Tire Derived Aggregate

Overview

Tire derived aggregate (TDA) consists of scrap tires cut into pieces that have a basic geometrical shape and range between 2 inches (50 mm) and 12 inches (305 mm) in size and are intended for use in civil engineering applications" (ASTM D6270-08).

There are two types of TDA: Type A with a maximum size of 3 in. (75 mm) and Type B with a maximum size of 12 in. (305 mm). While these are the most commonly used sizes, TDA specifications are determined by the end use and will differ based on the contractor's technical, environmental and economic requirements for the project. TDA has become the commonly accepted description for this material because it better conveys the intrinsic engineering value of size-reduced scrap tire pieces as compared to the term tire chip or tire shred. However, the terms are often used interchangeably. The properties of TDA that create this engineering value and that civil engineers, public works directors and contractors need are:

- Lightweight (weighs 1/3 of what soil weighs)
- Low earth pressure (1/2 that of soil)
- Good thermal insulation (8 times better than gravel)
- Good drainage (10 times better)
- Compressible
- Vibration mitigation
- Low cost

TDA has been used as a construction material for over twenty years for various applications including lightweight fill, thermal insulation, vibration attenuation and drainage layers. Since 1992, when the first civil engineering applications were introduced to the marketplace, the range of uses for scrap tires and scrap tire derived materials has grown. In virtually all civil engineering applications, the scrap tire material replaces some other material currently used in construction, including soil, clean fill, drainage aggregate, and lightweight fill materials such as expanded shale and polystyrene insulation blocks.

For projects that need its unique properties TDA is often the most cost effective solution. In addition, TDA offers a high volume use for scrap tires. Typically, one cubic meter of TDA fill consumes 100 tires. Projects can range from 20,000 tires per application to over 2 million tires per application. TDA is a suitable material for both small and large-scale civil engineering projects making them an attractive material for engineers and contractors seeking a wide range of use.

TDA Processing

In general, tire derived aggregate can be made from passenger and truck tires or a mixture of tire sizes. The tire feedstock for TDA can be derived from current flow tires, stockpiled tires or site cleanup tires.

To prepare TDA, tires are fed into a primary shredder that cuts the tires using knives that rotate at slow speed. The most popular type of primary shredder consists of groups of spaced circular blades mounted on pairs of counter-rotating shafts. Opposite each blade on one shaft, a spacer of equal width on the other shaft permits the blades to counter-rotate in overlapping fashion. Ideally, the knife blades operate with small clearances in the overlap area.

This type of primary shredder has hooks on the knives that help pull the tire into the blades and cut the tire lengthwise. The corners of the knives act as cutting edges that together with the adjoining blade edges of the knives on the opposing shaft create the scissor action needed to cut the tires.

Another type of primary shredder utilizes knife rotors and rotor spacers that are permanently attached to the knife rotors. The machine has detachable blade sections bolted to the knife rotor. Wear plates or liners are also secured to each side of the rotor to protect against wear. This machine design permits closer spacing tolerance between the edges of the adjacent blade than can be achieved with conventional hook and shear machines. Feed rollers align and feed tires to the knives in this type shredder.

In general, for both type shredders the width of a tire shred is controlled by the knife spacing while the length of a shred can be as much as the diameter of the tire. A single pass through the primary shredder's knife configuration usually produces hoop-shaped strips of tire sections of varying lengths and the width of the blade cutters.

Quality Considerations for TDA

The quality of TDA is determined by the sharpness of the shredder knives and maintenance of the blades. Machines with sharp knife edges and close clearances between the blades produce a clean-cut TDA with few exposed steel belts, tire cords or wire. Dull knives tend to drag the rubber between the blades and tear the tire shreds into pieces producing lots of exposed lengths of tire cords or wires. In some cases, dull knives can produce a significant amount of free wire, i.e., wire that is not at least partially embedded in rubber. Dull knives also tend to produce shreds with a larger width since they may not completely separate two pieces.

There are two kinds of wire in the tire. Bead wire is larger in diameter (about 1/8 inch diameter) and belt wire that is much smaller in diameter. While wire removal can be accomplished in several ways, some methods such as debeading tires prior to shredding may be too costly for producing TDA for civil engineering applications. More often, processors use magnets such as a head pulley magnet in which the head pulley at the top of the conveyor is magnetized and cross-belt magnets mounted over a conveyor belt or vibrating table to remove wire pieces.

Typically, one pass through a primary shredder produces rough shred TDA. Depending on the application, TDA can be further sized by multiple passes through the shredder. TDA can also be sized in a rotating screen called a trommel or in a classifier (also called a star screen). The trommel is a revolving cylindrical screen used for separating mixtures of materials into their constituents according to size and density. Also an apparatus for separating mixtures of materials, a classifier consists of rotating parallel bars, spaced several inches apart, which carry the large pieces off the end of the classifier.

TDA in Civil Engineering Applications

The majority of civil engineering applications for tire derived aggregate are occurring in the construction industry. Most prominent are TDA uses suitable for construction projects in road building and repair, transportation infrastructure, commercial and residential building and landfill design and construction. These uses are diverse and growing as contractors, engineers, designers and architects in both the public and private sectors realize the engineering properties and the economic and environmental value TDA brings to a project. In addition, new case studies, educational videos and mounting performance and monitoring data from full-scale instrumented projects are contributing to the expanded use of TDA.

There are five primary categories of civil engineering applications for TDA:

1. Road Construction

- Highway Embankments : TDA can be used as lightweight fill over weak foundation soils to limit settlement and increase slope stability. Based on the requirements of the project, TDA can also be used as replacement for conventional fill in embankments.
- Landslide Stabilization: TDA can be used as lightweight fill at the head of a landslide to reduce the weight pushing the slide downhill.
- Road Sub-grade: TDA can be used lightweight fill over weak soils.
- Thermal insulation to limit frost penetration: TDA used as an aggregate layer in road beds in cold climates can help mitigate the depth of frost penetration and associated effects that contribute to frost heaves.
- Retaining wall and bridge abutment backfill: using TDA as backfill behind retaining walls and bridge abutments reduces lateral forces on the inside o the retaining wall or abutment walls.
- Edge drains and pipe trenches: TDA has higher permeability than most granular aggregate and can be used as an effective medium for providing beneficial drainage in edge drains along roadsides, drainage layers beneath roads and in pipeline or other utility line trenches.

2. Septic System Construction

- TDA is used as a stone aggregate replacement in the absorption trenches of residential septic systems. TDA has a higher porosity than stone and can increase drain field storage capacity by 30 percent.

3. Light-rail Construction

- TDA reduces ground borne vibrations transmitted away from the tracks on commuter rail lines.
- Typically, a 1-ft. thick layer of TDA placed under the traditional stone ballast and gravel sub-ballast layers in light rail construction is effective in mitigating vibrations that transmit the noise of the passing train away from the tracks to adjacent homes and businesses.

4. Landfill Construction

- Drainage layer in a leachate collection system: TDA is incorporated as a component of the leachate collection system to provide drainage, limit freezing of underlying clay barriers (in cold climates) and protect the liner system from damage during construction and operation. TDA for this application is generally a maximum size of 3 inches.
- Leachate recirculation trenches: TDA can be used as backfill around leachate recirculation trenches typically replacing conventional materials such a granular soil. Leachate recirculation trenches are used to reintroduce collected leachate back into the waste.
- Gas collection trenches: TDA used in this application replaces granular soil as the bedding material for gas extraction pipes in the collection trenches These trenches are usually located beyond the footprint of the landfill to control the lateral migration of landfill gas.
- Gas collection layer: TDA layers provide good drainage and help protect clay and geomembrane liners in landfill gas collection systems.
- Drainage layers in landfill covers: TDA can be used as a drainage layer in landfill covers. In this application, the TDA is typically enclosed in geotextile decrease the amount of fines in the TDA layer and maintain TDA's high permeability.
- Cover system: TDA can be used as daily and intermediate cover material typically in a 50/50 mix of TDA and soil. Some applications also specify TDA size be no larger than 4 inches by 10 inches in size.

5. Building Foundations

- Backfill along foundation walls: TDA can be used as a lightweight backfill material along foundation walls in residential and commercial constructior
- TDA's physical properties, including its ability to allow water to drain quickly, its thermal insulation qualities and its low lateral earth pressure make this tire material well suited for this application.

TDA Product Characteristics

Type A TDA

- **Typical size:**

  3 inch minus
- **Volume and performance measures:**

  1 ton = 1.4 cubic yards

  1 ton = 100 tires

  1 ton = 100 tire

  In place density: 45-58 lbs. per cubic foot

  Permeability: >1 cm/sec for many applications
- **Uses:**

  Drainage material, septic leach fields

  Vibration dampening layer in light rail construction

Gas collection media

Leachate collection systems

Type B TDA

- **Typical size:**

  12 inch minus

- **Volume and performance measures:**

  1 ton = 1.5 cubic yards

  1 ton = 100 tires

  In place density: 45-50 lbs. per cubic foot

  Permeability: >1cm/sec for many applications

- **Uses:**

  Lightweight and conventional fill for embankments

  Lightweight backfill for retaining walls

  Vibration mitigation

Engineering Properties of TDA

Civil engineering applications for tire-derived aggregate are accepted and routine in many markets today. The means exist to process and reduce scrap tires to many particle sizes. It is also clear that these sized-reduced tire pieces have somewhat different engineering properties than other materials in that same size range and do not always qualify as direct replacements for the materials to which they seem comparable. The unique combination of physical properties found in tire derived aggregate will play a critical role in finding new and profitable uses and applications for TDA. These include:

• gradation	• specific gravity/water absorption
• unit weight	• thermal conductivity
• compressibility	• resilient modulus
• sheer strength	• lateral earth pressure
• time dependent settlement	• permeability

Effect of TDA on Water Quality

Field studies of tire shreds placed above the water table show that tire shreds pose no significant health or environmental risks. Studies, including a 2009 Minnesota Department of Transportation project, continue to evaluate applications in which tire shreds are placed below the water table.

Civil Engineering Uses for Whole Tires

Use of whole scrap tires and tire sidewalls in civil engineering project includes:

- Construction of retaining walls

- Drainage culverts
- Road-base reinforcement
- Erosion protection
- Fill material – whole baled tires

For these applications, it is the responsibility of the design engineer to determine the appropriateness of using scrap tires in a particular application and to select applicable tests and specifications to facilitate construction integrity and environmental protection.

Civil Engineering Standards

ASTM International, formerly the American Society for Testing and Materials (ASTM) produces the largest voluntary standards development systems in the world. This not-for-profit organization publishes thousands of standards per year used around the world to improve product quality, enhance safety, facilitate market access and trade, and build consumer confidence. Working in an open and transparent process, ASTM producer, user and consumer members participate in developing industry standards, test methods, specifications, guides and practices that support industries and governments worldwide.

The ASTM standard that applies to TDA and scrap tires used in civil engineering is:

ASTM D6270-08
"Standard Practice for Use of Scrap Tires in Civil Engineering Applications"

Provides guidance for testing the physical properties, design considerations, construction practices, and leachate generation potential of processed or whole scrap tires in lieu of conventional civil engineering materials, such as stone, gravel, soil, sand, lightweight aggregate, or other fill materials.

This practice is intended for use of scrap tires including: tire derived aggregate comprised of pieces of scrap tires, TDA/soil mixtures, tire sidewalls, and whole scrap tires in civil engineering applications. This includes use of TDA and TDA/soil mixtures as lightweight embankment fill, lightweight retaining wall backfill, drainage layers for roads, landfills and other applications, thermal insulation to limit frost penetration beneath roads, insulating backfill to limit heat loss from buildings, vibration damping layers for rail lines, and replacement for soil or rock in other fill applications. The practice also covers the use of whole scrap tires and tire sidewalls in construction and fill applications.

ASTM D6270-08 includes guidelines to minimize internal heating of TDA. The guidelines are applicable to fills less than 3 meters (10 feet) thick. Related material and design properties and data are provided in this standard to facilitate the use of TDA. The guidance document discusses the metal content for tire shreds as well as acceptable amounts of wire protrusion in TDA pieces. It lays out requirements for the general condition of tire shreds used in fill applications including a discussion on contaminants. In addition, the standard practice includes information about the effect of tire shreds on water quality.

TDA GLOSSARY OF TERMS

Bead Wire

High tensile steel wire surrounded by rubber, which forms the bead of a tire that provides a firm contact to the rim. The bead is the anchoring part of the tire, which is shaped to fit the rim and is constructed of the bead wire wrapped in woven fabric and held by the plies.

Civil Engineering Applications

A form of reusing scrap tires, either whole or shredded, in place of naturally occurring materials in construction.

Classifier

Any apparatus for separating mixtures of materials into their constituents according to size and density. Also referred to as a star screen.

Fines

Rubber material that passes through a standard size screen on which coarser fragments are retained.

Rough Shred

A piece of shredded tire that is larger than 2 inches by 2 inches by 2 inches, but smaller than 30 inches by 2 inches by 4 inches. It is usually the product of one-pass through a shredder or other size reduction machinery.

Tire Baling

Process in which up to 100 scrap passenger tires are placed onto a rod and compressed into a condensed block and secured with plastic or metal ties. Finished bales can weigh between 888 and 2,000 pounds.

Tire Chip

A piece of scrap tire that has a basic geometrical shape and is generally between 0.5 inches (12 mm) and 2 inches (50 mm) in size and has most of the wire removed.

Tire Derived Aggregate (TDA)

Pieces of scrap tires that have a basic geometrical shape and are generally between 12 mm and 305 mm (0.5 inches-12inches) in size and are intended for use in civil engineering applications.

Tire Shred

A piece of scrap tire that has a basic geometrical shape and is generally between 2 inches (50 mm) and 12 inches (305 mm) in size.

Trommel

A revolving cylindrical screen used for separating mixtures of materials into their constituents according to size and density. Also referred to as a trommel screen.

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