Draft Specifications and Design Guidelines for Use of Scrap Tires in Embankment Construction

Scrap tire disposal problem is one of the most pressing issues faced by the waste management industry today. Research efforts and industry initiatives have resulted in productive re-use applications for waste tires. These include scrap tires as a fuel source in industrial plants, crumb rubber from scrap tires as an important additive in asphalt products, and numerous other promising applications. However, current re-use levels are nowhere near sufficient to solve the scrap tire disposal problem in a sustaining way. The highway construction industry, which uses large volumes of construction materials, has been in the forefront attempting to find ways to use scrap tires. Two uses of scrap tires in this industry are tire bales as construction block units and scrap tire chips in embankment construction.

Over the past 12 months, TxDOT constructed approximately 29 million cubic yards of embankment under item 132. If a conservatively low one percent replacement of this with scrap tires is assumed, this would translate to 150, 215 bales, or 15 million tires!

The following specifications are intended to promote the use of scrap tires in the form of tire bales and as tire chips in applications where their use has been proven. Tire bales may be used as embankment fill, retaining wall backfill, and in gabion baskets. Scrap tire bales have also been successfully used as a fill material in stream bank erosion control. The following specification generally addresses all the above-mentioned applications.

Draft Specification to Incorporate the Use of Tire Bales in Embankment Construction

ITEM 132

EMBANKMENT

132.1. Description. This Item shall govern for the placement and compaction of all materials necessary for the construction of roadway embankments, levees and dykes or any designated section of the roadway where additional material is required.

132.2. Material. Materials may 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 one of the following types as shown on the plans, except that material which is in a retaining-wall-backfill area shall meet the requirements for backfill material of the pertinent retaining-wall item:

Type A. This material shall consist of suitable granular material, free from vegetation or other objectionable matter, and reasonably free from lumps of earth. This material shall be suitable for forming a stable embankment and, when tested in accordance with Test Methods Tex-104-E, Tex-105-E, Tex-106-E and Tex-107-E, Part II shall meet the following requirements:

The liquid limit shall not exceed	45
The plasticity index shall not exceed	15
The bar linear shrinkage shall not be less than	2

Type B. This material shall consist of suitable earth material such as rock, loam, clay, or other such materials as approved by the Engineer that will form a stable embankment.

Type C. This material shall be suitable and shall conform to the specification requirements shown on the plans.

Type D. This material shall be that obtained from required excavation areas shown on the plans and will be used in embankment.

Type E. This material shall consist of tire bales made of whole, used passenger vehicle tires or truck tires. Each bale shall contain only one type and size of tire, passenger or truck. The bales shall be produced in a tire baler or equivalent as approved by the Engineer. The tire baler shall be capable of compressing whole tires to reach a density not less than 35 lb/ft^3. Each bale shall use a minimum of 3 galvanized steel or stainless steel straps or wires. The bales shall not "explode" when all the straps are broken or cut.

The size and weight of each tire bale should be approved by the Engineer. To be eligible to supply tire bales to a project, the tire baler or the tire supplier shall be authorized to process waste tires by the Texas Natural Resource Conservation Commission.

The tire bales should be of uniform size within each project such that they can be easily stacked to facilitate rapid construction.

The tire bales should be load tested with the bale fully supported on a test floor approved by the Engineer. During load testing, the bale should be sandwiched between two steel plates. The top steel plate on which the load is applied shall be 1 inch thick and its size should be identical to the loaded area of the bale. I-section steel shall be used to distribute the load uniformly over the steel plate, as approved by the Engineer. The load shall be applied using a hydraulic ram with a load capacity of at least 400,000 lbs.

Two types of strength tests, a creep test and a compressive strength test, shall be conducted on tire bales. The creep test shall be conducted over 72 hours at a creep stress of 25 psi applied in the same direction along which loads are applied in the field. The maximum allowable creep strain shall not exceed 0.25. The compressive strength test shall be conducted until the tire bale fails or until an applied compressive stress of 100 psi, which ever is achieved first. In addition, the tire bales shall also have the following requirements:

The galvanized steel or stainless steel wires used as straps shall not break up to a stress of 50 psi as applied on the tire bale surface. With regard to corrosion of these straps, requirements stipulated in Item 423.2 shall be met. Tire bale fills covered with geomembranes, which makes the tire fill impermeable to air and water, may not be subjected to the pH and resistivity requirements stipulated in Item 423.2.

Type F. This material shall consist of either 100 percent scrap tire chips (also referred to as shreds) or a blend of scrap tire chips and conventional embankment fill material of Types A or B indicated above. The tire chips shall be obtained by shredding used passenger vehicle tires or truck tires. Based on the composition of the embankment material, embankment fills are divided into three classes;

Class I fills are constructed using a blend of scrap tire chips and Type A or B material. Tire chips in Class I fills shall be free of contaminants such as oil, grease, gasoline, diesel fuel, etc. that could create a fire hazard. Under no circumstances shall remains of tires subjected to a fire be used as a part of fill.

Class II fills are constructed either exclusively using tire chips or tire chips blended with less than 30 percent Type A or B material. The maximum allowable thickness of Class II tire chip fills is 3 feet. Tire chips in Class II fills shall be free of contaminants such as oil, grease, gasoline, diesel fuel, etc. that could create a fire hazard. Under no circumstances shall remains of tires subjected to a fire be used as a part of fill. For Class II fills, tire shreds shall have a maximum of 50 percent (by weight) passing the 1½ inch sieve and a maximum of five percent (by weight) passing the #4 sieve.

Class III fills are constructed exclusively using tire chips with a tire chip fill thickness between 3 feet and 10 feet. No tire chip fill should be constructed exclusively with tire chips with tire chip layer thickness greater than 10 feet. Tire chips in Class III fills shall be free of

contaminants such as oil, grease, gasoline, diesel fuel, etc. that could create a fire hazard. Under no circumstances shall remains of tires subjected to a fire be used as a part of fill. For Class III fills, tire chips shall have a maximum of 25 percent (by weight) passing the 1½ inch sieve and a maximum of one percent (by weight) passing the #4 sieve. The tire chips shall be free from organic matter such as wood, wood chips and other fibrous organic matter. The tire chips shall have less than 1 percent (by weight) of metal fragments, which are not at least partially encased in rubber. Metal fragments that are encased partially in rubber shall protrude no more than 1 inch from the cut edge of the tire shred on 75 percent of the pieces and no more than 2 inches on 100 percent of the pieces.

Class III fills shall also be constructed such that infiltration of water and air is minimized. Also, there shall be no direct contact between tire chips and soil containing organic matter, such as topsoil. A minimum of 18 inches thick mineral soil layer free of organic matter shall be placed and compacted over the tire chip fill. This mineral soil fill shall be separated from the tire chip fill by a geotextile to prevent the soil particles from washing into the voids in tire chip fill. For Class II fills, use of drainage features located at the bottom of the fill that could provide free access to air should be avoided. These drainage features may include, but not limited to open graded drainage layers on the side of the fill, and drainage holes in walls.

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.. Prior to placing any embankment, all work in accordance with Item 100, "Preparing Right of Way", shall have been completed on the areas over which the embankment is to be placed. Stump holes or other small excavations in the limits of the embankments shall be backfilled with suitable material and thoroughly tamped by approved methods before commencing embankment construction. The surface of the ground, including disk-loosened ground or any surface roughened by small washes or otherwise, shall be restored to approximately its original slope by blading or other methods. Where shown on the plans or required by the Engineer, the ground surface thus prepared shall be compacted by sprinkling and rolling.

The Engineer shall be notified sufficiently in advance of opening any material source to allow performance of any required testing.

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

Trees, stumps, roots, vegetation or other unsuitable materials shall not be placed in embankment.

Unless otherwise shown on the plans, all embankment shall be constructed in layers approximately parallel to the finished grade of the roadbed.

Embankments shall be constructed 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, it shall be continuously maintained to its finished section and grade until the project is accepted.

(2) Constructing Embankments.

(a) Earth Embankments. Earth embankments shall be defined as those composed principally of material other than rock, and shall be constructed of acceptable material from approved sources.

Unless otherwise specified, earth embankments shall be constructed in successive layers for the full width of the individual roadway cross section and in such lengths as are best suited to the sprinkling and compacting methods utilized.

A minor quantity of rock or broken concrete encountered in the construction of this project may be incorporated in the lower layers of the embankment if acceptable to the Engineer. Or, it may be placed in the deeper fills, in accordance with the requirements for the construction of rock embankments, provided such placement of rock is not immediately adjacent to structures or in areas where bridge foundations are to be constructed. Also, rock or broken concrete may be placed in the portions of embankments outside the limits of the completed roadbed width where the size of the rock or broken concrete prohibits its incorporation in the normal embankment layers. All exposed reinforced steel shall be cut and removed from the broken concrete.

Layers of embankment may be formed by utilizing equipment and methods which will evenly distribute the material.

Each layer of embankment shall be uniform as to material, density and moisture content before beginning compaction. Where layers of unlike materials abut each other, each layer shall be featheredged for at least 100 feet, or the material shall be so mixed as to prevent abrupt changes in the soil. No material placed in the embankment by dumping in a pile or windrow shall be incorporated in a layer in that position, but all such piles or windrows shall be moved by blading or similar methods. Clods or lumps of material shall be broken and the embankment material mixed by blading, harrowing, disking or similar methods until a uniform material of uniform density is achieved in each layer.

Sprinkling required to achieve the moisture content necessary for compaction shall meet the material requirements of Item 204, "Sprinkling". It shall be the responsibility of the Contractor to secure a uniform moisture content throughout the layer by such methods as may be necessary. In order to facilitate uniform wetting of the embankment material, the Contractor may apply water at the material source if the sequence and methods used do not cause an undue waste of water. Such procedures shall be subject to the approval of the Engineer.

(b) Rock Embankments. Rock embankments shall be defined as those composed principally of rock, and shall be constructed of acceptable material.

Unless otherwise specified, rock embankments normally shall be constructed in successive layers for the full width of the individual roadway cross section and 18 inches or less in depth. When, in the opinion of the Engineer, the rock sizes necessitate a greater depth of layer, the layer depth may be increased as necessary, but in no case shall the depth of layer exceed 2-1/2 feet. Each layer shall be constructed in such a manner that the interstices between the larger stones are filled with smaller stones and spells which have been created by this operation as well as from the placement of succeeding layers of material.

The maximum dimension of any rock used in embankment shall be less than the depth of the embankment layer, and in no case shall any rock over two (2) feet in its greatest dimension be placed in the embankment unless otherwise approved by the Engineer. Unless otherwise shown on the plans, the upper or final layer of the embankment shall be composed of material so graded that the density and uniformity of the surface layer may be secured by the "Ordinary Compaction" or "Density Control" method. Exposed oversize material shall be reduced by sledging or other methods as approved by the Engineer.

When "Ordinary Compaction" is specified, each embankment layer shall be rolled and sprinkled when and to the extent directed by the Engineer. When "Density Control" is specified, each layer shall be compacted to the required density as outlined for "Earth Embankments", except that in those layers where rock will make density testing difficult, when shown on the plans, the Engineer may require the layer to be proof rolled to insure proper compaction.

(c) Tire Bale Embankments. Tire bale embankments shall be defined as those composed of scrap tire bales which are covered by a layer of soil. The maximum height of the tire bale portion of the embankment shall not exceed 10 feet. When tire-bale embankments are constructed, steps should be taken to eliminate free access to oxygen, water and organic materials to the locations where tire bales are stacked. These can be easily achieved by locating the tire bales away from open or underground drains and by eliminating the organic material coming into contact with the tire fill. A geomembrane that meets the Department specifications shall be used to wrap around the scrap tire fill to provide long-term durability to the embankment. Any soil that will come into contact with the tires shall be subjected to the color test for organic impurities in accordance with Test Method Tex-408-A with the test result not showing a color darker than standard.

When tire bales are being placed in horizontal layers, a spacing of at least 6 inches shall be left for placement of a soil filler material to be placed between the tire bales. A cohesionless material such as sand or manufactured stone sand shall be used for this purpose such that it is easily packed or vibrated between the bales. The same material or local material with a PI less than 35 shall be used to provide a cushioning layer between successive layers of tire bales. This layer should be at least 12 inches thick in order to facilitate compaction using vibratory rollers as specified in Item 217.

Once compaction is completed on the last layer of tire bales, a geomembrane shall be used to completely cover the tire bale fill.

(c) Tire Chip Embankments. Tire chip embankments are constructed in 12-inch thick layers (in uncompacted form). For Class I fills, soil and tire chips shall be blended such that there is no likelihood of hrdrocarbon materials leaking from construction equipment onto the tire chips. They shall be mixed with equipment approved by the Engineer.

Any soil that will come into contact with the tires shall be subjected to the color test for organic impurities in accordance with Test Method Tex-408-A with the test result not showing a color darker than standard.

When Class II and Class III tire-chip embankments are constructed, steps should be taken to eliminate free access to oxygen, water and organic materials to the locations where tire chips are placed. This can be easily achieved by locating the tire chip fill away from open or underground drains and by eliminating the organic material coming into contact with the tire fill. A geomembrane that meets the Department specifications shall be used to wrap around the scrap tire fill to provide long-term durability to the embankment.

Rollers used for compaction of tire chip embankments shall meet the criteria in either Item 210, 211 or 212. Rollers with pneumatic tires shall not be used to compact tire chip fills.

(d) Embankment Adjacent to Culverts and Bridges. Embankments adjacent to culverts and bridges shall be compacted in the manner prescribed under Item 400, "Excavation and Backfill for Structures., or other appropriate bid items.

As a general practice, embankment material placed adjacent to any portion of any structure and in the first two layers above the top of any culvert or similar structure shall be free of any appreciable amount of gravel or stone particles more than four (4) inches in greatest dimension and of such gradation as to permit thorough compaction. When, in the opinion of the Engineer, such material is not readily available, the use of rock or gravel mixed with earth will be permitted, in which case no particle larger than 12 inches in greatest dimension and six (6) inches in least dimension may be used. The percentage of fines shall be sufficient to fill all voids and insure a uniform and thoroughly compacted mass of proper density. Tire bales may be used adjacent to culvert structures up to a height limit stipulated in Item 132.3 (2) c above. The bales shall be anchored to the culvert wall or into the underlying soil to a depth that will not allow stream erosion around or under the structure to wash away the tire bales under average storm water runoff conditions. This will be left to the discretion of the Engineer.

(3) Compaction Methods. Compaction of embankments shall be by "Ordinary Compaction" or "Density Control" as shown on the plans.

(a) Ordinary Compaction. When "Ordinary Compaction" is shown on the plans, the following provisions shall govern:

Each layer shall not exceed eight (8) inches of loose depth, unless otherwise directed by

the Engineer. Each layer shall be compacted 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. Compaction shall continue until there is no evidence of further compaction. Prior to and in conjunction with the rolling operation, each layer shall be brought to the moisture content directed by the Engineer, and shall be kept leveled 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.

(b) Density Control. When "Density Control" is shown on the plans, the following provisions shall apply:

Each layer shall be compacted to the required density by any method, type and size of equipment which will give the required compaction. The depth of layers, prior to compaction, shall depend upon the type of sprinkling, mixing and compacting equipment used. However, maximum depth (16 inches loose and 12 inches compacted) shall not be exceeded unless approved by the Engineer. For tire chip fills, the maximum depth (loose) shall not exceed 12 inches. Prior to and in conjunction with the rolling operation, each layer shall be brought to the moisture content necessary to obtain the required density and shall be kept leveled with suitable equipment to insure uniform compaction over the entire layer.

Each layer shall be sprinkled as required and compacted to the extent necessary to provide the density specified below, unless otherwise shown on the plans.

Description	**Density, Percent**	**Moisture**
Non-swelling soils with plasticity index less than 20	Not less than 98	
Swelling soils with plasticity index of 20 to 35	Not less than 98 nor more than 102	Not less than optimum
Swelling soils with plasticity index over 35	Not less than 95 nor more than 100	Not less than optimum
Tire bale embankments	Not less than 98	
Tire chip embankments	Not less than 98	

The density determination will be made in accordance with Test Method Tex-114-E. Field density determination will be made in accordance with Test Method Tex-115-E.

After each layer of earth embankment is complete, tests as necessary may be made by the

Engineer. When the material fails to meet the density requirements or should the material lose the required stability, density, moisture or finish before the next course is placed or the project is accepted, the layer shall be reworked as necessary to obtain the specified compaction, and the compaction method shall be altered on subsequent work to obtain specified density. Such procedure shall be subject to the approval of the Engineer.

Excessive loss of moisture shall be construed to exist when the subgrade soil moisture content is four (4) percent less than the optimum.

The Contractor may be required to remove a small area of the layer in order to facilitate the taking of density tests. Replacement and compaction of the removed material in the small area shall be at the Contractor's expense.

When shown on the plans and when directed by the Engineer, the Contractor shall proof roll in accordance with Item 216, "Rolling (Proof)". Soft spots shall be corrected as directed by the Engineer.

132.4. Tolerances. The tolerances shall be as follows:

(1) Grade Tolerances.

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

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

(2) Gradation Tolerances. The Engineer may accept the material, providing not more than one (1) out of the most recent five (5) gradation tests performed are outside the specified limit on any individual sieve by more than five (5) %.

(3) Density Tolerances. The Engineer may accept the work providing not more than one (1) out of the most recent five (5) density tests performed is outside the specified density, provided the failing test is no more than three (3.0) pounds per cubic foot outside the specified density.

(4) 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.

Retaining-wall-backfill areas which are also in embankment areas will be measured for payment as embankment except as shown on the plans; such material shall meet the requirements for backfill material of the pertinent retaining-wall item(s). Limits of measurement for embankment in retaining-wall areas will be as shown on Standard Detail Sheet "Earthwork Measurement at Retaining Walls" (EMRW) in the plans.

Shrinkage or swellage factors will not be considered in determining the calculated quantities.

(2) Class 1. Embankment will be measured in its original, natural position, and the volume computed in cubic yards by the method of average end area.

(3) Class 2. Embankment will be measured by the cubic yard in vehicles as delivered on the road.

(4) Class 3. Embankment will be measured by the cubic yard in its final position as the volume of embankment computed in place between (1) the original ground surfaces or the surface upon which the embankment is to be constructed, and (2) the lines, grades and slopes of the accepted embankment, using the average end area method.

(5) Class 4. Embankment will be measured by the each for the tire bales and by the cubic yard in vehicles as delivered on the road.

Class 3 is a plans quantity measurement Item and the quantity to be paid for will be that quantity shown in the proposal and on the "Estimate and Quantity" sheet of the contract plans, except as may be modified by Article 9. 8. If no adjustment of quantities is required, additional measurements or calculations will not be required.

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", of the compaction method, type and class specified. This price shall be full compensation for furnishing embankment and tires; 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 "Density Control" 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.

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.