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TMP POLYPROPYLENE BIAXIAL GEOGRIDS

QA/QC MANUAL

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EXECUTIVE SUMMARY

TMP America, LLC manufactures high-performance polypropylene geogrids which are used in soil reinforcement applications. The products help provide innovative and cost-effective alternatives to many traditional technologies and practices used in various construction markets including transportation, site development, waste containment and marine structures.

Quality Control (QC) and Quality Assurance (QA) procedures are carried out regularly to ensure the finished products meet or exceed the company's published specifications. These include laboratory tests and other evaluations conducted according to published and well-established industry standards. Appropriate corrective actions are employed to eliminate any non-conformance.

This manual describes the procedures adopted by TMP to ensure only the highest quality products are provided to its customers.

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1. INTRODUCTION

TMP is dedicated to providing the highest quality products to its customers. The purpose of this manual is to document the QA/QC procedures used during the manufacture of polypropylene biaxial (BX) geogrids; the general structure of a BX geogrid is shown in Figure 1. The procedures outlined in this document pertain to all stages of the production process for this product i.e. from the receipt of raw materials to shipping of the finished product.

BX geogrids are principally manufactured from Polypropylene (PP) granules. The polymer is first extruded to form a plastic sheet, perforated using a high-impact punch press and finally stretched in orthogonal directions within specialized ovens. The stretching process results in the alignment of the PP chain molecules and imparts the high stiffness at low strain characteristics associated with BX geogrids.

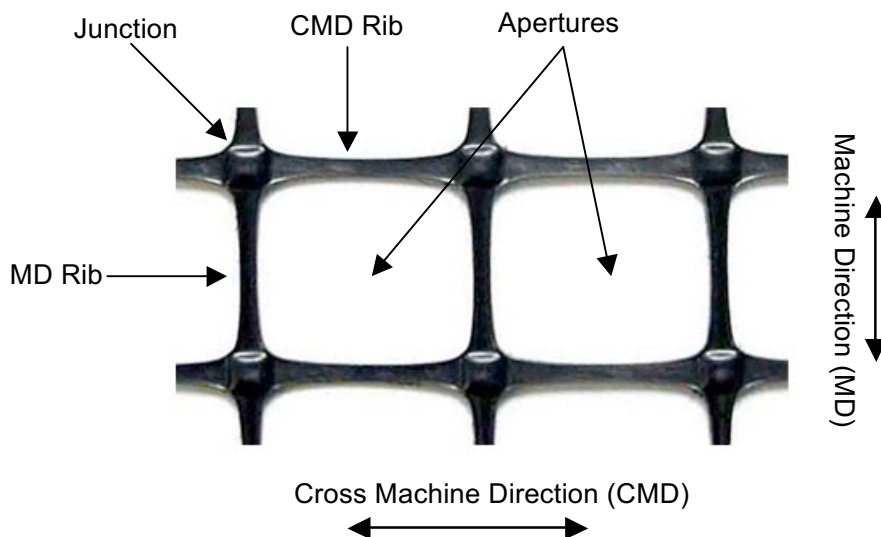


Figure 1: Typical biaxial geogrid structure

2. PROCEDURES USED DURING THE MANUFACTURING PROCESS

Quality Control procedures are carried out throughout each step of the manufacturing process. The principal product characteristics are measured at predetermined frequencies, with the data recorded and stored for future reference. For a given product run, in the event that any characteristics are found to be non-compliant with the process itself or the product's specification, that particular batch is tagged as being "non-conformant". A non-conformance report is developed documenting the issue(s) and corrective action is taken to prevent future reoccurrence. Non-conforming products are transferred to the plant's regrind facility and converted back into raw material form, ready for reuse if appropriate.

The physical and mechanical properties of BX geogrids are tested at predetermined frequencies using appropriate standards developed by American Society for Testing Materials (ASTM) and Geosynthetics Research Institute (GRI). Full details of the standards used by TMP are provided in the reference section at the back of this document.

2.1 Raw Materials

2.1.1 Polypropylene Resin

Testing and other protocols for the PP resin are detailed in Table 1. Bulk trucks deliver virgin PP resin to the plant in pellet form. At least one sample is retrieved from each truck and analyzed in the TMP laboratory using melt flow index testing. In addition, the resin manufacturer's identification and production lot numbers are recorded and stored for future reference along with the supplier's own quality control data.

Characteristic	Test Method	Frequency
Resin Identification	N/A	Once per delivery
Melt Flow Index	ASTM D1238 (B)	Once per sample

Table 1: Testing protocols for polypropylene resin

2.1.2 Masterbatch Resin

Masterbatch is a solid or liquid additive used for coloring plastics or imparting other material properties. In the case of BX geogrids, masterbatch resin is principally used to provide resistance to ultraviolet radiation. This ensures the reinforcement properties of the geogrid are maintained in the event that rolls are left exposed to sunlight for extended periods of time. Masterbatch deliveries to the TMP plant are analyzed in accordance with the same protocols identified in Table 1.

2.2 Main Manufacturing Process

2.2.1 Sheet Extrusion

The principal characteristics used in ensuring the quality of an extruded sheet are as follows:

- Sheet thickness
- Width
- Surface quality

Careful control of these properties is required in order to ensure uniform stretching during subsequent processing. The method of measurement and frequency for each sheet extrusion characteristic is summarized in Table 2.

Characteristic	Test Method	Frequency
Sheet Thickness	Micrometer	Once per 30 minutes
Sheet Width	Measuring Tape	Once per hour
Sheet Surface Quality	Visual Inspection	Continuous

Table 2. Testing protocols for extruded sheet

Any non-conformance is documented and corrected for during the subsequent stretching process. However, in the event that a particular non-conformance is deemed beyond correction, the batch is set aside for regrind or scrap.

2.2.2 Perforated Sheet

Careful control of the sheet perforation process is essential in order to ensure the size and uniformity requirements of the apertures developed during the subsequent stretching process are achieved. The main characteristics used to ensure quality during the sheet punching process are as follows:

- Sheet Width: Ensures proper roll sizing of the finished product
- MD Hole Pitch: The number of holes per unit length ultimately determines the size of the geogrid’s apertures
- MD Hole Alignment: Ensures all MD rows are parallel. Aperture alignment controls the amount of material between MD rows.
- Hole Squareness: Squareness is determined by measuring the angle of the cross-machine direction (XMD) rows from the edge of the roll. Aperture squareness affects the degree of bow and skew in the finished product
- Hole Quality: Ensures the punching tool is sharp in order to achieve uniform stretching during later processing

The method of measurement and frequency for each punched sheet characteristic is summarized in Table 3.

Characteristic	Method	Frequency
Sheet Width	Measuring Tape	Once per 30 minutes
MD Hole Pitch/Alignment	Calipers and Ruler	Once per 30 minutes
Hole Squareness	T-Square and Measuring Tape	Once per punch tool set-up
Hole Quality	Visual inspection	Once per 30 minutes

Table 3. Testing protocols for perforated sheet

The manner in which the hole pitch is determined is shown in Figure 2

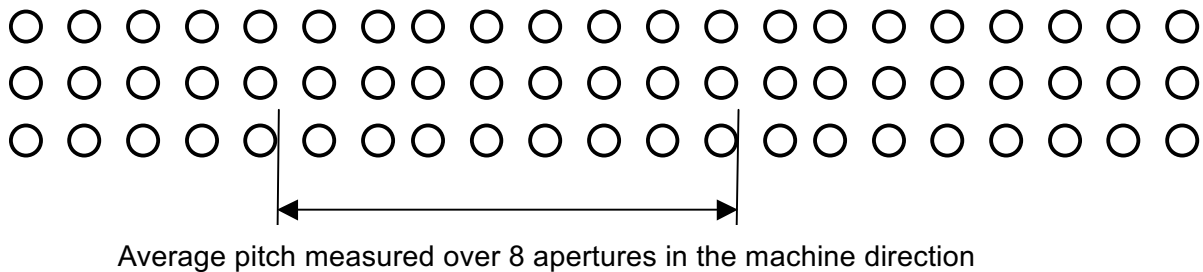


Figure 2: Measurement of hole pitch in MD

2.2.3 Oriented Sheet

The principal characteristics of the stretched sheet ultimately determines the material properties of the geogrid and its performance in service during dynamic and static loading. In particular, it is essential that the final product has the appropriate stiffness at low strain, provides adequate flexural stiffness in the vertical plane and sufficient torsional rigidity in the horizontal plane. The main characteristics used to ensure the quality of the final product are as follows:

- Finished roll width
- Rib count
- Sheet bow and skew
- Aperture size
- Weight per unit length
- Total roll weight

The method of measurement and frequency for each oriented sheet characteristic is summarized in Table 4

Characteristics	Method	Frequency
MD Aperture Length	Measuring Tape	Once per batch
XMD Aperture Length	Measuring Tape	Once per batch
MD Ribs per Unit Width	Measuring Tape	Once per batch
XMD Ribs per Unit Width	Measuring Tape	Once per batch
XMD Rib Bow	T-Square and measuring Tape	Once per batch
XMD Rib Skew	T-Square and measuring Tape	Once per batch
Roll Width	Measuring Tape	Once every 25 rolls

Table 4. Testing protocols during sheet orientation (stretching) process

2.2.4 Line Checks

In addition to the checks referenced above which are undertaken by the machine operators, line checks are also undertaken by TMP’s technicians. This is done in order to verify general production activity and ensure the accuracy of any measurements taken by the machine operators during the production process. These checks are typically conducted at least once per twelve-hour shift.

Each part of the manufacturing processes has a prescribed check list of items. Measurements taken by the technicians are compared with the company’s published product specification sheets and the machine operators’ own records. Any discrepancies are highlighted to the main machine operator and shift supervisor. All discrepancies are logged and a non-conformance report issued if appropriate.

The check list for the three main parts of the production process are presented in Table 5.

Process	Characteristics
Extrusion	Sheet Width Sheet Thickness Sheet Surface Inspection
Punching	Sheet Width Punched Hole Quality Punched Hole Pitch
Orientation	MD Aperture Length CMD Aperture Length Roll Width Bow Skew

Table 5 · Procedures adopted during line checking operations

2.3 Finished Product

Samples are taken from finished rolls on a regular basis and taken to the company’s on-site laboratory for testing. The material properties measured and the frequency at which these measurements are taken are presented in Table 6.

Characteristics	Method	Frequency
Ultimate MD and XMD Tensile Strength	ASTM D 6637	Once per 25 rolls
MD and XMD Tensile Strength @ 2% Strain	ASTM D 6637	Once per 25 rolls
MD and XMD Tensile Strength @ 5% Strain	ASTM D 6637	Once per 25 rolls
MD and XMD Elongation @ Break	ASTM D 6637	Once per 25 rolls
Weight per unit Length	Measuring Tape/Weight Scale	Once per shift

Table 6. Testing protocols for the finished product

If the tests conducted on a particular sample indicate that the product is “out-of-specification”, the production personnel are notified immediately. The necessary changes are made to ensure that

future rolls are produced to the correct specification. In addition, samples are taken and tested from the immediately preceding and subsequent rolls relative to the nonconforming roll. This procedure is repeated until both samples meet specification. All rolls in between are assigned for regrind.

2.4 Reporting

A Factory Test Report is developed for each product batch. These reports include the results for each roll tested in the laboratory. The reports are permanently stored and can be made available to customers upon request.

3. INDEPENDENT QUALITY ASSURANCE TESTING

In addition to the extensive in-house testing undertaken in TMP's own laboratory, samples of each product sku are regularly sent out to a fully accredited, independent testing facility located in North Georgia. The results from these tests are compared with those from the in-house testing, to ensure there are no significant discrepancies. Recent reports detailing the independent testing carried out on a particular product sku are available to customers upon request.

4. BATCH AND ROLL NUMBER NOMENCLATURE

Product traceability is a critical component of any Quality Control System. Each roll of geogrid supplied by TMP can be physically tracked to the testing carried out during a particular production run. The 13-character labelling system adopted by TMP is as follows:

Example nomenclature for geogrid label

S041601D01041

- “S” refers to the general geogrid type i.e. biaxial, uniaxial, etc. (S = biaxial geogrid)
- “04” refers to the production line used for manufacture of the product
- “16” refers to the year of manufacture i.e. “16” corresponds to 2016
- “01” refers to the month of manufacture
- “D” refers to the product sku
 - “A” = GG1100
 - “B” = GG1200
 - “C” = GG1515
 - “D” = GG2020
 - “E” = GG2525
 - “F” = GG3030
- “01” refers to the lot number
- “041” refers to the specific roll number



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5.0 SUMMARY

This manual provides a detailed account of the procedures employed in the manufacture of TMP's polypropylene biaxial geogrids. These procedures are strictly followed during each step of the manufacturing process to ensure the raw materials, production process and finished products meet or exceed the appropriate standards and specifications. A permanent record is kept of any testing undertaken and observations made during the production process or subsequent to it and this information can be made available to customers upon request.

TEST STANDARDS

ASTM Test Methods and Standards

ASTM D1238 (Procedure B) Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer

ASTM D4101 Standard Specification for Polypropylene Injection and Extrusion Materials

ASTM D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique

ASTM D4439 Terminology for Geosynthetics

ASTM D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

ASTM D6637 Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method

Geosynthetic Research Institute (GRI) Test Methods and Standards

GRI GG2 Geogrid Junction Strength (2000)