GROUND CONTROL TECHNIQUES UTILIZING POLYMER GRID STRUCTURES

By

Brian E. Travis

ABSTRACT

Lightweight polymer grids have recently been introduced to the mining industry. They are currently being used for roof and rib control, longwall shield recovery, safety guarding or barricade, high-wall screening, internal reinforcement of gunnite/shotcrete applications, sub-base reinforcement, construction of steepened slopes, retaining walls, mine reclamation (i.e., erosion control, turf reinforcement), and in numerous mining waste related projects.

These polymer mining grids utilize a strong, lightweight polymer, usually special grades of polypropylene or polyethylene. High tensile strengths are achieved by molecular orientation of these polymers in the manufacturing process.

The first step in the manufacturing process is to extrude the polymers into thick continuous sheets. These sheets are then punched, and drawn into open grid structures. Aperture size and configuration are controlled by the geometry of the punched hole and the degree to which the grids are stretched.

The drawing process is the key to the molecular orientation required for the tensile strength. These long chain polymer molecules in their natural state have a random orientation. When stretched, the molecules are pulled into a parallel alignment, thus creating a lightweight product with tensile strength comparable to steel.

The finished polymer mining grid product is a viable alternative to conventional supplemental roof control meshes such as chain link fence and welded wire.

Polymer mining grids are a fraction of the weight, have comparable load support qualities, and will not rust or corrode in even acidic or alkaline conditions. Specific flame retardant additives can also be incorporated to make the polymer grid self extinguishing for use in underground “gassy” environments.

INTRODUCTION

The use of polymer grid structures is expanding throughout the mining industry, as their use expands, so do their applications. They are applied in underground as well as surface mine and plant operations for a variety of mining and civil engineering projects.

These applications, as presented here, are broken into two groups. The first group is underground ground control techniques; the second is surface mining [civil/construction engineering] ground control techniques. Following is a discussion of the products, manufacturing process, applications, and techniques involved in their use.

1 Mining Products Manager, Tensor Earth Technologies, Inc., Morrow, GA

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MANUFACTURING PROCESS

The production of polymer grids for underground mining applications is accomplished in a three-stage manufacturing process:

1. SHEET EXTRUSION - A multi-component blending system allows for precise control of the raw material additives mix. This on-line blender feeds directly to the extruder, which compresses and melts the plastic pellets, then pumps the molten extrudate. A gear pump and a melt mixer are included in the extrusion system to provide a very accurate, consistent flow of a homogenous melt. At the end of the extruder is a sheet die, which evenly distributes the melt flow across the desired sheet width.

The sheetline portion of the process accepts the molten sheet, cools it slowly and uniformly, controls the sheet thickness, and provides for a smooth surface finish. The sheet thickness tolerances are very tight in the sheet process, with a +/- 1.0% specification in both the machine and transverse direction. The sheet thickness is monitored at all times with an on-line thickness profiler. The finished sheet is then wound onto large reel carts for transfer to the next process.

2. SHEET PUNCHING - The second stage of the polymer grid production process involves punching the sheet sheet with a pattern of holes, prior to its orientation. Specially designed punch tools and heavy duty presses are required. Several hole geometries and punch arrangements are possible, depending upon the finished product properties of the grid, in order to meet the requirements of the ground control application.

Once punched, the sheet is again wound onto reel carts for transfer to the orientation process.

3. ORIENTATION - The polymer raw materials used in the manufacture of the grids are selected for their excellent physical properties. However, the very high strength properties of the finished grid are not fully realized until the basic polymer's long chain molecules are stretched (oriented) for the mining grid, this is accomplished in a two stage process.

Initially, the punched sheet is heated to a critical point in the softening range of the polypropylene polymer. Once heated, the sheet is stretched in the machine direction, through a series of heated rollers. During this uniaxial stretching, polymer is drawn from the junctions into the rims as the orientation effect passes through the junction zones. This guarantees continuity in molecular orientation in the resultant structure.

In the second stage, the uniaxially oriented grid enters a heated tension frame (stretcher) where the material is stretched in the transverse direction, at right angles to the initial stretch. This biaxial stretch process imparts a high degree of orientation and stretch throughout all regions of the grid.

Exiting the stretching process, the material is quenched (stabilized), and then slit and wound to meet customer roll dimension requirements.

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UNDERGROUND APPLICATIONS

ROOF AND RIB CONTROL

Polymer grids structures are ideal for use in underground mines as a supplemental ground control product. They are utilized in conjunction with roof bolts, term bolts, steel sets or arches, or other "primary" ground control structures.

 Typically, the polymer grid is unrolled and applied to the rib or roof as depicted in Figures 1 and 2. They are used to contain debris that would fall from the roof or rib between the primary support structures (in this case, roof bolts).

These polymer grid structures are a fraction of the weight of comparable metal products, have comparable load support qualities, and will not rust or corrode in acidic or alkaline conditions. As a result, increased productivity and a reduction in lost time injuries have been reported by coal, metal and non-metal mines and in civil tunneling projects.

Another characteristic of these products that enhance their applicability to underground operations is that they will not impede excavation equipment. In this application, they are used in conjunction with fiberglass or composite bolts. This is important in pillar retreat mining, pilot tunnels, and in longwall "panel side" roof and rib control. In these applications, it is necessary to mine or cut through previously "screened" areas. These polymer structures can be cut into small pieces which prevents wrapping the material around continuous miner, shearer or road header drums. Thus, there is no damage to bits, bearings or conveyance systems. Typically, utilised metal products (i.e. welded wire, chain link, or expanded metal) must first be removed prior to excavation therefore exposing miners to unsafe, unstable ground conditions.
LONKINAIL SHIELD RECOVERY

One of the most innovative applications of these polymer grid structures is in their use in longwall shield recovery operations.

In this application, the polymer grids are employed to protect men and equipment during longwall “moves”. Traditionally, chain link or welded wire was incrementally applied over the longwall shields as the system approached the “stopping point” or as the panel was exhausted. This facilitated shield removal to the face by “sheathing” the shields to prevent gob or goaf from flowing into the workplace. However, due to their weight, this required handling and fastening (clipping) many small rolls together underground on the face.

When utilizing the polymer grid structures in this application it is possible to construct large segments of the longwall “screen” on the surface and transport it underground ready to be installed in one segment or in three or four segments 61 m (200 ft.) long. Following is a description of one method employed in this “screening” process.

Bolts are installed, at an angle, where the roof and rib meet. This usually requires ten (10) to twelve (12) roof bolts with plates and turnbuckles. These are spaced 76.2 cm (30 in.) apart or the width of cut of the shearer. Approximately 10.16 cm (4 in.) of bolt should be left exposed and installed between 2 + 16 and 1 + 85 and 2 + 00 and 2 + 27. (Figures 3 and 4)

The first roll is then attached, by chain, to the shearer and pulled onto the face. When the shearer has advanced 61 m. (200 ft.), the second roll is attached to the tail of the first roll and the shearer is advanced another 61 m. (200 ft.). This is done until the rolls are laying end to end the entire length of the face.

A spool of 14.3 mm (9/16 in.) or 19 mm (3/4 in.) wire rope is placed on a spool stand in the next crosscut. (Figure 5). Then the wire rope is attached onto the shearer and pulled to the tailgate allowing it to run on the toes of the shields. Then the wire rope is unhooked from the shearer and a loop is made in both ends using three (3) Crosby clamps (Figure 6). These loops are then hooked onto the first roof bolt in the head and tail gates and tensioned with a come-a-long.
The leading edge of the polymer grid is then fastened to the rope (duged). The seams between the 61 m. (200 ft.) rolls are also fastened (Figure 7). Once the rope and seams are duged, the rope is placed under the canopy tips. The shields can then be lowered and advanced and the remainder of the roll is hung under the canopy tip (Figure 8). A full face pass is made and the procedure is repeated until the stopping point is reached. The shields are now encompassed with the polymer grid and the wire ropes on 76.2 cm. (30 in.) centers running the length of the face.

The remaining gap between the canopy tips and the face is then bolted and planked and longwall equipment recovery can begin (Figure 9).

As mentioned above, this is only one of the many variations utilized to date. Other alternatives include fabricating one segment the entire width of the face (on the surface), then diging the wire ropes onto the grid, rolling it into a tight roll, and making one delivery to the face. Often times, the roll will be ensheathed in a fused polyethylene pipe to protect it during transport underground.

Productivity increases by reducing longwall move times. Operators employing these methods have reported saving from several shifts to several days off of their previous best longwall “move” times.

UNDERGROUND (MISCELLANEOUS)

There are many other “miscellaneous” applications in underground mining activities. The polymer grid structures are ideal for control of “soft bottom” (sub-base reinforcement), safety barricade, and, because of their flexural rigidity, they are being applied to ventilation curtains to prevent “leakage” or pressure loss.
SURFACE APPLICATIONS
(CIVIL/CONSTRUCTION ENGINEERING)

SUB-BASE REINFORCEMENT

Polymer grid structures (geogrids) are also applied to a wide range of engineering and construction ground control projects for surface applications.

In sub-base reinforcement (construction over soft soils), these geogrids have met new standards of load support capability for construction over soft soils and weak subgrades.

Roads, parking lots, embankments, foundations, rail lines, and commercial and industrial yards can all be constructed with greater strength and economy by utilizing the geogrid structures. Also, reliable site access, during construction, can be assured by reinforcing access roads with geogrid structures.

![Diagram of geogrid application](image)

**FIGURES 16 - 17**

SLOPE REINFORCEMENT

Highway, railway and property development embankments, containment dikes, levees and landslide repairs can all be reliably constructed at any slope angle, even vertical, without risk or the expense of conventional retaining walls. (Figures 18-23)

An unreinforced slope has a natural angle of repose that is dictated by the shear strength of its soil. Typically, this may range from 20° for clay to 35° for sand and gravel. With a typical safety factor, unreinforced soil slopes are usually constructed at angles of 30° to 35° from the horizontal.

Geogrids, when emplaced in soil, form a reinforced soil composite that has high internal stability. Geogrid reinforced slopes can, therefore, be constructed far more steeply than the soil's natural angle of repose. The result is much more efficient construction and use of land than conventional methods can safely allow. (Figures 24 and 25)

![Diagram of geogrid slope application](image)
These polymer grid structures are being applied as described above and in many other innovative applications. Both the products and the applications are constantly evolving to meet the mining industry's challenging needs.

Retaining Walls

These geogrids are utilized to mechanically reinforce vertical retaining walls in much the same manner as described in the steepened slope application. These walls must provide stability against the pressures exerted by backfill soils and heavy surcharge loads. Typically, they are used for architectural and site development applications (Figure 26).