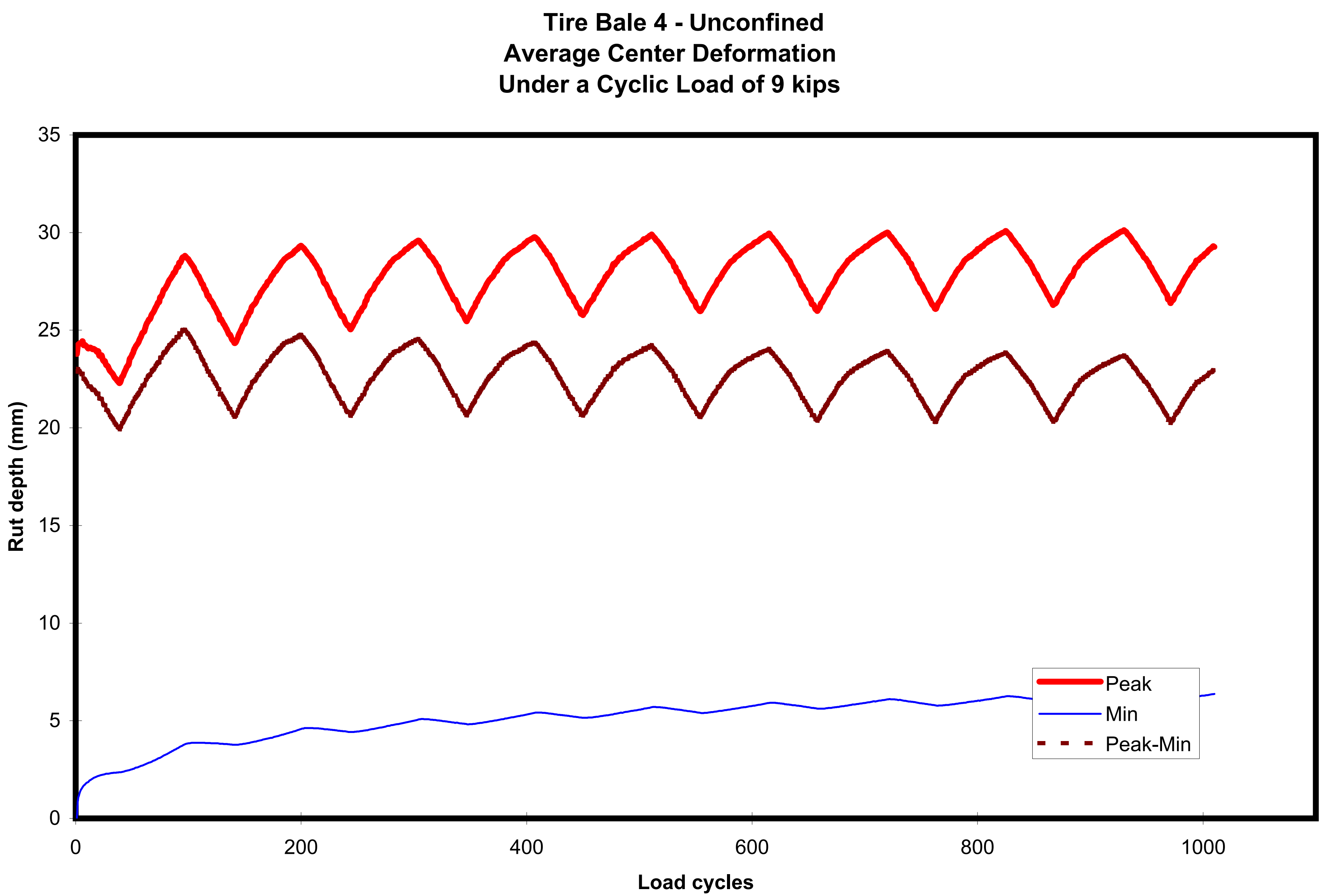
## Tire Bale 4 - Unconfined — Under a Cyclic Load of 9 kips

### Peak - Minimum Values

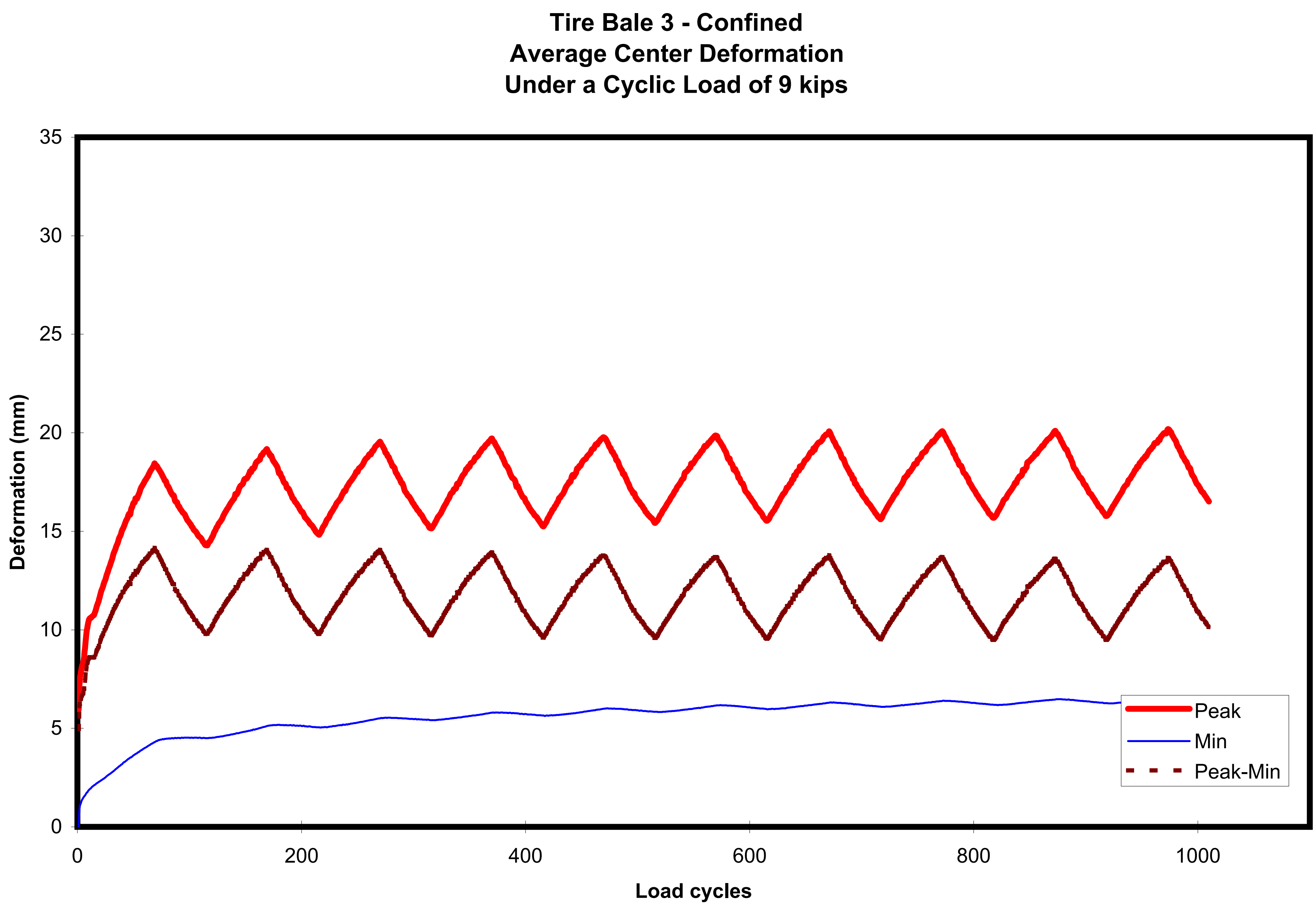
### Representative Data

| Cycle # | Cen. Def. | LC (kPa) | LC (psi) | LC (lbf) | SD3 (mm) | SD4 (mm) | SD5 (mm) |
|---|---|---|---|---|---|---|---|
| 1 | 22.86969 | 517.4256 | 75.044 | 8487.231 | 22.75925 | 23.34923 | 22.50059 |
| 2 | 23.00455667 | 516.7646 | 74.948 | 8476.389 | 22.91816 | 23.46237 | 22.63314 |
| 3 | 22.92195667 | 512.29804 | 74.300 | 8403.124 | 22.83149 | 23.40067 | 22.53371 |
| 4 | 22.84348 | 510.1476 | 73.988 | 8367.851 | 22.73994 | 23.31839 | 22.47211 |
| 5 | 22.74707333 | 507.3352 | 73.580 | 8321.720 | 22.63879 | 23.21557 | 22.38686 |
| 6 | 22.77967667 | 508.32804 | 73.724 | 8338.005 | 22.66775 | 23.2465 | 22.42478 |
| 7 | 22.51877333 | 500.8836 | 72.644 | 8215.896 | 22.41725 | 22.98425 | 22.15482 |
| 8 | 22.47276667 | 498.40304 | 72.285 | 8175.208 | 22.37875 | 22.92256 | 22.11699 |
| 9 | 22.38627667 | 495.25945 | 71.829 | 8123.644 | 22.28717 | 22.8352 | 22.03646 |
| 10 | 22.28383333 | 492.77887 | 71.469 | 8082.955 | 22.18608 | 22.74265 | 21.92277 |
| 11 | 22.13991 | 489.30445 | 70.965 | 8025.965 | 22.04155 | 22.5833 | 21.79488 |
| 12 | 22.14349667 | 487.15404 | 70.653 | 7990.692 | 22.04633 | 22.59874 | 21.78542 |
| 13 | 22.11347333 | 484.83887 | 70.317 | 7952.717 | 22.0271 | 22.54215 | 21.77117 |
| 14 | 22.03861 | 481.52987 | 69.838 | 7898.440 | 21.95488 | 22.47021 | 21.69074 |
| 15 | 21.94673 | 478.22187 | 69.358 | 7844.180 | 21.89705 | 22.35192 | 21.59122 |
| 16 | 21.95146667 | 475.40945 | 68.950 | 7798.048 | 21.89226 | 22.35196 | 21.61018 |
| 17 | 21.88609 | 473.42445 | 68.662 | 7765.489 | 21.83439 | 22.28002 | 21.54386 |
| 18 | 21.81038667 | 470.94387 | 68.302 | 7724.800 | 21.76699 | 22.17715 | 21.48702 |
| 19 | 21.71912 | 468.29687 | 67.918 | 7681.382 | 21.66581 | 22.08975 | 21.4018 |
| 20 | 21.75205333 | 466.97387 | 67.726 | 7659.681 | 21.70441 | 22.13095 | 21.4208 |
| 21 | 21.50433 | 464.32687 | 67.343 | 7616.263 | 21.45394 | 21.88933 | 21.16972 |
| 22 | 21.49114 | 462.17645 | 67.031 | 7580.990 | 21.45388 | 21.86876 | 21.15078 |
| 23 | 21.48281333 | 461.51445 | 66.935 | 7570.131 | 21.42023 | 21.85848 | 21.16973 |
| 24 | 21.26427667 | 458.37187 | 66.479 | 7518.584 | 21.21308 | 21.63736 | 20.94239 |
| 25 | 21.16128667 | 456.55229 | 66.215 | 7488.738 | 21.11189 | 21.52428 | 20.84769 |
| 26 | 21.15354 | 455.72487 | 66.095 | 7475.166 | 21.11189 | 21.52946 | 20.81927 |
| 27 | 20.93290333 | 451.75487 | 65.519 | 7410.047 | 20.89521 | 21.28783 | 20.61567 |
| 28 | 20.89223 | 451.09387 | 65.423 | 7399.204 | 20.85179 | 21.25187 | 20.57303 |
| 29 | 20.81411333 | 449.27429 | 65.159 | 7369.358 | 20.77469 | 21.17989 | 20.48776 |
| 30 | 20.65588 | 447.12387 | 64.848 | 7334.085 | 20.61096 | 21.02047 | 20.33621 |
| 31 | 20.57741667 | 445.79987 | 64.656 | 7312.368 | 20.53871 | 20.93313 | 20.26041 |
| 32 | 20.49615 | 443.98029 | 64.392 | 7282.522 | 20.45679 | 20.86115 | 20.17051 |
| 33 | 20.41288333 | 442.32645 | 64.152 | 7255.394 | 20.37497 | 20.77371 | 20.08997 |
| 34 | 20.30830667 | 441.33429 | 64.008 | 7239.120 | 20.27376 | 20.66063 | 19.99053 |
| 35 | 20.20429667 | 439.34929 | 63.720 | 7206.560 | 20.15334 | 20.57329 | 19.88626 |
| 36 | 20.15522333 | 438.1907 | 63.552 | 7187.556 | 20.10521 | 20.51673 | 19.84373 |
| 37 | 20.05064333 | 436.2057 | 63.264 | 7154.997 | 20.00409 | 20.40365 | 19.74419 |
| 38 | 20.00814667 | 434.55187 | 63.024 | 7127.869 | 19.96549 | 20.3574 | 19.70155 |
| 39 | 19.92846667 | 434.2207 | 62.976 | 7122.437 | 19.87886 | 20.28542 | 19.62112 |
| 40 | 20.05396333 | 435.37929 | 63.144 | 7141.441 | 20.01366 | 20.40872 | 19.73951 |
| 41 | 20.21903 | 440.1757 | 63.840 | 7220.116 | 20.17261 | 20.58868 | 19.8958 |
| 42 | 20.27739 | 441.99529 | 64.104 | 7249.962 | 20.23044 | 20.63496 | 19.96677 |
| 43 | 20.39817667 | 444.64229 | 64.488 | 7293.380 | 20.35571 | 20.7583 | 20.08052 |
| 44 | 20.51892667 | 446.29645 | 64.728 | 7320.513 | 20.48087 | 20.88173 | 20.19418 |
| 45 | 20.66107333 | 449.93529 | 65.255 | 7380.201 | 20.6158 | 21.03595 | 20.33147 |
| 46 | 20.71309333 | 451.75487 | 65.519 | 7410.047 | 20.66872 | 21.08223 | 20.38833 |
| 47 | 20.79458667 | 453.07887 | 65.711 | 7431.764 | 20.741 | 21.16447 | 20.47829 |
| 48 | 21.04749 | 456.22145 | 66.167 | 7483.311 | 21.00117 | 21.42149 | 20.71981 |
| 49 | 21.10294667 | 459.03387 | 66.575 | 7529.443 | 21.05409 | 21.47808 | 20.77667 |
| 50 | 21.24498667 | 460.52229 | 66.791 | 7553.857 | 21.19384 | 21.62716 | 20.91396 |
| 51 | 21.30876333 | 462.01104 | 67.007 | 7578.277 | 21.25639 | 21.69908 | 20.97082 |
| 52 | 21.47666333 | 465.64987 | 67.534 | 7637.964 | 21.425 | 21.86362 | 21.14137 |
| 53 | 21.53676333 | 466.97387 | 67.726 | 7659.681 | 21.4924 | 21.91497 | 21.20292 |
| 54 | 21.62830667 | 468.79345 | 67.990 | 7689.527 | 21.56953 | 22.01781 | 21.29758 |
| 55 | 21.71171333 | 470.94387 | 68.302 | 7724.800 | 21.65138 | 22.11033 | 21.37343 |
| 56 | 21.77181667 | 472.26687 | 68.494 | 7746.501 | 21.70922 | 22.16178 | 21.44445 |
| 57 | 21.91546667 | 474.74845 | 68.854 | 7787.206 | 21.85853 | 22.31086 | 21.57701 |
| 58 | 21.98043333 | 475.57487 | 68.974 | 7800.762 | 21.92108 | 22.36736 | 21.65286 |
| 59 | 22.13399333 | 478.05645 | 69.334 | 7841.466 | 22.0705 | 22.53189 | 21.79959 |
| 60 | 22.17483667 | 479.37945 | 69.526 | 7863.167 | 22.12341 | 22.57303 | 21.82807 |
| 61 | 22.19772667 | 480.04145 | 69.622 | 7874.026 | 22.14275 | 22.59871 | 21.85172 |
| 62 | 22.42784333 | 485.33445 | 70.389 | 7960.846 | 22.35468 | 22.8403 | 22.08855 |
| 63 | 22.52211 | 487.31945 | 70.677 | 7993.406 | 22.45576 | 22.92258 | 22.18799 |
| 64 | 22.60380667 | 487.98145 | 70.773 | 8004.264 | 22.53771 | 23.00996 | 22.26375 |
| 65 | 22.69209333 | 491.12404 | 71.229 | 8055.812 | 22.6196 | 23.10765 | 22.34903 |
| 66 | 22.70506667 | 490.62845 | 71.157 | 8047.682 | 22.63398 | 23.11797 | 22.36325 |
| 67 | 22.86857333 | 494.59845 | 71.733 | 8112.802 | 22.79778 | 23.29787 | 22.51007 |
| 68 | 22.92539 | 495.09404 | 71.805 | 8120.931 | 22.86999 | 23.34408 | 22.5621 |
| 69 | 22.98083667 | 495.75604 | 71.901 | 8131.789 | 22.91819 | 23.40068 | 22.62364 |
| 70 | 23.06391 | 497.90645 | 72.213 | 8167.062 | 22.99041 | 23.48292 | 22.7184 |
| 71 | 23.16692333 | 500.38804 | 72.573 | 8207.767 | 23.09159 | 23.59607 | 22.81311 |
| 72 | 23.25641333 | 501.71104 | 72.764 | 8229.468 | 23.20241 | 23.67317 | 22.89366 |
| 73 | 23.34150333 | 503.86145 | 73.076 | 8264.741 | 23.26499 | 23.77594 | 22.98358 |
| 74 | 23.34804667 | 502.53845 | 72.884 | 8243.040 | 23.27469 | 23.78112 | 22.98833 |
| 75 | 23.57819 | 505.68104 | 73.340 | 8294.587 | 23.49144 | 24.02271 | 23.22042 |
| 76 | 23.57949333 | 505.01904 | 73.244 | 8283.728 | 23.49141 | 24.01247 | 23.2346 |
| 77 | 23.71678667 | 508.32804 | 73.724 | 8338.005 | 23.63109 | 24.16149 | 23.35778 |
| 78 | 23.84080667 | 510.97504 | 74.108 | 8381.424 | 23.75629 | 24.29 | 23.47613 |
| 79 | 23.86017333 | 509.81645 | 73.940 | 8362.419 | 23.77555 | 24.30036 | 23.50461 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 80 | 23.92392667 | 510.8096 | 74.084 | 8378.710 | 23.82857 | 24.37231 | 23.5709 |
| 81 | 24.00863333 | 512.29804 | 74.300 | 8403.124 | 23.91527 | 24.45455 | 23.65608 |
| 82 | 24.12148667 | 514.28304 | 74.588 | 8435.684 | 24.03565 | 24.57792 | 23.75089 |
| 83 | 24.20306 | 515.60604 | 74.780 | 8457.385 | 24.09833 | 24.6653 | 23.84555 |
| 84 | 24.23389333 | 514.7796 | 74.660 | 8443.829 | 24.15125 | 24.68587 | 23.86456 |
| 85 | 24.30100333 | 516.93004 | 74.972 | 8479.102 | 24.21393 | 24.76297 | 23.92611 |
| 86 | 24.35786333 | 517.59104 | 75.068 | 8489.945 | 24.26203 | 24.81443 | 23.99713 |
| 87 | 24.45877667 | 518.91504 | 75.260 | 8511.662 | 24.34883 | 24.91202 | 24.11548 |
| 88 | 24.43954 | 518.25304 | 75.164 | 8500.803 | 24.34398 | 24.90178 | 24.07286 |
| 89 | 24.5962 | 521.72645 | 75.667 | 8557.777 | 24.50775 | 25.06117 | 24.21968 |
| 90 | 24.64685 | 522.0576 | 75.715 | 8563.209 | 24.54625 | 25.11771 | 24.27659 |
| 91 | 24.64037333 | 521.72645 | 75.667 | 8557.777 | 24.54628 | 25.1125 | 24.26234 |
| 92 | 24.82344667 | 524.87004 | 76.123 | 8609.341 | 24.72928 | 25.313 | 24.42806 |
| 93 | 24.78229 | 523.8772 | 75.979 | 8593.055 | 24.68593 | 25.25651 | 24.40443 |
| 94 | 24.93914667 | 526.0276 | 76.291 | 8628.328 | 24.84006 | 25.42613 | 24.55125 |
| 944 | 22.69595 | 479.7109 | 69.574 | 7868.604 | 22.84115 | 23.3287 | 21.918 |
| 945 | 22.62002 | 477.5605 | 69.262 | 7833.331 | 22.71106 | 23.231 | 21.918 |
| 946 | 22.56824333 | 475.9064 | 69.022 | 7806.200 | 22.63403 | 23.1385 | 21.9322 |
| 947 | 22.47182333 | 471.7709 | 68.422 | 7738.366 | 22.48947 | 22.9843 | 21.9417 |
| 948 | 22.39353333 | 468.9585 | 68.014 | 7692.234 | 22.3835 | 22.8507 | 21.9464 |
| 949 | 22.35843333 | 467.8009 | 67.846 | 7673.247 | 22.3257 | 22.789 | 21.9606 |
| 950 | 22.28901 | 465.1539 | 67.462 | 7629.828 | 22.20053 | 22.6964 | 21.9701 |
| 951 | 22.18514333 | 462.6724 | 67.103 | 7589.125 | 22.06563 | 22.5576 | 21.9322 |
| 952 | 22.13459 | 461.3494 | 66.911 | 7567.424 | 22.01747 | 22.5062 | 21.8801 |
| 953 | 21.96593333 | 457.3794 | 66.335 | 7502.305 | 21.8537 | 22.3108 | 21.7333 |
| 954 | 21.92859 | 455.8909 | 66.119 | 7477.889 | 21.81035 | 22.28002 | 21.6954 |
| 955 | 21.83099 | 454.5669 | 65.927 | 7456.172 | 21.71887 | 22.1875 | 21.5866 |
| 956 | 21.70841 | 452.0864 | 65.567 | 7415.485 | 21.58397 | 22.05896 | 21.4823 |
| 957 | 21.65273667 | 450.1014 | 65.279 | 7382.925 | 21.54062 | 21.99209 | 21.4255 |
| 958 | 21.55149333 | 448.1164 | 64.992 | 7350.366 | 21.43947 | 21.88421 | 21.3308 |
| 959 | 21.45869667 | 445.4694 | 64.608 | 7306.947 | 21.32868 | 21.80191 | 21.2455 |
| 960 | 21.34928333 | 444.1464 | 64.416 | 7285.246 | 21.2371 | 21.68365 | 21.1271 |
| 961 | 21.29036667 | 442.1614 | 64.128 | 7252.687 | 21.16973 | 21.61687 | 21.0845 |
| 962 | 21.20404667 | 440.8374 | 63.936 | 7230.970 | 21.08297 | 21.53457 | 20.9946 |
| 963 | 21.08532 | 437.5294 | 63.456 | 7176.709 | 20.96737 | 21.42659 | 20.862 |
| 964 | 20.99209 | 436.2064 | 63.264 | 7155.008 | 20.87588 | 21.32379 | 20.7766 |
| 965 | 20.86667667 | 433.5594 | 62.880 | 7111.590 | 20.73623 | 21.2056 | 20.6582 |
| 966 | 20.79639667 | 431.5744 | 62.592 | 7079.030 | 20.69289 | 21.1233 | 20.573 |
| 967 | 20.71132667 | 429.7548 | 62.328 | 7049.184 | 20.6013 | 21.03078 | 20.5019 |
| 968 | 20.63951333 | 428.4308 | 62.136 | 7027.467 | 20.52912 | 20.95372 | 20.4357 |
| 969 | 20.42265667 | 422.4758 | 61.273 | 6929.788 | 20.31237 | 20.7378 | 20.2178 |
| 970 | 20.45042667 | 424.1299 | 61.513 | 6956.920 | 20.3412 | 20.76858 | 20.2415 |
| 971 | 20.24838667 | 419.1678 | 60.793 | 6875.527 | 20.1293 | 20.57326 | 20.0426 |
| 972 | 20.34459667 | 422.3104 | 61.249 | 6927.075 | 20.24005 | 20.66584 | 20.1279 |
| 973 | 20.39323 | 423.7998 | 61.465 | 6951.505 | 20.27865 | 20.70694 | 20.1941 |
| 974 | 20.46649333 | 425.1228 | 61.657 | 6973.206 | 20.36529 | 20.77379 | 20.2604 |
| 975 | 20.64961333 | 430.4158 | 62.424 | 7060.026 | 20.52905 | 20.97939 | 20.4404 |
| 976 | 20.74741667 | 432.2354 | 62.688 | 7089.873 | 20.64465 | 21.0719 | 20.5257 |
| 977 | 20.7896 | 433.5594 | 62.880 | 7111.590 | 20.67844 | 21.10786 | 20.5825 |
| 978 | 20.84180667 | 434.2214 | 62.976 | 7122.449 | 20.73624 | 21.15928 | 20.6299 |
| 979 | 20.98076 | 438.1914 | 63.552 | 7187.568 | 20.86622 | 21.31356 | 20.7625 |
| 980 | 21.08654 | 440.0109 | 63.816 | 7217.413 | 20.977 | 21.41122 | 20.8714 |
| 981 | 21.17969667 | 442.1614 | 64.128 | 7252.687 | 21.06377 | 21.51402 | 20.9613 |
| 982 | 21.27101333 | 444.9728 | 64.536 | 7298.802 | 21.16974 | 21.6014 | 21.0419 |
| 983 | 21.39188667 | 447.7852 | 64.943 | 7344.933 | 21.26604 | 21.73512 | 21.1745 |
| 984 | 21.45994333 | 448.7774 | 65.087 | 7361.208 | 21.34789 | 21.78644 | 21.2455 |
| 985 | 21.57433667 | 452.2518 | 65.591 | 7418.198 | 21.45877 | 21.90984 | 21.3544 |
| 986 | 21.63824333 | 454.2368 | 65.879 | 7450.757 | 21.50693 | 21.987 | 21.4208 |
| 987 | 21.73627333 | 455.3944 | 66.047 | 7469.745 | 21.61772 | 22.0898 | 21.5013 |
| 988 | 21.81746333 | 457.8759 | 66.407 | 7510.449 | 21.71402 | 22.15657 | 21.5818 |
| 989 | 21.90917667 | 459.3644 | 66.623 | 7534.864 | 21.80068 | 22.26455 | 21.6623 |
| 990 | 22.01198 | 462.6724 | 67.103 | 7589.125 | 21.88745 | 22.37249 | 21.776 |
| 991 | 21.99101333 | 462.0114 | 67.007 | 7578.283 | 21.86333 | 22.36221 | 21.7475 |
| 992 | 22.12465 | 465.3194 | 67.486 | 7632.543 | 22.0078 | 22.49075 | 21.8754 |
| 993 | 22.18529 | 465.9814 | 67.583 | 7643.402 | 22.0656 | 22.56277 | 21.9275 |
| 994 | 22.32933667 | 470.1168 | 68.182 | 7711.234 | 22.23418 | 22.72213 | 22.0317 |
| 995 | 22.30934667 | 469.4548 | 68.086 | 7700.375 | 22.21973 | 22.68611 | 22.0222 |
| 996 | 22.33457667 | 470.4469 | 68.230 | 7716.648 | 22.2487 | 22.73753 | 22.0175 |
| 997 | 22.40078 | 473.2594 | 68.638 | 7762.781 | 22.3643 | 22.83004 | 22.008 |
| 998 | 22.45755667 | 475.9064 | 69.022 | 7806.200 | 22.44133 | 22.93284 | 21.9985 |
| 999 | 22.49246667 | 476.5674 | 69.118 | 7817.042 | 22.4895 | 22.9894 | 21.9985 |
| 1000 | 22.50081333 | 476.4019 | 69.094 | 7814.327 | 22.51362 | 22.99972 | 21.9891 |
| 1001 | 22.59046333 | 479.8764 | 69.598 | 7871.319 | 22.63397 | 23.14362 | 21.9938 |
| 1002 | 22.62195 | 481.8614 | 69.886 | 7903.878 | 22.70625 | 23.1848 | 21.9748 |
| 1003 | 22.65861 | 482.3569 | 69.957 | 7912.006 | 22.75923 | 23.2465 | 21.9701 |
| 1004 | 22.6951 | 483.6809 | 70.150 | 7933.723 | 22.8074 | 23.303 | 21.9749 |
| 1005 | 22.77826667 | 486.9889 | 70.629 | 7987.984 | 22.9423 | 23.4366 | 21.9559 |
| 1006 | 22.81201667 | 488.3119 | 70.821 | 8009.685 | 22.98565 | 23.5087 | 21.9417 |
| 1007 | 22.84686667 | 489.8014 | 71.037 | 8034.117 | 23.0483 | 23.5601 | 21.9322 |
| 1008 | 22.88162667 | 491.1244 | 71.229 | 8055.817 | 23.12048 | 23.6064 | 21.918 |
| 1009 | 22.94147667 | 492.9439 | 71.493 | 8085.662 | 23.20243 | 23.704 | 21.918 |
| 1010 | 22.89504333 | 491.7864 | 71.325 | 8066.676 | 23.14463 | 23.632 | 21.9085 |



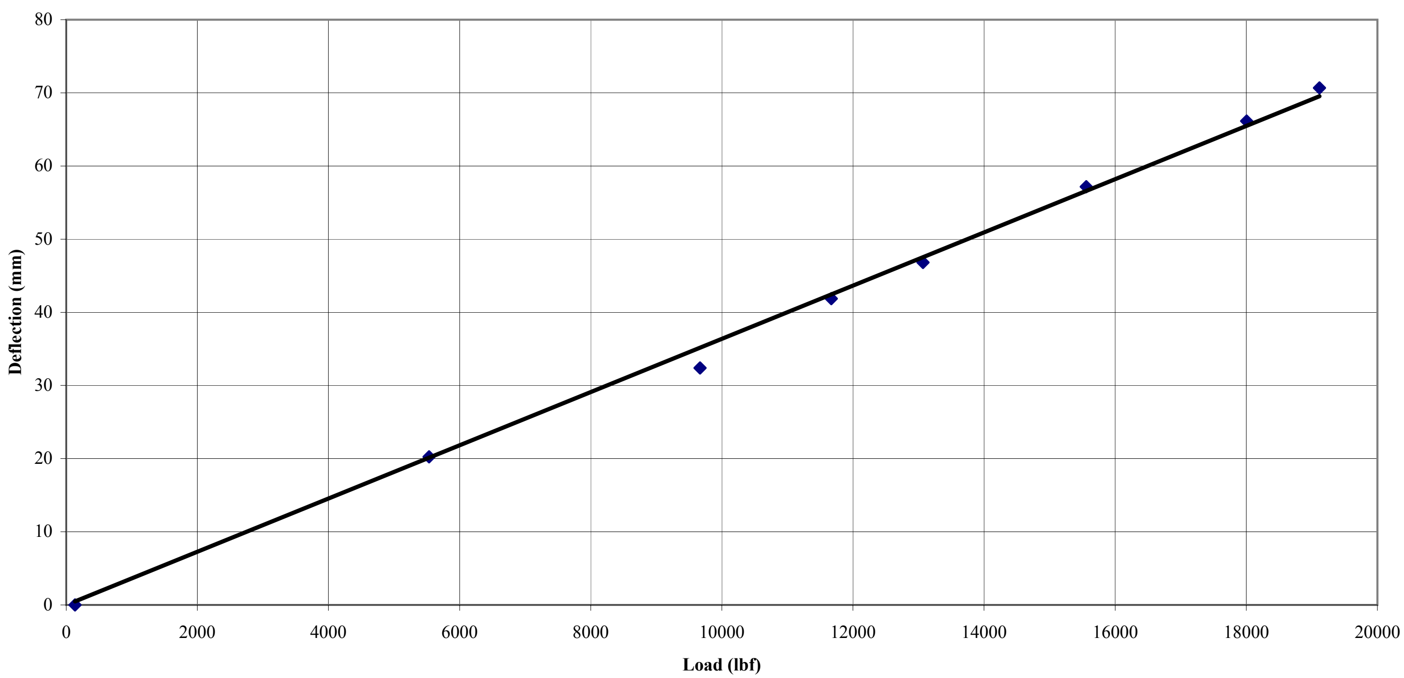

Tire Bale 4 - unconfined


Tire Bale 3 - Confined
Average Center Deformation
Under a Cyclic Load of 9 kips
Deformation (mm)
Load cycles
0
5
10
15
20
25
30
35
0
200
400
600
800
1000
Peak
Min
Peak-Min

# Tire Bale 4 - Unconfined
# Compressibility at Static Working Loads

| Load | | | | SD3 | | | SD4 | | | SD5 | | | Average Deflection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (voltage) | (kPa) | (psi) | (lbf) | (voltage) | (mm) | (change mm) | (voltage) | (mm) | (change mm) | (voltage) | (mm) | (change mm) | (mm) |
| -3.94 | 8.1306 | 1.179202 | 133.3646 | -7 | -13.33714 | 0 | -5.03 | -3.032136 | 0 | -5.02 | -2.870978 | 0 | 0 |
| -1.51 | 337.4199 | 48.9369 | 5534.633 | -1.93 | 6.668571 | 20.005713 | 0.5 | 20.25635 | 23.288489 | -0.52 | 14.58767 | 17.45865 | 20.25095067 |
| 0.35 | 589.4685 | 85.49217 | 9668.936 | 0 | 14.28416 | 27.6213 | 4 | 34.9959 | 38.028039 | 3.1 | 28.63219 | 31.503164 | 32.38416767 |
| 1.25 | 711.4275 | 103.1802 | 11669.41 | 1.23 | 19.13762 | 32.474757 | 7.51 | 49.77757 | 52.809702 | 5.37 | 37.43911 | 40.310083 | 41.86484733 |
| 1.88 | 796.7988 | 115.5618 | 13069.73 | 1.77 | 21.2684 | 34.605543 | 9.2 | 56.89466 | 59.926799 | 6.81 | 43.02587 | 45.896851 | 46.809731 |
| 3 | 948.57 | 137.5736 | 15559.21 | 3.64 | 28.64723 | 41.984376 | 12.15 | 69.318 | 72.350134 | 9.72 | 54.3158 | 57.186778 | 57.17376267 |
| 4.1 | 1097.631 | 159.1923 | 18004.23 | 5.75 | 36.97308 | 50.310225 | 14.25 | 78.16173 | 81.193864 | 12.24 | 64.09264 | 66.963622 | 66.15590367 |
| 4.6 | 1165.386 | 169.019 | 19115.6 | 7.14 | 42.45788 | 55.795026 | 15.42 | 83.08895 | 86.121085 | 13.05 | 67.2352 | 70.106179 | 70.67409667 |

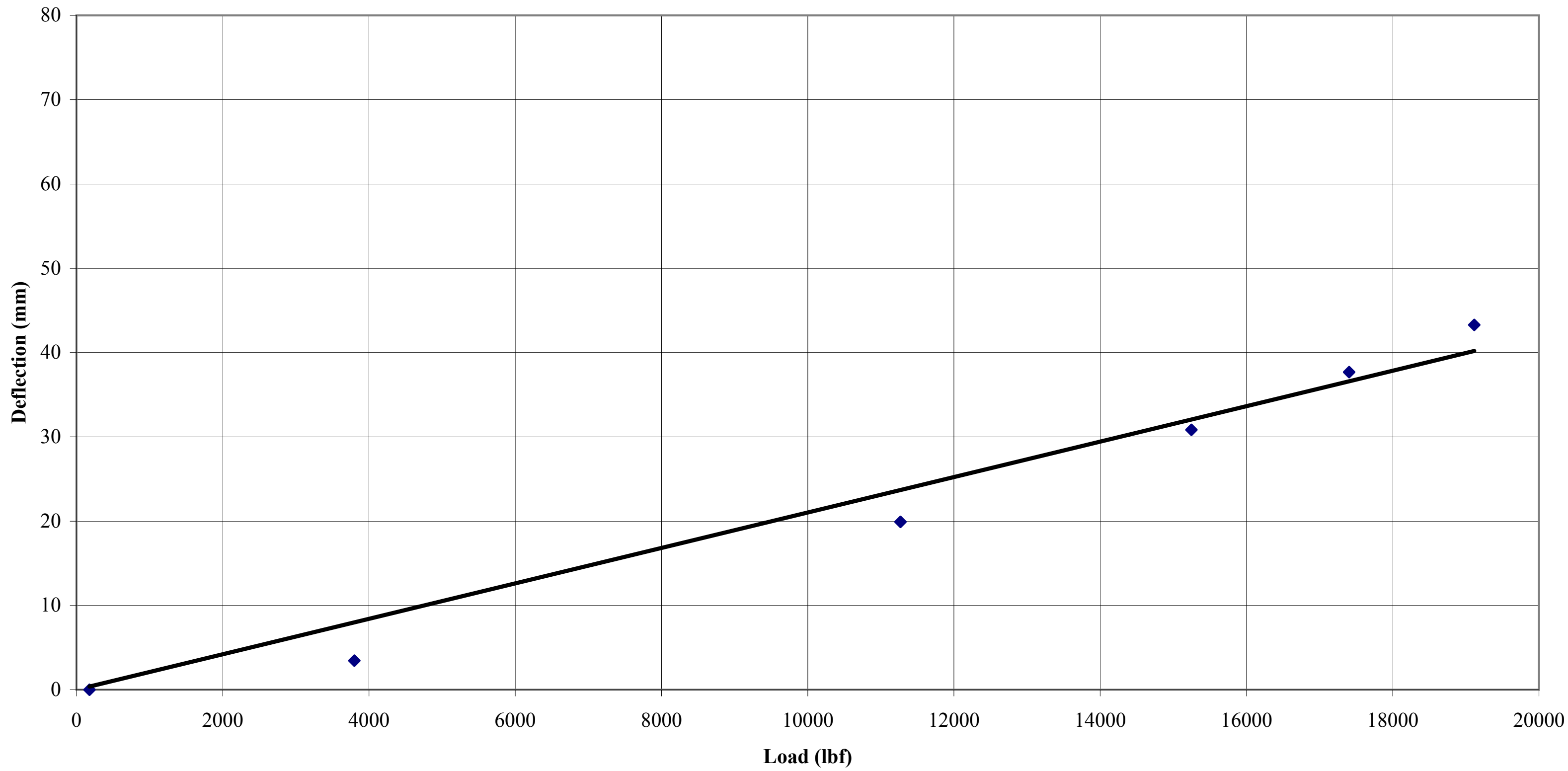
**Tire Bale 4 - Unconfined**
**Compressibility at Static Working Loads**



## Tire Bale 3 - Confined
## Compressibility at Static Working Loads

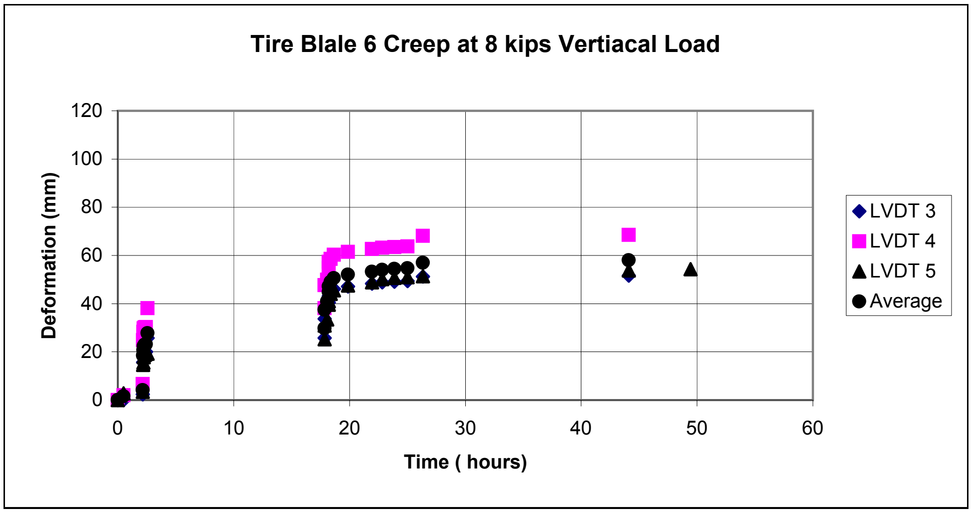
| Load (voltage) | (kPa) | (psi) | (lbf) | SD3 (voltage) | (mm) | (change mm) | SD4 (voltage) | (mm) | (change mm) | SD5 (voltage) | (mm) | (change mm) | Average Deflection (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -3.92 | 10.8408 | 1.57227 | 177.8195 | -6.08 | -9.706914 | 0 | -5.31 | -4.2113 | 0 | -5.18 | -3.49173 | 0 | 0 |
| -2.29 | 231.7221 | 33.60727 | 3800.892 | -6.04 | -9.549078 | 0.157836 | -3.52 | 3.326927 | 7.538227 | -4.5 | -0.853534 | 2.638196 | 3.444753 |
| 1.07 | 687.0357 | 99.6426 | 11269.31 | -4.47 | -3.354015 | 6.352899 | 3.17 | 31.50052 | 35.711824 | -0.62 | 14.1997 | 17.691432 | 19.91871833 |
| 2.86 | 929.5986 | 134.8221 | 15248.02 | -2.54 | 4.261572 | 13.968486 | 6.71 | 46.40853 | 50.619826 | 2.02 | 24.44211 | 27.93384 | 30.84071733 |
| 3.83 | 1061.043 | 153.8859 | 17404.09 | -1.55 | 8.168013 | 17.874927 | 9.25 | 57.10523 | 61.316528 | 3.55 | 30.37805 | 33.869781 | 37.68707867 |
| 4.6 | 1165.386 | 169.019 | 19115.6 | -0.69 | 11.56149 | 21.268401 | 11.45 | 66.37009 | 70.581388 | 4.61 | 34.49053 | 37.982263 | 43.27735067 |

## Tire Bale 3 - Confined
## Compressibility at Static Working Loads



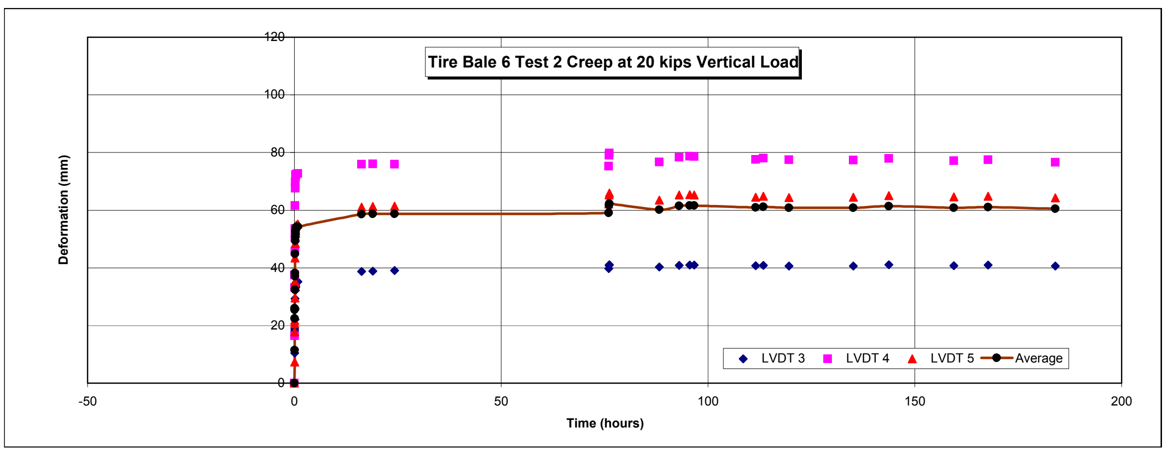
Bale 6 8 kips

| Date | Time | | Time Interval (hr) | Deformation LVDT 3 (mm) | LVDT 4 (mm) | LVDT 5 (mm) | Average (mm) |
|---|---|---|---|---|---|---|---|
| 5/8/2004 | 21:45 | 5/8/2004 21:45 | 0.00 | 0 | 0 | 0 | 0 |
| 5/8/2004 | 21:57 | 5/8/2004 21:57 | 0.20 | 29.12074 | 12.84447 | 8.108573 | 16.69126 |
| 5/8/2004 | 21:59 | 5/8/2004 21:59 | 0.23 | 35.5131 | 17.94014 | 10.70797 | 21.38707 |
| 5/8/2004 | 22:04 | 5/8/2004 22:04 | 0.32 | 36.06553 | 22.362 | 13.11339 | 23.84697167 |
| 5/9/2004 | 10:06 | 5/9/2004 10:06 | 12.35 | 38.86712 | 23.28849 | 13.61775 | 25.25778367 |
| 5/9/2004 | 10:35 | 5/9/2004 10:35 | 12.83 | 39.34062 | 23.87807 | 14.08331 | 25.767335 |
| 5/9/2004 | 10:40 | 5/9/2004 10:40 | 12.92 | 39.459 | 24.00441 | 14.1997 | 25.887704 |
| 5/9/2004 | 14:55 | 5/9/2004 14:55 | 17.17 | 42.18167 | 27.41556 | 16.8767 | 28.824643 |
| 5/9/2004 | 15:16 | 5/9/2004 15:16 | 17.52 | 42.22113 | 27.45768 | 16.95429 | 28.87769833 |
| | | | | | | | |
| 6/2/2004 | 15:35 | 6/2/2004 15:35 | 0.00 | 0 | 0 | 0 | 0 |
| 6/2/2004 | 16:05 | 6/2/2004 16:05 | 0.50 | -0.039459 | 1.979311 | 2.793384 | 1.577745333 |
| 6/2/2004 | 17:45 | 6/2/2004 17:45 | 2.17 | 2.36754 | 6.611741 | 3.49173 | 4.157003667 |
| 6/2/2004 | 17:46 | 6/2/2004 17:46 | 2.18 | 15.62576 | 24.88878 | 14.66527 | 18.393271 |
| 6/2/2004 | 17:47 | 6/2/2004 17:47 | 2.20 | 18.42735 | 28.25782 | 15.5188 | 20.73465867 |
| 6/2/2004 | 17:50 | 6/2/2004 17:50 | 2.25 | 19.53221 | 29.77389 | 17.76903 | 22.358374 |
| 6/2/2004 | 17:54 | 6/2/2004 17:54 | 2.32 | 19.84788 | 30.1108 | 18.73895 | 22.89920767 |
| 6/2/2004 | 18:00 | 6/2/2004 18:00 | 2.42 | 19.88734 | 30.06868 | 19.04933 | 23.00178167 |
| 6/2/2004 | 18:01 | 6/2/2004 18:01 | 2.43 | 20.04517 | 30.27925 | 19.08812 | 23.13751433 |
| 6/2/2004 | 18:10 | 6/2/2004 18:10 | 2.58 | 25.72727 | 38.07015 | 19.24331 | 27.680244 |
| 6/3/2004 | 9:26 | 6/3/2004 9:26 | 17.85 | 25.72727 | 38.07015 | 25.25685 | 29.68475567 |
| 6/3/2004 | 9:27 | 6/3/2004 9:27 | 17.87 | 33.69799 | 47.6298 | 30.92121 | 37.41633267 |
| 6/3/2004 | 9:40 | 6/3/2004 9:40 | 18.08 | 39.26171 | 49.94602 | 33.40422 | 40.87064667 |
| 6/3/2004 | 9:47 | 6/3/2004 9:47 | 18.20 | 40.44548 | 54.66267 | 39.57294 | 44.89369633 |
| 6/3/2004 | 9:48 | 6/3/2004 9:48 | 18.22 | 43.20761 | 57.35791 | 40.96963 | 47.178381 |
| 6/3/2004 | 9:58 | 6/3/2004 9:58 | 18.38 | 44.43083 | 58.57918 | 44.0346 | 49.01487067 |
| 6/3/2004 | 10:15 | 6/3/2004 10:15 | 18.67 | 46.04865 | 60.2637 | 45.47008 | 50.59414667 |
| 6/3/2004 | 11:28 | 6/3/2004 11:28 | 19.88 | 47.11405 | 61.48498 | 47.52633 | 52.04178367 |
| 6/3/2004 | 13:32 | 6/3/2004 13:32 | 21.95 | 48.33728 | 62.62203 | 48.88422 | 53.28117533 |
| 6/3/2004 | 14:25 | 6/3/2004 14:25 | 22.83 | 48.85024 | 63.12739 | 50.16452 | 54.04738333 |
| 6/3/2004 | 15:27 | 6/3/2004 15:27 | 23.87 | 49.16591 | 63.42218 | 50.70768 | 54.43192367 |
| 6/3/2004 | 16:35 | 6/3/2004 16:35 | 25.00 | 49.40267 | 63.67486 | 51.01806 | 54.69852633 |
| 6/3/2004 | 17:55 | 6/3/2004 17:55 | 26.33 | 51.2967 | 68.05461 | 51.32843 | 56.89324633 |
| 6/4/2004 | 11:42 | 6/4/2004 11:42 | 44.12 | 51.65183 | 68.51785 | 53.81144 | 57.993707 |
| 6/4/2004 | 17:02 | 6/4/2004 17:02 | 49.45 | | | 54.3546 | |



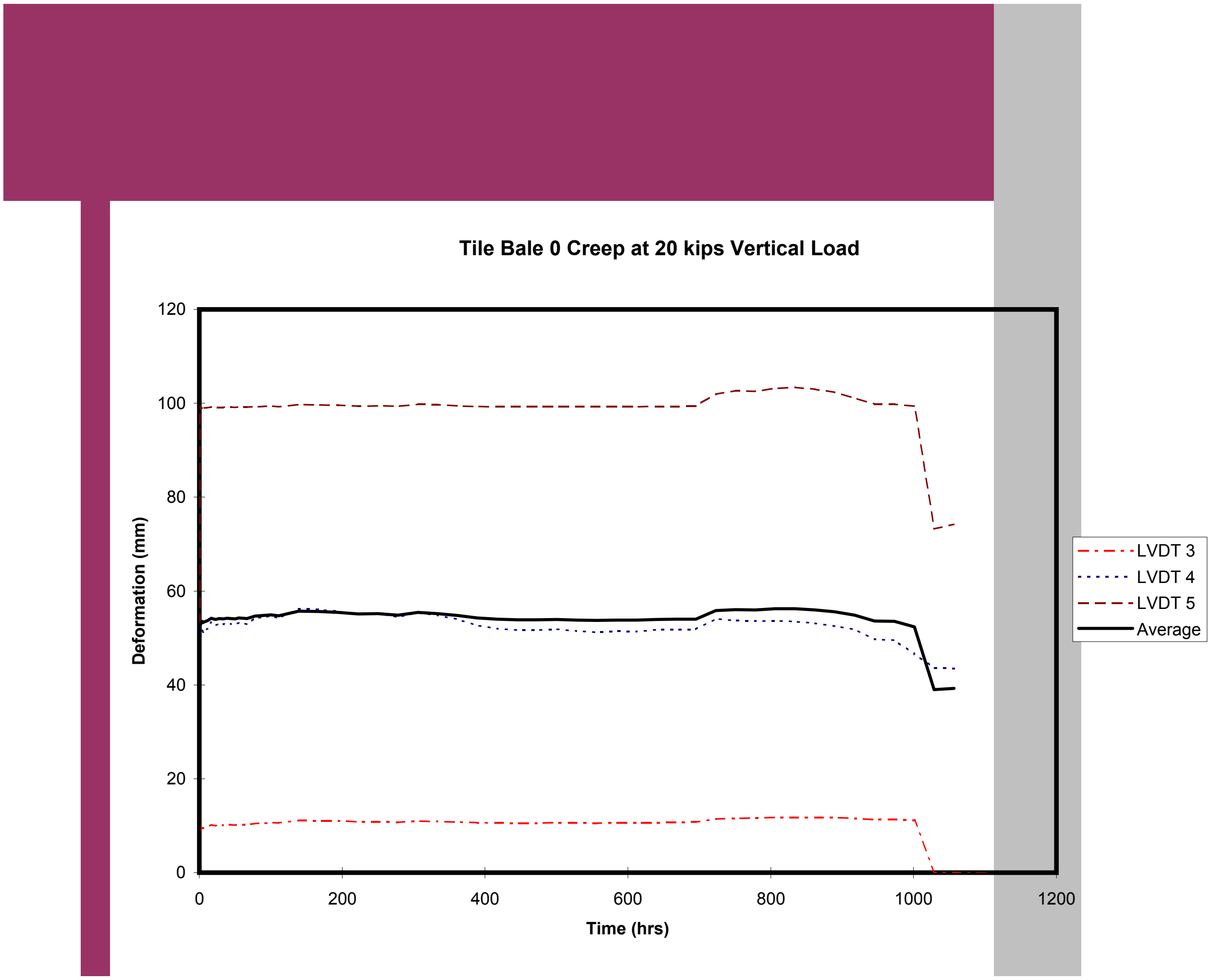
## Tire Bale 6 Test 2 Creep at 20 kips Vertical Load

| Date Time | Change in Time (days) | Change in Time (hrs) | Load Cell voltage | (kPa) | (psi) | (lbf) | Voltage | Corr. Displ. (mm) | Voltage | Corr. Displ. (mm) | Voltage | Corr. Displ. (mm) | LVDT 3 (mm) | LVDT 4 (mm) | LVDT 5 (mm) | Average (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/9/2004 16:53 | 0 | 0.00 | -4.00 | 0.00 | 0.00 | 0.00 | -4.77 | -33.106101 | -5.36 | -40.723271 | -5.23 | -36.895947 | 0 | 0 | 0 | 0 |
| 9/9/2004 16:56 | 0.002083333 | 0.05 | -3.00 | 135.51 | 19.65 | 2222.74 | -2.12 | -22.649466 | -1.45 | -24.257088 | -3.33 | -29.524517 | 10.45664 | 16.46618 | 7.37143 | 11.43142 |
| 9/9/2004 16:57 | 0.002777778 | 0.07 | -0.10 | 528.49 | 76.65 | 8668.70 | -0.59 | -16.612239 | 2.51 | -7.58034 | -0.65 | -19.126921 | 16.49386 | 33.14293 | 17.76903 | 22.46861 |
| 9/9/2004 16:58 | 0.003472222 | 0.08 | 0.30 | 582.69 | 84.51 | 9557.80 | -0.2 | -15.073338 | 3.55 | -3.200588 | 0.1 | -16.217146 | 18.03276 | 37.52268 | 20.6788 | 25.41142 |
| 9/9/2004 16:58 | 0.003472222 | 0.08 | 0.57 | 619.28 | 89.82 | 10157.94 | -0.01 | -14.323617 | -5.1 | -3.200588 | 0.37 | -15.169627 | 18.78248 | 37.52268 | 21.72632 | 26.0105 |
| 9/9/2004 17:00 | 0.004861111 | 0.12 | 1.50 | 745.31 | 108.09 | 12225.09 | 0.84 | -10.969602 | -3.15 | 5.011447 | 2.37 | -7.410227 | 22.1365 | 45.73472 | 29.48572 | 32.45231 |
| 9/9/2004 17:01 | 0.005555556 | 0.13 | 2.50 | 880.82 | 127.75 | 14447.84 | 1.7 | -7.576128 | -2 | 9.854442 | 3.8 | -1.862256 | 25.52997 | 50.57771 | 35.03369 | 37.04713 |
| 9/9/2004 17:01 | 0.005555556 | 0.13 | 2.57 | 890.30 | 129.12 | 14603.43 | 1.8 | -7.181538 | -1.28 | 12.886578 | -5.05 | -1.862256 | 25.92456 | 53.60985 | 35.03369 | 38.18937 |
| 9/9/2004 17:04 | 0.007638889 | 0.18 | 3.50 | 1016.33 | 147.40 | 16670.58 | 2.67 | -3.748605 | 0.62 | 20.888048 | -2.89 | 6.517896 | 29.3575 | 61.61132 | 43.41384 | 44.79422 |
| 9/9/2004 17:05 | 0.008333333 | 0.20 | 4.20 | 1111.18 | 161.16 | 18226.50 | 3.39 | -0.907557 | 2.05 | 26.910207 | -1.6 | 11.522709 | 32.19854 | 67.63348 | 48.41866 | 49.41689 |
| 9/9/2004 17:05 | 0.008333333 | 0.20 | 4.35 | 1131.51 | 164.11 | 18559.91 | -5.35 | -0.907557 | 2.54 | 28.973744 | -1.09 | 13.501356 | 32.19854 | 69.69702 | 50.3973 | 50.76429 |
| 9/9/2004 17:11 | 0.0125 | 0.30 | 4.42 | 1140.99 | 165.48 | 18715.50 | -5.11 | 0.039459 | 2.88 | 30.405586 | -0.7 | 15.014439 | 33.14556 | 71.12886 | 51.91039 | 52.0616 |
| 9/9/2004 17:13 | 0.013888889 | 0.33 | 4.49 | 1150.48 | 166.86 | 18871.10 | -4.98 | 0.552426 | 3.09 | 31.289959 | -0.49 | 15.829176 | 33.65853 | 72.01323 | 52.72512 | 52.79896 |
| 9/9/2004 17:13 | 0.013888889 | 0.33 | 4.52 | 1154.55 | 167.45 | 18937.78 | -4.95 | 0.670803 | -5.26 | 31.289959 | -0.46 | 15.945567 | 33.7769 | 72.01323 | 52.84151 | 52.87722 |
| 9/9/2004 17:18 | 0.017361111 | 0.42 | 4.66 | 1173.52 | 170.20 | 19248.96 | -4.73 | 1.538901 | -5.17 | 31.668976 | -0.03 | 17.613838 | 34.645 | 72.39225 | 54.50979 | 53.84901 |
| 9/9/2004 17:22 | 0.020138889 | 0.48 | 4.59 | 1164.03 | 168.82 | 19093.37 | -4.66 | 1.815114 | -5.16 | 31.711089 | 0.06 | 17.963011 | 34.92122 | 72.43436 | 54.85896 | 54.07151 |
| 9/9/2004 17:45 | 0.036111111 | 0.87 | 4.60 | 1165.39 | 169.02 | 19115.60 | -4.6 | 2.051868 | -5.1 | 31.963767 | 0.13 | 18.23459 | 35.15797 | 72.68704 | 55.13054 | 54.32518 |
| 9/10/2004 9:08 | 0.677083333 | 16.25 | 4.39 | 1136.93 | 164.89 | 18648.82 | -3.68 | 5.682096 | -4.33 | 35.206468 | 1.67 | 24.209328 | 38.7882 | 75.92974 | 61.10528 | 58.60774 |
| 9/10/2004 11:49 | 0.788888889 | 18.93 | 4.37 | 1134.22 | 164.50 | 18604.37 | -3.65 | 5.800473 | -4.31 | 35.290694 | 1.7 | 24.325719 | 38.90657 | 76.01397 | 61.22167 | 58.71407 |
| 9/10/2004 17:05 | 1.008333333 | 24.20 | 4.32 | 1127.44 | 163.52 | 18493.23 | -3.62 | 5.91885 | -4.32 | 35.248581 | 1.73 | 24.44211 | 39.02495 | 75.97185 | 61.33806 | 58.77829 |
| 9/12/2004 20:52 | 3.165972222 | 75.98 | 3.78 | 1054.27 | 152.90 | 17292.95 | -3.43 | 6.668571 | -4.48 | 34.574773 | 1.93 | 25.21805 | 39.77467 | 75.29804 | 62.114 | 59.06224 |
| 9/12/2004 20:58 | 3.170138889 | 76.08 | 4.54 | 1157.26 | 167.84 | 18982.23 | -3.15 | 7.773423 | -3.59 | 38.32283 | 2.75 | 28.399404 | 40.87952 | 79.0461 | 65.29535 | 61.74033 |
| 9/12/2004 21:04 | 3.174305556 | 76.18 | 4.64 | 1170.81 | 169.81 | 19204.51 | -3.1 | 7.970718 | -3.42 | 39.038751 | 2.92 | 29.058953 | 41.07682 | 79.76202 | 65.9549 | 62.26458 |
| 9/13/2004 9:07 | 3.676388889 | 88.23 | 3.99 | 1082.72 | 157.03 | 17759.72 | -3.29 | 7.220997 | -4.15 | 35.964502 | 2.28 | 26.575945 | 40.3271 | 76.68777 | 63.47189 | 60.16225 |
| 9/13/2004 13:54 | 3.875694444 | 93.02 | 4.34 | 1130.15 | 163.91 | 18537.69 | -3.15 | 7.773423 | -3.74 | 37.691135 | 2.73 | 28.32181 | 40.87952 | 78.41441 | 65.21776 | 61.5039 |
| 9/13/2004 16:27 | 3.981944444 | 95.57 | 4.34 | 1130.15 | 163.91 | 18537.69 | -3.14 | 7.812882 | -3.68 | 37.943813 | 2.76 | 28.438201 | 40.91898 | 78.66708 | 65.33415 | 61.64007 |
| 9/13/2004 17:35 | 4.029166667 | 96.70 | 4.34 | 1130.15 | 163.91 | 18537.69 | -3.13 | 7.852341 | -3.7 | 37.859587 | 2.75 | 28.399404 | 40.95844 | 78.58286 | 65.29535 | 61.61222 |
| 9/14/2004 8:25 | 4.647222222 | 111.53 | 4.09 | 1096.28 | 159.00 | 17982.00 | -3.19 | 7.615587 | -3.93 | 36.890988 | 2.54 | 27.584667 | 40.72169 | 77.61426 | 64.48061 | 60.93885 |
| 9/14/2004 10:15 | 4.723611111 | 113.37 | 4.15 | 1104.41 | 160.17 | 18115.36 | -3.16 | 7.733964 | -3.84 | 37.270005 | 2.62 | 27.895043 | 40.84007 | 77.99328 | 64.79099 | 61.20811 |
| 9/14/2004 16:30 | 4.984027778 | 119.62 | 4.03 | 1088.15 | 157.82 | 17848.63 | -3.21 | 7.536669 | -3.97 | 36.722536 | 2.51 | 27.468276 | 40.64277 | 77.44581 | 64.36422 | 60.8176 |
| 9/15/2004 8:00 | 5.629861111 | 135.12 | 4.02 | 1086.79 | 157.62 | 17826.41 | -3.2 | 7.576128 | -4 | 36.596197 | 2.53 | 27.54587 | 40.68223 | 77.31947 | 64.44182 | 60.8145 |
| 9/15/2004 16:35 | 5.9875 | 143.70 | 4.17 | 1107.12 | 160.57 | 18159.82 | -3.11 | 7.931259 | -3.85 | 37.227892 | 2.68 | 28.127825 | 41.03736 | 77.95116 | 65.02377 | 61.33743 |
| 9/16/2004 8:20 | 6.64375 | 159.45 | 3.97 | 1080.01 | 156.64 | 17715.27 | -3.18 | 7.655046 | -4.04 | 36.427745 | 2.56 | 27.662261 | 40.76115 | 77.15102 | 64.55821 | 60.82346 |
| 9/16/2004 16:35 | 6.9875 | 167.70 | 4.07 | 1093.57 | 158.60 | 17937.54 | -3.13 | 7.852341 | -3.95 | 36.806762 | 2.63 | 27.93384 | 40.95844 | 77.53003 | 64.82979 | 61.10609 |
| 9/17/2004 8:50 | 7.664583333 | 183.95 | 3.86 | 1065.11 | 154.48 | 17470.77 | -3.21 | 7.536669 | -4.17 | 35.880276 | 2.48 | 27.351885 | 40.64277 | 76.60355 | 64.24783 | 60.49805 |



## Tile Bale 0 Creep at 20 kips Vertical Load

| Reading # | Time (hrs) | LC (kPa) | LC (psi) | LC (lbf) | LVDT 3 (mm) | LVDT 4 (mm) | LVDT 5 (mm) | Average (mm) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0005561 | 28.5841 | 4.146 | 468.859 | 0 | 0 | 19.49326 | 6.497753 |
| 10 | 0.005561 | 28.5841 | 4.146 | 468.859 | 0.03854 | 0 | 0.01894 | 0.01916 |
| 20 | 0.011122 | 29.2458 | 4.242 | 479.713 | 0 | 0 | 0.03788 | 0.012627 |
| 50 | 0.027805 | 115.925 | 16.813 | 1901.495 | 0.05781 | 0.06169 | 6.78189 | 2.300463 |
| 100 | 0.05561 | 145.038 | 21.035 | 2379.030 | 0.03854 | 0.14394 | 12.0104 | 4.064293 |
| 200 | 0.11122 | 292.59 | 42.435 | 4799.297 | 0.19268 | 1.95348 | 32.20456 | 11.45024 |
| 400 | 0.22244 | 494.4 | 71.704 | 8109.546 | 0.65509 | 7.17648 | 49.33647 | 19.05601 |
| 500 | 0.27805 | 613.5 | 88.978 | 10063.120 | 1.3487 | 14.59972 | 62.33196 | 26.09346 |
| 1000 | 0.5561 | 1130.93 | 164.022 | 18550.423 | 8.18852 | 48.23498 | 94.63786 | 50.35379 |
| 2000 | 1.1122 | 1144.82 | 166.036 | 18778.258 | 9.151872 | 50.70254 | 99.12756 | 52.99399 |
| 3000 | 1.6683 | 1114.38 | 161.621 | 18278.957 | 9.132605 | 50.59972 | 98.96211 | 52.89815 |
| 4000 | 2.2244 | 1118.35 | 162.197 | 18344.076 | 9.248208 | 50.90814 | 98.96211 | 53.03949 |
| 5000 | 2.7805 | 1122.99 | 162.870 | 18420.185 | 9.402344 | 51.21664 | 99 | 53.20633 |
| 6000 | 3.3366 | 1129.6 | 163.829 | 18528.608 | 9.5179469 | 51.56614 | 99.01894 | 53.36768 |
| 7000 | 3.8927 | 1138.2 | 165.076 | 18669.672 | 9.6142823 | 51.93634 | 99.03788 | 53.5295 |
| 8000 | 4.4488 | 1105.78 | 160.374 | 18137.893 | 9.5179469 | 51.48394 | 99 | 53.33396 |
| 9000 | 5.0049 | 1092.55 | 158.455 | 17920.884 | 9.4794127 | 51.29884 | 99 | 53.25942 |
| 10000 | 5.561 | 1098.5 | 159.318 | 18018.481 | 9.5179469 | 51.42224 | 99.03788 | 53.32602 |
| 20000 | 11.122 | 1089.9 | 158.071 | 17877.416 | 9.82622 | 52.05974 | 99.09472 | 53.66023 |
| 30000 | 16.683 | 1127.62 | 163.542 | 18496.130 | 10.192295 | 53.27294 | 99.20838 | 54.22454 |
| 40000 | 22.244 | 1081.96 | 156.920 | 17747.178 | 10.038158 | 52.67654 | 99.15155 | 53.95542 |
| 50000 | 27.805 | 1096.52 | 159.031 | 17986.003 | 10.134494 | 53.06724 | 99.15155 | 54.11776 |
| 60000 | 33.366 | 1072.04 | 155.481 | 17584.462 | 10.134494 | 52.92334 | 99.17049 | 54.07611 |
| 70000 | 38.927 | 1081.96 | 156.920 | 17747.178 | 10.250096 | 53.19064 | 99.20838 | 54.21637 |
| 80000 | 44.488 | 1065.42 | 154.521 | 17475.876 | 10.192295 | 53.04674 | 99.22732 | 54.15545 |
| 90000 | 50.049 | 1059.47 | 153.658 | 17378.279 | 10.153761 | 52.86164 | 99.15155 | 54.05565 |
| 100000 | 55.61 | 1076.67 | 156.152 | 17660.407 | 10.250096 | 53.25234 | 99.20838 | 54.23694 |
| 120000 | 66.732 | 1046.89 | 151.833 | 17171.932 | 10.211562 | 52.96444 | 99.20838 | 54.12813 |
| 140000 | 77.854 | 1093.21 | 158.551 | 17931.710 | 10.500568 | 54.25994 | 99.3031 | 54.68787 |
| 160000 | 88.976 | 1089.24 | 157.975 | 17866.591 | 10.57764 | 54.42444 | 99.35993 | 54.78734 |
| 180000 | 100.098 | 1100.49 | 159.607 | 18051.122 | 10.65471 | 54.75344 | 99.39782 | 54.93532 |
| 200000 | 111.22 | 1068.73 | 155.001 | 17530.169 | 10.5969 | 54.21884 | 99.3031 | 54.70628 |
| 250000 | 139.025 | 1130.26 | 163.925 | 18539.434 | 11.13638 | 56.25454 | 99.77669 | 55.72254 |
| 300000 | 166.83 | 1111.08 | 161.143 | 18224.828 | 11.09785 | 56.06944 | 99.68198 | 55.61642 |
| 350000 | 194.635 | 1087.92 | 157.784 | 17844.939 | 11.07858 | 55.71994 | 99.58726 | 55.46193 |
| 400000 | 222.44 | 1052.19 | 152.602 | 17258.867 | 10.86664 | 55.04134 | 99.41676 | 55.10825 |
| 450000 | 250.245 | 1070.71 | 155.288 | 17562.647 | 10.86664 | 55.26754 | 99.51148 | 55.21522 |
| 500000 | 278.05 | 1040.28 | 150.875 | 17063.509 | 10.73177 | 54.44504 | 99.41676 | 54.86452 |
| 550000 | 305.855 | 1076.01 | 156.057 | 17649.581 | 11.02078 | 55.43204 | 99.81458 | 55.42247 |
| 600000 | 333.66 | 1052.85 | 152.698 | 17269.692 | 10.96298 | 54.83574 | 99.77669 | 55.1918 |
| 650000 | 361.465 | 1017.78 | 147.611 | 16694.446 | 10.82811 | 54.01314 | 99.51148 | 54.78424 |
| 700000 | 389.27 | 986.021 | 143.005 | 16173.509 | 10.69324 | 52.71774 | 99.34099 | 54.25066 |
| 750000 | 417.075 | 963.524 | 139.742 | 15804.496 | 10.5969 | 52.05974 | 99.3031 | 53.98658 |
| 800000 | 444.88 | 955.584 | 138.591 | 15674.257 | 10.55837 | 51.73064 | 99.3031 | 53.86404 |
| 850000 | 472.685 | 965.509 | 140.030 | 15837.055 | 10.57764 | 51.71014 | 99.3031 | 53.86363 |
| 900000 | 500.49 | 975.434 | 141.470 | 15999.853 | 10.65471 | 51.89514 | 99.32204 | 53.9573 |
| 950000 | 528.295 | 953.599 | 138.303 | 15641.698 | 10.5969 | 51.48394 | 99.3031 | 53.79465 |
| 1000000 | 556.1 | 949.629 | 137.727 | 15576.579 | 10.57764 | 51.27834 | 99.28415 | 53.71338 |
| 1050000 | 583.905 | 954.26 | 138.399 | 15652.540 | 10.67397 | 51.50454 | 99.32204 | 53.83352 |
| 1100000 | 611.71 | 953.599 | 138.303 | 15641.698 | 10.67397 | 51.40164 | 99.32204 | 53.79922 |
| 1150000 | 639.515 | 970.802 | 140.798 | 15923.875 | 10.71251 | 51.79234 | 99.35993 | 53.95493 |
| 1200000 | 667.32 | 964.185 | 139.838 | 15815.338 | 10.73177 | 51.83354 | 99.37887 | 53.98139 |
| 1250000 | 695.125 | 979.404 | 142.046 | 16064.972 | 10.78957 | 51.83354 | 99.39782 | 54.00698 |
| 1300000 | 722.93 | 1091.23 | 158.264 | 17899.232 | 11.44466 | 54.15714 | 101.974181 | 55.85866 |
| 1350000 | 750.735 | 1084.61 | 157.304 | 17790.646 | 11.59879 | 53.74584 | 102.694047 | 56.01289 |
| 1400000 | 778.54 | 1069.39 | 155.096 | 17540.995 | 11.67586 | 53.60194 | 102.542496 | 55.9401 |
| 1450000 | 806.345 | 1082.62 | 157.015 | 17758.004 | 11.79146 | 53.70474 | 103.205531 | 56.23391 |
| 1500000 | 834.15 | 1074.68 | 155.864 | 17627.766 | 11.79146 | 53.54024 | 103.413913 | 56.24854 |
| 1550000 | 861.955 | 1057.48 | 153.369 | 17345.637 | 11.79146 | 53.12894 | 103.016092 | 55.97883 |
| 1600000 | 889.76 | 1038.95 | 150.682 | 17041.694 | 11.75293 | 52.57374 | 102.353058 | 55.55991 |
| 1650000 | 917.565 | 1005.87 | 145.884 | 16499.089 | 11.59879 | 51.81294 | 101.12171 | 54.84448 |
| 1700000 | 945.37 | 924.485 | 134.080 | 15164.147 | 11.30979 | 49.71551 | 99.85247 | 53.62592 |
| 1750000 | 973.175 | 924.485 | 134.080 | 15164.147 | 11.30979 | 49.57157 | 99.79564 | 53.559 |
| 1800000 | 1000.98 | 851.701 | 123.524 | 13970.285 | 11.19418 | 46.56938 | 99.41676 | 52.39344 |
| 1850000 | 1028.785 | 29.2458 | 4.242 | 479.713 | 0.05781 | 43.64943 | 73.28818 | 38.99847 |
| 1900000 | 1056.59 | 33.2158 | 4.817 | 544.832 | 0.03854 | 43.54662 | 74.23537 | 39.27351 |
| 1950000 | 1084.395 | 20.6441 | 2.994 | 338.621 | -0.09633 | 17.95144 | 72.09472 | 29.98328 |
| 1989000 | 1106.0829 | 19.9824 | 2.898 | 327.767 | -0.07706 | 17.76644 | 72.01894 | 29.90277 |


Tile Bale 0 Creep at 20 kips Vertical Load
120
100
80
60
40
20
0
Deformation (mm)
0
200
400
600
800
1000
1200
Time (hrs)
LVDT 3
LVDT 4
LVDT 5
Average

# Pull Out Test

Project No. : GTX-G0581 Test By: JW, SS, & HJ
Project Name: Tire Bale Study Test Date: 9/3/2004
Tire Bale No.: 3

Normal Load, lbs 2000

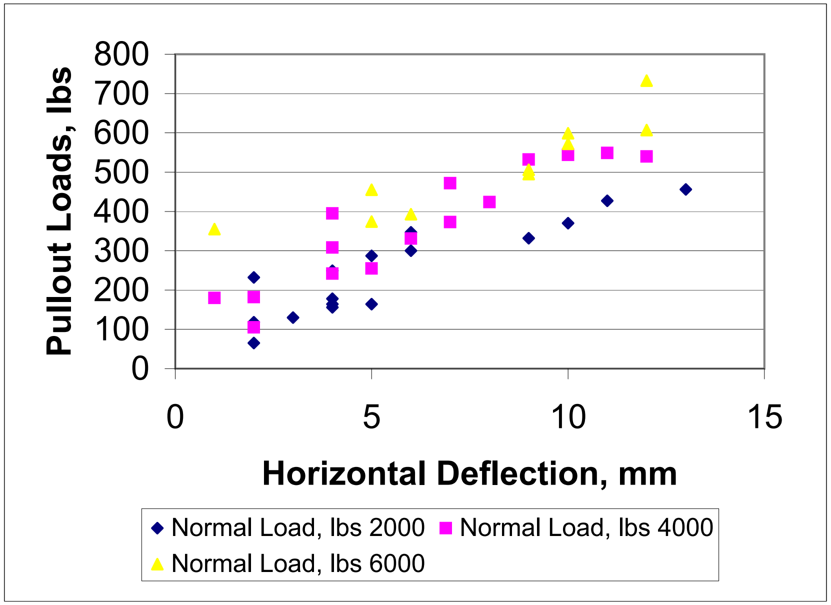
| Loads Initial (lbs) | Final (lbs) | Increment (lbs) | Horizontal Deflection Total (mm) | Increment (mm) |
|---|---|---|---|---|
| 90 | 155 | 65 | 2 | 2 |
| 144 | 262 | 118 | 4 | 2 |
| 207 | 337 | 130 | 7 | 3 |
| 244 | 408 | 164 | 11 | 4 |
| 342 | 498 | 156 | 15 | 4 |
| 450 | 614 | 164 | 20 | 5 |
| 532 | 710 | 178 | 24 | 4 |
| 617 | 849 | 232 | 26 | 2 |
| 760 | 1009 | 249 | 30 | 4 |
| 895 | 1195 | 300 | 36 | 6 |
| 1052 | 1339 | 287 | 41 | 5 |
| 1205 | 1552 | 347 | 47 | 6 |
| 1394 | 1726 | 332 | 56 | 9 |
| 1572 | 1942 | 370 | 66 | 10 |
| 1752 | 2179 | 427 | 77 | 11 |
| 1857 | 2313 | 456 | 90 | 13 |

Normal Load, lbs 4000

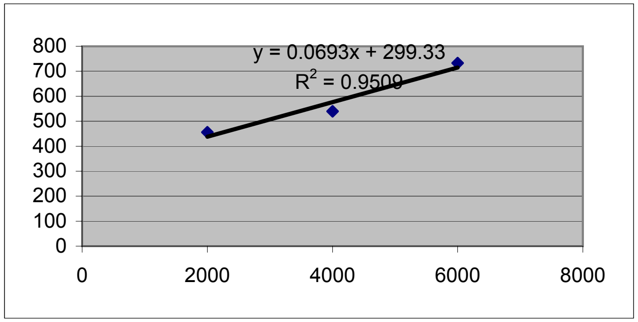
| Loads Initial (lbs) | Final (lbs) | Increment (lbs) | Horizontal Deflection Total (mm) | Increment (mm) |
|---|---|---|---|---|
| 204 | 384 | 180 | 1 | 1 |
| 334 | 439 | 105 | 3 | 2 |
| 420 | 602 | 182 | 5 | 2 |
| 510 | 752 | 242 | 9 | 4 |
| 634 | 889 | 255 | 14 | 5 |
| 787 | 1095 | 308 | 18 | 4 |
| 964 | 1295 | 331 | 24 | 6 |
| 1145 | 1540 | 395 | 28 | 4 |
| 1394 | 1767 | 373 | 35 | 7 |
| 1600 | 2024 | 424 | 43 | 8 |
| 1847 | 2319 | 472 | 50 | 7 |
| 2130 | 2662 | 532 | 59 | 9 |
| 2340 | 2889 | 549 | 70 | 11 |
| 2580 | 3124 | 544 | 80 | 10 |
| 2922 | 3462 | 540 | 92 | 12 |

Normal Load, lbs 6000

| Loads Initial (lbs) | Final (lbs) | Increment (lbs) | Horizontal Deflection Total (mm) | Increment (mm) |
|---|---|---|---|---|
| 245 | 600 | 355 | 3 | 1 |
| 540 | 914 | 374 | 8 | 5 |
| 824 | 1217 | 393 | 14 | 6 |
| 1097 | 1552 | 455 | 19 | 5 |
| 1404 | 1899 | 495 | 28 | 9 |
| 1724 | 2230 | 506 | 37 | 9 |
| 2079 | 2651 | 572 | 47 | 10 |
| 2405 | 3004 | 599 | 57 | 10 |
| 2800 | 3407 | 607 | 69 | 12 |
| 3209 | 3942 | 733 | 81 | 12 |




| | |
|---|---|
| 2000 | 456 |
| 4000 | 540 |
| 6000 | 733 |



GeoTesting express

**Project No :** GTX G0581
**Tested By:** HJ, SD, DC & JW
**Test Date:** 12/16/2004 - 12/27/04

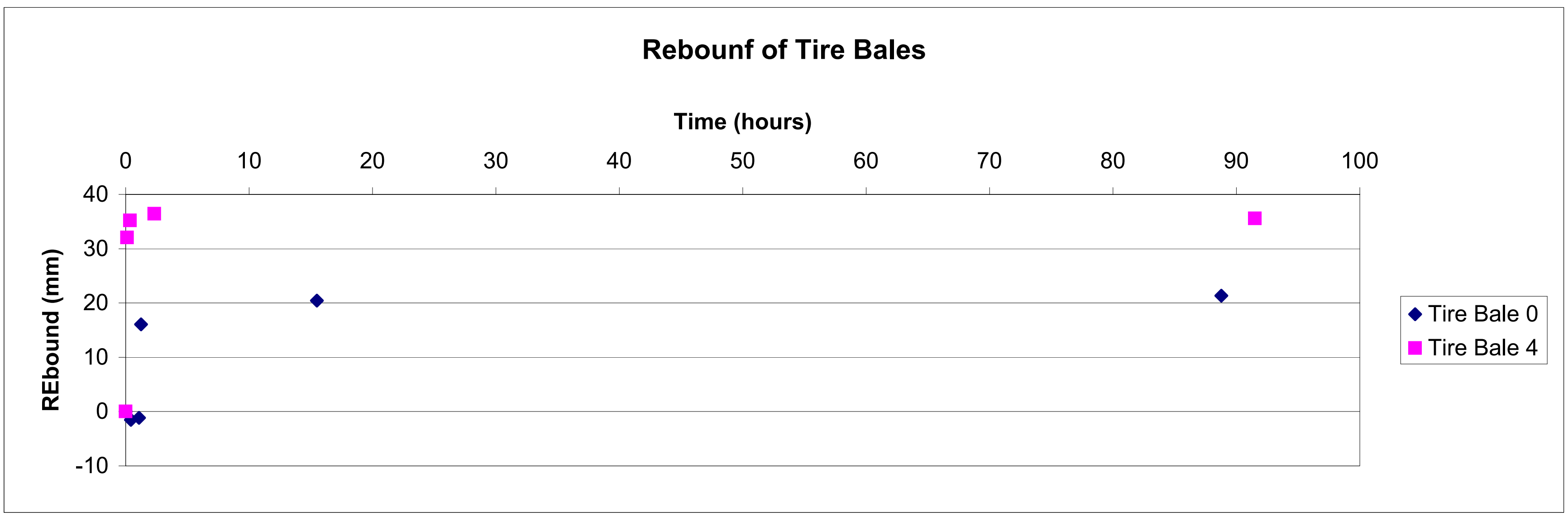
**Project Name:** Tire Bale Study
**Reviewed By:** JW
**Review Date:**

**Tire Bale 0**

| Date/Time | Elapsed Time (hour) | (voltage) | (mm) | Swell (mm) | (voltage) | (mm) | Swell (mm) | (voltage) | (mm) | Swell (mm) | Average Swell (mm) | voltage | kPa | kPa | psi | lbs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/16/04 15:35 | 0.00 | -2.13 | 5.9 | 0.0 | 1.55 | 24.7 | 0.0 | 3.2 | 30.3 | 0.0 | 0.0 | -3.76 | 32.5 | 0.0 | 0.0 | 0.0 |
| 12/16/04 16:00 | 0.42 | -2.15 | 5.8 | 0.1 | 2.36 | 28.1 | -3.4 | 3.48 | 31.5 | -1.2 | -1.5 | -3.61 | 52.8 | 20.3 | 3.0 | 333.7 |
| 12/16/04 16:40 | 1.08 | -2.15 | 5.8 | 0.1 | 2.4 | 28.3 | -3.6 | 3.18 | 30.2 | 0.1 | -1.1 | -3.6 | 54.2 | 21.7 | 3.1 | 355.9 |
| Release of the vertical load | | | | | | | | | | | | Swell Presuure= | | 60.3 psi | | |
| 12/16/04 16:50 | 1.25 | -3.72 | -0.4 | 6.3 | -0.37 | 16.6 | 8.1 | -4.72 | -3.6 | 33.9 | 16.1 | | | | | |
| 12/17/04 7:05 | 15.50 | -4.7 | -4.3 | 10.1 | -2 | 9.7 | 15.0 | -5.26 | -5.9 | 36.2 | 20.4 | | | | | |
| 12/20/04 8:22 | 88.78 | -4.83 | -4.8 | 10.7 | -2.55 | 7.4 | 17.3 | -5.25 | -5.9 | 36.2 | 21.4 | | | | | |

**Tire Bale 4**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/23/04 14:00 | 0.00 | -5.9 | -9.0 | 0.0 | -5.23 | | | -5.15 | -6.0 | 0.0 | 0 |
| 12/23/04 14:07 | 0.12 | 0.67 | 16.9 | 25.9 | LVDT was pushed out | | | -2.05 | 6.2 | 12.2 | 32.04071 |
| 12/23/04 14:21 | 0.35 | 1.28 | 19.3 | 28.3 | | | | -1.68 | 7.7 | 13.7 | 35.1777 |
| 12/23/04 16:20 | 2.33 | 1.36 | 19.7 | 28.6 | | | | -1.2 | 9.5 | 15.6 | 36.44039 |
| 12/27/04 9:30 | 91.50 | 0.79 | 17.4 | 26.4 | | | | -0.5 | 12.3 | 18.3 | 35.57229 |



# Unconfined Compression of Tire Bales

**a study performed at the Georgia Insitute of Technolgy**

The objective of this experimental investigation was to find the vertical and circumferential deformations resulting from a vertical compression load for three tire bales. Following is a report on the four tests conducted. The first two tests were conducted on tire bale No. 7, and the next two on tire bales Nos. 2 and 8. All data are presented in the Appendix. Load versus Vertical and Circumferential graphs are given in the main body of the report.

## Test Setup

A structural steel frame with columns forming an eight foot square was positioned and posttensioned to the concrete structural test floor. Two square concrete platens measuring 66" wide by 20" deep were used for top and bottom load bearing surfaces positioned in the middle of the steel frame as shown in Figure 1. In the first test it was found that the top platen was over rotating due to the non-uniformity of the tire bale. The problem was mitigated by attaching outriggers to all four sides of the top platen. A 1000 kip actuator was positioned in the center of the columns and applied the load to the top platen which distributed the load evenly to the tire bale. A 700 kip load cell was attached to the actuator to measure the applied load. Four 40-in. string potentiometers were positioned at the corners to measure vertical deformation. Vertical deformation at the corners also was measured using a measuring tape accurate to 1/16-inch. The circumference was measured by hand using a flexible metal measuring tape threaded through eye hooks around the middle of the tire bales to ensure consistency of measurements. Measurements were taken every 10 kips through 100 kips and then every 25 kips thereafter.

Figure 1: Test setup

## Test Results: Tire Bale #7, Test No. 1

Test No.1 on Tire bale #7 was conducted on March 24th. Bale dimensions were recorded as well as vertical displacements at the four corners of the platen and circumference was taken at the middle and top and bottom quarter heights. Initial dimensions are given in Table 1. Figure 2 shows the initial test setup. Figures 3 through 5 present load versus vertical and circumferential graphs.

Table 1: Initial dimensions of Tire Bale # 7

| | |
|---|---|
| **Date** | 3/24/2004 |
| **Tire Bale #** | 7 |
| **Test #** | 1 |

| | **Dimensions (in)** | | | | **Average** |
|---|---|---|---|---|---|
| **Height** | 30.875 | 31.875 | 30.063 | 32.625 | 31.359 |
| **Length** | 65.500 | 63.750 | | | 64.625 |
| **Width** | 61.000 | 60.750 | | | 60.875 |


Figure 2: Tire Bale # 7, Test # 1

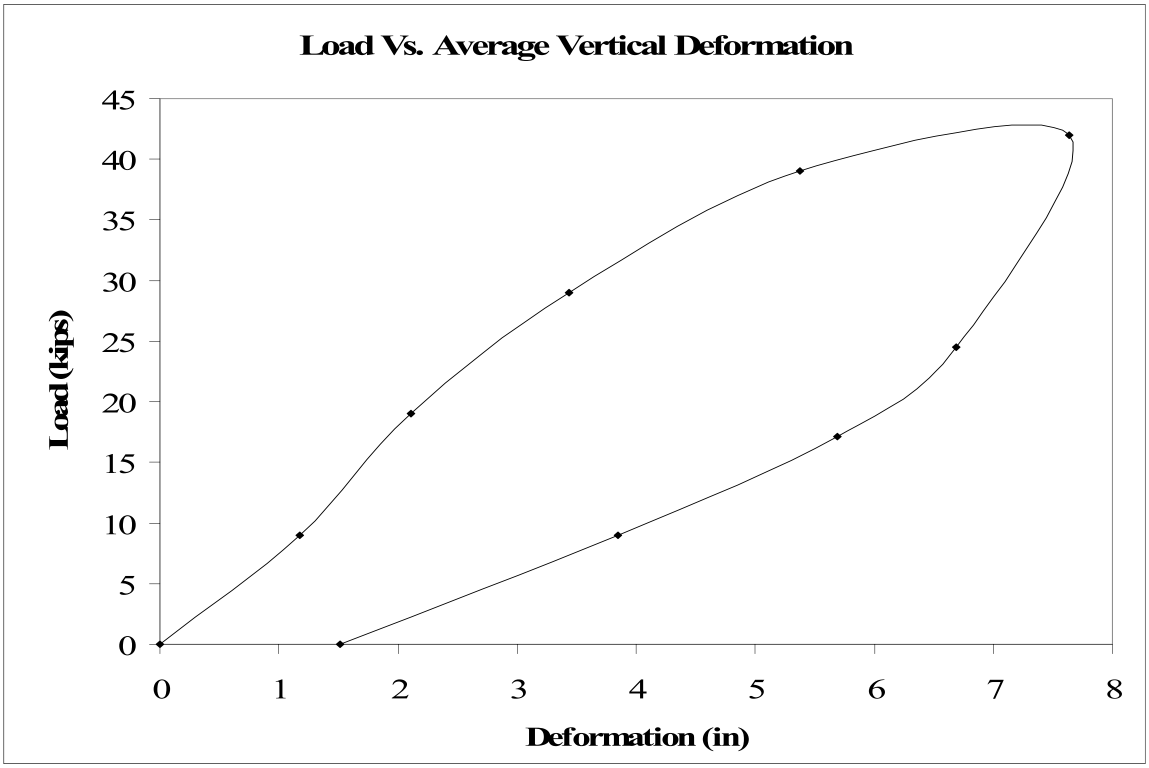



Figure 3: Tire Bale #7, Test No.1, Load vs. Average Vertical Deformation

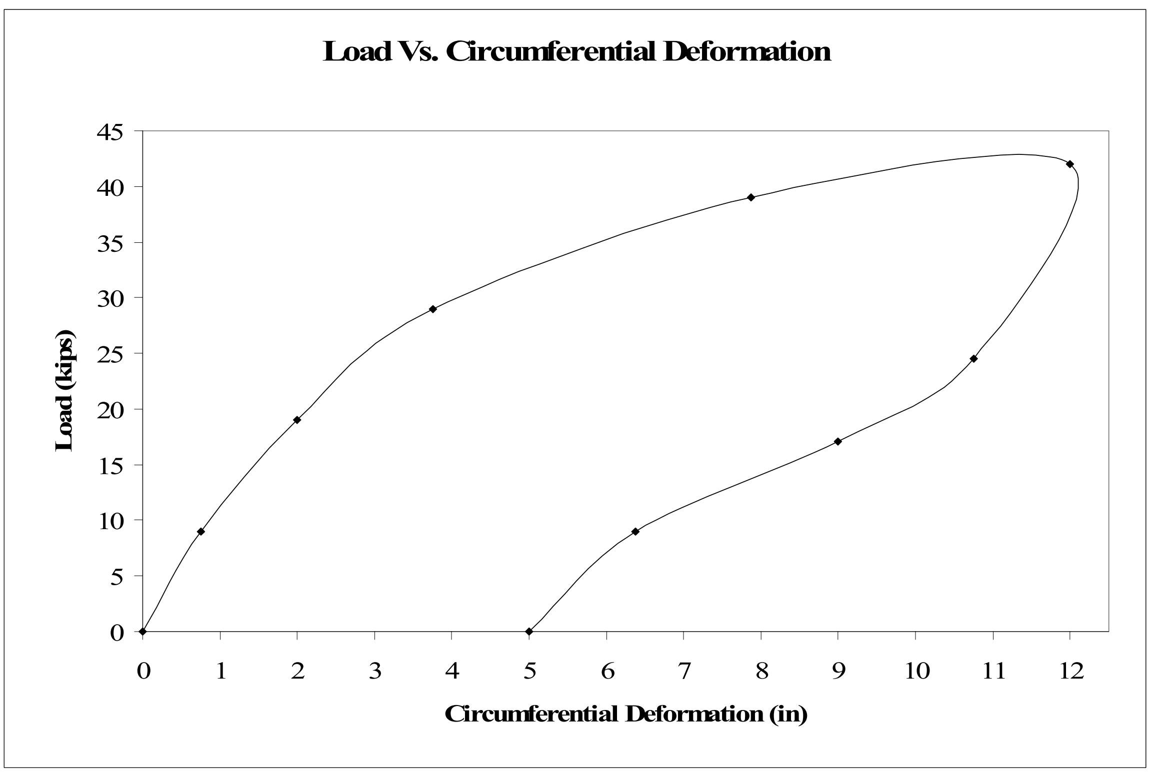



Figure 4: Tire Bale #7, Test No.1, Load vs. Circumferential Deformation

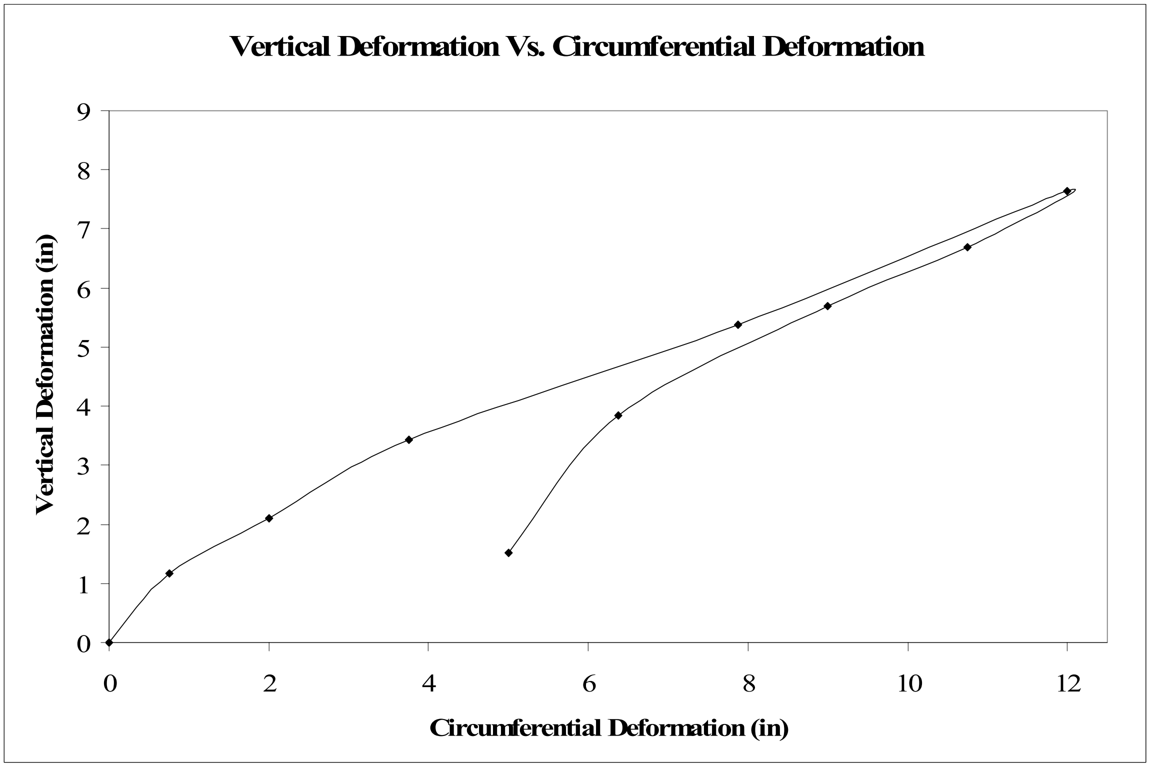



Figure 5: Tire Bale #7, Test No.1, Vertical Deformation vs. Circumferential Deformation

Test # 1 on Tire Bale #7 loaded the bale to 42 kips, where it was observed that the platen rotated and would have to be supported to inhibit that rotation.

## Test Results: Tire Bale #7, Test #2

Test #2 was conducted on May 24th on Tire bale #7. Bale dimensions were recorded as well as vertical displacements at the four corners of the platen and the circumference was taken at the middle. Circumferential measurements were only taken at the middle due to the inaccuracy of the results from Test # 1 at the top and bottom quarter heights. Initial dimensions are given in Table 2. Figure 6 shows the test setup. Figures 7 through 9 present load versus vertical and circumferential graphs.

Table 2: Initial dimensions of Tire Bale # 7

| | |
|---|---|
| **Date** | 5/24/2004 |
| **Tire Bale #** | 7 |
| **Test #** | 2 |

| | **Dimensions (in)** | | | | **Average** |
|---|---|---|---|---|---|
| **Height** | 30.188 | 30.250 | 30.500 | 30.375 | 30.328 |
| **Length** | 65.500 | 63.750 | | | 64.625 |
| **Width** | 61.000 | 60.750 | | | 60.875 |

Figure 6: Circumferential measurements. Outriggers mitigated rotation problem.

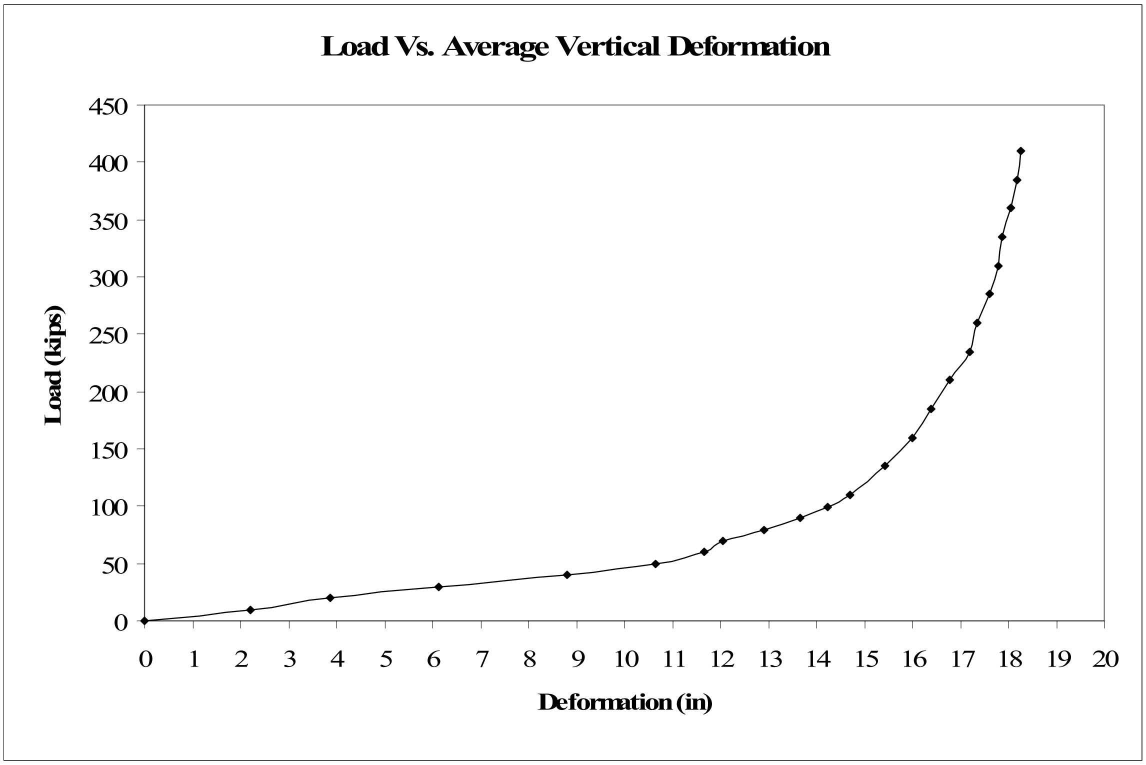



Figure7: Tire Bale #7, Test No.2, Load vs. Average Vertical Deformation

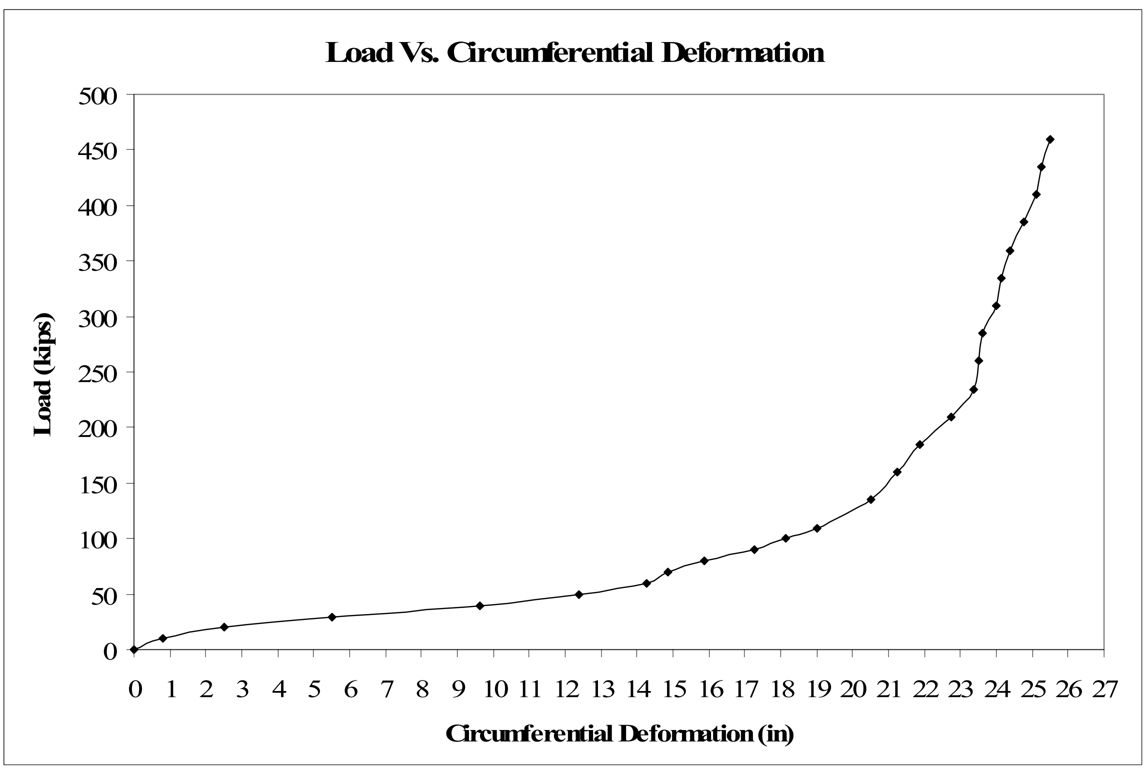



Figure 8: Tire Bale #7, Test No.2, Load vs. Circumferential Deformation

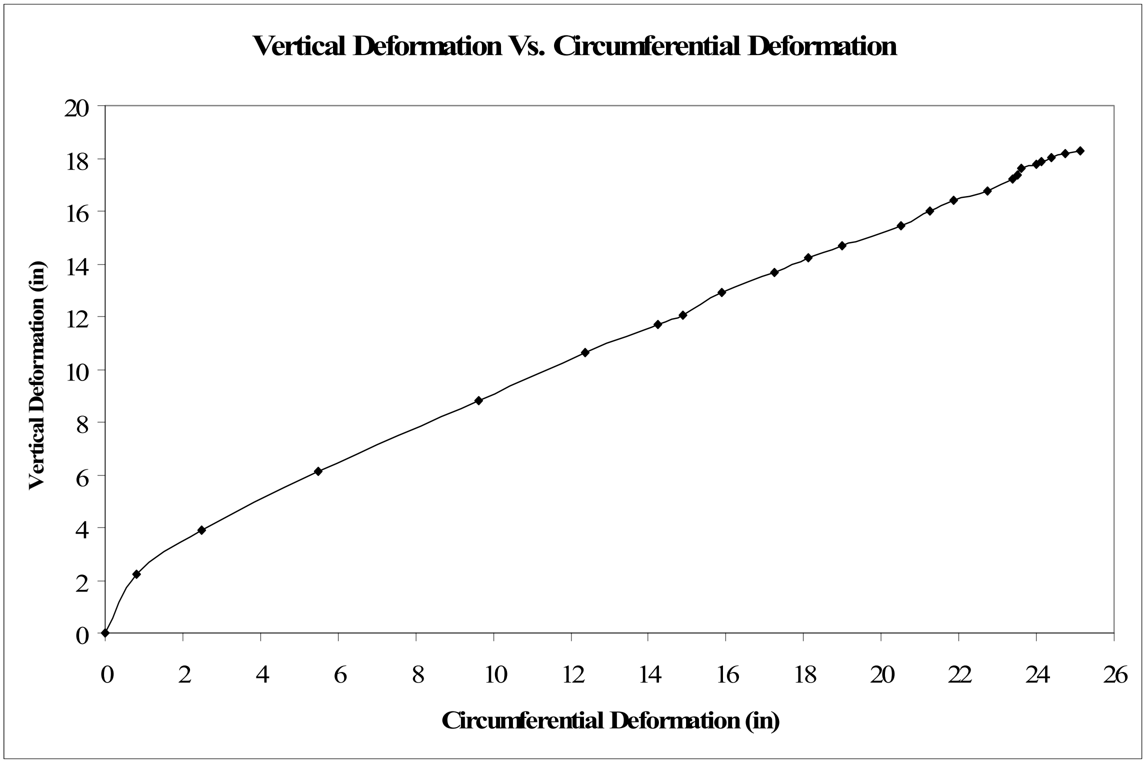



Figure 9: Tire Bale #7, Test No.2, Vertical Deformation vs. Circumferential Deformation

The second test on Tire Bale # 7 loaded the bale to 460 kips. Two of the bale's metal wires broke above 400 kips. Bale # 7 had a permanent vertical deformation of 1.2 in. and a permanent circumferential deformation of 7.75 in.

## Test Results: Tire Bale #2

Tire Bale # 2 was tested on July 21st. Bale dimensions were recorded as well as vertical displacements at the four corners of the platen and circumference was taken at the middle. Initial dimensions are given in Table 3. Figure 10 shows Tire Bale #2 loaded to 500 kips. Figures 11 through 13 present load versus vertical and circumferential graphs.

Table 3: Initial dimensions of Tire Bale # 2

| | |
|---|---|
| **Date** | 7/21/2004 |
| **Tire Bale #** | 2 |

| | **Dimensions (in)** | | | | **Average** |
|---|---|---|---|---|---|
| **Height** | 34.125 | 33.8125 | 34.5625 | 33.8125 | 34.08 |
| **Length** | 68.25 | 62.875 | | | 65.56 |
| **Width** | 62.1875 | 60.5 | | | 61.34 |

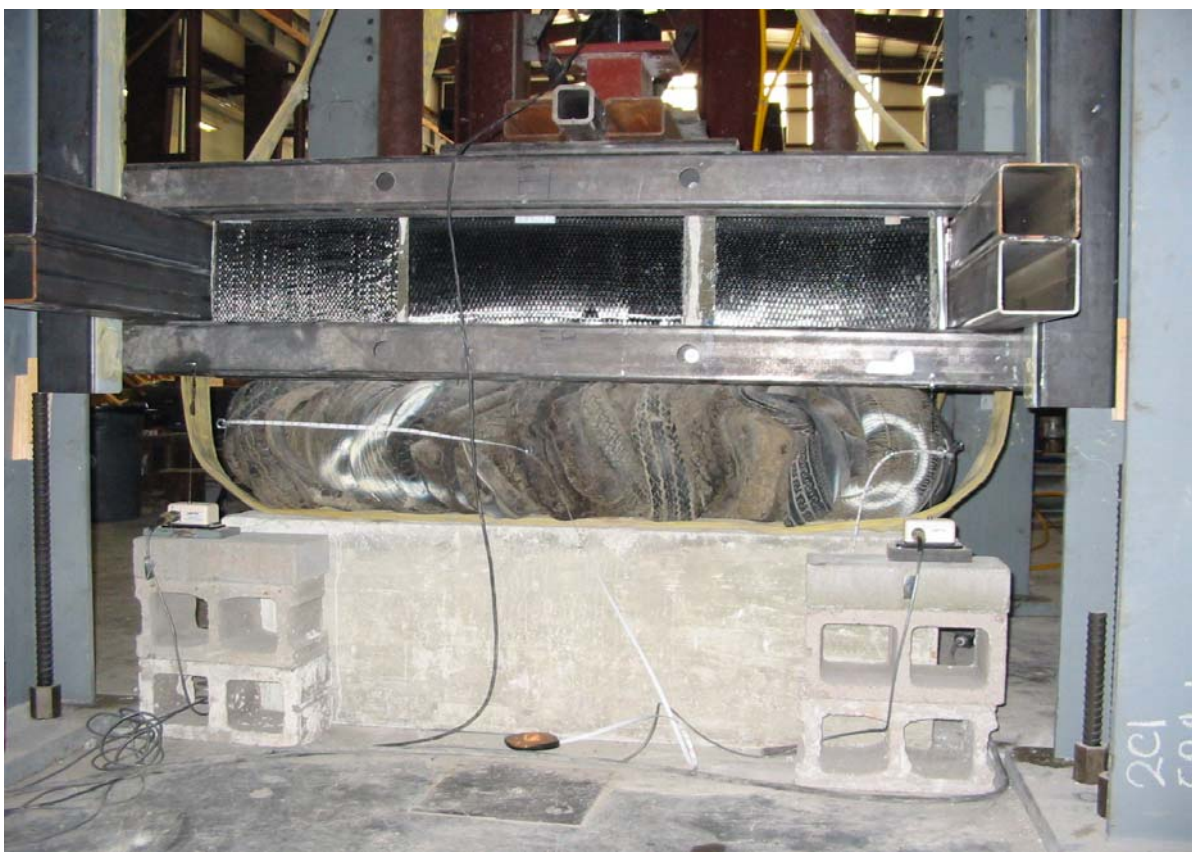


Figure 10: Tire Bale # 2 loaded to 500 kips

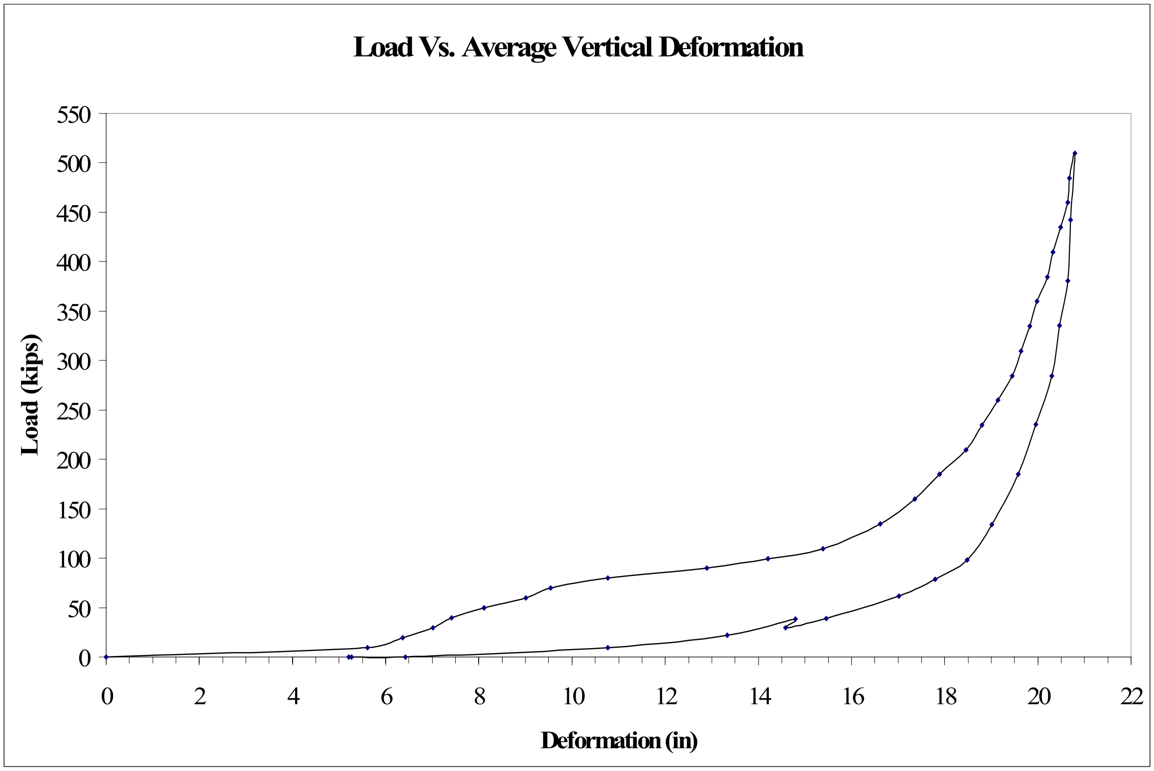



Figure 11: Tire Bale #2, Load vs. Average Vertical Deformation

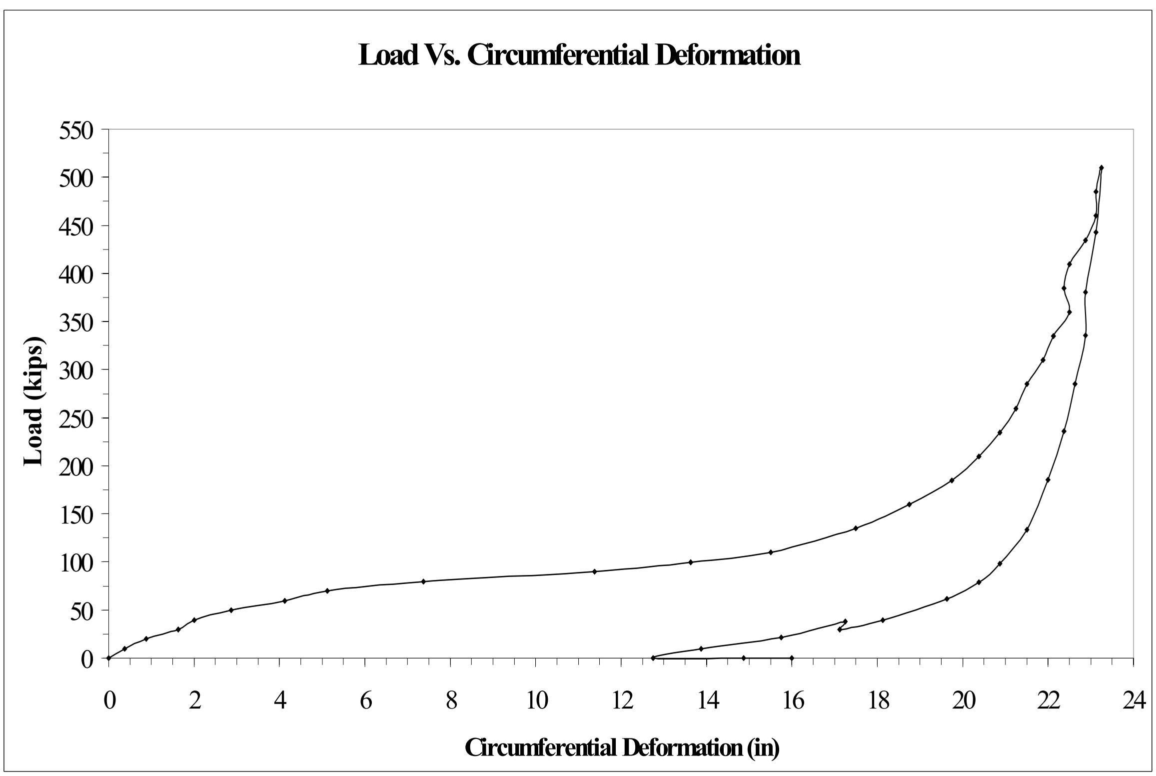



Figure 12: Tire Bale #2, Load vs. Circumferential Deformation

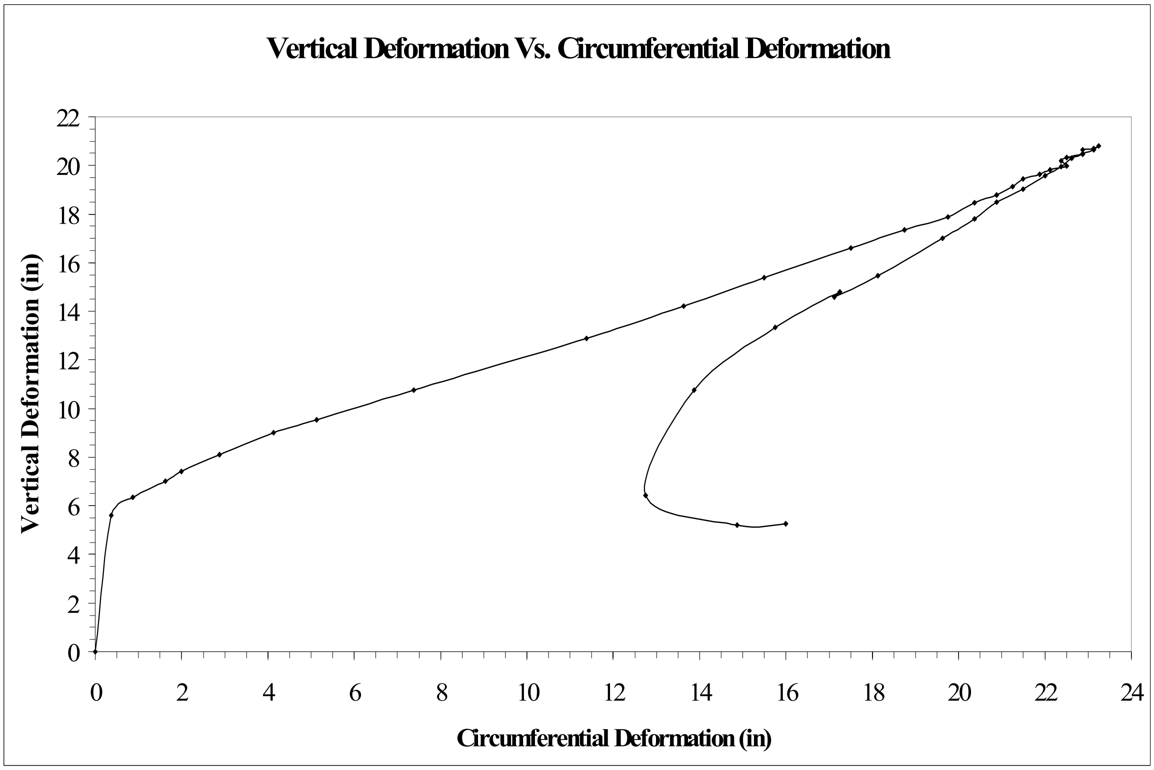



Figure 13: Tire Bale #2, Vertical Deformation vs. Circumferential Deformation

Tire Bale # 2 was loaded to 510 kips. Two of the bale's metal wires broke. Bale # 2 underwent 5.3 in. of permanent vertical deformation and 16 in. of permanent circumferential deformation.

## Test Results: Tire Bale #8

Tire Bale # 8 was tested on July 22nd. Bale dimensions were recorded as well as vertical displacements at the four corners of the platen and circumference was taken at the middle. Initial dimensions are given in Table 4. Figure 14 shows Tire Bale #8 loaded to 592 kips. Figures 15 through 17 present load versus vertical and circumferential graphs.

Table 4: Initial dimensions of Tire Bale # 8

| | |
|---|---|
| **Date** | 7/22/2004 |
| **Tire Bale#** | 8 |

| | Dimensions (in) | | | | Average |
|---|---|---|---|---|---|
| **Height** | 31.5 | 32 | 31.875 | 31.5 | 31.72 |
| **Length** | 67.5 | 64 | | | 65.75 |
| **Width** | 61 | 61.5 | | | 61.25 |

Figure 14: Tire Bale # 8 loaded to 592 kips

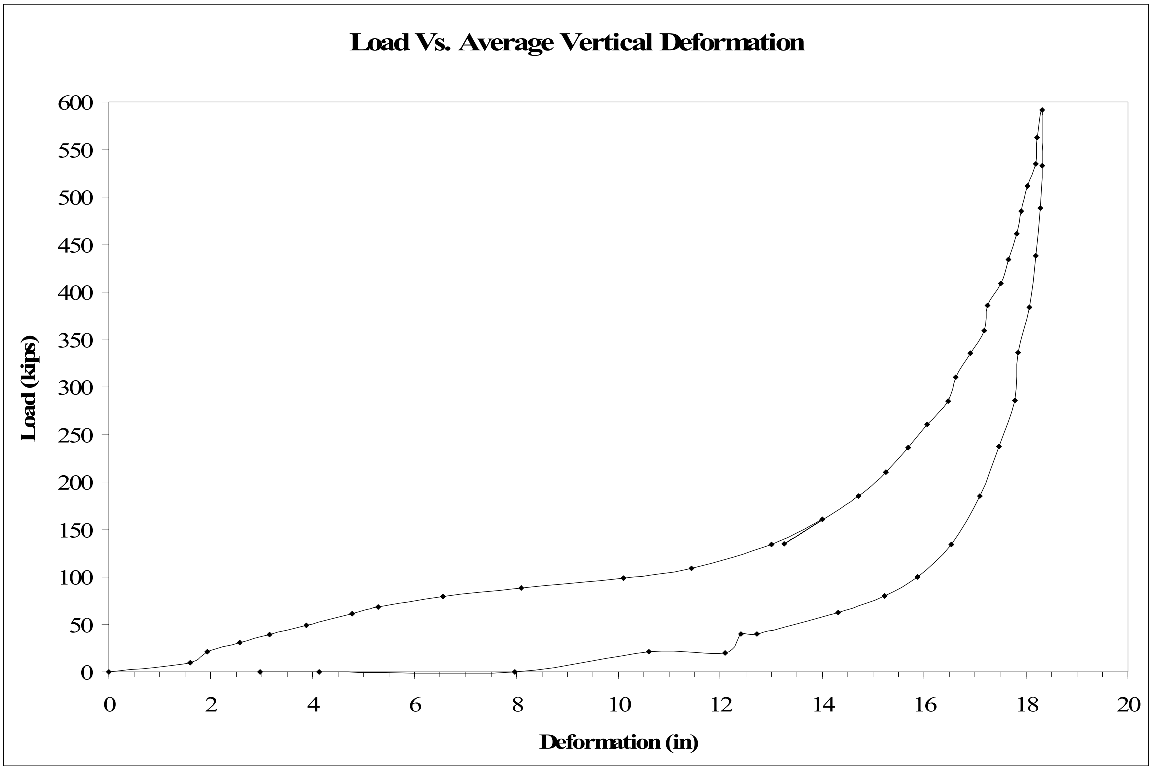



Figure 15: Tire Bale #8, Load vs. Average Vertical Deformation

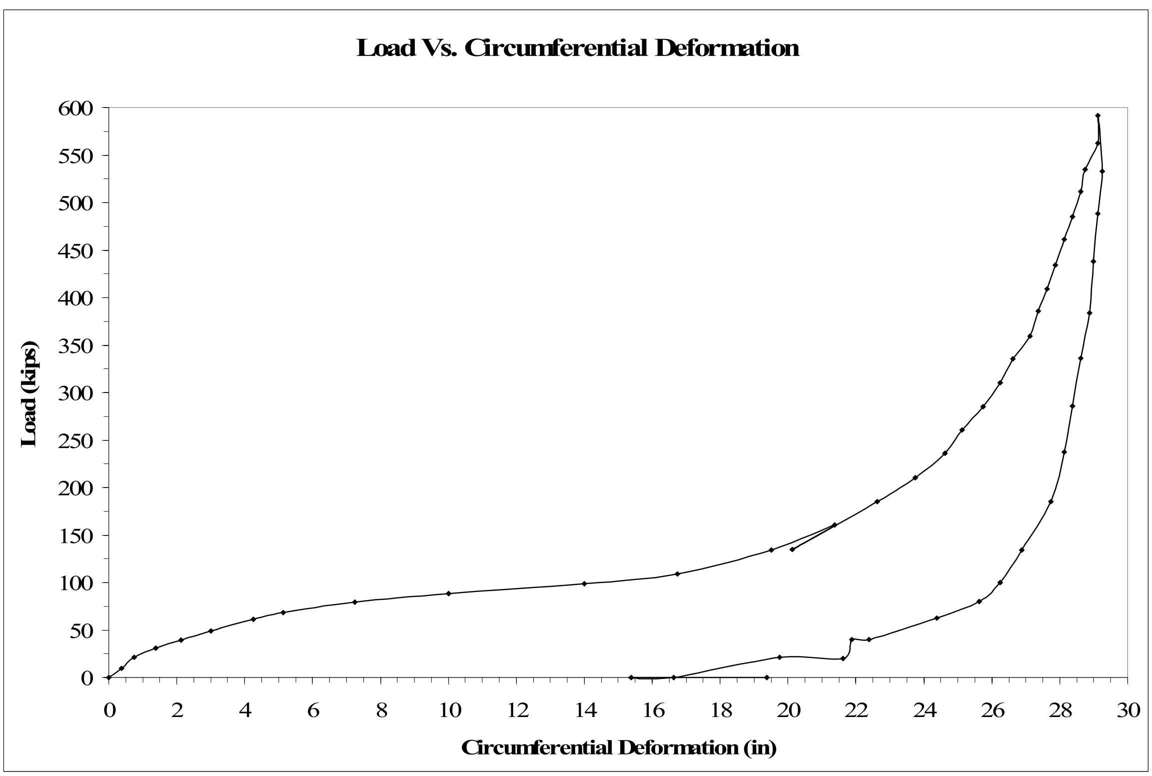



Figure 16: Tire Bale #8, Load vs. Circumferential Deformation

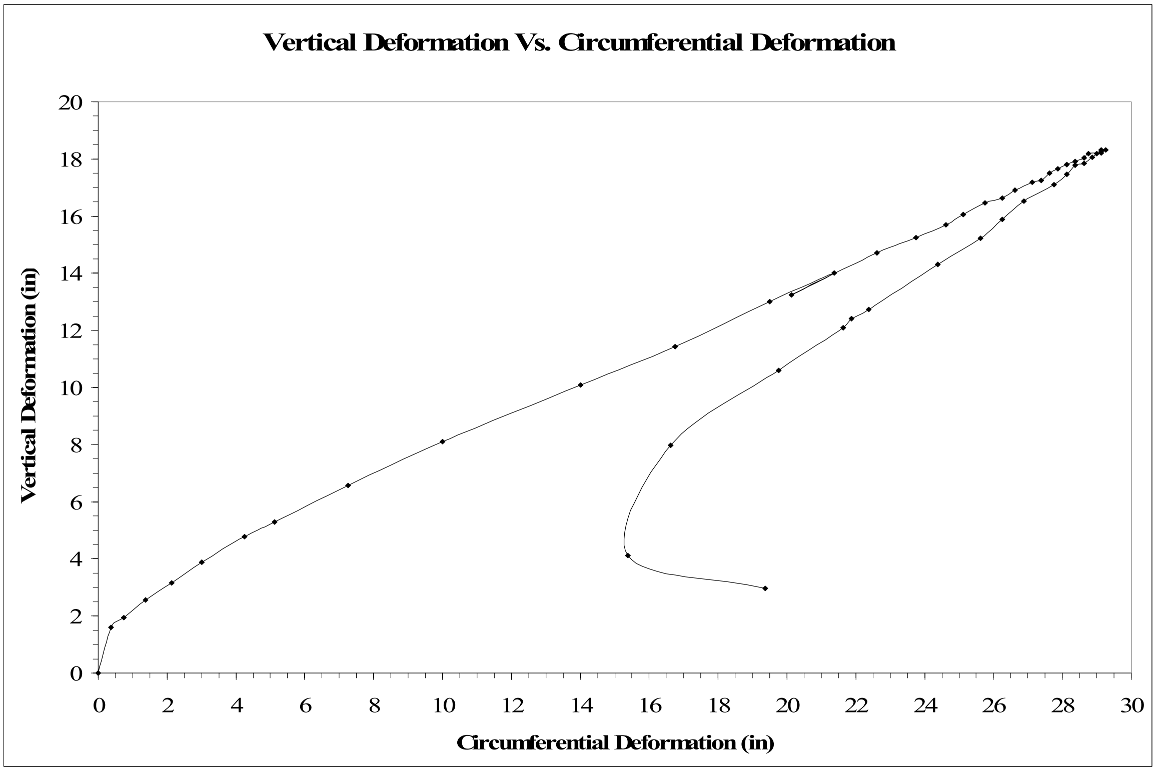



Figure 17: Tire Bale #2, Vertical Deformation vs. Circumferential Deformation

Tire Bale # 8 was loaded to 592 kips. Metal wires broke at 62 kips and 175 kips. Bale # 8 underwent 3 in. of permanent vertical deformation and 19.4 in. of permanent circumferential deformation.

# Appendix: Experimental Data

| | |
|---|---|
| **Date** | 3/24/2004 |
| **Tire Bale #** | 7 |
| **Test #** | 1 |

| **Dimensions (in)** | | | | | **Average** |
|---|---|---|---|---|---|
| **Height** | 30.875 | 31.875 | 30.063 | 32.625 | 31.359 |
| **Width** | 65.500 | 63.750 | | | 64.625 |
| **Length** | 61.000 | 60.750 | | | 60.875 |

| **Load (kips)** | | **Deformation (in)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Applied** | **Actual** | **Vert 1** | **Vert 2** | **Vert 3** | **Vert 4** | **Average Vertical** | **Circum Bot** | **Circum Mid** | **Circum Top** |
| w/o Platten | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| w/ Platten | 9 | 1.500 | 0.875 | -0.188 | 2.500 | 1.172 | 0.250 | 0.750 | 0.500 |
| 10 | 19 | 2.438 | 1.875 | 0.625 | 3.500 | 2.109 | 5.750 | 2.000 | 0.375 |
| 20 | 29 | 3.750 | 3.125 | 2.063 | 4.813 | 3.438 | 10.500 | 3.750 | 4.875 |
| 30 | 39 | 5.500 | 5.375 | 4.188 | 6.438 | 5.375 | 13.625 | 7.875 | 8.000 |
| 33 | 42 | 6.250 | 8.875 | 8.000 | 7.438 | 7.641 | 13.875 | 12.000 | 11.750 |
| 15.5 | 24.5 | 5.375 | 7.938 | 6.813 | 6.625 | 6.688 | 12.125 | 10.750 | 11.250 |
| 8.1 | 17.1 | 4.625 | 6.688 | 5.688 | 5.750 | 5.688 | 10.875 | 9.000 | 10.250 |
| w/ Platten | 9 | 3.813 | 3.750 | 2.813 | 5.000 | 3.844 | 7.000 | 6.375 | 4.250 |
| w/o Platten | 0 | 2.063 | 1.875 | 0.313 | 1.813 | 1.516 | 5.000 | 5.000 | -2.875 |
| w/o Platten | 0 | | | | | | 5.000 | 0.000 | -1.500 |
| w/o Platten | 0 | | | | | | 0.25 | 0.75 | 0.5 |

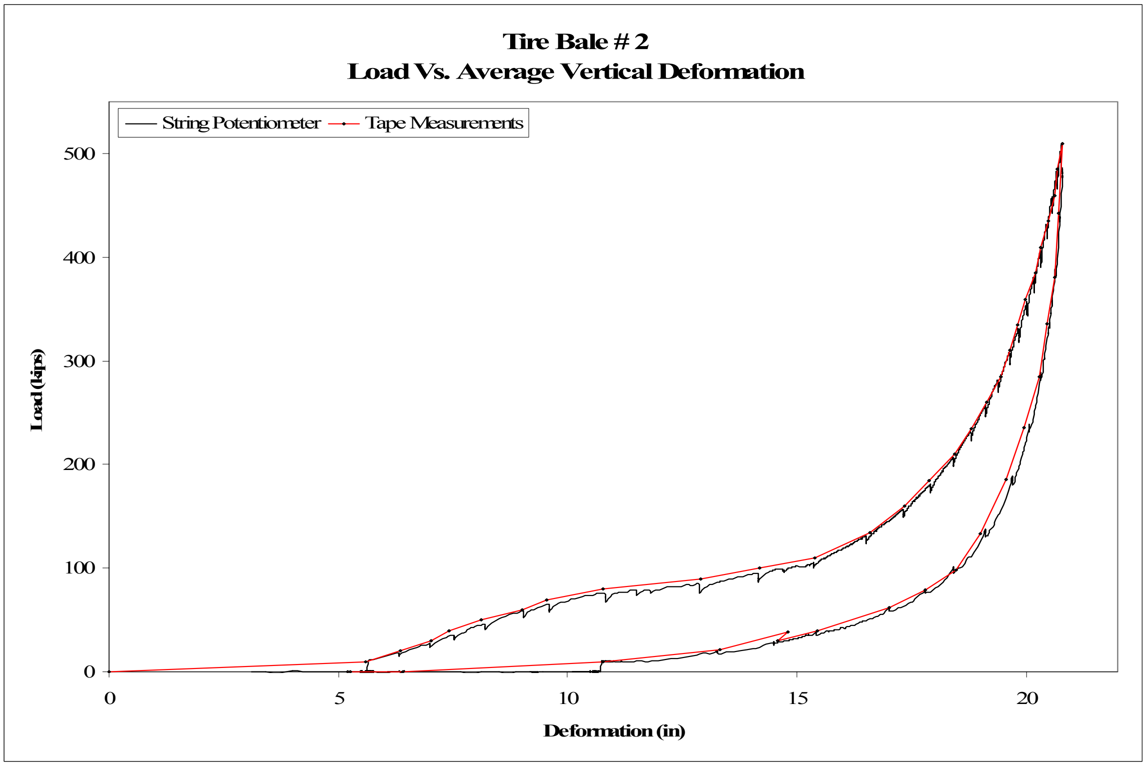
| | |
|---|---|
| **Date** | 5/24/2004 |
| **Tire Bale #** | 7 |
| **Test #** | 2 |

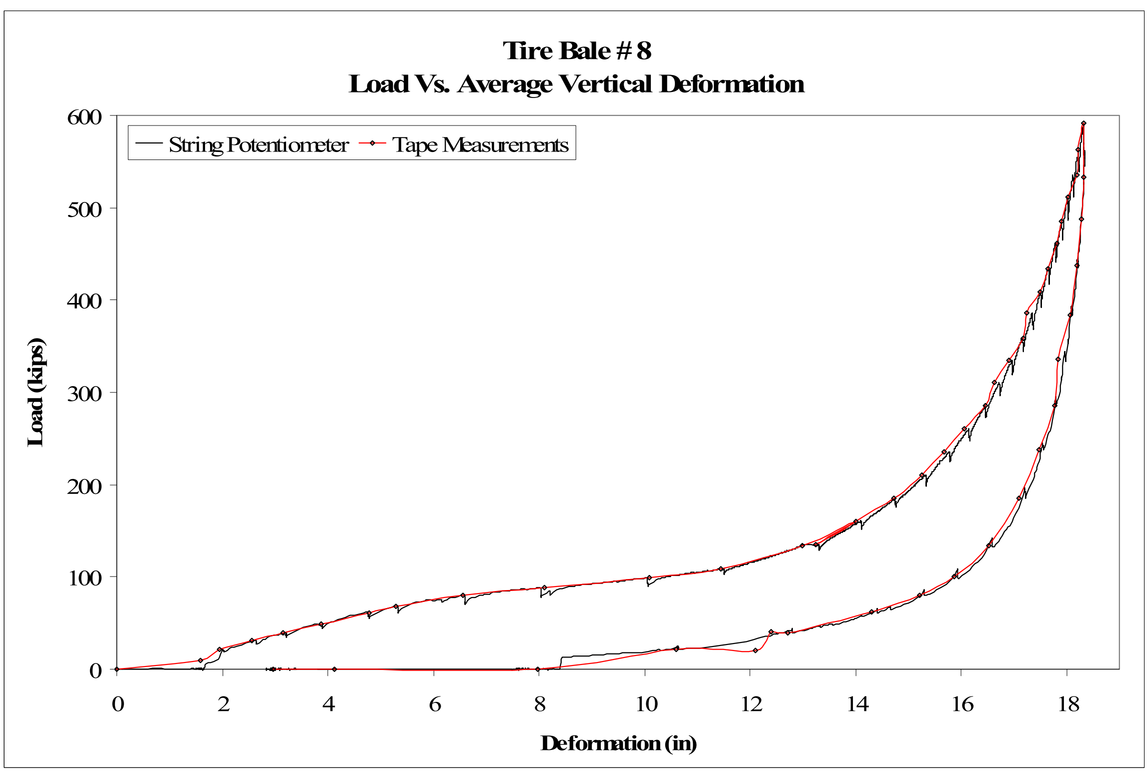
| **Dimensions (in)** | | | | | **Average** |
|---|---|---|---|---|---|
| **Height** | 30.188 | 30.250 | 30.500 | 30.375 | 30.328 |
| **Width** | 65.5 | 63.75 | | | 64.625 |
| **Length** | 61.0 | 60.75 | | | 60.875 |

| **Load (kips)** | | **Deformation (in)** | | | | | |
|---|---|---|---|---|---|---|---|
| **Applied** | **Actual** | **Vert 1** | **Vert 2** | **Vert 3** | **Vert 4** | **Average Vertical** | **Circum Mid** |
| w/o Platten | 0.0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| w/ Platten | 9.7 | 2.9375 | 1.625 | 1.5 | 2.75 | 2.20 | 0.81 |
| 10 | 19.7 | 4.6875 | 3.375 | 3.125 | 4.3125 | 3.88 | 2.50 |
| 20 | 29.7 | 6.9375 | 5.625 | 5.375 | 6.5625 | 6.13 | 5.50 |
| 30 | 39.7 | 9.8125 | 8.375 | 7.875 | 9.125 | 8.80 | 9.63 |
| 40 | 49.7 | 11.6875 | 10.25 | 9.625 | 11.0625 | 10.66 | 12.38 |
| 50 | 59.7 | 12.4375 | 11.375 | 10.75 | 12.125 | 11.67 | 14.25 |
| 60 | 69.7 | 12.5625 | 12.1875 | 11.375 | 12.125 | 12.06 | 14.88 |
| 70 | 79.7 | 13.6875 | 12.875 | 12.25 | 12.875 | 12.92 | 15.88 |
| 80 | 89.7 | 14.375 | 13.625 | 13 | 13.625 | 13.66 | 17.25 |
| 90 | 99.7 | 14.9375 | 14.25 | 13.5 | 14.25 | 14.23 | 18.13 |
| 100 | 109.7 | 15.4375 | 14.6875 | 14 | 14.6875 | 14.70 | 19.00 |
| 125 | 134.7 | 16.1875 | 15.5 | 14.5 | 15.5625 | 15.44 | 20.50 |
| 150 | 159.7 | 16.8125 | 15.9375 | 15.25 | 16 | 16.00 | 21.25 |
| 175 | 184.7 | 17.1875 | 16.25 | 15.5 | 16.625 | 16.39 | 21.88 |
| 200 | 209.7 | 17.6875 | 16.625 | 15.75 | 17.0625 | 16.78 | 22.75 |
| 225 | 234.7 | 18.1875 | 16.875 | 16.25 | 17.5 | 17.20 | 23.38 |
| 250 | 259.7 | 18.1875 | 17 | 16.5 | 17.6875 | 17.34 | 23.50 |
| 275 | 284.7 | 18.4375 | 17.25 | 16.75 | 18 | 17.61 | 23.63 |
| 300 | 309.7 | 18.6875 | 17.375 | 16.75 | 18.375 | 17.80 | 24.00 |
| 325 | 334.7 | 18.9375 | 17.375 | 16.75 | 18.4375 | 17.88 | 24.13 |
| 350 | 359.7 | 19.1875 | 17.5 | 16.875 | 18.625 | 18.05 | 24.38 |
| 375 | 384.7 | 19.1875 | 17.8125 | 16.875 | 18.875 | 18.19 | 24.75 |
| 400 | 409.7 | 19.4375 | 17.625 | 17 | 19 | 18.27 | 25.13 |
| 425 | 434.7 | | | | | | 25.25 |
| 450 | 459.7 | | | | | | 25.50 |
| w/o platten | 0 | 1.1875 | 0.875 | 1.125 | 1.5625 | 1.19 | 7.75 |

| Date | 7/21/2004 | | | | | | |
|---|---|---|---|---|---|---|---|
| Tire Bale# | 2 | | | | | | |
| | | | | | | | |
| Load (kips) | | Deformation (in) | | | | | |
| Measured | Actual | Vert 1 | Vert 2 | Vert3 | Vert 4 | Average | Circum |
| w/o platen | 0 | 0 | 0 | 0 | 0 | 0.00 | 0 |
| w/platen | 9.72 | 5.75 | 4.8125 | 6.0625 | 5.8125 | 5.61 | 0.375 |
| 10 | 19.72 | 6.375 | 5.5625 | 6.6875 | 6.8125 | 6.36 | 0.875 |
| 20 | 29.72 | 7 | 6.1875 | 7.3125 | 7.5625 | 7.02 | 1.625 |
| 30 | 39.72 | 7.5 | 6.5625 | 7.5625 | 8.0625 | 7.42 | 2 |
| 40 | 49.72 | 8.25 | 7.3125 | 8.3125 | 8.5625 | 8.11 | 2.875 |
| 50 | 59.72 | 9.125 | 8.0625 | 9.1875 | 9.6875 | 9.02 | 4.125 |
| 60 | 69.72 | 9.625 | 8.5625 | 9.6875 | 10.3125 | 9.55 | 5.125 |
| 70 | 79.72 | 10.875 | 9.8125 | 11.0625 | 11.3125 | 10.77 | 7.375 |
| 80 | 89.72 | 12.875 | 12.0625 | 13.3125 | 13.3125 | 12.89 | 11.375 |
| 90 | 99.72 | 14.125 | 13.3125 | 15.0625 | 14.3125 | 14.20 | 13.625 |
| 100 | 109.72 | 15.125 | 14.5625 | 16.3125 | 15.5625 | 15.39 | 15.5 |
| 125 | 134.72 | 16.125 | 15.8125 | 17.5625 | 16.9375 | 16.61 | 17.5 |
| 150 | 159.72 | 17 | 16.6875 | 18.3125 | 17.4375 | 17.36 | 18.75 |
| 175 | 184.72 | 17.625 | 17.3125 | 18.8125 | 17.8125 | 17.89 | 19.75 |
| 200 | 209.72 | 18.125 | 17.8125 | 19.3125 | 18.5625 | 18.45 | 20.375 |
| 225 | 234.72 | 18.5 | 18.1875 | 19.5625 | 18.9375 | 18.80 | 20.875 |
| 250 | 259.72 | 18.75 | 18.5625 | 19.9375 | 19.3125 | 19.14 | 21.25 |
| 275 | 284.72 | 19.125 | 18.8125 | 20.3125 | 19.5625 | 19.45 | 21.5 |
| 300 | 309.72 | 19.25 | 18.9375 | 20.5625 | 19.8125 | 19.64 | 21.875 |
| 325 | 334.72 | 19.5 | 19.0625 | 20.8125 | 19.9375 | 19.83 | 22.125 |
| 350 | 359.72 | 19.625 | 19.3125 | 20.9375 | 20.0625 | 19.98 | 22.5 |
| 375 | 384.72 | 19.875 | 19.5625 | 21.0625 | 20.3125 | 20.20 | 22.375 |
| 400 | 409.72 | 20 | 19.6875 | 21.1875 | 20.4375 | 20.33 | 22.5 |
| 425 | 434.72 | 20.125 | 19.8125 | 21.3125 | 20.6875 | 20.48 | 22.875 |
| 450 | 459.72 | 20.25 | 19.9375 | 21.5625 | 20.8125 | 20.64 | 23.125 |
| 475 | 484.72 | 20.25 | 20.0625 | 21.5625 | 20.8125 | 20.67 | 23.125 |
| 500 | 509.72 | 20.375 | 20.0625 | 21.6875 | 21.0625 | 20.80 | 23.25 |
| 433 | 442.56 | 20.375 | 20.0625 | 21.5625 | 20.8125 | 20.70 | 23.125 |
| 371 | 380.55 | 20.25 | 19.9375 | 21.5625 | 20.8125 | 20.64 | 22.875 |
| 326 | 335.59 | 20.125 | 19.75 | 21.4375 | 20.5625 | 20.47 | 22.875 |
| 275 | 284.75 | 19.875 | 19.5625 | 21.1875 | 20.5625 | 20.30 | 22.625 |
| 226 | 235.60 | 19.625 | 19.4375 | 20.6875 | 20.0625 | 19.95 | 22.375 |
| 176 | 185.29 | 19.375 | 18.9375 | 20.4375 | 19.5625 | 19.58 | 22 |
| 124 | 133.75 | 18.75 | 18.3125 | 19.9375 | 19.0625 | 19.02 | 21.5 |
| 89 | 98.48 | 18.125 | 17.6875 | 19.5625 | 18.5625 | 18.48 | 20.875 |
| 69 | 78.80 | 17.625 | 17.1875 | 18.5625 | 17.8125 | 17.80 | 20.375 |
| 52 | 61.71 | 16.875 | 16.4375 | 17.8125 | 16.9375 | 17.02 | 19.625 |
| 30 | 39.26 | 15.125 | 14.8125 | 16.5625 | 15.3125 | 15.45 | 18.125 |
| 20 | 29.50 | 14.375 | 13.8125 | 15.5625 | 14.5625 | 14.58 | 17.125 |
| 29 | 38.26 | 14.5 | 14.0625 | 15.8125 | 14.8125 | 14.80 | 17.25 |
| 12 | 21.74 | 13.125 | 12.6875 | 14.3125 | 13.1875 | 13.33 | 15.75 |
| w/ platen | 9.72 | 10.75 | 10.3125 | 11.8125 | 10.1875 | 10.77 | 13.875 |
| w/o platen | 0 | 6 | 6.3125 | 7.0625 | 6.3125 | 6.42 | 12.75 |
| w/o platen | 0 | 5.375 | 4.8125 | 5.5625 | 5.0625 | 5.20 | 14.875 |
| w/o platen | 0 | 5.5 | 4.8125 | 5.5625 | 5.1875 | 5.27 | 16 |

| Date | 7/22/2004 | | | | | | |
|---|---|---|---|---|---|---|---|
| Tire Bale# | 8 | | | | | | |
| | | | | | | | |
| Load (kips) | | Deformation (in) | | | | | |
| Measured | Actual | Vert 1 | Vert 2 | Vert3 | Vert 4 | Average | Circum |
| w/o platen | 0 | 0 | 0 | 0 | 0 | 0.00 | 0 |
| w/platen | 9.72 | 1 | 2.25 | 1.875 | 1.25 | 1.59 | 0.375 |
| 11.6 | 21.3 | 1.5 | 2.5 | 2.125 | 1.625 | 1.94 | 0.75 |
| 21.0 | 30.7 | 2.25 | 3 | 2.625 | 2.375 | 2.56 | 1.375 |
| 29.5 | 39.3 | 2.75 | 3.5 | 3.375 | 3 | 3.16 | 2.125 |
| 39.6 | 49.3 | 3.5 | 4.125 | 4.125 | 3.75 | 3.88 | 3 |
| 51.8 | 61.5 | 4.375 | 4.875 | 5.125 | 4.75 | 4.78 | 4.25 |
| 58.6 | 68.3 | 5 | 5.375 | 5.375 | 5.375 | 5.28 | 5.125 |
| 69.8 | 79.5 | 6.5 | 6.5 | 6.625 | 6.625 | 6.56 | 7.25 |
| 78.4 | 88.1 | 8.125 | 7.875 | 8.25 | 8.125 | 8.09 | 10 |
| 89.2 | 99.0 | 10.125 | 9.875 | 10.125 | 10.25 | 10.09 | 14 |
| 99.1 | 108.8 | 11.5 | 11.25 | 11.375 | 11.625 | 11.44 | 16.75 |
| 124.7 | 134.4 | 13 | 12.875 | 13 | 13.125 | 13.00 | 19.5 |
| 151.0 | 160.7 | 13.875 | 14 | 14 | 14.125 | 14.00 | 21.375 |
| 125.2 | 134.9 | 13.125 | 13.25 | 13.375 | 13.25 | 13.25 | 20.125 |
| 175.6 | 185.3 | 14.5 | 14.75 | 14.875 | 14.75 | 14.72 | 22.625 |
| 200.4 | 210.2 | 15.125 | 15.25 | 15.375 | 15.25 | 15.25 | 23.75 |
| 226.1 | 235.8 | 15.5 | 15.75 | 15.875 | 15.625 | 15.69 | 24.625 |
| 250.7 | 260.4 | 15.875 | 16.125 | 16.25 | 16 | 16.06 | 25.125 |
| 275.7 | 285.4 | 16.25 | 16.5 | 16.625 | 16.5 | 16.47 | 25.75 |
| 300.5 | 310.3 | 16.5 | 16.625 | 16.875 | 16.5 | 16.63 | 26.25 |
| 325.5 | 335.2 | 16.75 | 17 | 17 | 16.875 | 16.91 | 26.625 |
| 349.4 | 359.1 | 17 | 17.125 | 17.375 | 17.25 | 17.19 | 27.125 |
| 375.8 | 385.6 | 17.125 | 17.25 | 17.375 | 17.25 | 17.25 | 27.375 |
| 399.4 | 409.1 | 17.375 | 17.5 | 17.75 | 17.375 | 17.50 | 27.625 |
| 424.7 | 434.5 | 17.5 | 17.625 | 17.875 | 17.625 | 17.66 | 27.875 |
| 451.5 | 461.2 | 17.5 | 17.75 | 18 | 18 | 17.81 | 28.125 |
| 475.6 | 485.3 | 17.75 | 17.875 | 18.25 | 17.75 | 17.91 | 28.375 |
| 502.0 | 511.7 | 17.75 | 18 | 18.375 | 18 | 18.03 | 28.625 |
| 525.4 | 535.2 | 18 | 18 | 18.375 | 18.375 | 18.19 | 28.75 |
| 552.9 | 562.6 | 18 | 18.125 | 18.375 | 18.375 | 18.22 | 29.125 |
| 582.1 | 591.9 | 18.125 | 18.25 | 18.375 | 18.5 | 18.31 | 29.125 |
| 523.4 | 533.1 | 18.25 | 18.25 | 18.25 | 18.5 | 18.31 | 29.25 |
| 478.5 | 488.2 | 18.125 | 18.25 | 18.25 | 18.5 | 18.28 | 29.125 |
| 428.2 | 438.0 | 18 | 18.125 | 18.25 | 18.375 | 18.19 | 29 |
| 374.2 | 384.0 | 17.875 | 18 | 18.125 | 18.25 | 18.06 | 28.875 |
| 326.3 | 336.0 | 17.75 | 17.875 | 17.875 | 17.875 | 17.84 | 28.625 |
| 276.3 | 286.0 | 17.625 | 17.75 | 17.75 | 18 | 17.78 | 28.375 |
| 227.8 | 237.5 | 17.375 | 17.5 | 17.5 | 17.5 | 17.47 | 28.125 |
| 175.1 | 184.9 | 17 | 17.125 | 17.125 | 17.125 | 17.09 | 27.75 |
| 124.3 | 134.0 | 16.5 | 16.5 | 16.625 | 16.5 | 16.53 | 26.875 |
| 90.4 | 100.1 | 15.75 | 15.875 | 15.875 | 16 | 15.88 | 26.25 |
| 70.5 | 80.2 | 15.125 | 15.25 | 15.375 | 15.125 | 15.22 | 25.625 |
| 52.7 | 62.4 | 14.25 | 14.25 | 14.375 | 14.375 | 14.31 | 24.375 |
| 30.2 | 39.9 | 12.625 | 12.75 | 12.875 | 12.625 | 12.72 | 22.375 |
| 30.6 | 40.3 | 12.375 | 12.375 | 12.375 | 12.5 | 12.41 | 21.875 |
| 10.5 | 20.2 | 11.875 | 12.125 | 12.375 | 12 | 12.09 | 21.625 |
| 11.8 | 21.5 | 10.5 | 10.625 | 10.75 | 10.5 | 10.59 | 19.75 |
| w/ platen | 8 | 8 | 8 | 8.125 | 7.75 | 7.97 | 16.625 |
| w/o platen | 0 | 3.625 | 4.75 | 4.375 | 3.75 | 4.13 | 15.375 |
| w/o platen | 0 | 2.5 | 3.5 | 3.125 | 2.75 | 2.97 | 19.375 |


Tire Bale # 2
Load Vs. Average Vertical Deformation
String Potentiometer
Tape Measurements
Load (kips)
500
400
300
200
100
0
0
5
10
15
20
Deformation (in)


Tire Bale # 8
Load Vs. Average Vertical Deformation
String Potentiometer
Tape Measurements
Load (kips)
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
18
Deformation (in)

## APPENDIX E Specifications for Tire Shreds and Tire Bale Applications

**Beneficial Use Determination, Baled Tires in Road Construction, New York State DEP, January 2003**

**Texas DOT Preliminary Draft Specification for Tire Bale Embankments**

**Summary page for ASTM D 6270-98 Standard Practice for Use of Scrap Tires in Civil Engineering Applications**

**New York State Department of Environmental Conservation**
**Division of Solid and Hazardous Materials, Region 9**
270 Michigan Avenue, Buffalo, New York, 14203-2999
**Phone:** (716) 851-7220 • **FAX:** (716) 851-7226
**Website:** www.dec.state.ny.us

Erin M. Crotty
Commissioner


January 9, 2003

RECEIVED
JAN 13 2003
By

Mr. Kenneth P. Smith
Deputy Director- Transportation
Chautauqua County Department of Public Facilities
454 North Work Street
Falconer, New York 14733

Dear Mr. Smith:

BUD #764-9-07
Use of Baled Tires in Road Construction

Department staff have reviewed the petition for a Beneficial Use Determination (BUD) submitted by Chautauqua County requesting the New York State Department of Environmental Conservation (Department) determine that waste tires, when baled and used as a substitute for lightweight aggregate (subbase) in road construction in marginal soils, constitutes a beneficial use. Chautauqua County stated that baled tires weigh one-fifth the weight of conventional materials used in road subbase construction. The County proposes to obtain waste tires from non-permitted waste tire piles and tire amnesty days, bale the tires at the Chautauqua County landfill, and use the tire bales pursuant to the County's Department of Public Facilities Division of Transportation planned road construction projects. The BUD petition submitted by Chautauqua County on September 18, 2002 is a case specific BUD petition for road construction using baled tires, however, specific future sites have not yet been identified.

On September 28, 1998, the Department issued a 6 NYCRR Research Development and Demonstration (RD&D) Permit (9-0699-00033/00001) to use approximately 2,000 tire bales for subgrade material on three unpaved road segments, each 1,000 feet in length. An EPA Waste Tire Stockpile Abatement/Demonstration grant was obtained by the County to partially fund the tire baler and clean-up of a waste tire stockpile used in the tire bales. The RD&D permit was renewed on November 24, 1999, and again on September 21, 2000, to include the use of baled tires under an asphalt road section (Kabob Road). The permit was amended on April 7, 2000 to include the collection of waste tires during amnesty days, and again renewed on July 24, 2002 to extend it through October 31, 2002.

Based on the information contained in the petition, and the evaluation of the performance during the RD&D permit, the Department is approving the Beneficial Use Determination requested by Chautauqua County, subject to the following conditions:

1) Tire baling shall be conducted at the Chautauqua County Landfill, located in the Town of Ellery. Baling shall be carried out in the same area where the tire bales are currently stored, on the west side of the border fence, east of the Landfill Transfer Station. Tire bales shall be stored at the landfill while awaiting placement.

2) No later than 30 days prior to commencement of construction of a new road section, the County must inform the Department, in writing, of the proposed work location, the length of road, the number of tires/tire bales involved, and dates of work. The County shall submit construction drawings and contract specifications, signed by a Professional Engineer licensed to practice in New York, which conform with condition No. 4 below.

3) Only NYSDEC 6 NYCRR Part 364 permitted Waste Tire Transporters may transport baled or unbaled tires.

4) The County shall use accepted engineering practices in the design and construction of the road. The placement of the waste tires as subbase shall be in accordance with applicable requirements of ASTM D6270-98 Standard Practice for Use of Scrap Tires in Civil Engineering Applications and in accordance with the recommendations of the New York State Department of Transportation (NYSDOT), which are contained in the June 17, 1998 letter from Wesley Moody to Jeffrey Schmitt, the Proposal to Bale Tires for Use in Subgrade Construction/ Research, Development & Demonstration (RD&D) Permit dated July 27, 1998, and the Application for Renewal to Permit dated October 29, 1999.

5) Signs shall be posted at the beginning and end of each road section (four signs for each section) which will clearly delineate the section of road containing the tire bales and advise motorists that the road surface may freeze prematurely. The County shall erect signage with language such as "The next 'x' feet of this road features baled whole tires as subgrade. Road surface may freeze faster than surrounding areas."

6) Chautauqua County, or the municipality where the road is located, shall routinely inspect and carry out maintenance and resurfacing operations to ensure that the tire bales remain in place, and do not become exposed.

7) An annual report must be submitted by March 1 of the following year to:

Mr. Mark Hans
Division of Solid & Hazardous Materials
NYSDEC
270 Michigan Avenue
Buffalo, NY 14203

Mr. Jeffrey Schmitt
Bureau of Waste Reduction & Recycling
NYSDEC
625 Broadway
Albany, NY 12233

The Department reserves the right to modify, suspend, or revoke this determination at any time should conditions warrant. Additionally, this determination does not exempt the operation from any other local, state, or federal requirements.

If you have any questions, please contact me at (716) 851-7220.

Sincerely,

Mark J Hans

Mark J. Hans, P.E.
Regional Solid Materials Engineer

cc: Mr. Jeffrey Schmitt, P.E.; Chief, Beneficial Use Section, Albany

**SPECIAL SPECIFICATION**

**ITEM 1XXX**

**TIRE BALE EMBANKMENT**

**132.1. Description.** Construct embankment courses composed of scrap tire bales and soil in accordance with the typical sections, lines and grades shown on the plans or as directed by the Engineer.

**132.2. Material.** Furnish materials of uniform quality that meet the requirements of the plans and specifications. Notify the Engineer of the proposed sources of materials to be used at least 30 days prior to production. Do not change any material source without written approval from the Engineer. When a source change is approved, the Engineer will verify that the specification requirements are met be furnished from required excavation in the areas shown in the plans or from off right of way sources obtained by the Contractor and meeting the requirements herein. All embankment shall conform to the following type:

**Type A.** Furnish tire bales made of whole, used passenger or light to medium truck tires. Produce bales in a tire baler or equivalent as approved by the Engineer. Bales shall have a density not less than 35 $lb/ft^3$. Provide a minimum of 5 galvanized steel or stainless steel straps or wires per bale. The bales shall not "explode" when all the straps are broken or cut. Bales shall be of uniform shape and size.

Furnish tire bales that only use scrap tires generated or stored within the State of Texas. Tire balers and baling sites shall be authorized to process scrap tires by the Texas Commission of Environmental Quality. Obtain approval of fire prevention and suppression plans by the Engineer and the local Fire Department 2 weeks prior to the commencement of baling and storing operations.

Load test representative tire bales with the bale fully supported on a test floor approved by the Engineer. Test each bale placed between two steel plates that completely cover the surface area of the top and bottom of the bale. The top steel plate shall be 1 inch thick. Distribute the load uniformly over the steel plate using a steel I-section beam as approved by the Engineer. Apply the load using a hydraulic ram with a load capacity of at least 400,000 lbs.

Conduct two types of strength tests, a creep test and a compressive strength test, for each tested tire bale. Conduct the creep test for 72 hours at a creep stress of 25 psi applied in the same direction as the loads are applied in the field. The maximum allowable creep strain shall not exceed 0.25. Conduct the compressive strength test until the tire bale fails or until an applied compressive stress of 100 psi is applied.

Furnish galvanized steel or stainless steel wires straps with a minimum break stress of 50 psi as applied on the tire bale surface. Corrosion of the straps shall meet the requirements of Item 423.2. Tire bale fills covered with geomembranes, which makes the tire fill impermeable to air and water, are not subject to the pH and resistivity requirements of Item 423.2.

**132.3. Construction Methods.**
**(1) General.** When off right of way sources are involved, the Contractor's attention is directed to Item 7, Legal Relations and Responsibilities to the Public. Complete all work prior to placing any embankment in accordance with Item 100, "Preparing Right of Way" on the areas over which the embankment is to be placed. Backfill stump holes or other small excavations in the limits of the embankments with suitable material and thoroughly tamp by approved methods before commencing embankment construction. Restore the surface of the ground, including disk-loosened ground or any surface roughened by small washes or otherwise, to approximately its original slope. Compact the ground surface by sprinkling and rolling where shown on the plans or required by the Engineer.

Notify the Engineer sufficiently in advance of opening any material source to allow performance of any required testing.

Unless otherwise shown on the plans, loosen the surfaces of unpaved areas (except rock) which are to receive embankment by scarifying to a depth of at least 6 inches. Cut hillsides into steps before embankment materials are placed. Begin placement of embankment materials at the low side of hillsides and slopes. Compact materials which have been loosened simultaneously with the new embankment materials placed upon it. Do not exceed the total depth of loosened and new materials beyond the permissible depth of the layer to be compacted as specified in Subarticle 132.3.(3).(a) and (b).

Do not place trees, stumps, roots, vegetation or other unsuitable materials in the embankment.

Unless otherwise shown on the plans, construct all layers approximately parallel to the finished grade of the roadbed.

Construct embankments to the grade and sections shown on the plans or as established by the Engineer. Each section of the embankment shall correspond to the detailed section or slopes established by the Engineer. After completion of the roadway, maintain it to its' finished section and grade until the project is accepted.

**(2) Constructing Embankments.**
**(a) Tire Bale Embankments.** Tire bale embankments shall be defined as those composed of scrap tire bales which comprise the core of the structure. The maximum height of the tire bale portion of the embankment shall not exceed 20 feet.

Construct a 12" granular base drainage layer at the bottom of the embankment before placing the tire bales as shown on the typical sections. Extend the granular base layer sufficiently to allow water to freely drain away from the embankment structure.

Construct the embankment such that infiltration of water and air is minimized. Place all tire bales with the restraining straps in the longitudinal direction of the roadway.

Place an 8 inch compacted soil layer between each tire bale layer. Use a soil with a PI less than 35 to provide a cushioning layer between successive layers of tire bales. Test all soil in contact with the tire bales Test Method Tex-408-A, Organic Color, with the test result not showing a color darker than standard. Furnish and place a geomembrane that meets Department specifications over the final layer of the tire bales to provide long-term durability to the embankment.

Provide an 18 inch minimum thick mineral soil layer free of organic matter on the side slopes. Place a 2-4 inch thick top layer of compost meeting the requirements of Item 161. Seed as directed under Item 164.

**(3) Compaction Methods.** Compaction of embankments shall be by "Ordinary Compaction".

Place each soil layer between the tire bales not to exceed twelve (12) inches of loose depth. Compact each layer in accordance with the provisions governing the Item or Items of "Rolling". Unless otherwise specified on the plans, the rolling equipment shall be as approved by the Engineer. Continue compaction until there is no evidence of further compaction. Prior to and in conjunction with the rolling operation, bring each layer to the moisture content directed by the Engineer, and keep level with suitable equipment to insure uniform compaction over the entire layer. Should the subgrade, for any reason or cause, lose the required stability or finish, it shall be recompacted and refinished at the Contractor's expense.

When shown on the plans and when directed by the Engineer, proof roll in accordance with Item 216, "Rolling (Proof)". Correct soft spots as directed by the Engineer.

**132.4. Tolerances.** The tolerances shall be as follows:

**(1) Grade Tolerances.**

**(a) Stage Construction.** Correct any deviation in excess of 0.1 foot in cross section and 0.1 foot in 16 feet measured longitudinally by loosening, adding or removing the material, reshaping and recompacting by sprinkling and rolling.

**(b) Turnkey Construction.** Correct any deviation in excess of 1/2 inch in cross section and 1/2 inch in 16 feet measured longitudinally by loosening, adding or removing the material, reshaping and recompacting by sprinkling and rolling.

**(2) Plasticity Tolerances.** The Engineer may accept the material providing not more than one (1) out of the most recent five (5) plasticity index samples tested are outside the specified limit by no more than two (2) points.

**132.5. Measurement**. This Item will be measured as follows:

**(1) General.** Shrinkage or swellage factors will not be considered in determining the calculated quantities.

**(2)** Embankment will be measured by the each for the tire bales and by the cubic yard in vehicles for the soil as delivered on the road.

**132.6. Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Embankment". This price shall be full compensation for furnishing tire bales; for soil; for hauling; for placing, compacting, finishing and reworking; and for all labor, royalty, tools, equipment and incidentals necessary to complete the work.

When proof rolling is shown on the plans and directed by the Engineer, it will be paid for in accordance with Item 216, "Rolling (Proof)".

When "Ordinary Compaction" is shown on the plans, all sprinkling and rolling, except proof rolling, will not be paid for directly, but will be considered subsidiary to this Item, unless otherwise shown on the plans.

When subgrade is constructed under this project, correction of soft spots in the subgrade will be at the Contractor's expense. When subgrade is not constructed under this project, correction of soft spots in the subgrade will be in accordance with Article 4.3.

Referenced Documents | Standards Search | Other Standards Products

# Document Summary



## D6270-98(2004) Standard Practice for Use of Scrap Tires in Civil Engineering Applications

**Developed by Subcommittee:** D34.06
**See Related Work by this Subcommittee**
**Adoptions:**
**Book of Standards Volume:** 11.04

CLICK TO VI
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### 1. Scope

1.1 This practice provides guidance for testing the physical properties and gives dat assessment of the leachate generation potential of processed or whole scrap tires ir conventional civil engineering materials, such as stone, gravel, soil, sand, or other materials. In addition, typical construction practices are outlined.

### 2. Referenced Documents

C127 Test Method for Specific Gravity and Absorption of Coarse Aggregate
D422 Test Method for Particle-Size Analysis of Soils
D698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard (12,400 ft-lbf/ft (600 kN-m/m))
D1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modifiec (56,000 ft-lbf/ft (2,700 kN-m/m))
D2434 Test Method for Permeability of Granular Soils (Constant Head)
D3080 Test Method for Direct Shear Test of Soils Under Consolidated Drained Condi
D4253 Test Methods for Maximum Index Density and Unit Weight of Soils Using a V Table
T274 Standard Method of Test for Resilient Modulus of Subgrade Soils
Method 1311 Toxicity Characteristics Leaching Procedure

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### Index Terms

construction practices; landfills; leachate; lightweight fill; retaining walls; roads; sc
83.160.01

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**APPENDIX F. References for Governmental Legislation and Scrap Tire Reuse Programs**

**State Regulations on Scrap Tires, Colorado,**
**by Rubber Manufacturer's Association**

**www Address for Scrap Tire Legislation Brief Sheets**

**State Scrap Tire Fees and Point of Collection**

# COLORADO

## STATE REGULATIONS ON SCRAP TIRES

Scrap tire regulations for storage, disposal and processing facilities are found in Section 10 of state law, 6CCR 1007-2 Part A, the Colorado Regulations Pertaining to Solid Waste Disposal Sites & Facilities. These regulations:

- require all scrap tire recycling facilities to have a certificate of designation for a solid waste facilities.
- require operators of a scrap tire disposal facility to submit a plan for approval by the CO Dept. of Public Health and the Environment (CDPHE), which describes activities, equipment to be used, and inventory-tracking mechanism. As well, operators must submit annual reports on the amounts of scrap tires received at the facility, and the amounts recycled, disposal on-site, and shipped off-site.
- address maintenance of on-site roads, litter collection, fencing, signage, and on-site telephones.
- require facilities to have operating fire lanes and emergency readiness, and to report a fire or other emergency to CDPHE and the local health department, with details on causes, and corrective action.
- requires tire recycling and disposal facilities to have an attendant.

CRS 25-17-202 establishes the CO waste tire recycling development fee, set up Waste Tire Recycling Development Cash Fund, encourages source reduction and market development. After standard administrative costs, two-thirds of the monies go to the CO Dept. of Local Affairs (see next paragraph) and one-third goes to the CO Commission on Higher Education, which uses it for giving out grants from its Advanced Technology Fund on recycling and waste-related research.

CRS 24-32-114 allocates funds from the Waste Tire Recycling Development Cash Fund, to be administered by the CO Dept. of Local Affairs, on a proportional basis: 50% is for grants to jurisdictions to clean up illegal tire piles; 20% is for incentive grants to public entities purchasing products made from recycled Colorado-generated scrap tires; and 30 percent is partial reimbursement to end users and processors, up to $50/T. Rules have been promulgated for the end user portion of the program under this statute. It authorizes the use of a consultant on scrap tire recycling and management matters at the CO Dept. of Local Affairs, in lieu of specialized staff knowledge. The use of inmate labor in waste tire cleanups is encouraged (and this is further supported in CRS 17-24-123.

More information on the Dept. of Local Affairs program is online at http://www.dola.state.co.us/LGS/FA/wtf.htm. More information on the CO Commission on Higher Education's Advanced Technology Fund is online at http://www.state.co.us/cche/techno/waste.html. Colorado statutes can be searched on a Lexis/Nexis public website at http://198.187.128.12/colorado/lpext.dll?f=templates&fn=fs-main.htm&2.0

## MAJOR MARKETS

One cement kiln currently uses TDF as a supplemental fuel. A ground rubber producer markets patented soil amendment products to recreational and municipal uses. Several brokers supply ground rubber for use in roadway crack sealant products. A number of companies shred tires and sell them for uses such as alternate daily cover for landfills, soil reclamation projects, and other uses. Another company bales tires for uses such as construction material and for use on ranches. A pilot project by the CDPHE is expected to be complete in 2003, and approval is anticipated for the use of shredded tires in septic systems.

## STATE CONTACTS

Anne Peters, CO Dept. of Local Affairs Waste Tire Program Consultant, Div. of Local Gov't, 303.494.4934 vox, 303.494.4880 fax, annep@indra.com email, 1313 Sherman St., Room 521, Denver, CO 80203

Glen Mallory, Department of Health, Hazardous Materials and Waste Management Division, 4210 East 11th Ave., Denver, Colorado 80220, telephone 303-692-3445, FAX 303-759-5355.

from Anne Peters, DOLA Waste Tire Program Consultant to STMC-RMA 1/03

## SCRAP TIRES :: STATE ISSUES



**SCRAP TIRE LEGISLATION BREIFING SHEETS**

**The following are files are downloadable PDF summaries of a state's legislation on scrap tire activities. Click on the below to see the details.**

| STATE | LAST UPDATED |
|---|---|
| Alabama | 2003 |
| Alaska | 2003 |
| Arizona | 2003 |
| Arkansas | 2003 |
| California | 2003 |
| Colorado | 2003 |
| Connecticut | 2003 |
| Delaware | 2003 |
| Florida | 2003 |
| Georgia | 2003 |
| Hawaii | 2003 |
| Idaho | 2003 |
| Illinois | 2003 |
| Indiana | 2003 |
| Iowa | 2003 |
| Kansas | 2003 |
| Kentucky | 2003 |
| Louisiana | 2000 |
| Maine | 2003 |
| Maryland | 2003 |
| Massachusetts | 2003 |
| Michigan | 2003 |
| Minnesota | 2003 |
| Mississippi | 2003 |
| Missouri | 2003 |
| Montana | 2003 |
| Nebraska | 2003 |
| Nevada | 2003 |
| New Hampshire | 2003 |
| New Jersey | 2003 |
| New Mexico | 2003 |
| New York | 2003 |
| North Carolina | 2003 |
| North Dakota | 2003 |
| Ohio | 2003 |
| Oklahoma | 2003 |
| Oregon | 2003 |
| Pennsylvania | 2003 |
| Rhode Island | 2003 |
| South Carolina | 2003 |
| South Dakota | 2003 |
| Tennessee | 2003 |
| Texas | 2003 |
| Utah | 2003 |
| Vermont | 2003 |
| Virginia | 2003 |
| Washington | 2003 |
| West Virginia | 2003 |
| Wisconsin | 2003 |
| Wyoming | 2003 |

**State Scrap Tire Fees and Point of Collection**:

| | | |
|---|---|---|
| Alabama | No Fee | TD pays county license fee |
| Alaska | No Fee | |
| Arizona | 2% sales tax (Max $2) | TD Collects |
| Arkansas | $1.75 per tire | TD Collects |
| California | $0.25 per tire | TD Collects |
| Colorado | $1.00 per tire | TD Collects |
| Connecticut | No fee | |
| Delaware | No fee | |
| Florida | $1.00 per tire | TD Collects |
| Georgia | $1.00 per tire | TD Collects |
| Hawaii | $ 1.00 per tire | Importer pays: New in 2000 |
| Idaho | ($1.00 per tire | TD Collected: Sunset 6-30-96) |
| Illinois | $1.00 per tire | TD Collects |
| Indiana | $0.25 per tire | TD Collects |
| Iowa | part of $5 vehicle title fee | Collected by state |
| Kansas | $0.50 per tire | TD Collects |
| Kentucky | $1.00 per tire | TD Collects |
| Louisiana | $2.00 per tire | TD Collects |
| Maine | $1.00 per tire | TD Collects |
| Maryland | $0.40 per tire | TD Collects: Amt. reduced in 2000 |
| Massachusetts | No fee | |
| Michigan | $0.50 per tire surcharge on vehicle title | State collects |
| Minnesota | $4.00 on vehicle title transfers | State collects |
| Mississippi | $1.00 per tire | TD Collects |
| Missouri | $0.50 per tire | TD Collects |
| Montana | No fee | |
| Nebraska | $1.00 per tire | TD Collects |
| Nevada | $1.00 per tire | TD Collects |
| New Hampshire | No state fee; towns may levy fee | |
| New Jersey | No fee | |
| New Mexico | Add on to vehicle registration | State collects |
| New York | No fee | |
| North Carolina | 2% sales tax | TD Collects |
| North Dakota | New vehicle sales fee | State collects |
| Ohio | $0.50 per tire | Collected at wholesale level |
| Oklahoma | $1.00 per pass/$3.50 per trck | TD Collects |
| Oregon | ($1.00 per tire | TD Collected: Sunset 10-1-92) |
| Pennsylvania | $1.00 per tire | TD Collects: Spent on mass |
| transit | | |
| Rhode Island | $0.50 per tire | TD Collects |
| South Carolina | $2.00 per tire | TD Collects |

| | | |
|---|---|---|
| South Dakota | $0.25 /tire/vehicle($1 max) registration fee | State collects |
| Tennessee | $1.00 per tire | TD Collects |
| Texa ($2.00 per tir | TD Collected: Sunset 12-31-97) | |
| Utah | $0.50 per tire | TD Collects |
| Vermont | No fee | |
| Virginia | $0.50 per tire | TD Collects |
| Washington | (Retail fee | TD Collected: Sunset 1996) |
| West Virginia | $5.00 per title | State collects: New in 2000 |
| Wisconsin | ($2.00 fee on vehicle titles | State collected: Sunset 6-30-96) |
| Wyoming | No fee | |

Key:

| | |
|---|---|
| TD pays county license fee | Tire dealer buys license from county to accept scrap tires |
| Importer pays: | Whomever imports tires into Hawaii pays the fee. |
| TD Collects: | Tire Dealer collects the fee at the tire retail sale |
| State collects: | State collects the tire fee through the process by which the underlying fee is collected. |
| Wholesale level collects: | Fee is collected from wholesaler on first sale in state. |

Source: State Scrap Tire Programs A Quick Reference Guide: 199 Update, US EPA, Solid Waste and Emergency Response, EPA-530-B-99-002, August 1999

Additional information on post 1999 activity from published sources.

**Summary:**

States with active programs or fees: 35

Tire dealer collects in 25
State collects in 7
Wholesale level collects in 1
Tire dealer license in 1
Importer pays in 1

Sunset programs: 5

Tire dealer collected in 4
State collected in 1

No fees: 10 states

Compiled By: Scrap Tire Management Council
1400 K Street, NW
Washington, D.C. 20005
202-682-4880
www.rma.org/tiresn.html

## APPENDIX G. Fire Protection Issues and Guidelines for Scrap Tires

**The Colorado Department of Public Health and Environment, State Board of Health/Hazardous Materials and Waste Management Division CCR 1007-2, Section 10, Scrap Tire Facilities.**

**Title 14 California Code of Regulations Division 7 Integrated Waste Management Board (IWMB), Chapter 3, Article 5.5 titled Waste Tire Storage and Disposal Standards (Sections 17350 to 17356)**

# DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

## State Board of Health/Hazardous Materials and Waste Management Division

## 6 CCR 1007-2

## PART 1 - REGULATIONS PERTAINING TO SOLID WASTE SITES AND FACILITIES

SECTION 1.0

ADMINISTRATIVE INFORMATION

Applicable to all existing or new solid waste facilities.

1.1 GENERAL INFORMATION

1.1.1 Authority These regulations are promulgated pursuant to the "Solid Wastes Disposal Sites and Facilities Act", Title 30, Article 20, Part 1, Colorado Revised Statutes (CRS), as amended. These regulations replace and supersede the "Solid Wastes Disposal Sites and Facilities Regulations", adopted February 16, 1972, and effective April 1, 1972.

1.1.2 Referenced materials This document may refer to documents produced by other agencies. All cited references are for that reference that is valid on the particular date of adoption of the pertinent section of these regulations and do not include later amendments or editions of the incorporated material. Copies of the referenced material may be reviewed during normal business hours at the Colorado Department of Public Health and Environment. Information on accessing the referenced documents may be obtained by contacting the:

Colorado Department of Public Health and Environment
Program Manager
Solid Waste Section
Hazardous Materials and Waste Management Division
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530
Phone: (303) 692-3300

## SECTION 10

## SCRAP TIRE FACILITIES

### 10.1 GENERAL PROVISIONS AND APPLICABILITY

(A) All scrap tire facilities that are not regulated under the Recycling Section 8 of these regulations shall have a certificate of designation. On-site disposal shall comply with the applicable provisions of the Solid Waste regulations and shall occur at approved solid waste disposal facilities.

(B) This section 10.0 does not apply to facilities that recycle scrap tires in compliance with Section 8.0 of these Regulations.

### 10.2 STANDARDS FOR SCRAP TIRE DISPOSAL FACILITIES

10.2.1 (A) When applying for a certificate of designation, the operator of a scrap tire disposal facility shall submit a plan for approval by the Department and the local governing body. The plan shall describe, in detail, the nature of the activity, the types and capacities of equipment that will be used, all methods of processing and storage, the means to be used to track inventory on a volume or weight basis, and the proposed method and procedures for closure.

(B) Financial assurance for closure and post-closure care per Section 1.8 of these regulations is required of all scrap tire disposal facilities.

(C) Portions of Section 2 apply to scrap tire facilities as applicable to the nature of material being managed and the site-specific characteristics and that are not duplicated in this Section 10. Subsection 2.3 does not apply to scrap tire facilities.

10.2.2 An annual report shall be submitted by the facility to the Department and the local governing body by May 1 of each year. The report shall state the amounts of scrap tires received at the facility, processed, disposed of on-site, and shipped off-site for the preceding calendar year.

10.2.3 The facility shall maintain all-weather access roads to those areas of active operation and as necessary to meet the fire control plan required by subsection 10.2.9 of these Regulations.

10.2.4 The facility shall collect litter in order to avoid a fire hazard or a nuisance and control the growth of vegetation to minimize potential fuel sources.

10.2.5 Adequate fencing, natural barriers or other security measures to preclude public entry shall extend around the entire perimeter of the facility and shall include a lockable gate or gates.

10.2.6 Prominent signs shall be posted in public view at the entrance to the facility with the name of the facility, the hours which the facility is open for public use, a listing of the wastes accepted at the facility, and a phone number for a 24-hour emergency contact. A copy of the Certificate of Designation resolution or the Certificate of Designation must be available for inspection at the site.

10.2.7 The operator shall maintain a working telephone at the facility.

10.2.8 (A) The operator of a scrap tire facility shall have a written vector control plan that shall be submitted to the Department and the local governing body.

(B) If pesticides are used in vector control efforts, they shall be used in accordance with the Pesticide Applicator's Act, C.R.S. § 35-10-101.

10.2.9 (A) The operator shall submit a fire control plan to the Department and the local governing body specifying the facility's fire lane locations and widths, the means that are assumed to be used to extinguish fires, and designation of a facility emergency coordinator.

This plan shall be in accordance with local fire codes and the plan shall be written by a qualified professional and submitted to and approved by the local fire control authority. A copy of the local fire control authority approval shall be forwarded to the Department.

(B) The minimum standards to be allowed for tire pile storage will be as follows:

(1) In no case shall storage piles of whole tires, tire bales, or tire shreds that are stored on open ground, as opposed to storage in open pits or cells, be larger than 50 feet in width and no higher than 15 feet above grade. An approved field measurement system must be employed to facilitate estimates of pile dimensions.

(2) A minimum of 40 feet shall be maintained between piles of whole, shredded, or baled tires to allow access for fire fighting equipment.

(3) A minimum distance of 50 feet of clear area is to be maintained from all property lines.

10.2.10 The facility shall immediately notify the local health department and the Colorado Department of Public Health and Environment in the event of a fire or other emergency. Within two weeks of this notification, the facility shall submit a report on the emergency to the Department and the local governing body. This report shall describe the origins of the emergency, the actions that have been taken, actions that are currently being taken or are planned, results or anticipated results of these actions, and an approximate date of resolution of the problems generated by the emergency.

10.2.11 During all stages of operation the facility shall have an attendant who is responsible for site activities.

# Chapter 3. Minimum Standards for Solid Waste Handling and Disposal

## Article 5. Solid Waste Storage and Removal Standards

**Section 17301. Applicability of Standards.**
The standards in this Article shall apply to all facilities, equipment, or vehicles used for storage, removal, transport, and other handling of solid wastes.

**Section 17302. Conformance with plan.**
After the effective date of the county solid waste management plan required by Section 66780 of the Government Code, solid waste storage and removal shall be in conformance with said plan.

**Section 17311. General.**
The owner, operator and/or occupant of any premise, business establishment, industry, or other property, vacant or occupied, shall be responsible for the safe and sanitary storage of all solid waste accumulated on the property.

**Section 17312. Storage.**
(H) In all cases in which garbage and rubbish are combined, the standards for garbage shall prevail. The property owner or occupant shall store solid waste on his premises or property or shall require it to be stored or handled in such a manner so as not to promote the propagation, harborage, or attraction of vectors, or the creation of nuisances.

**Section 17313. Design Requirements.**
The design of any new, substantially remodeled or expanded building or other facility shall provide for proper storage or handling which will accommodate the solid waste loading anticipated and which will allow for efficient and safe waste removal or collection. The design shall demonstrate to local land use and building permit issuing authorities that it includes the required provisions.

**Section 17314. Operator Responsibility.**
Where the collection operator furnishes storage containers, he is responsible for maintaining the containers in good condition (ordinary wear and tear excepted) unless they are furnished under other terms, conditions, or agreements. He shall plan with the property owner and/or occupant as to placement of storage containers to minimize traffic, Aesthetic and other problems both on the property and for the general public.

**Section 17315. Garbage Containers.**
Property owners and tenants shall deposit all garbage and putrescible matter or mixed garbage and rubbish in containers which are either non-absorbent, water-tight, vector-resistant, durable, easily cleanable, and designed for safe handling, or in paper or plastic bags having sufficient strength and water tightness and which are designed for the containment of refuse. Containers for garbage and rubbish should be of an adequate size and in sufficient numbers to contain without overflowing, all the refuse that a household or other establishment generates within the designated removal period. Containers when filled shall not exceed reasonable lifting weights for an average physically fit individual except where mechanical loading systems are used. Containers shall be maintained in a clean, sound condition free from putrescible residue.

**Section 17316. Identification of Containers.**
Containers of one cubic yard or more owned by the collection service operator shall be identified with the name and telephone number of the agent servicing the container.

**Section 17317. Use of Container.**
No person shall tamper with, modify, remove from, or deposit solid wastes in any container which has not been provided for his use, without the permission of the container owner.

**Section 17331. Frequency of Refuse Removal.**
(H) The owner or tenant of any premises, business establishment or industry shall be responsible for the satisfactory removal of all refuse accumulated by him on his property or his premises. To prevent propagation, harborage, or attraction of flies, rodents or other vectors and the creation of nuisances, refuse, except for inert materials, shall not be allowed to remain on the premises for more than seven days, except when:

(a) disruptions due to strikes occur, or

(b) severe weather conditions or "Acts of God" make collection impossible using normal collection equipment, or

(c) official holidays interrupt the normal seven day collection cycle in which case collection may be postponed until the next working day. Where it is deemed necessary by the local health officer because of the propagation of vectors and for the protection of public health, more frequent removal of refuse shall be required.

**Section 17332. Regulation of Operators.**
Each person providing residential, commercial, or industrial solid waste collection services shall comply with all local government licenses, permits, or written approval requirements applicable to the city or county in which such services are provided. Such written approval shall be contingent upon the operator's demonstrated capability to comply with these standards and use of equipment which is safe and sanitary. Each enforcement agency of solid waste collection shall maintain a complete listing of all persons holding written approvals to provide solid waste collection services within its jurisdiction. The listing shall contain the name, office, address, telephone number and emergency telephone number if different of each such person, the number and types of vehicles employed by such person in providing such solid waste collection services, and the types of materials authorized for handling.

**Section 17333. Operator Qualifications.**
When a city, county or special district authorizes or designates a person or firm to provide solid waste collection services within the territory under its jurisdiction through contract, franchise, permit, or license the local government shall obtain proof that such person or firm has adequate financial resources and experience to properly conduct the operation authorized. The facts needed to establish proof shall include but not be limited to the following:

(a) The filing of a performance bond or equivalent security with the local government in a reasonable amount, together with

(b) Evidence submitted to the local government and to the enforcement agency that the person or firm has experience sufficient to meet the needs of the situation within the jurisdiction.

**Section 17334. Ownership of Waste Materials.**
Solid wastes subject to collection by a collection service operator shall become the property of the collection service operator subject to local ordinances or contract conditions after such time as the authorized collector takes possession of the wastes.

**Section 17341. Equipment Construction.**
(H) All equipment used for the collection and/or transportation of solid waste shall be durable, easily cleanable and designed for safe handling, and constructed to prevent loss of wastes from the equipment during collection or transportation. If such equipment is used to collect or transport garbage, other wet or liquid producing wastes, or wastes composed of fine particles, such equipment shall in all cases be non-absorbent and leak resistant. All equipment shall be maintained in good condition and cleaned in a frequency and in a manner so as to prevent the propagation or attraction of flies, rodents or other vectors and the creation of nuisances.

**Section 17342. Equipment Safety.**
(H) Vehicles and equipment used in the transport of garbage and rubbish shall be constructed and maintained in such a manner as to minimize the health and safety hazards to collection personnel and the public.

**Section 17343. Equipment Parking.**
A refuse collection service operator must designate an off-street location where all refuse collection vehicles will be parked when not in service, except in an emergency.

**Section 17344. Identification of Operator.**
Each vehicle used for the collection and transport of refuse shall be clearly marked with the name of the agency or firm operating the vehicle.

**Section 17345. Inspection of Equipment.**
(H) Equipment used for solid waste collection shall be made available for inspection as requested by the appropriate Enforcement Agency.

## Article 5.5. Waste Tire Storage and Disposal Standards

**Section 17350. Applicability.**
(a) Any facility storing 500 or more waste tires outdoors must comply with the technical and operational standards in sections 17351 through 17355 of this Article.

(b) Any facility storing waste tires indoors must comply with the technical and operational standards in section 17356 of this Article.

(c) Waste tires that are disposed of by burying at a solid waste disposal facility are addressed in section 17355 of this Article.

(d) For purposes of determining the applicability of this Chapter, altered waste tires shall be counted as passenger tire equivalents (PTE).

**Note:**

***Authority cited:***
*Section 40502, 42820, 42830 and 43020 of the Public Resources Code.*

***Reference:***
*Sections 42820, 42821, 42830, 42832 and 43020 of the Public Resources Code.*

**Section 17351. Fire Prevention Measures.**

(a) Communication equipment shall be maintained at all facilities, if they are staffed by an attendant, to ensure that the site operator can contact local fire protection authorities in the event of fire.

(b) Adequate equipment to aid in the control of fires must be provided and maintained at the facility at all times. At a minimum the following items shall be maintained on site and in working order at all times:

(1) One (1) dry chemical fire extinguisher;
(2) One (1) two and one-half gallon water extinguisher;
(3) One (1) pike pole or comparable pole at least 10 feet in length to seperate burning from nonburning tires; and
(4) One (1) round point and one (1) square point shovel.
(5) One (1) dry chemical fire extinguisher with a minimum rating of 4A:40BC shall be carried on each piece of fuel-powered equipment used to handle waste tires;

(c) An adequate water supply shall be available for use by the local fire authority. The water supply shall be capable of delivering at least 1000 gallons per minute for a duration of at least three hours and at least 2000 gallons per minute for a duration of at least three hours if the sum of altered plus whole waste tires exceeds 10,000.

(d) All of the requirements of subsections (b) and (c) shall apply unless the local fire authority having jurisdiction over a particular facility determines that a different requirement is necessary or adequate to meet the intent of these regulations for fire control and the protection of life and property. This may include the availability of earth moving equipment or other approved means to control the tire fire. Any change in, or any new, local fire authority requirements that affect the requirements in this Article shall be reported to the Board by the operator within 30 days after their effective date. Any requirements approved by the local fire authority shall be subject to Board concurrence at the time of issuance or renewal of the permit.

**Note:**

***Authority cited:***
*Sections 40502, 42820, 42830 and 43020 of the Public Resources Code.*

***Reference:***
*Sections 42820, 42821, 42830, 42832 and 43020 of the Public Resources Code.*

**Section 17352. Facility Access and Security.**
(a) Signs--for facilities open to the public a sign shall be posted at the facility entrance stating the name of the operator, operating hours, and site rules.

(b) Attendant--An attendant shall be present when the facility is open for business if the facility receives tires from persons other than the operator of the facility.

(c) Access--An access road to the facility must be maintained passable for emergency equipment and vector control vehicles at all times. Unauthorized access must be strictly controlled.

**Note:**

***Authority cited:***
*Sections 40502, 42820, 42830 and 43020 of the Public Resources Code.*

***Reference:***
*Sections 42820, 42821, 42830, 42832 and 43020 of the Public Resources Code.*

**Section 17353. Vector Control Measures.**

(a) All waste tires shall be stored in a manner which prevents the breeding and harborage of mosquitoes, rodents, and other vectors by any of the following means:

(1) Cover with impermeable barriers other than soil to prevent entry or accumulation of precipitation; or

(2) Use of treatments or methods to prevent or eliminate vector breeding as necessary, provided the control program is approved as appropriate and effective by the local vector control authority, if such authority exists. If no local vector control authority exists, the local Environmental Health Department or other local agency with authority over vector control shall approve the vector control plan. Any control program approved by the local vector control authority shall be subject to Board concurrence at the time of issuance or renewal of the waste tire facility permit.

**Note:**

***Authority cited:***
*Section 40502, 42820, 42830 and 43020 of the Public Resources Code.*

***Reference:***
*Section 42820, 42821, 42830, 42832 and 43020 of the Public Resources Code.*

**Section 17354. Storage of Waste Tires Outdoors.**

(a) Except as provided in subsection (c) waste tires shall be restricted to individual piles, which include stacks and racks of tires that do not exceed 5,000 square feet of contiguous area. Any pile shall not exceed 50,000 cubic feet in volume or 10 feet in height. Piles shall not exceed 6 feet in height when within 20 feet of any property line or perimeter fencing. Waste tires shall not be located within 10 feet of any property line or perimeter fencing. The minimum distance between waste tire piles and between waste tire piles and structures that are located either on-site or off-site shall be as specified in Table I.

(b) Except as provided in subsection (c) waste tires shall be separated from vegetation and other potentially flammable materials by no less than 40 feet. Accessible fire lanes with a minimum width as specified in Table I shall be provided between tire storage units. Fire lanes shall be kept free of flammable or combustible material and vegetation. Access to fire lane(s) for emergency vehicles must be unobstructed at all times. Open flames, blow torches, or highly flammable materials, including but not limited to, tire inner tubes, are prohibited within 40 feet of a waste tire pile.

**Table I**
**Minimum Separation Distances (Ft.)**

| Length of Exposed Face (Ft.) | Tire Storage Pile Height (Ft.) | | |
|---|---|---|---|
| | **6** | **8** | **10** |
| 25 | 50 | 56 | 62 |
| 50 | 66 | 75 | 84 |
| 100 | 84 | 100 | 116 |
| 150 | 99 | 117 | 135 |
| 200 | 111 | 130 | 149 |
| 250 | 118 | 140 | 162 |

(c) All of the requirements in subsections (a) and (b) shall apply to the storage of waste tires unless, for any particular requirement, the local fire authority having jurisdiction over a particular facility determines that a different requirement is necessary or adequate to meet the intent of these regulations for the prevention of fire and the protection of life and property. Any change in, or any new, local fire authority requirements that affect the requirements in this Article shall be reported to the Board by the operator within 30 days after their effective date. Any requirements approved by the local fire authority shall be subject to Board concurrence at the time of issuance or renewal of the permit.

(d) Surface water drainage shall be directed around and away from the waste tire storage area.

(e) Waste tires at existing waste tire facilities shall not be stored on surfaces with grades that will interfere with fire fighting equipment or personnel unless mitigation measures have been approved in writing by the local fire authority, or a fire safety engineer registered by the State of California. Measures established by a fire safety engineer shall be subject to approval by the local fire authority.

(f) New waste tire facilities shall not:

(1) Be sited in any area where they may be subjected to immersion in water during a 100-year storm unless the operator demonstrates to the Board that the facility will be designed and operated so as to prevent waste tires from migrating off site; or

(2) Be located on sites with grades or other physical features that will interfere with fire fighting equipment or personnel.

(g) Tires must be removed from rims immediately upon arrival at the facility.

(h) The site shall be designed and constructed to provide protection to bodies of water from runoff of pyrolytic oil resulting from a potential tire fire.

**Note:**

***Authority cited:***
*Section 40502, 42820, 42830 and 43020 of the Public Resources Code.*

***Reference:***
*Section 42820, 42821, 42830, 42832 and 43020 of the Public Resources Code.*

**Section 17355. Disposal of Waste Tires at Solid Waste Facilities.**
(a) Waste tires may not be landfilled in a solid waste disposal facility which is permitted pursuant to Chapter 3 of Part 4 of the Public Resources Code, commencing with section 44001, unless they are permanently reduced in volume prior to disposal by shredding, or other methods subject to the EA approval and Board approval.

(b) The requirement of subsection (a) shall not apply to: waste tires received which are commingled with municipal solid waste that arrive in loads, where the waste tires comprise less than one-half of one (0.5) percent by weight of the total load, or where the waste tires inadvertently arrive in homeowner delivered household loads of mixed waste and are not readily removable from the waste stream; or

(c) All waste tires stored at a solid waste facility shall meet the requirements of this Article.

**Note:**

***Authority cited:***
*Section 40502, 42820, 42830 and 43020 of the Public Resources Code.*

***Reference:***
*Section 42820, 42821, 42830, 42832 and 43020 of the Public Resources Code.*

**Section 17356. Indoor Storage.**
Waste tires stored indoors must be stored under conditions that meet or exceed those in "The Standard for Storage of Rubber Tires", National Fire Protection Association, NFPA 231D-1989 edition, published by the National Fire Protection Association, which is incorporated by reference. This requirement shall apply unless the local fire authority having jurisdiction over a particular facility determines that a different requirement is necessary or adequate to meet the intent of these regulations for fire control and the protection of life and property. Any change in, or any new, local fire authority requirements that affect the requirements in this Article shall be reported to the Board by the operator within 30 days after their effective date.

**Note:**

***Authority cited:***
*Section 40502, 42820, 42830 and 43020 of the Public Resources Code.*

***Reference:***
*Section 42820, 42821, 42830, 42832 and 43020 of the Public Resources Code.*

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## APPENDIX H. Colorado DOT Costs for Embankment Materials and Related Items

The average unit material prices provided by CDOT in August 2004 for recent embankment projects are listed in the following table.

**Table H.1 Average Colorado DOT unit prices for selected materials**

| CDOT Item | Volume (1,000 cb. yd) | 2001 | | 2002 | | 2003 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | No. of Projects | Ave. Cost ($/cy) | No. of Projects | Ave. Cost ($/cy) | No. of Projects | Ave. Cost ($/cy) | **Total Projects** | **Ave. Cost ($/cy)** |
| **703.08 (b) Class 2 Structure Backfill Material (Note 1) (Note 2)** | <2.5 | 7 | 20.11 | 16 | 13.22 | 14 | 13.75 | 37 | 15.69 |
| | *2.5 to 5.0* | *5* | *14.34* | *5* | *9.81* | *5* | *10.45* | *15* | *11.53* |
| | *5.0 to 10.0* | *9* | *8.53* | *5* | *9.51* | *3* | *12.92* | *17* | *10.32* |
| | *10.0 to 50.0* | *9* | *7.32* | *11* | *6.22* | *11* | *7.69* | *31* | *7.08* |
| | 50.0 to 100. | 7 | 4.77 | 2 | 5.97 | 5 | 6.21 | 14 | 5.65 |
| | > 100. | 4 | 5.06 | 4 | 3.36 | 3 | 3.29 | 11 | 3.90 |
| ***Subtotal or Average for 2,500 to 50,000 cy*** | | ***23*** | ***10.06*** | ***21*** | ***8.51*** | ***19*** | ***10.35*** | ***63*** | ***9.64*** |
| ***Percent of Total*** | | ***56*** | ***NA*** | ***86*** | ***NA*** | ***46*** | ***NA*** | ***50.6*** | ***NA*** |
| **Total or Average for 0 to >100,000 cy** | | **41** | **10.02** | **43** | **8.02** | **41** | **9.05** | **125** | **9.03** |
| **703.08 (a) Class 1 Structure Backfill Material** | NA | | | | | | | | 15.00 to 20.00 |
| **703.09 Filter Material** (Note 3) — Class A | NA | | | | | | | | 30.37 |
| Class B | NA | | | | | | | | 44.53 |
| Class C | NA | | | | | | | | 21.84 |
| **Class A Separator geotextile, Table 712-8** (Note 4) | NA | | | | | | | | Ave 2.00 ($/sy) |
| **Special Fill – Clean Sand** | Estimated cost could range from $15 to $40 /cy, depends on availability, quantity, and transportation costs (Note 5) | | | | | | | | Ave. 22.00 |

Notes:
1. Embankment replaced by tire bale fill. Total projects with volume < 50,000 cb. yd. = 80 % of typical projects
2. The data for 2003 includes 1 project of 1.858 million cy (at $1.4 0 /cb. yd), plus annual volume of 1.103 million cb. yd.
3. Ave cost for 2001 to 2003. Use Class B for cost estimate for a base drain layer. See Table 7.3.
4. Use between tire bale fill and soil buffer layer. See Table 7.3.
5. Use in and around tire bales. See Table 7.3.