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www.mechanicalconcrete.com U.S.Patent 7,470,092 B2

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Proposed West Virginia Division of Highways Draft
General Specification for the Construction of
Mechanical Concrete® Geocylinder Confinement Systems
For Roadway Base or Shoulders,
Gravity Retaining Walls or Mechanically Stabilized Earth (MSE) Walls,
Load Bearing Walls, Abutments or Load Bearing Pier Foundations.

General Description: This work shall consist of furnishing and installing geocylindrical aggregate reinforcement in accordance with these specifications and in reasonable close conformity with the lines, grades and dimensions shown on the plans or established by the Engineer. Design details for Mechanical Concrete® geocylinder aggregate reinforcement, base aggregate minimum thickness, asphalt thickness and associated details shall be shown on the plans.

Using accepted civil engineering design techniques and processes and traditional construction techniques, Mechanical Concrete® geocylinders may be designed and constructed to function as a foundation, road base, gravity or mechanically stabilized earth (MSE) retaining walls or load bearing walls, bridge abutment or pier beam support.

The technique consists of confining stone or other suitable aggregate materials within a structural geocylinder. This stabilizes and solidifies the stone. The geocylinders are thin-walled circular, cylindrical segments. The geocylinders are filled with stone aggregates, sand, or other granular soil materials. The structural geocylinders function as lateral reinforcing by confining the aggregates and resisting the lateral pressure generated within the aggregates from its dead weight and from any the superimposed dead and live loads

General Execution of the Work: The Contractor shall be responsible for obtaining the geocylinder aggregate reinforcement materials, as supplied through the Reinforced Aggregates Company, www.mechanicalconcrete.com, or a designated tire recycling organization, and associated materials and components that meet all requirements of the Specification. For the purpose of this specification geocylinders are tire-derived-geo-cylinders, TDGC, made from a waste auto tire by removing both sidewalls.

The geocylinders and the aggregate fill shall be placed on the prepared subgrade soil in a flat, single layer, collection creating a web covering the area to be stabilized. The subgrade soil shall be of suitable bearing strength and graded or leveled to the appropriate design elevations. If specified, a layer of separation fabric or geosynthetic mesh shall be placed on top of the subgrade soil. The geocylinders shall be arranged to cover the area shown on the drawings. The TDGC shall be laid out, *round or circular to the eye*, in tangent point contact with other cylinders. This means the TDGC shall not visibly appear oval or egg shaped. The boundary of the area to be coved shall be out lined with edge cylinders which shall contact two or three other cylinders. The interior cylinders shall be placed to fill in the bounded area and make tangent point contact with three or four other cylinders. In roadway base and foundation uses, before filling with

stone, to preserve their arrangement and geometry each geocylinder shall be nailed with a nail gun to the immediately adjacent cylinders with a nail of sufficient length to fully penetrate the cylinder wall thicknesses of both cylinders or otherwise attached with a screw, string or wire. Then each horizontal layer of geocylinders shall be filled with the specified aggregate material.

When the application specifies additional reinforcement on top of or between layers of geocylinders, as shown on the drawings, geo-synthetic mesh material the width of the geocylinder area to be covered is placed on the top of the stone filled geocylindrical segments. This material is intended to further integrate the cylindrical elements into a relatively uniform structural mass suitable for sustaining its own weight and further distributing the weight of superimposed loads.

The Mechanical Concrete® geocylinders may be designed to function as the facing wall of a mechanically stabilized earth (MSE) retaining wall system. The MSE geo-synthetic mesh reinforcing layers shall be anchored to the TDGC by extending the MSE grid layer on top of the filled stone surface the full width of the diameter of the geocylindrical element overhanging the external face of the cylinder.

Multiple wythe walls designed and constructed as gravity retaining walls or as load bearing walls and as temporary bridge abutments, use the same basic bearing and retaining wall design and construction procedures. For load bearing walls the height shall not exceed six (6) times the wall thickness without additional wall stiffening measures being designed.

Materials

Certification of Materials and Submittals:

Specification Compliance Certification: Prior to construction the Contractor shall submit to the Engineer a certification that the tire-derived-geo-cylinders has been evaluated and are in full compliance with this Specification. The Contractor's submittal package shall include; but not be limited to; the Supplier's written certification that all tire-derived-geo-cylinders used to produce the Mechanical Concrete® were made from waste auto tires that were sold in the commerce of the United States of America and met all the original tire specifications and requirements for use on over the road automobiles or trucks.

Base Course Reinforcement Tire-Derived-Geo-Cylinders: The geocylindrical reinforcing shall be a thin walled, circular, cylindrical segment of a material suitable for absorbing the circumferential tensile stresses resulting from the lateral pressure generated by the weight of the stone and any superimposed dead and live loads.

For the purpose of this specification the geocylindrical reinforcing element is a used automobile tire with both the sidewalls removed. The tire-derived-geo-cylinders diameters shall not exceed 28 inches and not be less than 24 inches. The tire-derived-geo-cylinder width shall be not less than 7 inches and not exceed 8 and one half inches. Passenger car tires shall have sidewalls removed to within one inch of the surface of the tread to a tolerance of plus three-quarters of an inch (one and three quarters inches) and minus of zero. The tire-derived-geo-cylinders, TDGC, shall be of uniform diameter and tread width and have no internal steel for fiber belts exposed in the tread surface. When

functioning as a tire, the tire-derived-geo-cylinder shall have had a maximum operating air pressure of at least 44psi.

Earth Retention Reinforcement Tire-Derived-Geo-Cylinders: For wall segments using stacked tire-derived-geo-cylinders: the overall 'inflated diameter' dimension of passenger car and light truck tires shall be within plus or minus one-half inch and the 'loaded section width' dimension shall be within plus or minus one half inch; the overall 'inflated diameter' dimension of 'medium' (large semi and dump) truck tires shall be within plus or minus one inch and the 'loaded section width' dimension shall be within plus or minus one inch. Passenger car and light trucks tires shall have sidewalls removed to within one inch of the surface of the tread to a tolerance of plus three-quarters of an inch (one and three quarters inches) and minus of zero. Medium (Semi) truck tires shall have sidewalls removed to within two inches of the surface of the tread to a tolerance of plus three quarters of an inch (two and three quarter inches) and minus of zero inches. All tire cylinders so prepared and used as Mechanical Concrete® geocylinders shall have sufficient circumferential tensile strength to withstand the lateral stress generated by the weight of stone aggregates and the superimposed loads based on standard hoop stress calculations. The maximum Mechanical Concrete® internal pressure on the inside of the tire-derived-geo-cylinder shall not exceed 25 psi for auto and light truck tires and 50 psi for medium truck tires when experiencing a standard AASHTO Truck Wheel Load.

Stone: For structural applications and foundations the stone aggregate placed inside the geocylinders shall be limestone or other suitable virgin or recycled stone, recycled asphalt pavement, industrial slag or stone aggregate with a comparable compressive strength. In remote areas, local river gravel may be used. For highway use the size of the stone shall conform to AASHTO coarse aggregate size number 57 or number 3 or another selected relatively uniform sized stone particle gradation approved by the engineer. The engineer may specify the use of sand, indigenous granular soil materials or the recycling of existing roadway or shoulder stone base be placed in the geocylinders if the material is suitable and without excessive clay fines. Roadway shoulders shall be surfaced on top of the geocylinders with 4 inches of optimally compacted one-and-one half inch crusher run stone aggregates.

Stone Leveling Course: The site subgrade shall be prepared to receive the Mechanical Concrete® geocylinders by removing all topsoil and organic materials and generally graded to the specified elevation down to an undisturbed soil with a suitable bearing capacity to sustain the loads generated by the structure to be built.

For structures such as abutments, piers or walls and other multiple-course vertical applications, to receive the first course of Mechanical Concrete® geocylinders at the appropriate elevation, a minimum four inch leveling course of three-quarter inch crusher run limestone or equivalent material shall be placed and compacted to ninety percent of standard Procter density. This leveling course shall be six inches wider than the diameter of the geocylinders and shall be level to within plus or minus one half inch vertical in thirty six inches horizontal.

When soft subgrades such as soft clays and sands are encountered with allowable bearing pressures equal to or less than one ton per square foot; for roadway base stabilization, shoulder stabilization, site stabilization, and other horizontal applications; a minimum of one layer of woven separation fabric shall be first placed to cover such soils where Mechanical Concrete® geocylinders are to be placed.

Method of Construction: All work shall commence from the elevation of the subgrade leveling course or separation fabric and as shown on the drawings. Geocylindrical segments shall be placed, *round or circular to the eye*, one by one so that each is in contact with the next and those geocylinders around it. This means the TDGC shall not visibly appear oval or egg shaped. For dozer / machine aggregate filling each cylindrical element shall be attached to the next element with a nail, string or wire or other acceptable exterior use device to temporarily preserve the arrangement and geometry of the geocylinders during the stone filling process.

The geocylinders shall be laid relatively plumb and level to the line and grade shown on the drawings. The vertical face of these elements in a single wythe wall shall be not laid steeper than a slope of one horizontal to six vertical.

Each layer of geocylindrical cell elements shall be placed on top of the previous layer and attached together in the same manner to preserve their overall geometrical relationship during the construction process. These vertical geocylindrical elements shall be laid at the batter slope shown on the drawings but not steeper than one horizontal to six vertical. As the each row is filled with stone, adequate and appropriate care, by means of a plumb line or other leveling device, shall be taken to see that the line and grade geometry shown on the drawings is preserved.

When the design calls for the insertion of a layer of geo-synthetic mesh, the fabric shall be placed between the geocylindrical segments and laid the full width of the geocylinder and extend to overhang its face as a friction anchorage for the geo-synthetic mesh. Intermediate layers of cylinders shall then be laid. When a next level of geo-synthetic mesh is called for by the design it shall be placed in a similar manner.

The work shall proceed in this manner until the Mechanical Concrete® structure or site is completed.

Multiple Wythe Walls: For structural bearing walls such as bridge abutments, piers or gravity retaining walls, the plans may call for multiple wythe walls of Mechanical Concrete® geocylinders. The geocylinders in the second wythe shall be nested at the interface of the cylinders in the adjacent wythe. Each cylinder in the second wythe shall be nail attached otherwise attached to the cylinders in the adjacent wythe at each contact point. In addition to this attachment a layer of geo-synthetic mesh shall be laid covering both wythes at every other course. If three or more wythes are called for by the plans they shall be constructed in a like manner. Multiple wythe bearing walls shall be constructed vertically plumb and shall be made of geocylinders of equal original diameters with a tolerance of plus or minus one quarter of an inch and original widths of plus or minus one quarter of an inch. In all other respects multiple wythe walls shall be constructed in accordance with these specifications.

Roadway Bases and Site Stabilization: Mechanical Concrete® geocylinders for use in a confined aggregate roadway base or in construction site stabilization requires topsoil and cover to be excavated to the level of the subgrade for the desired road cross section width. Where soft subgrade soils remain, with allowable bearing pressures equal to or less than one ton per square foot, and/or if positive drainage is desired; as a minimum requirement one layer of woven stabilization geotextile fabric shall be placed covering the exposed subgrade extending into and covering the ditch section.

The geocylinders are first laid out on the subgrade, *round or circular to the eye*, to outline the area boundary to be covered and then the bounded area is filled in generally parallel rows. Each geocylinder will contact the adjacent geocylinder and those in the next row at one point. When interior geocylinders are in place they shall be in contact with adjacent geocylinders at a minimum of three points. This shall proceed until the entire width of the roadway area is covered. In roadway base uses, before filling with stone, to preserve their arrangement and geometry each cylinder shall be nailed with a nail gun to the immediately adjacent cylinder with a nail of sufficient length to fully penetrate the cylinder wall thicknesses of both cylinders or otherwise attached with string or wire. An interior cylinder shall be attached a minimum of three locations with adjacent cylinders. Geocylinders shall be hand adjusted upward during nailing so that the top surface is relatively flat.

The appropriate specified aggregate is then placed inside the geocylinder. It shall achieve an optimum density based on gradation characteristics or by means of further compaction. Unless otherwise specified the size of the stone shall conform to AASHTO coarse aggregate size number 57. A minimum four , (4”), wearing course of compacted, one-and-one-half inch, crusher run, stone aggregates shall then be placed on top of the Mechanical Concrete® prior to paving or other surfacing. Ditches shall extend four to six inches (4” to 6”) below the subgrade soil elevation and be filled to the upper surface of the Mechanical Concrete® with 3 to 4 inch ‘gabion’ stone to the elevation of the top of the geocylinders.

Mechanical Concrete® road bases can support any type of wearing surface. If hydraulic concrete, asphalt concrete, or resin impregnated or compacted stone surfaces are used they shall be designed and constructed to meet the wheel loading, duty requirements and drainage requirements of the roadway and standard state highway specifications. For compacted stone surfaces a minimum crown or side slope of one-half-inch per foot is herewith specified.

Single Pier Foundations: Mechanical Concrete® for use as a pier foundation generally requires topsoil and cover to be excavated to a frost free subgrade depth suitable to the geographic locale. This use assumes that the engineer, contractor or owner has established through tests or other acceptable engineering methods that the subgrade soil or geologic material is suitable to support the required superimposed foundation loads and that the superimposed loads do not exceed 12 tons per square foot. For a single diameter geocylinder pier foundation the subgrade is leveled and covered with a suitable layer of vinyl or non-woven geotextile. The first cylinder is then placed and filled with an appropriate stone as called for in these specifications. Additional cylinders are placed on top of each other until the desired height is reached. In no case shall a single cylinder

pier height exceed four (4) times the diameter of the cylinder. A leveling layer of number 8's or hydraulic cement mortar shall be applied to the top cylinder stone prior to placing the structural beam or column elements.

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