

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

## **APPENDICES**

# **TIRE BALES IN HIGHWAY APPLICATIONS: FEASIBILITY AND PROPERTIES EVALUATION**

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**COLORADO DEPARTMENT OF TRANSPORTATION  
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**



## CHAUTAUQUA COUNTY, NEW YORK 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

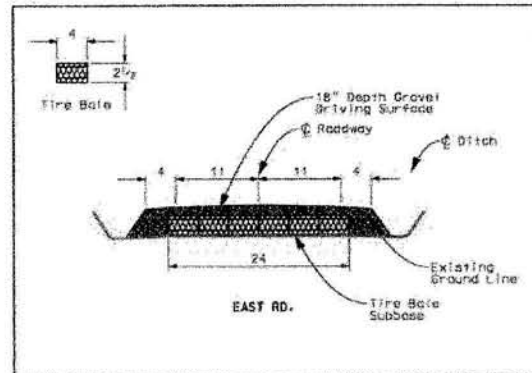
*Clearing Chautauqua County's of scrap tires through a "tire amnesty" program, while beneficially reusing the tires in baled form in roadbed construction as a cost-effective alternative to a typical stone drainage layer when used in areas of marginal (wet) soils.*

#### 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
	<b>TOTAL TAXPAYER SAVINGS PER TIRE .....</b>	<b>\$1.60 EACH</b>

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
	<b>TOTAL TAXPAYER SAVINGS FOR ENTIRE TIRE AMNESTY PROGRAM .....</b>	<b>\$819,176.00</b>

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
	<b>TOTAL TAXPAYER SAVINGS FOR 1000' ROADBED CONSTRUCTION .....</b>	<b>\$3,050.00</b>

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
	<b>TOTAL TAXPAYER SAVINGS FOR ALL ROADBED CONSTRUCTION PROJECTS .....</b>	<b>\$11,065.40</b>



## **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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Chautauqua County  
Department of Public Facilities  
454 North Work Street  
Falconer, NY 14733  
(716) 661-8461  
(716) 665-4496 (fax)

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**

**SCRAP TIRES :: SCRAP TIRE MARKETS**

[Scrap Tires and the Environment](#) | [Scrap Tire Markets](#) | [Conferences & Events](#) | [State Issues](#)

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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**

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

**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**

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

**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 components account for the rubber used to make the tire.

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

TREAD	32.6%
<b>BASE</b>	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%
	<u>100.0%</u>

**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 100 pounds of steel belts and bead wire in a passenger car tire.

662 Cromwell Avenue, St. Paul, MN 55114-1776  
 (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:

<u>Type of Test</u>	<u>Maximum Load</u>	<u>Avg. Ultimate Deflection, inch.</u>	<u>Time of ultimate Deflection, If applicable</u>
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**

<u>Time (min.)</u>	<u>Average Deflection (inches)</u>
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

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**CREEP AND LOAD TEST ON TIRE BAIL**

**TEST RESULTS:** (Cont.)

**Creep Test** (Cont.)

<u>Time (min.)</u>	<u>Average Deflection (inches)</u>
1620	7.55
2820	8.02
4320	8.06

The load remained constant at 88,000 pounds.

**Load Deflection Test**

<u>Load (Lbs.)</u>	<u>Average Deflections (inches)</u>
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

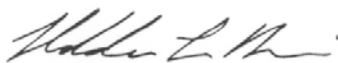
\*A bundle strap failed at approximately 175,000 pounds.

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**



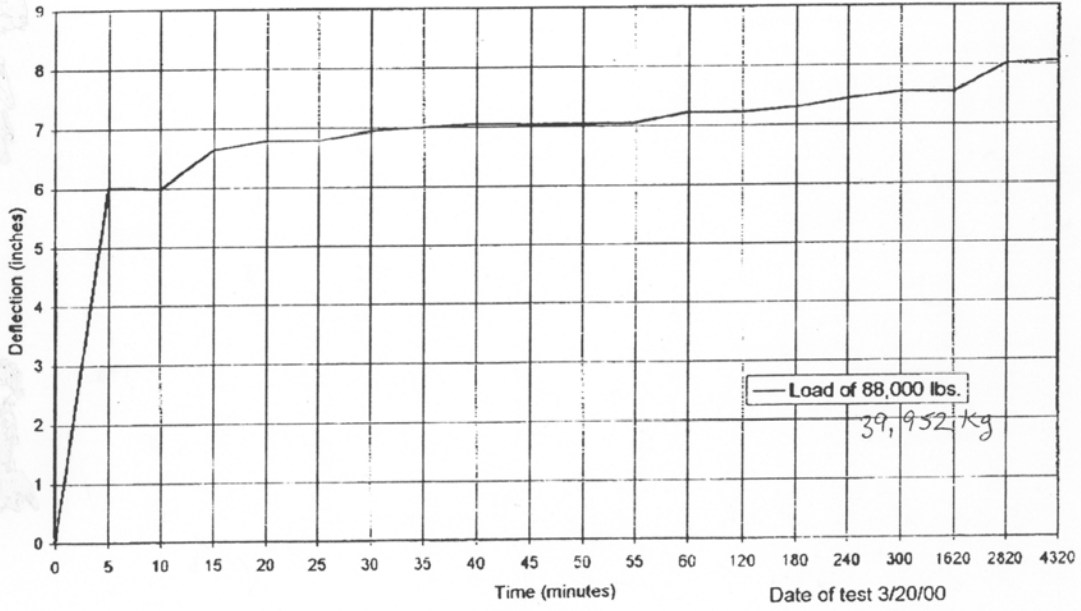
Thaddeaus L. Harnois  
Staff Engineer  
Construction Materials Department  
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John D. Lee, P.E.  
Senior Staff Engineer  
Construction Materials Department



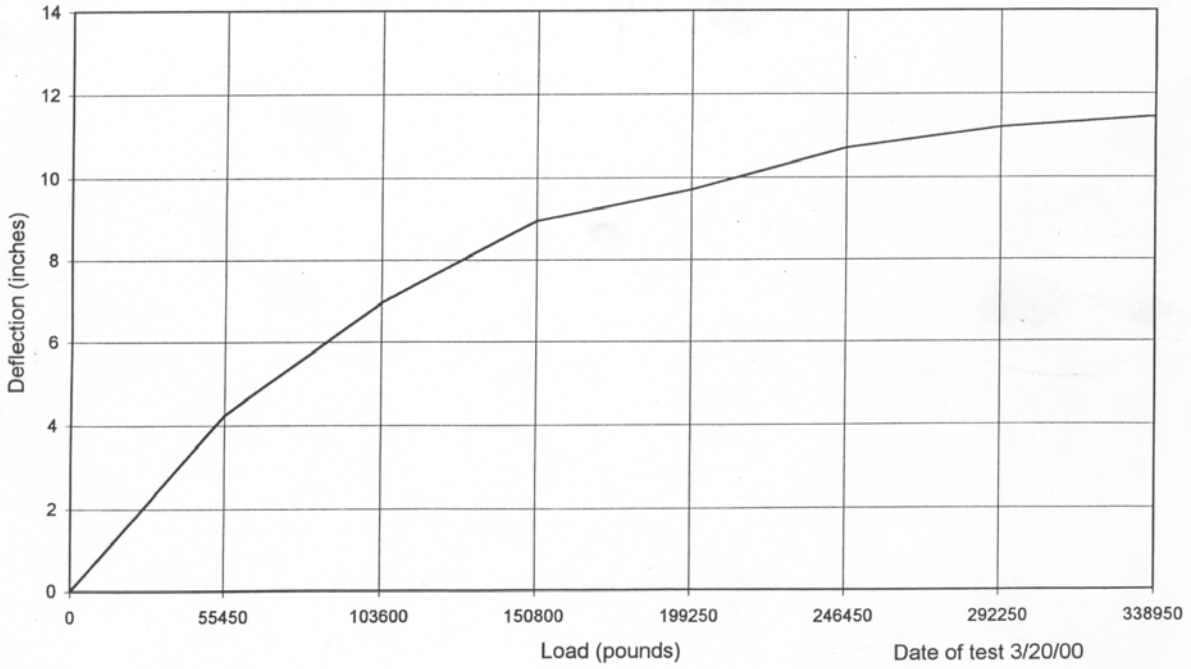
CREEP TEST (Deflection vs. Time)  
ENCORE SYSTEMS  
Project No. 03-0066





LOAD DEFLECTION TEST  
ENCORE SYSTEMS  
Project No. 03-0066

STORK®



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



## **GeoTesting Express, Inc.**

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Alpharetta, GA 30022

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phone: 770-645-6575  
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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 tests 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 greater 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 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 shrink 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  $1 \pm 0.5$  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 ( $\tau$ )	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





## GEOMETRY, DRY, WET AND SUBMERGED UNIT WEIGHT

**Project No. :** GTX G0581  
**Tested By:** SD  
**Test Date:** 4/5/2004

**Project Name:** Tire Bale Study  
**Reviewed By:** JW  
**Review Date:** 4/9/2004

Tare Weight, lbs:	23
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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 <sup>3</sup>	59.0	54.1	54.4	54.4	59.2
As received Unit Weight, lbs/ft <sup>3</sup>	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		

## VERTICAL PERMEABILITY OF TIRE BALES

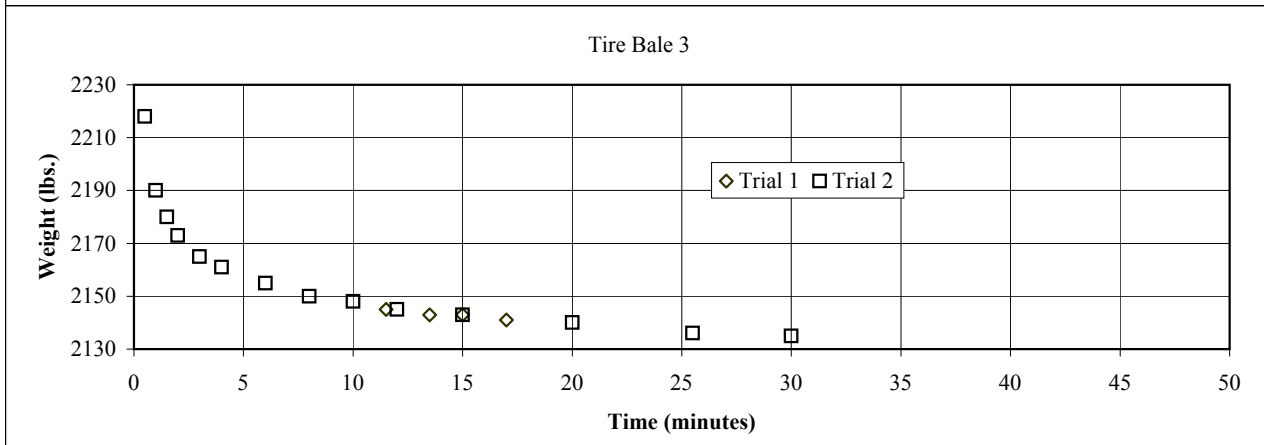
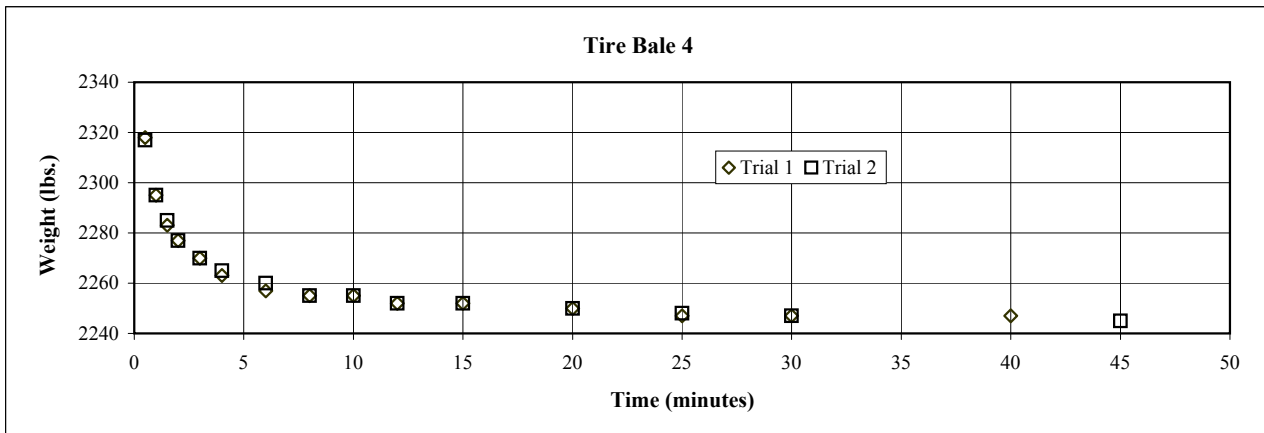
Project No. : GTX G0581  
 Tested By: SD  
 Test Date: 4/12/2004

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**  
**Peak Values**  
**Representative Data**

Up to row 1310    Up to column CF

Cycle #	Gen. 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

Peak

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**

Cycle #	Cen. Def.	Representative Data					
		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

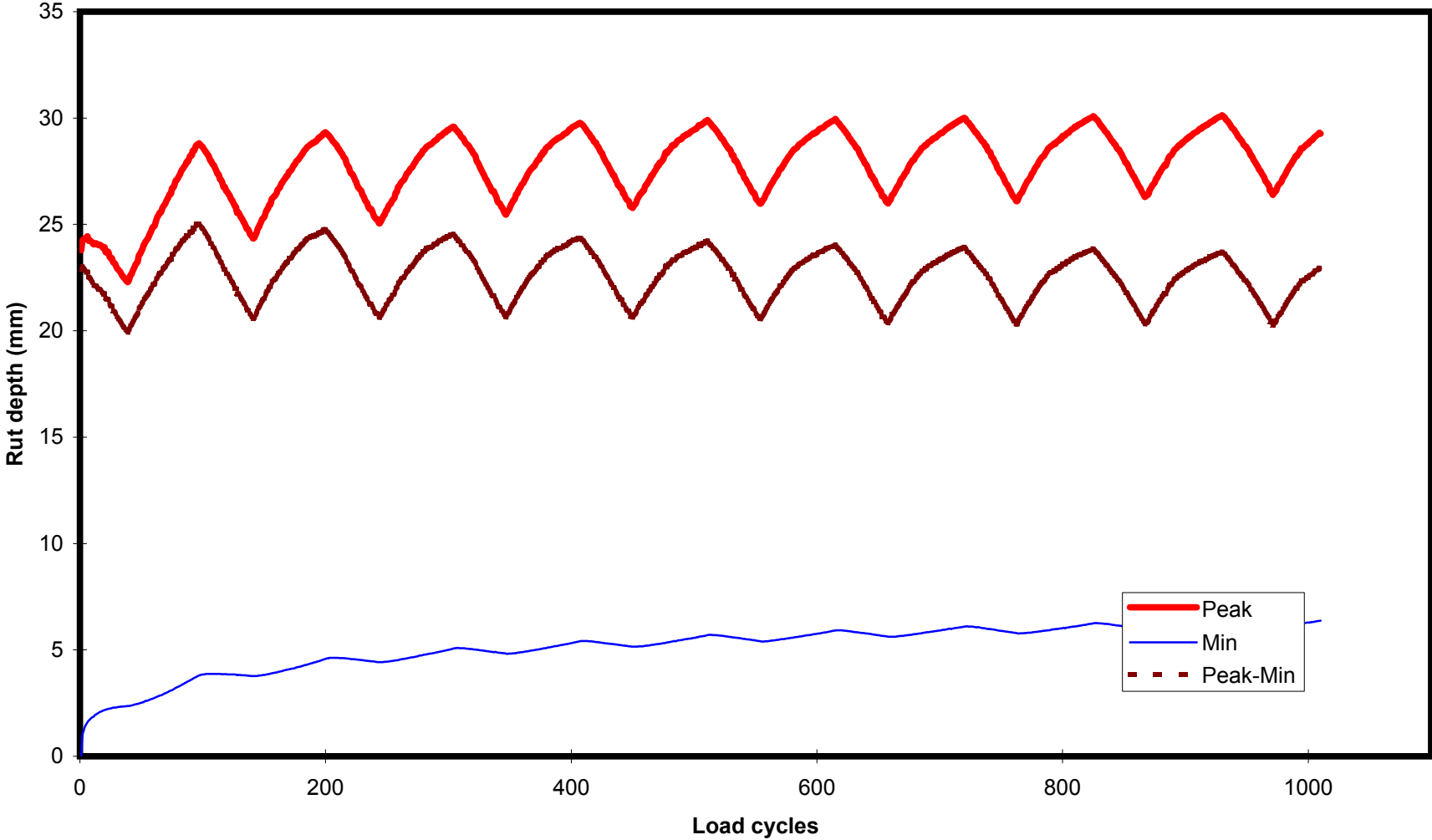
84	3.393603333	10.0574	1.459	164.970	3.34284	3.4186	3.41937
85	3.42446	9.89196	1.435	162.256	3.37656	3.4443	3.45252
86	3.452266667	9.89196	1.435	162.256	3.40546	3.47514	3.4762
87	3.48152	9.89196	1.435	162.256	3.43436	3.50085	3.50935
88	3.520456667	9.89196	1.435	162.256	3.47771	3.53169	3.55197
89	3.54013	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	6.3273
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**

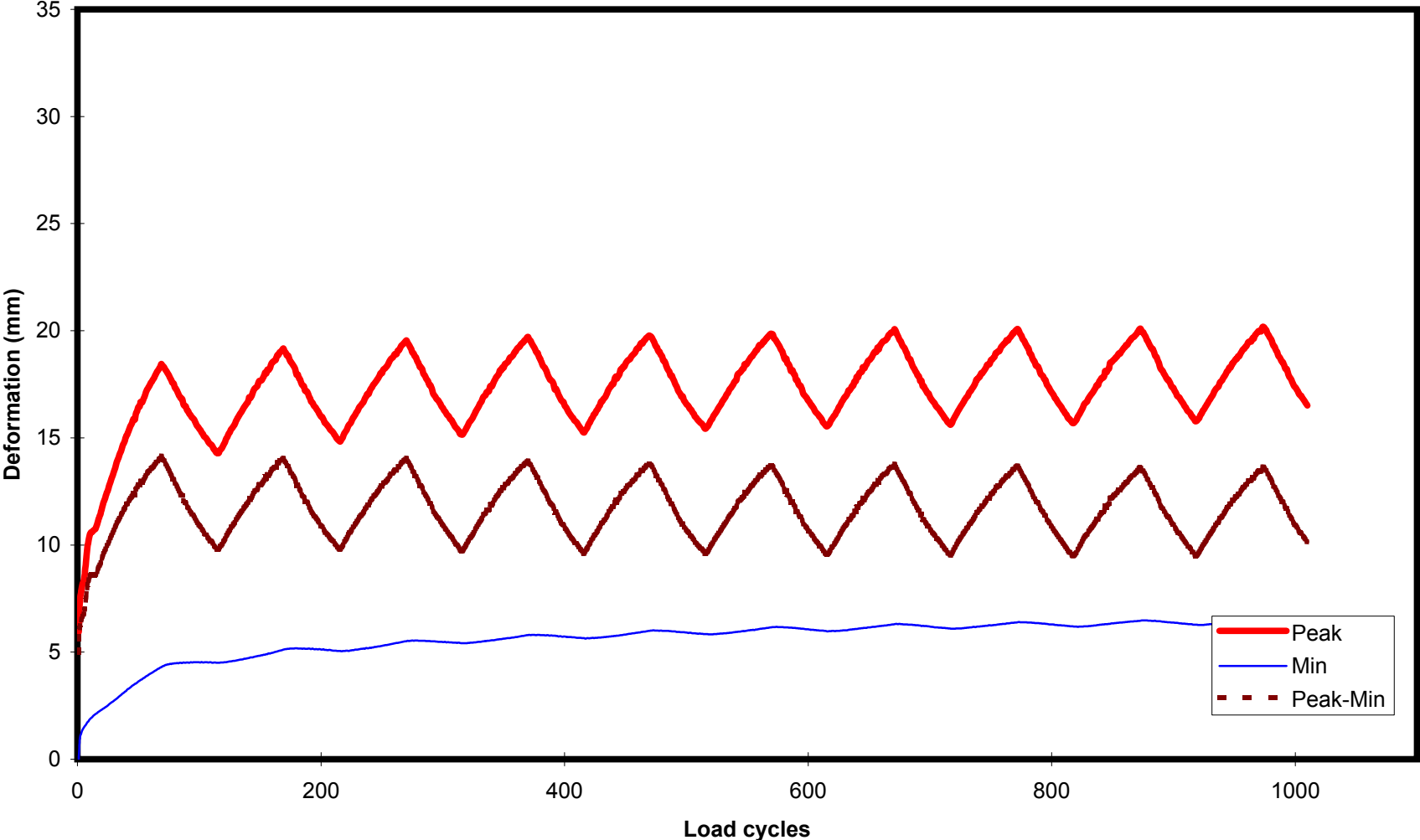
Cycle #	Gen. Def.	LC (kPa)	LC (psi)	LC (lbf)	SD3 (mm)	SD4 (mm)	SD5 (mm)
1	22.86969	517.4256	75.044	8487.231	22.75925	23.34923	22.50059
2	23.00455667	516.7646	74.948	8476.389	22.91816	23.46237	22.63314
3	22.92195667	512.29804	74.300	8403.124	22.83149	23.40067	22.53371
4	22.84348	510.1476	73.988	8367.851	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	21.711171333	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	22.05209	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  
Average Center Deformation  
Under a Cyclic Load of 9 kips**



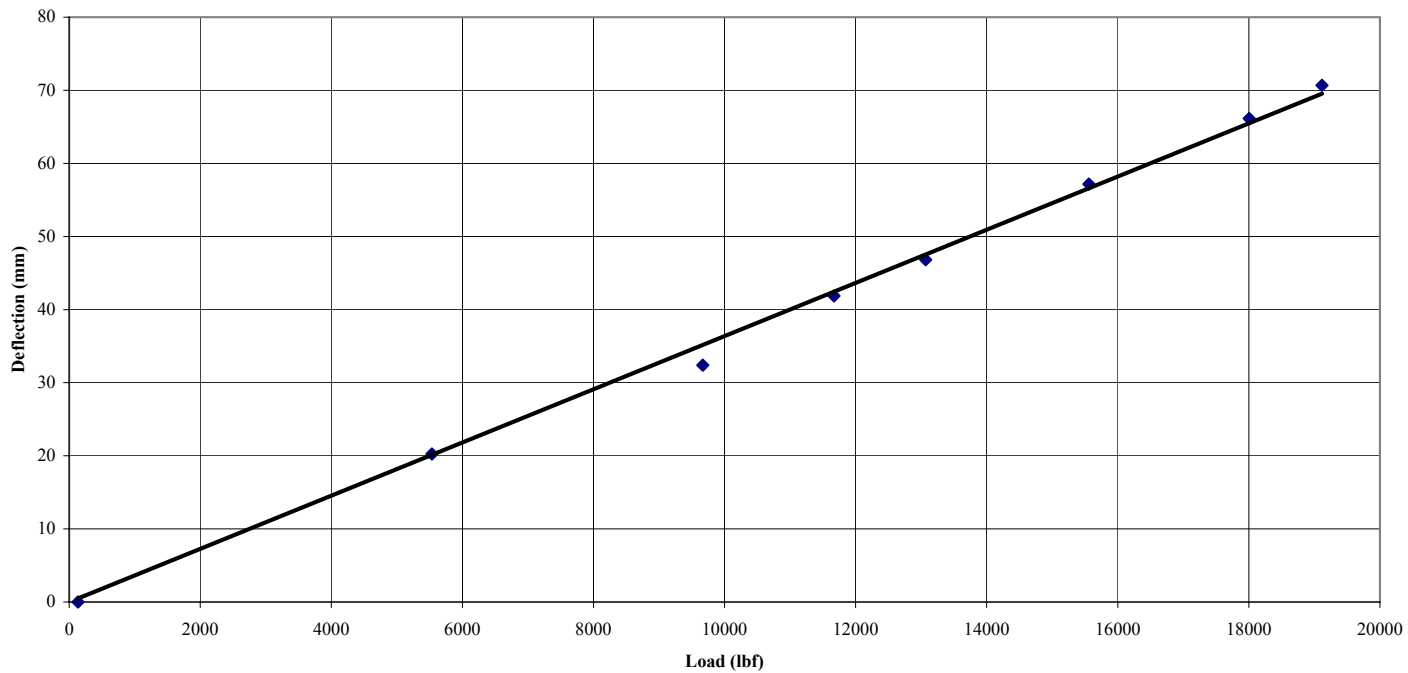
**Tire Bale 3 - Confined**  
**Average Center Deformation**  
**Under a Cyclic Load of 9 kips**



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

Load (voltage)	SD3			SD4			SD5			Average Deflection (change mm)			
	(kPa)	(psi)	(lbf)	(voltage)	(mm)	(change mm)	(voltage)	(mm)	(change mm)		(voltage)	(mm)	(change 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

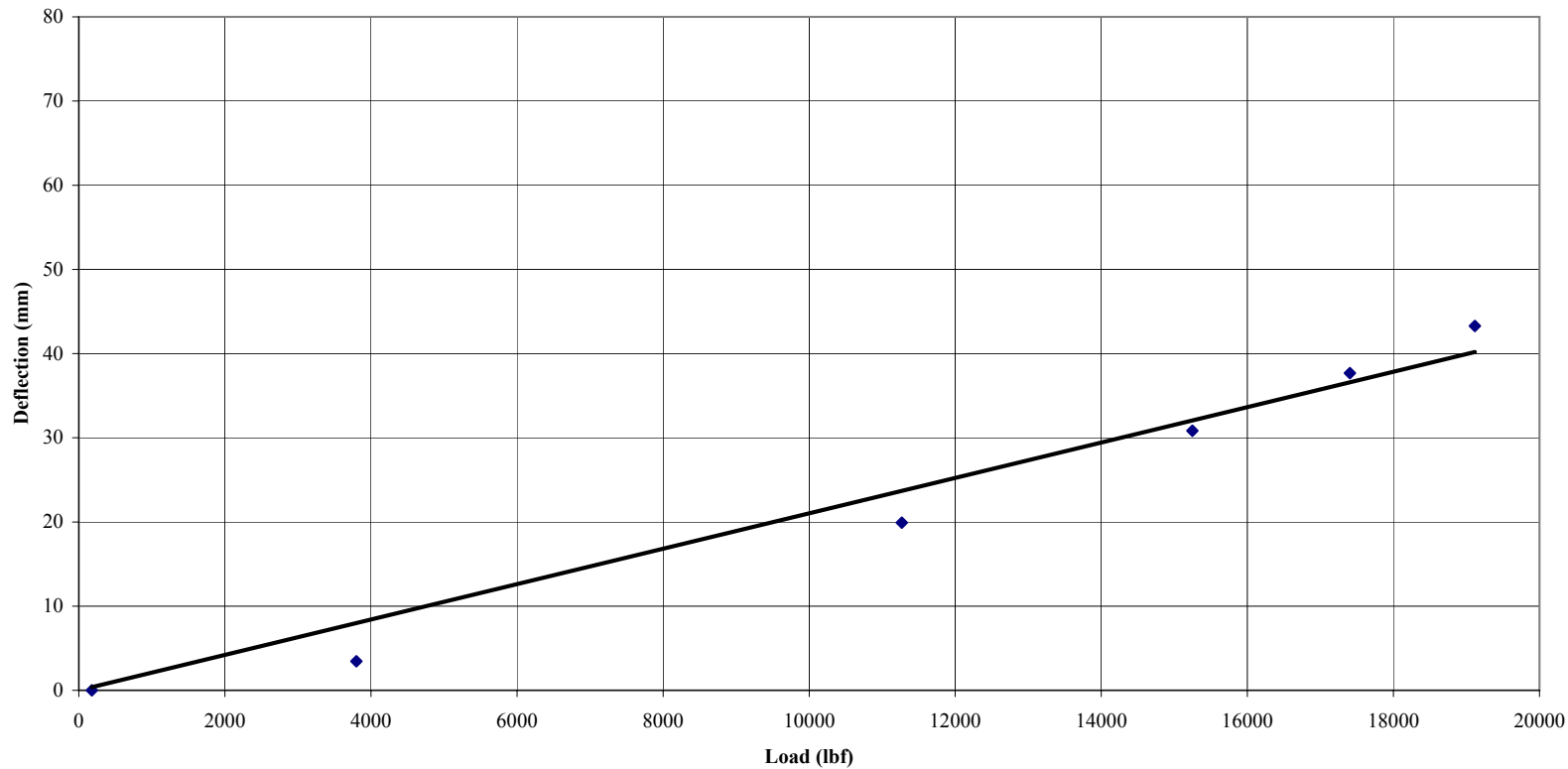
## Tire Bale 4 - Unconfined Compressibility at Static Working Loads



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

Load	SD3			SD4			SD5			Average Deflection	
(voltage) (kPa) (psi) (lbf)	(voltage) (mm)	(change mm)	(voltage) (mm)	(change mm)	(voltage) (mm)	(change mm)	(voltage) (mm)	(change mm)	(mm)	(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	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		

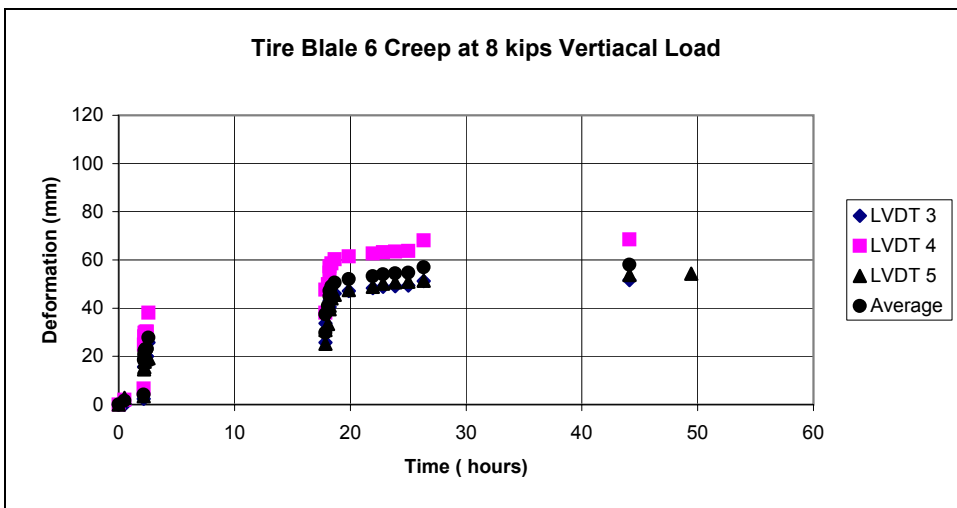
## Tire Bale 3 - Confined Compressibility at Static Working Loads



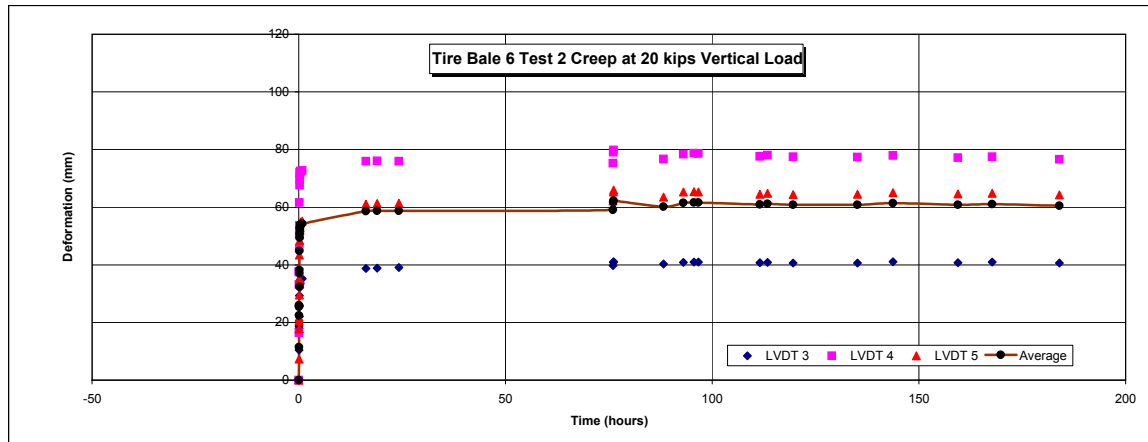


Bale 6 8 kips

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	



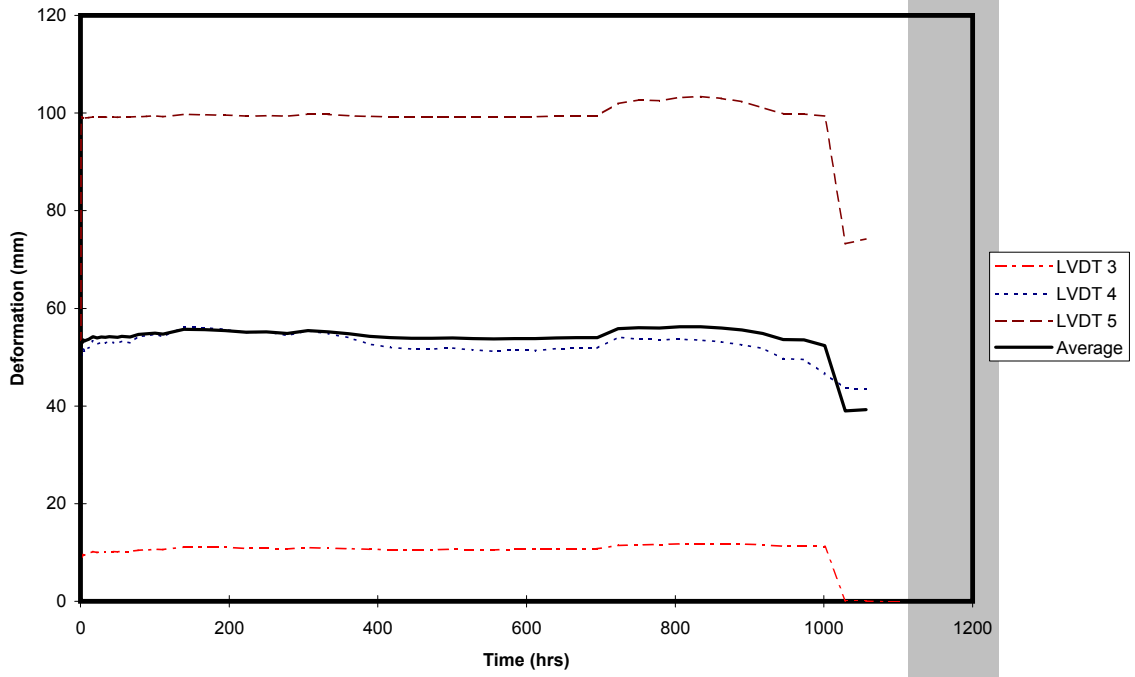
Tire Bale 6 Test 2 Creep at 20 kips Vertical Load																											
Date Time	Change in Time (days)	Change in Time (hrs)	Load Cell				Voltage	Corr. Displ. (mm)	Voltage	Corr. Displ. (mm)	Voltage	Corr. Displ. (mm)	LVDT 3 (mm)	LVDT 4 (mm)	LVDT 5 (mm)	Average (mm)											
			voltage	(kPa)	(psi)	(lbf)																					
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	0.000561	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

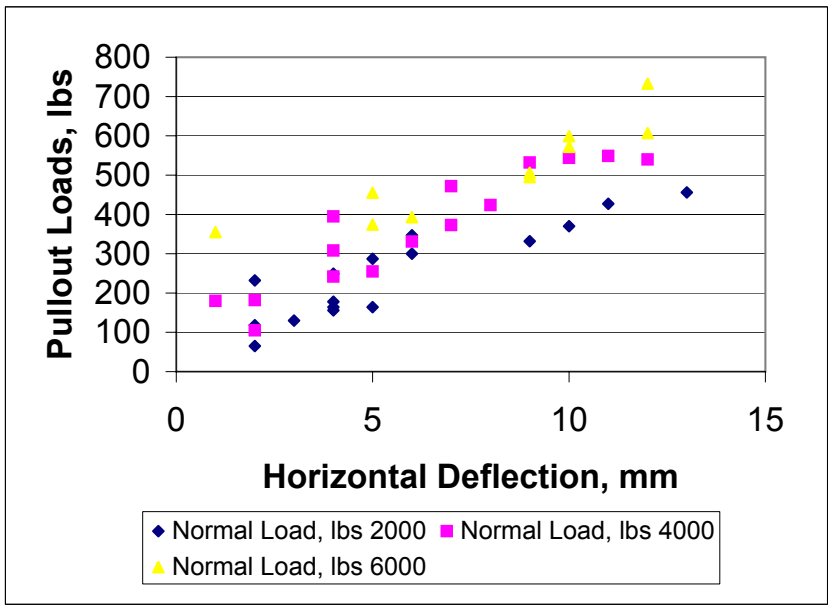
Tile Bale 0 Creep at 20 kips Vertical Load



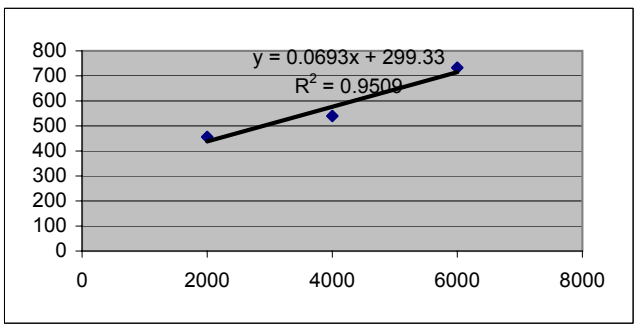
# Pull Out Test

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					Normal Load, lbs 4000					Normal Load, lbs 6000				
Loads		Horizontal Deflection			Loads		Horizontal Deflection			Loads		Horizontal Deflection		
Initial (lbs)	Final (lbs)	Increment (lbs)	Total (mm)	Increment (mm)	Initial (lbs)	Final (lbs)	Increment (lbs)	Total (mm)	Increment (mm)	Initial (lbs)	Final (lbs)	Increment (lbs)	Total (mm)	Increment (mm)
90	155	65	2	2	204	384	180	1	1	245	600	355	3	1
144	262	118	4	2	334	439	105	3	2	540	914	374	8	5
207	337	130	7	3	420	602	182	5	2	824	1217	393	14	6
244	408	164	11	4	510	752	242	9	4	1097	1552	455	19	5
342	498	156	15	4	634	889	255	14	5	1404	1899	495	28	9
450	614	164	20	5	787	1095	308	18	4	1724	2230	506	37	9
532	710	178	24	4	964	1295	331	24	6	2079	2651	572	47	10
617	849	232	26	2	1145	1540	395	28	4	2405	3004	599	57	10
760	1009	249	30	4	1394	1767	373	35	7	2800	3407	607	69	12
895	1195	300	36	6	1600	2024	424	43	8	3209	3942	733	81	12
1052	1339	287	41	5	1847	2319	472	50	7					
1205	1552	347	47	6	2130	2662	532	59	9					
1394	1726	332	56	9	2340	2889	549	70	11					
1572	1942	370	66	10	2580	3124	544	80	10					
1752	2179	427	77	11	2922	3462	540	92	12					
1857	2313	456	90	13										



2000	456
4000	540
6000	733



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

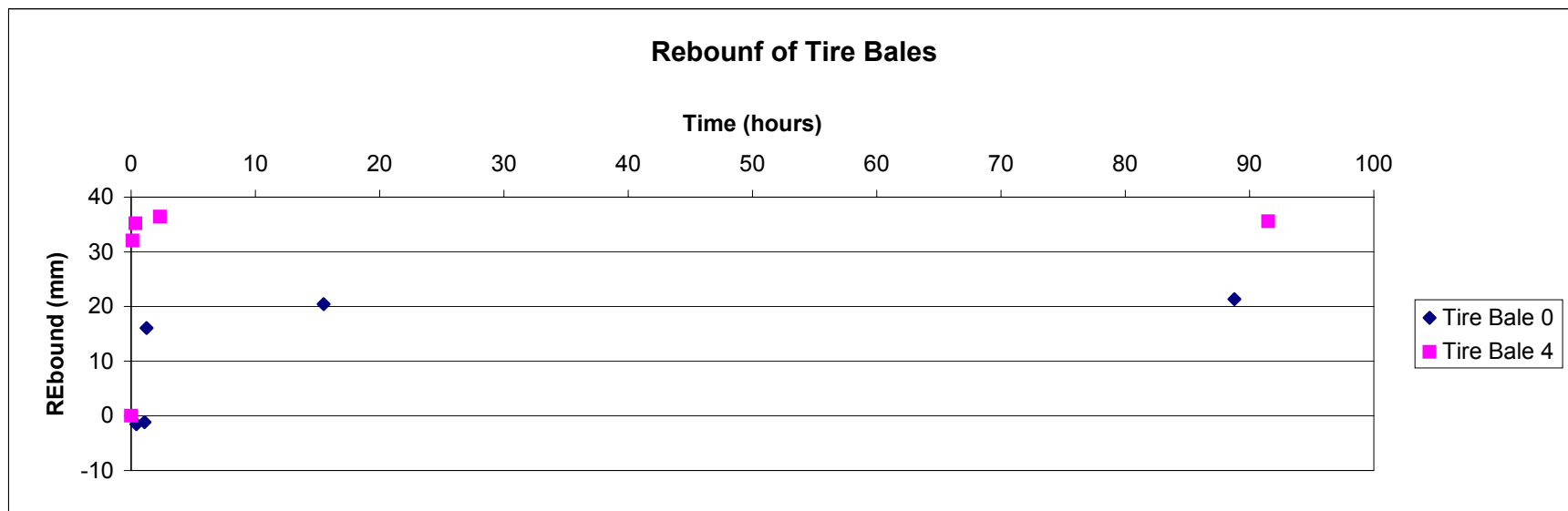
**Project Name:** Tire Bale Study  
**Reviewed By:** JW  
**Review Date:** \_\_\_\_\_

**Tire Bale 0**

Date/Time	Elapsed Time (hour)										Average Swell (mm)					
		(voltage)	(mm)	Swell (mm)	(voltage)	(mm)	Swell (mm)	(voltage)	(mm)	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 Institute of Technology

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 24<sup>th</sup>. 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

<b>Date</b>	3/24/2004
<b>Tire Bale #</b>	7
<b>Test #</b>	1

	Dimensions (in)				Average
<b>Height</b>	30.875	31.875	30.063	32.625	31.359
<b>Length</b>	65.500	63.750			64.625
<b>Width</b>	61.000	60.750			60.875



Figure 2: Tire Bale # 7, Test # 1



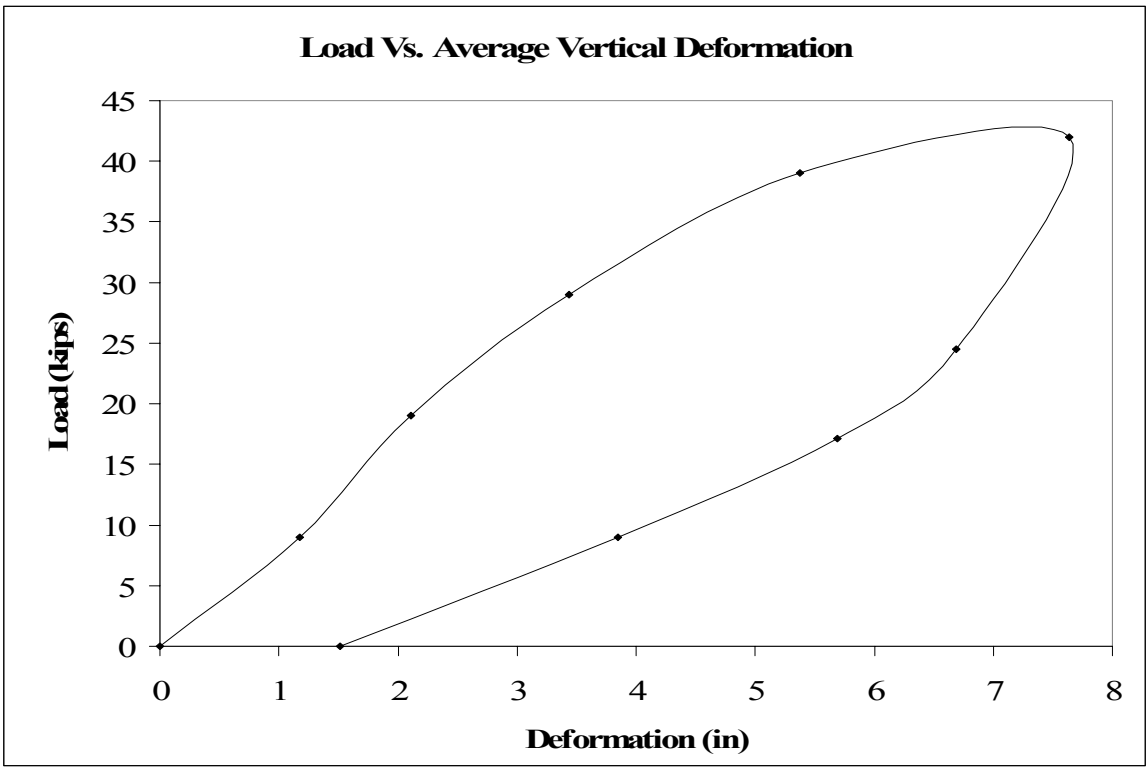


Figure 3: Tire Bale #7, Test No.1, Load vs. Average Vertical Deformation

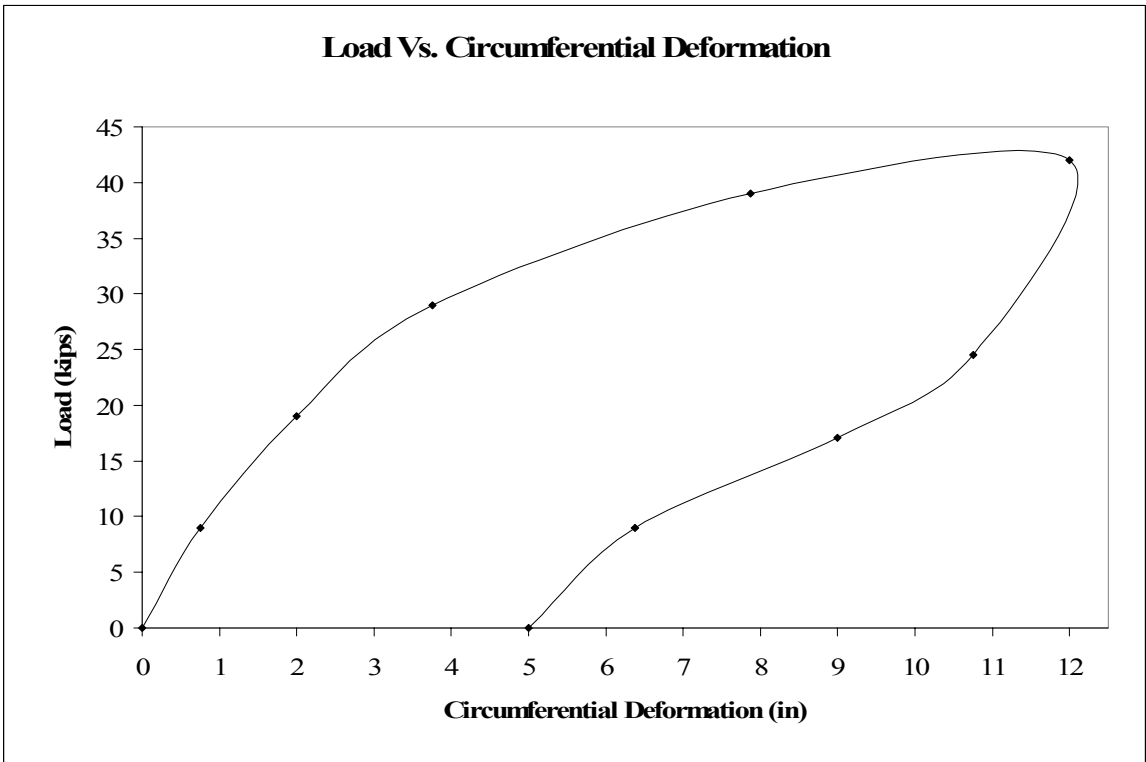


Figure 4: Tire Bale #7, Test No.1, Load vs. Circumferential Deformation

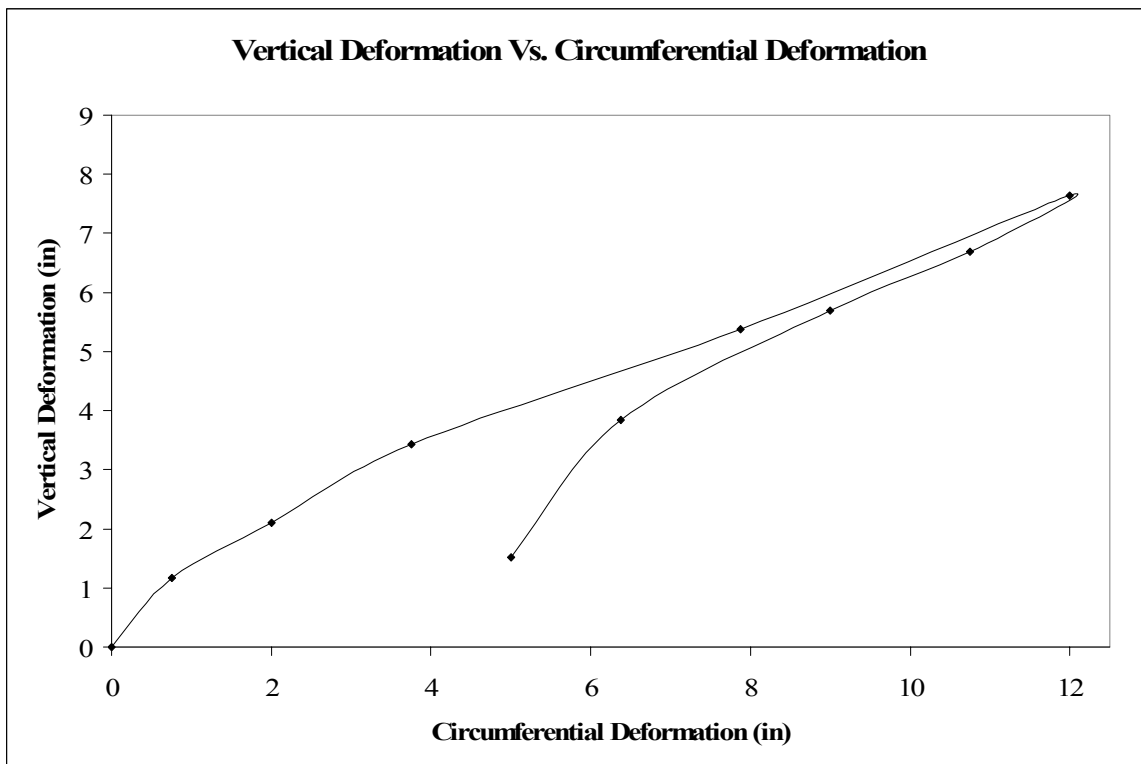


Figure 5: Tire Bale #7, Test No.1, Vertical Deformation vs. Circumferential Deformation

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 24<sup>th</sup> 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

<b>Date</b>	5/24/2004
<b>Tire Bale #</b>	7
<b>Test #</b>	2

	Dimensions (in)				Average
<b>Height</b>	30.188	30.250	30.500	30.375	30.328
<b>Length</b>	65.500	63.750			64.625
<b>Width</b>	61.000	60.750			60.875



Figure 6: Circumferential measurements. Outriggers mitigated rotation problem.

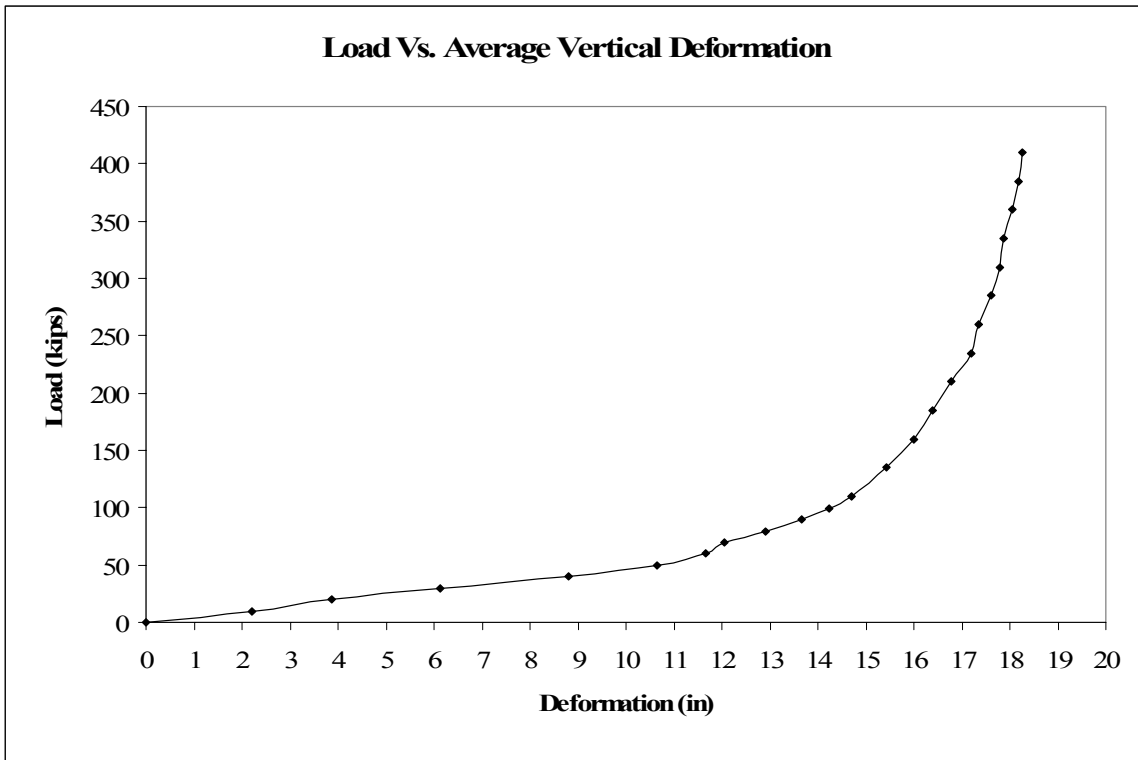


Figure7: Tire Bale #7, Test No.2, Load vs. Average Vertical Deformation

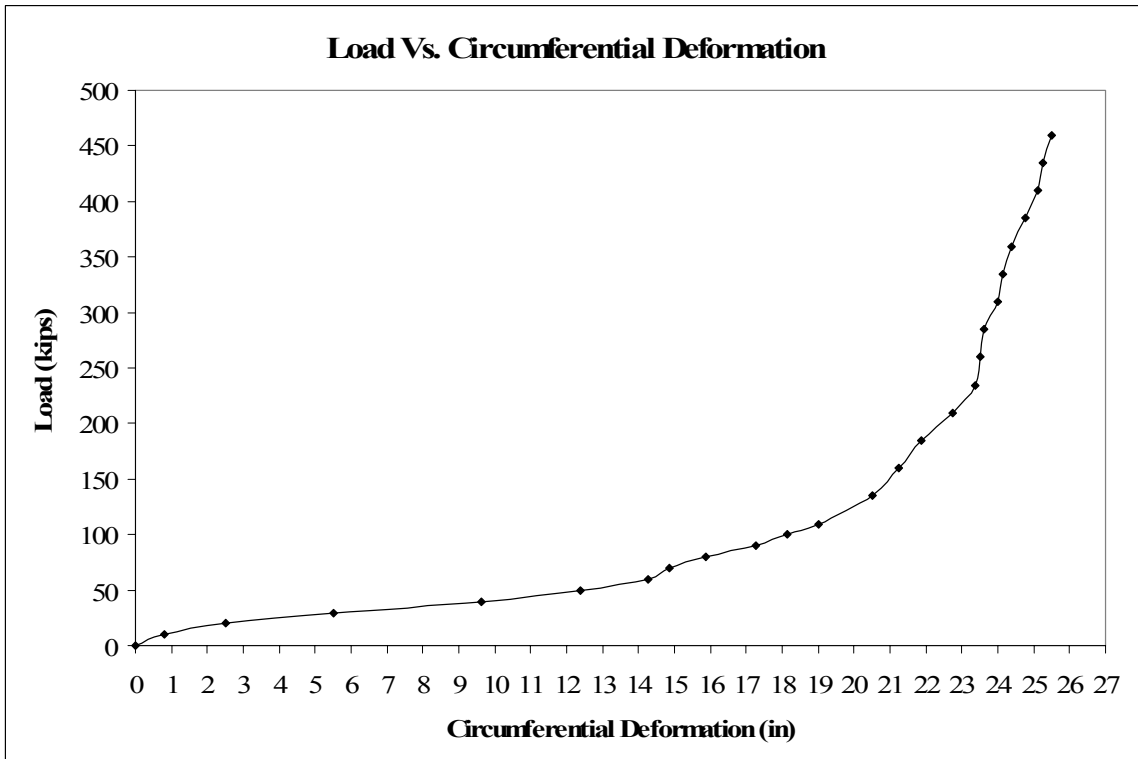


Figure 8: Tire Bale #7, Test No.2, Load vs. Circumferential Deformation

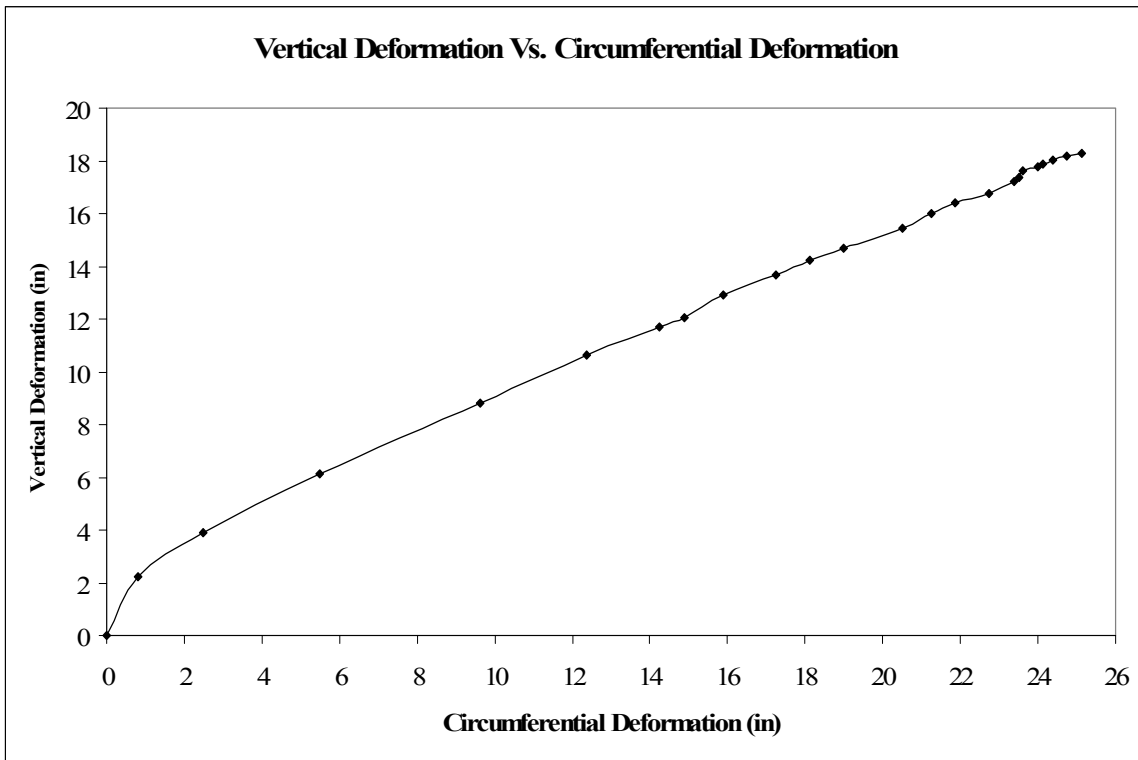


Figure 9: Tire Bale #7, Test No.2, Vertical Deformation vs. Circumferential Deformation

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 21<sup>st</sup>. 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

<b>Date</b>	7/21/2004
<b>Tire Bale #</b>	2

	Dimensions (in)				Average
<b>Height</b>	34.125	33.8125	34.5625	33.8125	34.08
<b>Length</b>	68.25	62.875			65.56
<b>Width</b>	62.1875	60.5			61.34

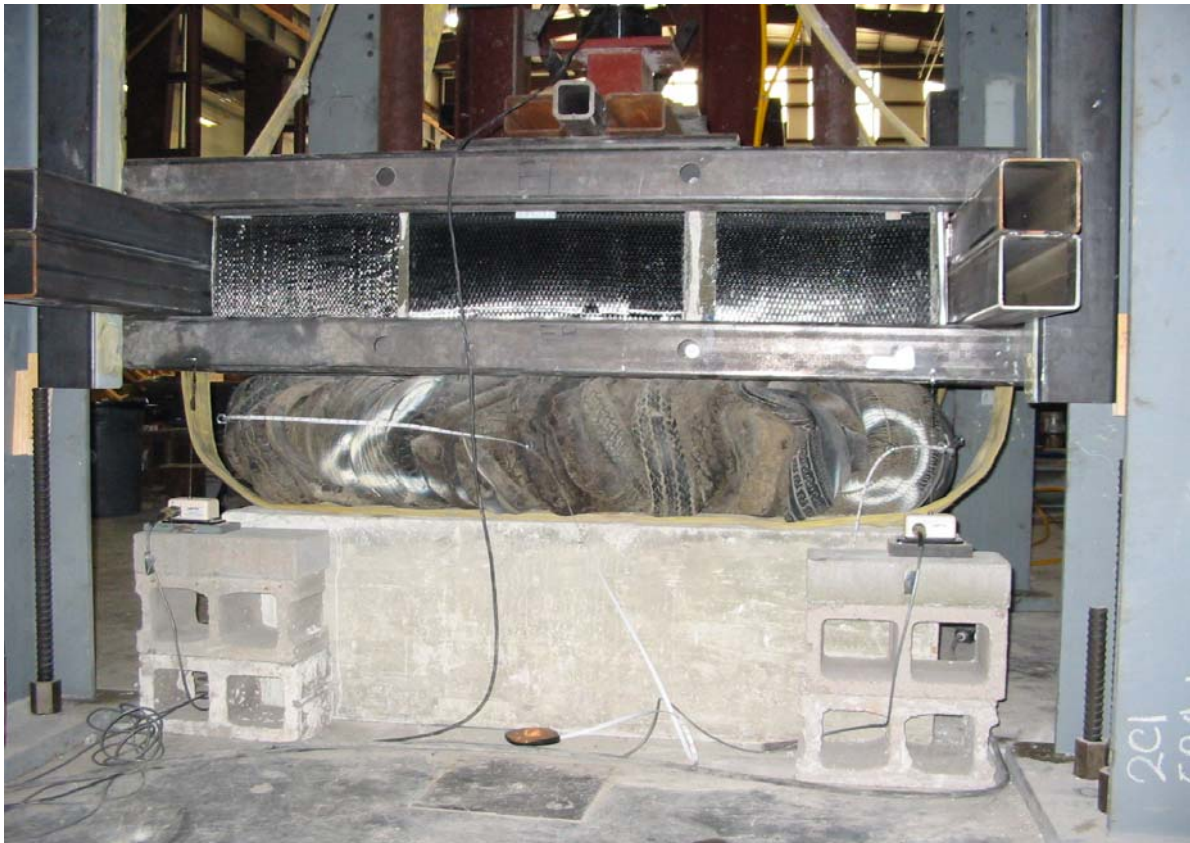


Figure 10: Tire Bale # 2 loaded to 500 kips

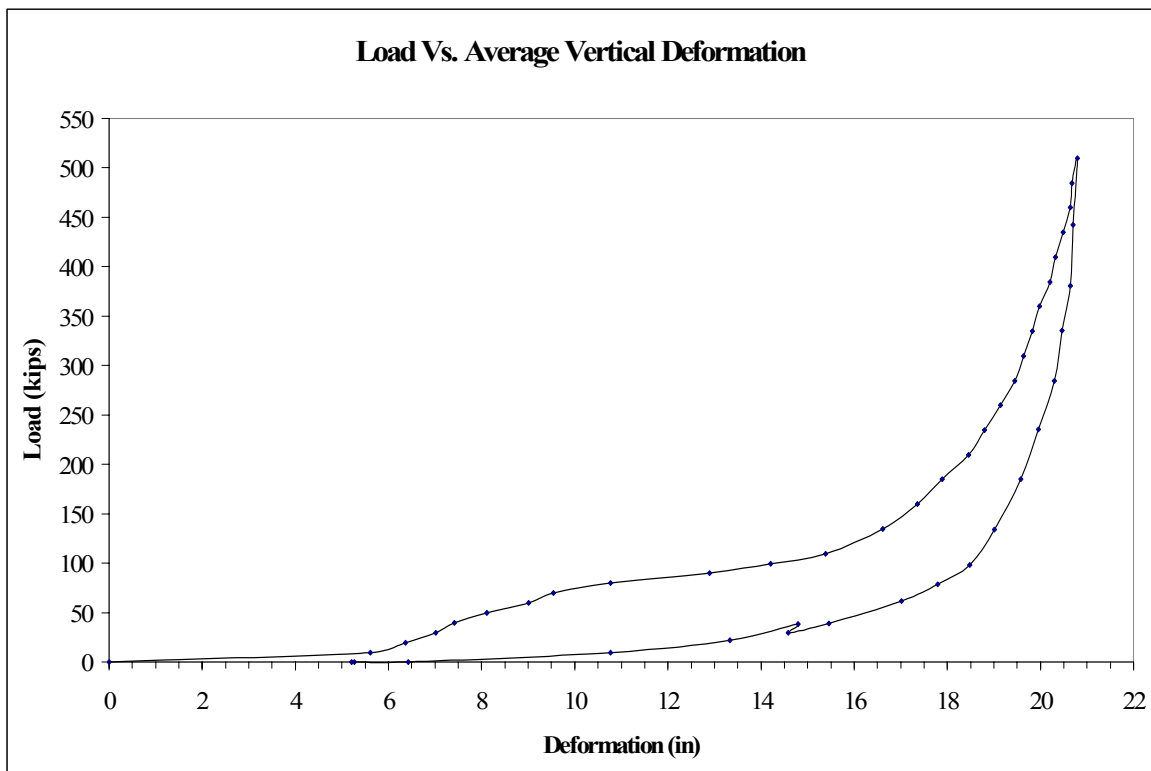


Figure 11: Tire Bale #2, Load vs. Average Vertical Deformation

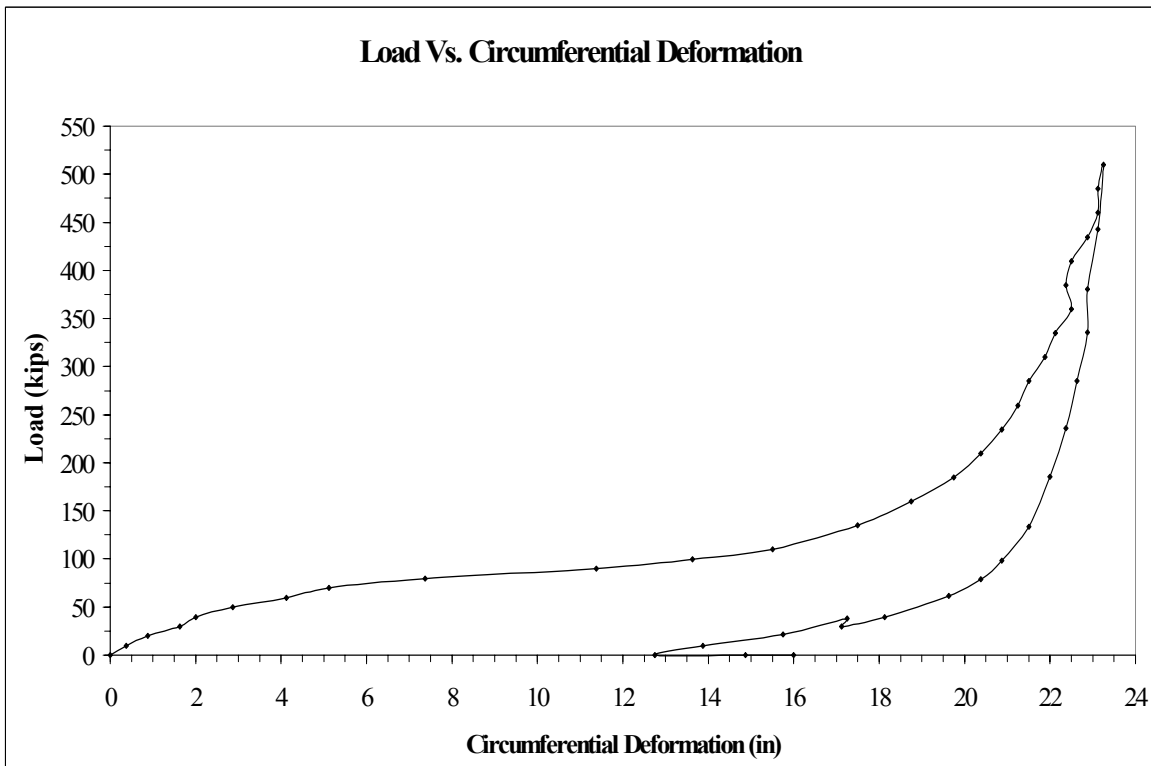


Figure 12: Tire Bale #2, Load vs. Circumferential Deformation

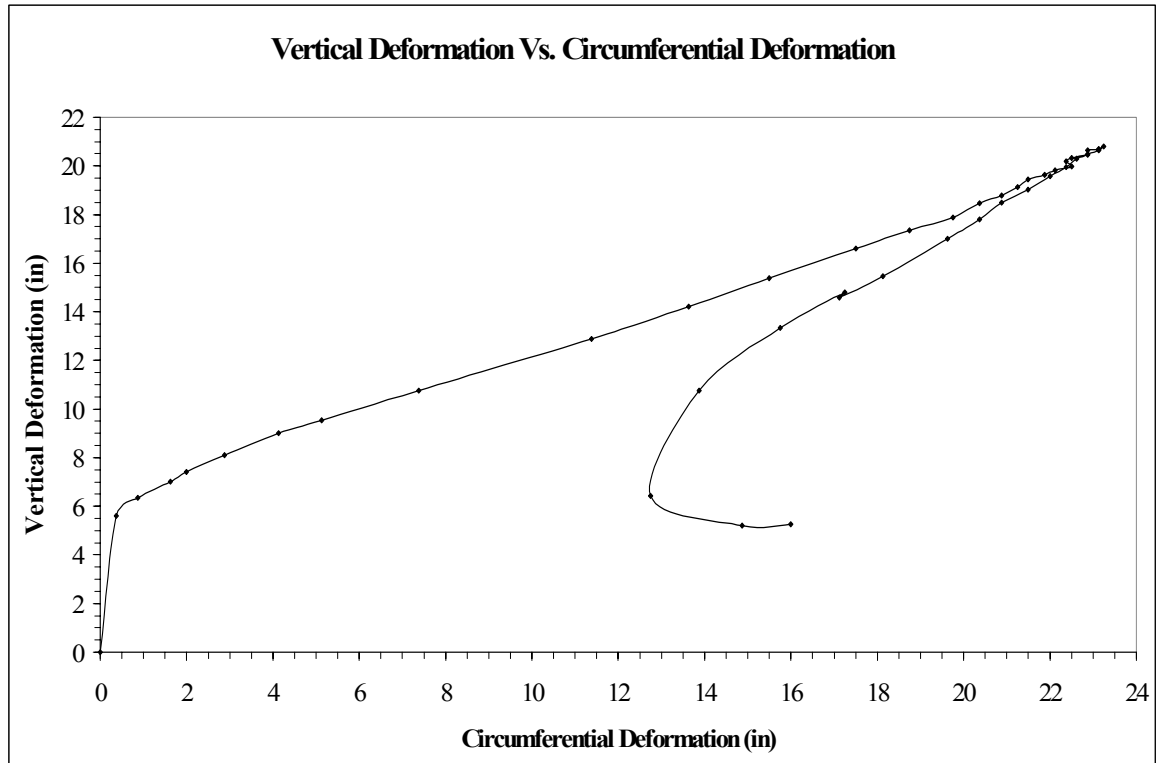


Figure 13: Tire Bale #2, Vertical Deformation vs. Circumferential Deformation

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 22<sup>nd</sup>. 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

<b>Date</b>	7/22/2004
<b>Tire Bale#</b>	8

	<b>Dimensions (in)</b>				<b>Average</b>
<b>Height</b>	31.5	32	31.875	31.5	31.72
<b>Length</b>	67.5	64			65.75
<b>Width</b>	61	61.5			61.25



Figure 14: Tire Bale # 8 loaded to 592 kips

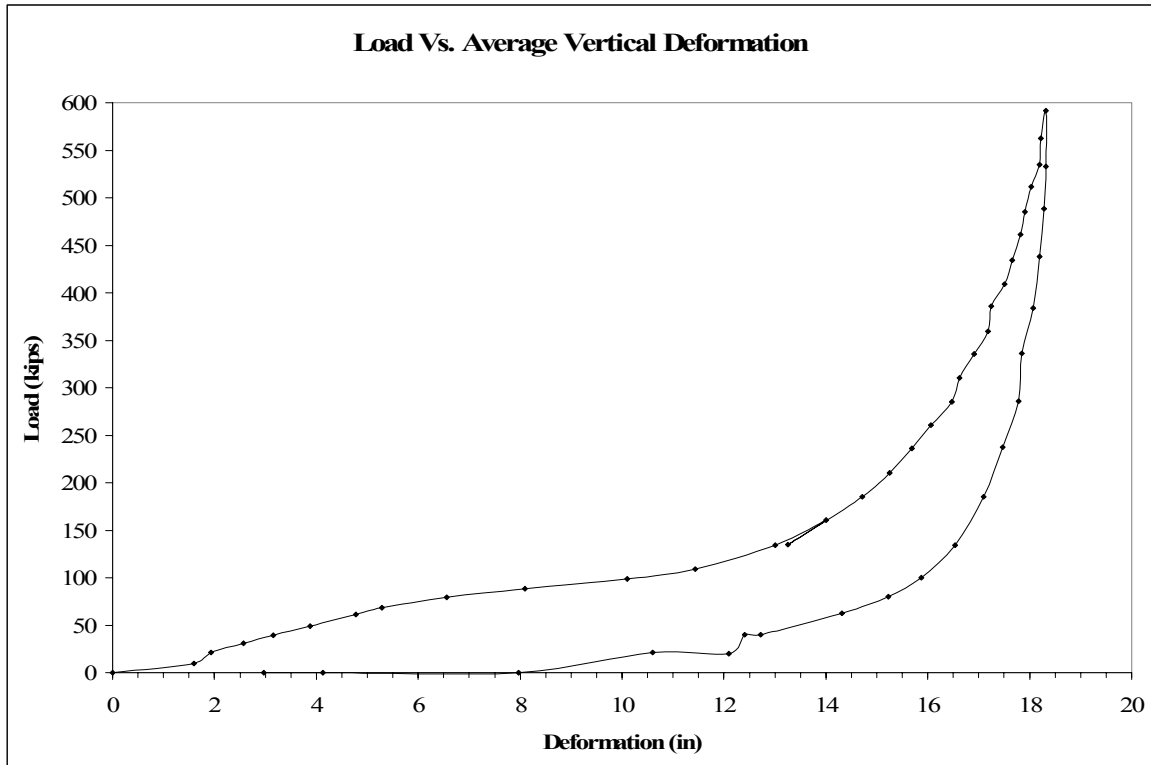


Figure 15: Tire Bale #8, Load vs. Average Vertical Deformation

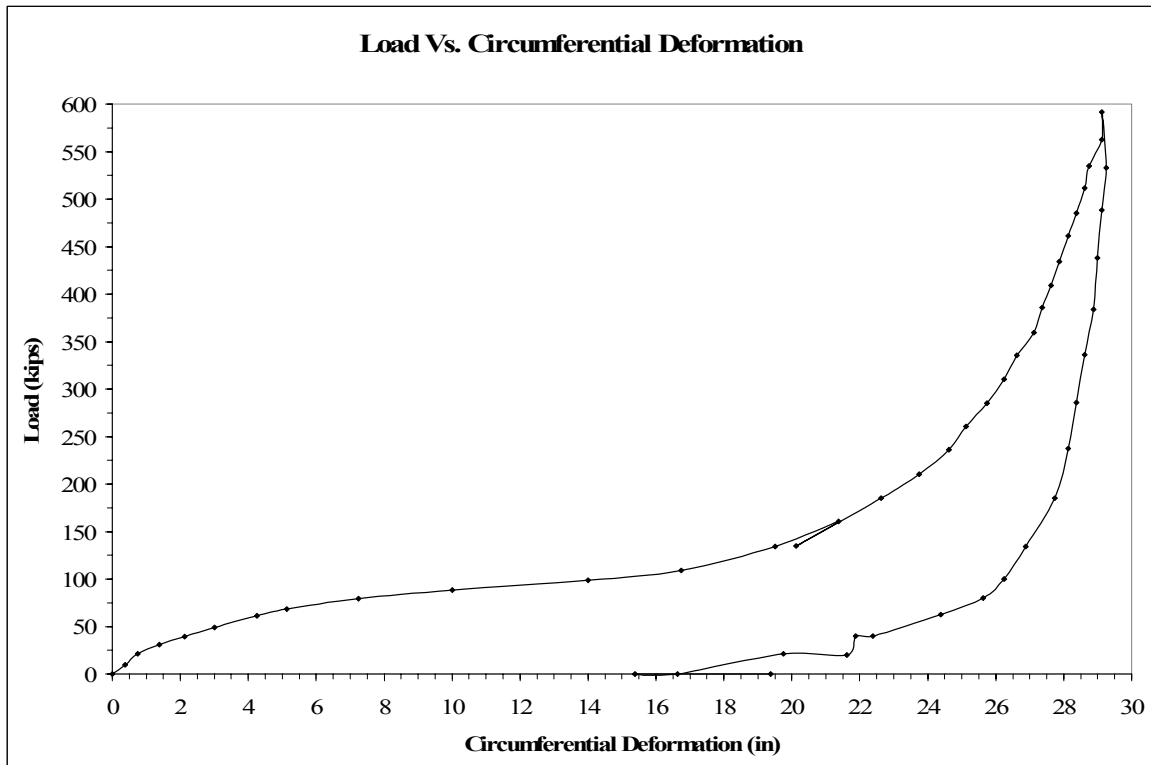


Figure 16: Tire Bale #8, Load vs. Circumferential Deformation

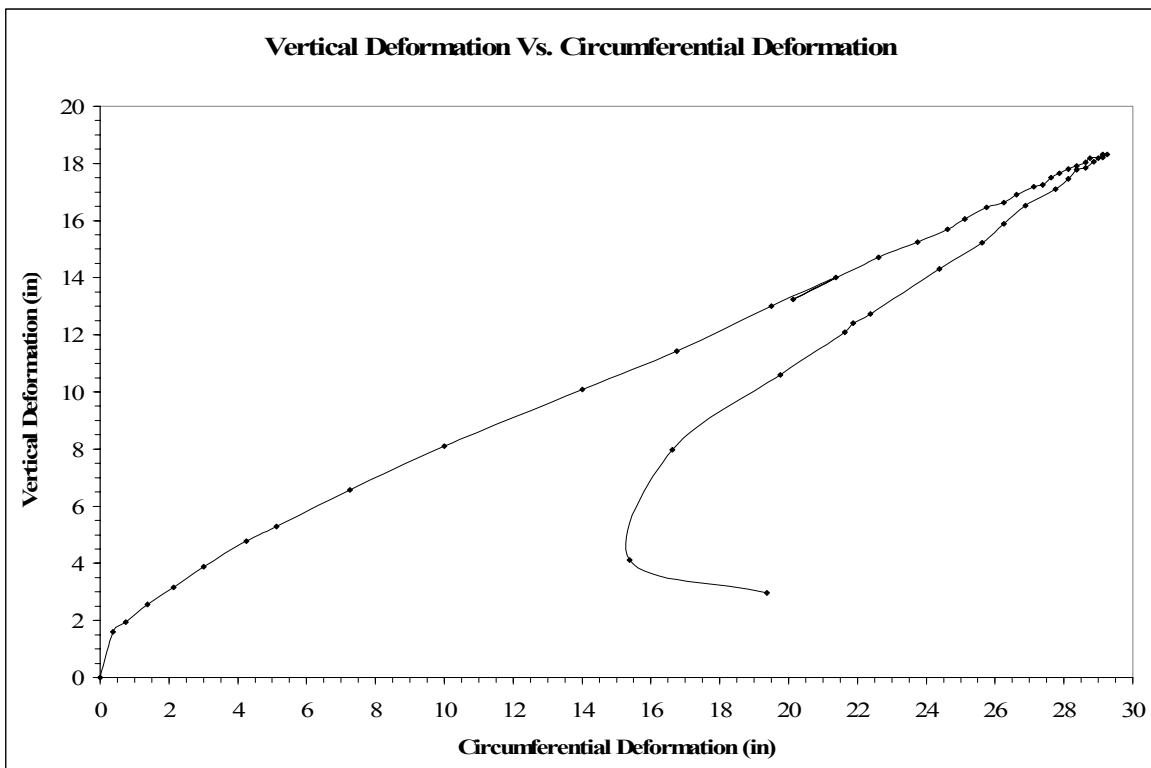


Figure 17: Tire Bale #2, Vertical Deformation vs. Circumferential Deformation

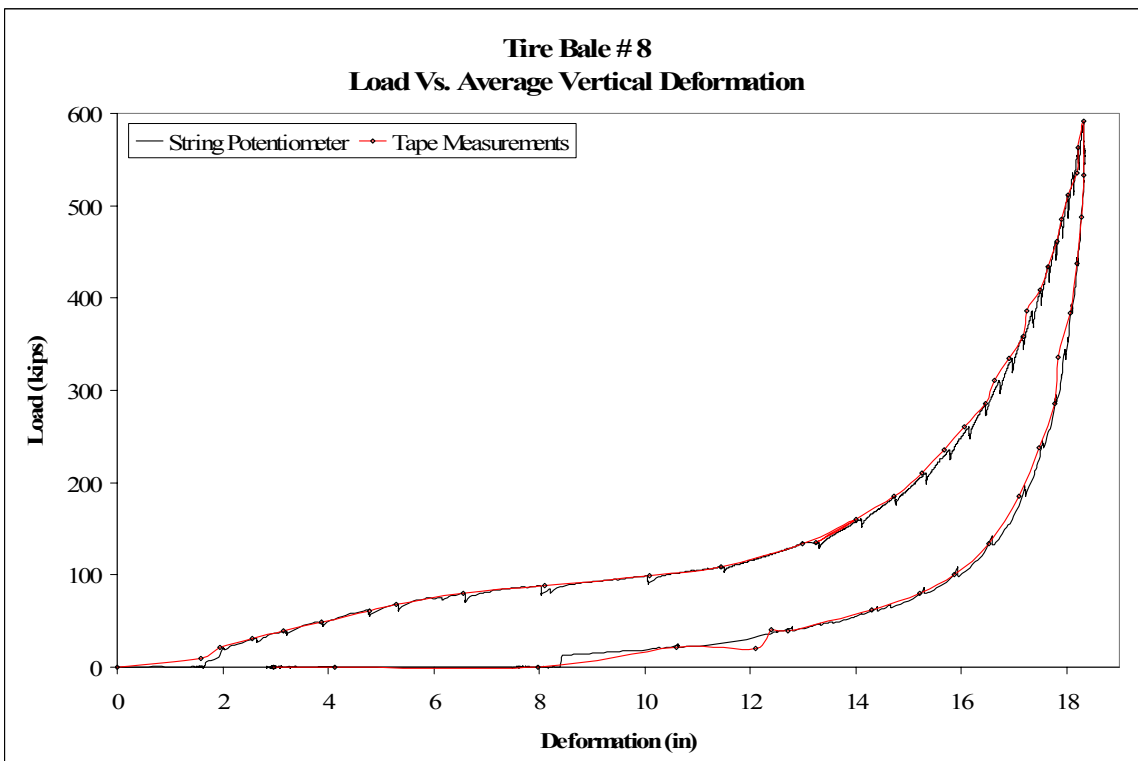
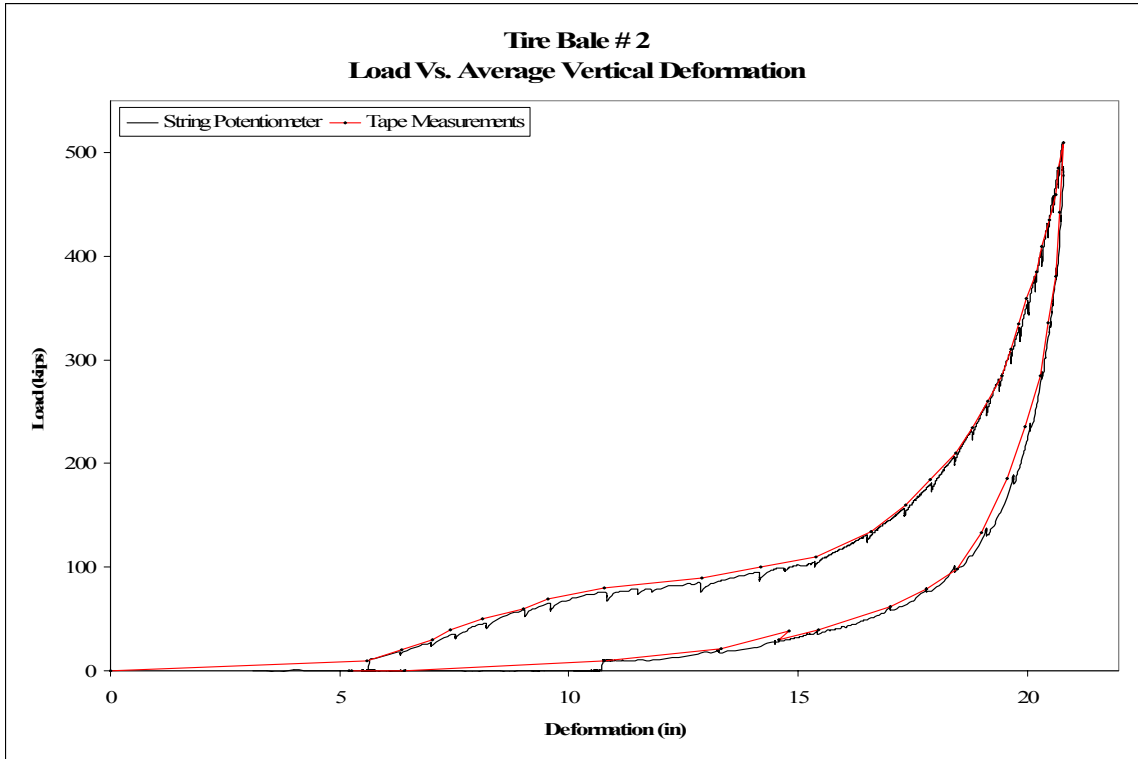
Tire Bale # 8 was loaded to 592 kips. Metal wires broke at 62 kips and 175 kips. Bale # 8 underwent 3 in. of permanent vertical deformation and 19.4 in. of permanent circumferential deformation.

## 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	CircumBot	CircumMid	CircumTop
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	CircumMid		
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



**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**

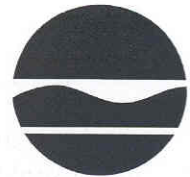


**New York State Department of Environmental Conservation  
Division of Solid and Hazardous Materials, Region 9**

270 Michigan Avenue, Buffalo, New York, 14203-2999

Phone: (716) 851-7220 • FAX: (716) 851-7226

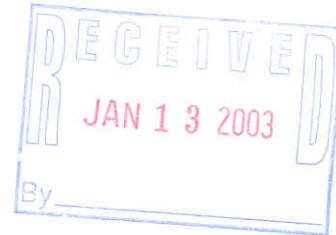
Website: www.dec.state.ny.us



Erin M. Crotty  
Commissioner

January 9, 2003

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, 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<sup>3</sup>. 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

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### 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

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#### 1. Scope

1.1 This practice provides guidance for testing the physical properties and gives data assessment of the leachate generation potential of processed or whole scrap tires in 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 Modified (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 Conditions  
[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

#### Index Terms

construction practices; landfills; leachate; lightweight fill; retaining walls; roads; scrap tires  
 83.160.01

**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](mailto: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.

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**SCRAP TIRE LEGISLATION BRIEFING 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	South Carolina	2003
Alaska	2003	South Dakota	2003
Arizona	2003	Tennessee	2003
Arkansas	2003	Texas	2003
California	2003	Utah	2003
Colorado	2003	Vermont	2003
Connecticut	2003	Virginia	2003
Delaware	2003	Washington	2003
Florida	2003	West Virginia	2003
Georgia	2003	Wisconsin	2003
Hawaii	2003	Wyoming	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		

**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 truck	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 tire)	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.

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## 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.

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**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 separate 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.

<b>Table I Minimum Separation Distances (Ft.)</b>			
<b>Length of Exposed Face (Ft.)</b>	<b>Tire Storage Pile Height (Ft.)</b>		
	<b>6</b>	<b>8</b>	<b>10</b>
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.

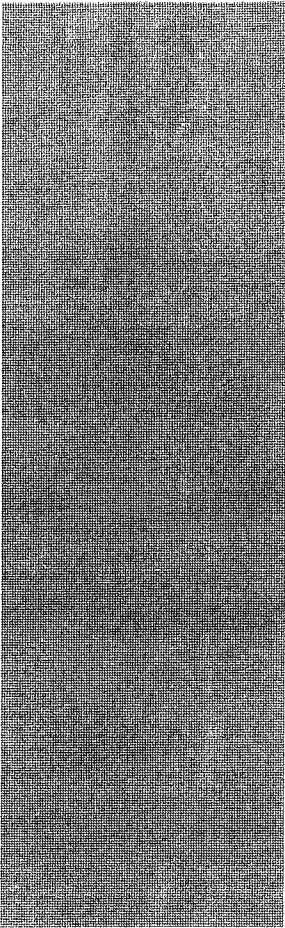
**Section 17355. Disposal of Waste Tires at Solid Waste Facilities.**

(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		Total Projects	Ave. Cost (\$/cy)
		No. of Projects	Ave. Cost (\$/cy)	No. of Projects	Ave. Cost (\$/cy)	No. of Projects	Ave. Cost (\$/cy)		
<b>703.08 (b) Class 2 Structure Backfill Material (Note 1) (Note 2)</b>	<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
<b>Subtotal or Average for 2,500 to 50,000 cy</b>		<b>23</b>	<b>10.06</b>	<b>21</b>	<b>8.51</b>	<b>19</b>	<b>10.35</b>	<b>63</b>	<b>9.64</b>
<b>Percent of Total</b>		<b>56</b>	<b>NA</b>	<b>86</b>	<b>NA</b>	<b>46</b>	<b>NA</b>	<b>50.6</b>	<b>NA</b>
<b>Total or Average for 0 to &gt;100,000 cy</b>		<b>41</b>	<b>10.02</b>	<b>43</b>	<b>8.02</b>	<b>41</b>	<b>9.05</b>	<b>125</b>	<b>9.03</b>
<b>703.08 (a) Class 1 Structure Backfill Material</b>	NA								15.00 to 20.00
<b>703.09 Filter Material (Note 3)</b>	Class A	NA							30.37
	Class B	NA							44.53
	Class C	NA							21.84
<b>Class A Separator geotextile, Table 712-8 (Note 4)</b>	NA								Ave 2.00 (\$/sy)
<b>Special Fill – Clean Sand</b>	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.									