BI-DESIGN©
USER'S MANUAL

V2.0 October, 2013

Updates & Revisions

Release No.	Date	Revision Description
V1.0	6/1/2012	Initial Issue
V2.0	10/16/2013	Updated for V2.0

BI-DESIGN USER'S MANUAL

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1 GENERAL INFORMATION

1.1 BI-DESIGN Software Terms and Conditions of Use

BI-DESIGN software is a tool for use by engineers and other professionals to assist them in determining the proper E'GRID® geogrid products to use in their design of earth structures which incorporate geogrids. BI-DESIGN software is only a tool and is not a substitute for professional judgment. BOSTD is not engaged in engineering or rendering any other forms of professional design service. Competent professional design services should always be sought. Anyone making use of BI-DESIGN software does so at their own risk.

All data and calculations (including drawings) produced by the BI-DESIGN software are based on principles, formulas, safety factors and assumptions set out in the BI-DESIGN User's Manual (which can be accessed within the BI-DESIGN software). The professional using the BI-DESIGN software is responsible for determining if the principles, formulas, safety factors and assumptions are appropriate for the particular site conditions and project requirements for which geogrids will be used.

The BI-DESIGN software has been designed in such a way that will give a specific type of result from the data that has been entered. Geogrid product input data provided by BOSTD is based on average values obtained during QC and QA product testing. Site condition values used in the BI-DESIGN software are provided by the software user. Since the BI-DESIGN software is based upon assumption of average site condition values and BOSTD is not familiar with any specific site values, it is the responsibility of the professional using the BI-DESIGN software to check the results obtained from the BI-DESIGN software against the specific characteristics of the site at which the geogrids will be used. The entire risk as to quality or usability of the information contained in or produced by the BI-DESIGN software is with the user.

Each person using the BI-DESIGN software, by clicking the "Accept" button, (a) acknowledges that the BI-DESIGN software is based on general principles, formulas, safety factors and assumptions that are not specific to any particular site or project and that the user has access to such general principles, formulas, safety factors and assumptions for purposes of determining acceptability for their specific site and project and (b) agrees (1) to assume all risks related to the use of the BI-DESIGN software in connection with the specific site and project involved, (2) the program is only an aid and no warranties of any kind are made or implied concerning the suitability of BI-DESIGN software for any particular site or project or the accuracy of output with respect to any specific application and (3) to indemnify and hold harmless BOSTD and Affiliates from any and all claims, loss, damage and expense, including without limitation attorneys' fees, resulting from bodily injury, death, property damage or otherwise arising out of or connected with any use of the BI-DESIGN software.

BOSTD and Affiliates retains title to and ownership of all aspects of and interests in the BI-DESIGN software, including, without limitation, patents, copyrights, trademarks, trade secrets and other intellectual property rights.

*The term "BOSTD and Affiliates" as used in these terms and conditions of use means BOSTD Geosynthetics Qingdao, Ltd., NewGrids, Ltd., NewGrids, LLC, GeoConcepts, LLC and each of their affiliates, directors, officers, employees, agents and distributors.

E'GRID is a registered trademark

1.2 Software Overview

*Putting **you** in control of **your** projects is our goal. So, **BOSTD** compliments its product offerings by furnishing design tools that follow accepted design standards. These are focused on optimizing biaxial geogrid performance and project economy for roads and other trafficked structures.*

BI-DESIGN is interactive software designed to assist contractors and engineers in selecting the appropriate geogrid product to solve their soft subgrade problems, enhance pavement performance and save time and/or money. The software incorporates state-of-practice design methodologies validated by nearly thirty years of worldwide performance history to give the user peace of mind. User-friendly modules include:

"***QUICK CALC***": Allows for quick geogrid/aggregate thickness selections based on field- proven prescriptive methods for reducing costs and time associated with access/temporary road construction, subgrade improvement under pavements and other non-surfaced roads and working platforms. This module is designed for use where a quick solution is required for poor subgrade conditions. Input data required is minimal and easily gathered by field personnel.

"***SUB SAVE***": For use where a more rigorous analytical approach and comparison of various geogrid reinforced and non-reinforced scenarios are needed to reduce the potential for subgrade overstressing. This module uses the design method for geogrid-reinforced unpaved roads developed by Dr. J.P. Giroud and Dr. Jie Han and published in the August 2004 volume of the ASCE Geotechnical and Geoenvironmental Journal. This methodology has been widely used since its publication and been adopted by the Federal Highway Administration in their course "Overview of FHWA Geosynthetic Design and Construction Guidelines (FHWA NHI-07-092).

"***BASE RF***": This module allows for analysis of geogrid reinforced flexible pavements to determine the optimum reinforcement geogrid/base course combination to: reduce initial construction costs, increase pavement life span or a combination of these benefits. The software allows application of geogrid-specific-traffic benefit ratios (TBRs) developed using 30 years biaxial geogrid research and field performance data to the AASHTO '93 flexible pavement design guide methodology.

"***ESTIMATOR***": Results from the other modules feed into this tool to facilitate quick material and cost estimates as well as cost comparison amongst geogrid/aggregate combinations being considered.

"***SPEC PLUS***": This module includes comprehensive example hand calculations, simple "drop in" engineering specifications, detail drawings and installation guides. All information required by engineers and contractors to support the proper use of geogrid reinforcement technology is available here.

1.3 References

As with any technical software, the output is only as good as the user's understanding of the input parameters and the basis for them. It is strongly suggested that the users of BI-DESIGN read and familiarize themselves with the following references before using the software:

American Association of State Highway and Transportation Officials (AASHTO), 1986, "AASHTO Guide for Design of Pavement Structures - Volume 2," Washington, D.C.

American Association of State Highway and Transportation Officials (AASHTO), 1993, "AASHTO Guide for Design of Pavement Structures," Washington, D.C.

American Association of State Highway and Transportation Officials (AASHTO), 2010, "Standard of Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures," AASHTO Designation: R50-09, Washington, D.C.

FHWA, 2006, "Geotechnical Aspects of Pavements," U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., Report Number FHWA NHI-05-037.

FHWA, 2008, "Geosynthetic Design & Construction Guidelines Reference Manual", U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., Report Number FHWA NHI-07-092.

Geosynthetic Materials Association (GMA), 2000, "White Paper II: Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures," IFAI Bookstore, Roseville, MN.

Giroud, J.P. and Han, J., 2004a, "Design method for geogrid-reinforced unpaved roads–Part I: theoretical development", ASCE Journal of Geotechnical and Geoenvironmental Engineering, 130(8), 776-786.

Giroud, J.P. and Han, J., 2004b, "Design method for geogrid-reinforced unpaved roads–Part II: calibration and verification", ASCE Journal of Geotechnical and Geoenvironmental Engineering, 130(8), 787-797.

Perkins, S.W., et al. (2004), "Development of Design Methods for Geosynthetic Reinforced Flexible Pavements," Federal Highway Administration, Report Number DTFH61-01-X-00068.

Webster, S.L. (1992), "Geogrid Reinforced Base Course for Flexible Pavements for Light Aircraft: Test Section, Construction Laboratory Tests, and Design Criteria," Geotechnical Laboratory, Department of the Army, Waterways Experiment Station, Corps of Engineers, Report Number DOT/FAA/RD-92-25.

White, D.W. (1991), "Literature Review on Geotextiles to Improve Pavements for General Aviation Airports, U.S. Department of Transportation, Federal Aviation Administration.

Zornberg, J.G., et al., 2008, "Validating Mechanisms in Geosynthetic Reinforced Pavements," Texas Department of Transportation, Center for Transportation Research, Report Number FHWA/TX-08/0-4829-1.

1.4 Points of Contact

For information, pricing and technical assistance contact your local E'GRID Distributor. If you don't have a contact already you may go to:

- Visit www.conteches.com/contact to find our Distributor nearest you;
- Or, contact our nationwide distribution partner at:

Contech Engineered Solutions
9025 Centre Point Dr. Suite 400
West Chester, OH 45069
www.conteches.com/egrid

Tel: 800-338-1122
Email: info@conteches.com

2 GETTING STARTED

2.1 Operating System Requirements

BI-DESIGN has been developed to run inside your favorite web browser. Although the software will function in all known browser platforms, it works best in the latest version of Internet Explorer.© If you experience difficulty and are not using the latest version of your browser, updating the browser may solve the problem.

In obtain maximum functionality/benefit, it is recommended that you have the following types of software installed on your computer:

Required:

- An internet capable browser: Internet Explorer preferred but not required.

Recommended:

- Adobe Acrobat© Reader: Required to view the User Manual, Example calculations, etc. This software may be obtained for free at: www.get.adobe.com/reader/

- CAD Software: Software capable of opening *.DXF drawing files is required for manipulation of the typical details provided. Static details are also provided in *.PDF format.

- Word Processing Software: Software capable of opening *.RTF files is required for manipulation of the drop-in specifications provided.

2.2 Opening/Installing BI-DESIGN

There are three ways to access and use the software. You may select one or more of the following options:

- If you have a connection to the internet available and prefer to work online: Go to www.bostd-bi-design.com and visit the page titled BI-DESIGN. You can simply run the software directly from our website without any additional downloads, installs, etc. This is the preferred method as it will ensure that you are always working with the latest version of the software.
- If you have a connection to the internet available but prefer to work offline or are frequently without access to the internet: Go to www.bostd-bi-design.com and visit the page titled BI-DESIGN to download the necessary files to install the software on your Desktop. Once installed, the software will operate without a connection to the internet. If you choose to operate in this manner, it is strongly suggested that you check www.bostd-bi-design.com frequently for the latest updates. Also, please be aware that the links in "SPEC PLUS," on the "Home" page and from the "HELP" button will not function if you do not have an internet connection available. To access the "SPEC PLUS" documentation and this manual when offline, go to the folder containing BI-DESIGN on your hard drive and open the subfolder named "Documents."

- If you do not have access to the internet, and/or prefer to work offline: Contact your local E'GRID Distributor or contact Contech Engineered Solutions at (800) 338-1122 to request that a copy of the software be sent to you for installation your computer. If you choose to operate in this manner, it is strongly suggested that you check with us frequently to obtain the latest updates. Also, please be aware that the links in "SPEC PLUS," on the "Home" page and from the "HELP" button will not function if you do not have an internet connection available. To access the "SPEC PLUS" documentation and this manual when offline, go to the folder containing BI-DESIGN on your hard drive and open the subfolder named "Documents."

2.3 Operating BI-DESIGN

Once you have access to the software, simply click on the "Home" tab, and read the basic instructions to get started. A few important points and notes to remember are listed below:

- **READ AND ACCEPT THE TERMS OF USE AGREEMENT:** You will have to read and agree to the Terms of Use Agreement posted on our website and in Section 1.1 of this manual BEFORE you can operate the software.

- **TO SAVE YOUR WORK:** In order to maintain free and easy access to the software and respect your right to privacy, the software operates completely within your web browser. The downside to this is that you cannot directly save your input information or results to return at a later time. The best way to save your work is to click on the "PRINT/SAVE PAGE" button (to capture the information on the active module) or the "PRINT/SAVE ALL" (to capture all information from every module). These buttons are located at the bottom of every module.

- **WHEN PRINTING:** You may send the printed output to any printer/file writing software installed on your computer. Keep in mind that as with any webpage calculator, printed output from BI-DESIGN does not always format perfectly. However, all required information will be printed in a readable form. If you desire more formally formatted results, contact your local E'GRID Distributor for assistance.

- **FOR HELP:** Simply click on the "HELP" button at the bottom of each module and this manual will load in a separate window.

- **FOR QUOTATIONS/TECHNICAL ASSISTANCE:** Simply call your local E'GRID Distributor OR click on the "SUBMIT" button at the bottom of any page. This will send an email directly to your local E'GRID Distributor with the details of your project (be certain to fill out the "Project Information" page with your contact information so we can reach you). A local E'GRID Distributor will contact you within two working days of your request.

- **TO CHANGE UNIT SYSTEMS:** BI-DESIGN operates in metric units by default. If you prefer to use Imperial (US Standard) system, you may select this option in the "Project Information" module. Be aware, that you will need to carefully check your input if you switch unit systems while working on a project. Although the default values will automatically convert in most cases, any information you directly input will not.

- **AUTO CALCULATION:** BI-DESIGN operates like any web based calculator. All results are automatically recalculated every time you change any cell. As soon as you hit "ENTER" or leave the cell, all results are instantly updated.

- **MODULE GUIDE:** A brief description of the purpose of each module is provided below:

    - Home: Includes the Terms of Use Agreement and Basic Instructions.

    - Project Information: Enter information about yourself and the project to include with printed submittals and when using the "Submit" function of the software. The Unit System is also selected on this page.

    - QUICK CALC: For quick recommendations when soft soils are encountered and very little information is available. Perfect for developing a quick solution for construction access roads, temporary working platforms, emergency access, laydown yards, etc.

    - SUB SAVE: For more detailed analysis to determine the best solution for dealing with soft subgrade conditions when more geotechnical information is available. This module is intended to help the user with geogrid reinforcement recommendations under temporary or permanent stone surfaced roads, railways, working platforms, storage yards and other trafficked surfaces.

    - BASE RF: For assistance in designing flexible pavements incorporating geogrid reinforcement of the granular base layer. Punched and drawn, biaxial geogrids have been used to reduce pavement cost and/or increase life for nearly 30 years. This module will help you evaluate the potential benefits to your asphalt surfaced roads, parking lots, storage yards, etc.

    - ESTIMATOR: For cost comparison of results produced in the SUB SAVE and BASE RF modules. This tool will allow you to input local price information and quantify the savings by including geogrids in your project plan.

    - SPEC PLUS: Provides links to example calculations, drop-in guide specifications, CAD details and installation guidance.

3 USING THE SOFTWARE

This section provides detailed instructions, notes and guidance for using each module of the software. In addition to this manual, it is strongly suggested that the user obtain and refer to the applicable references listed in Section 1.3.

3.1 General Use and Navigation

Before operating the software, you must read, understand and accept the Terms and Conditions of Use (See Section 1.1 of this Manual). A link to these terms and a check box indicating acceptance is provided on the Home Tab (See Figure 3-1). You must check this acceptance box in order to operate the software.

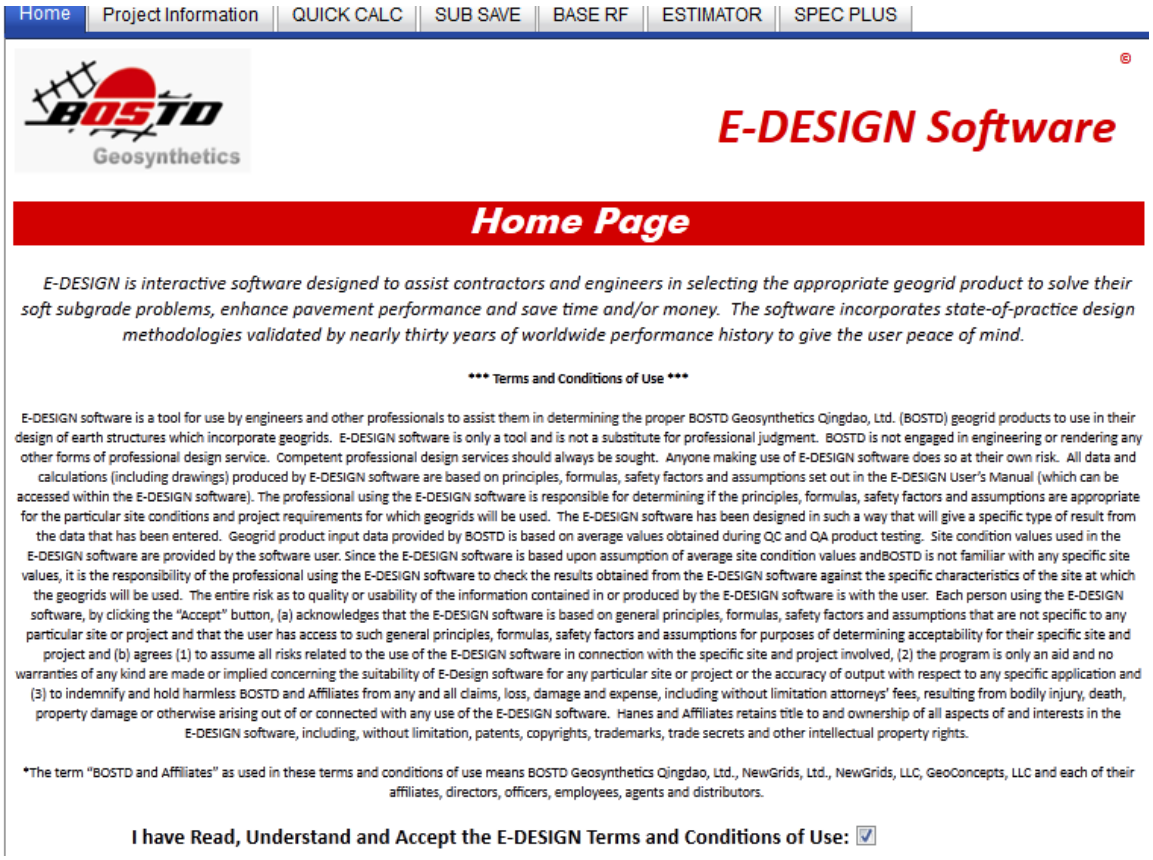


Figure 3-1. Acceptance of Terms and Conditions of Use - On the "Home" Tab

BI-DESIGN is organized into modules. Each module has the look and feel of a standard web page. Navigation between modules is accomplished by clicking on the tabs at the top of every page as illustrated in Figure 3-2.

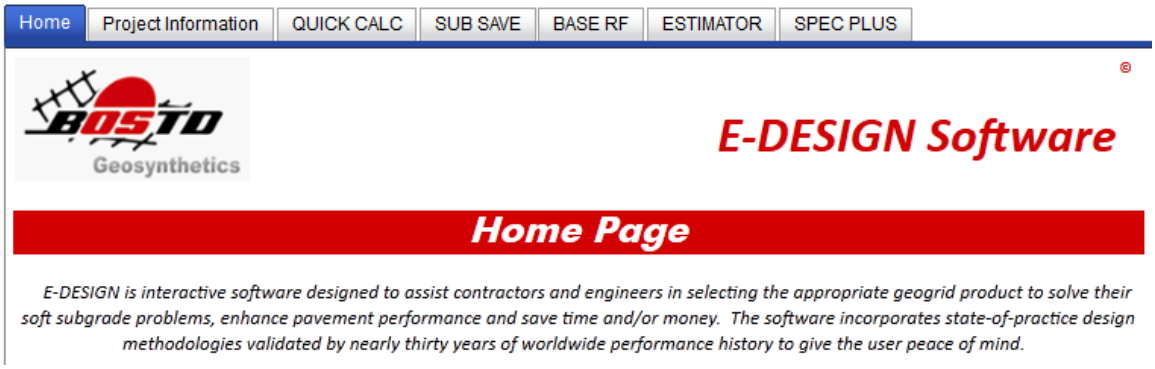


Figure 3-2. Navigation Tabs - Visible at the Top of All Pages

In addition to the navigation tabs, a set of buttons for general actions is included at the bottom of each page. These buttons are shown in Figure 3-3. A brief description of functionality is provided in the following paragraphs.

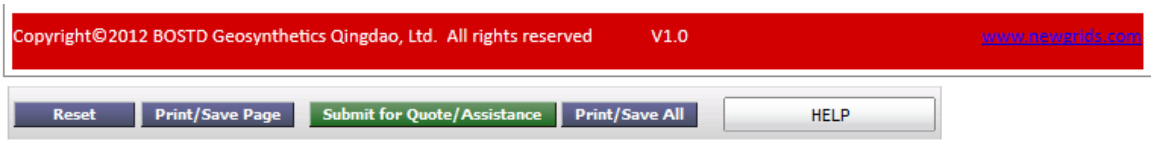


Figure 3-3. General Buttons at the Bottom of All Pages

|Reset| Resets ALL input values to blank/default values. This also resets the "Accept Terms and Conditions of Use" check box to the unchecked setting so you must re-accept the terms before continuing if |Reset| is selected.

|Print/Save Page| Prints input/results from the active module ONLY. This and the |Print/Save All| button are the ONLY ways to SAVE your input/results for future use. You may send output to any printer or file writer (such as Adobe Acrobat) installed on your computer.

|Submit for Quote/Assistance| Allows you to send an email containing all input/results to your local Contech Distributor for assistance with quotes, technical issues, etc. We will generally contact you within one business day of receiving your request. Please be certain to fill out the contact information on the Project Information Page before submitting.

|Print/Save All| Prints input/results from ALL modules. This and the |Print/Save Page| button are the ONLY ways to SAVE your input/results for future use. You may send output to any printer or file writer (such as Adobe Acrobat) installed on your computer.

|HELP| Opens this User Manual in a separate window.

TIP - Auto Calculation: BI-DESIGN operates like any web based calculator. All results are automatically recalculated every time you change any cell. As soon as you hit "ENTER" or leave the cell, all results are instantly updated.

3.2 Home

The "Home" module provides general instructions for use of the software as well as a general description of all other modules. You must visit the "Home" module each time you begin using the software or hit the "Reset" button to review/accept the Terms and Conditions of Use.

3.3 Project Information

The "Project Information" module contains system of units selection options (Imperial - US Standard OR Metric) and allows the user to input project details and contact information. This information is not required. However, it is useful if printed output is desired and when you intend to send the information to your local E'GRID Distributor using the "Submit" button at the bottom of the page.

TIP - Unit System Selection: If you elect to change the global unit system during evaluation of a project, you must be certain to check each input value carefully. While the software will automatically convert default values to the selected unit system, user input values ARE NOT automatically converted.

3.4 QUICK CALC

The "QUICK CALC" module allows for quick geogrid/aggregate thickness selections based on field-proven prescriptive methods for reducing costs and time associated with access/temporary road construction, subgrade improvement under pavements and other non-surfaced roads and working platforms. This module is designed for use where a quick solution is required for poor subgrade conditions. Input data required is minimal and easily gathered by field personnel. Where more rigorous analysis is required, it is suggested that the "SUB SAVE" module be used.

3.4.1 Technical Basis

The analysis performed and recommendations provided in the "QUICK CALC" module are based on the design method developed by Giroud and Han (2004a, 2004b). However, input parameters are developed based on simple field observations and correlations, not geotechnical test results or Geotechnical Engineering Recommendations. Consequently, recommendations derived from running "QUICK CALC" should be viewed as approximate and/or preliminary.

3.4.2 Input Required

Fairly simple and limited input parameter selection is required to obtain recommendations from "QUICK CALC." Figures 3-4 through 3-6 illustrate required input entries. Descriptions and guidance for each parameter are provided in the paragraphs that follow.

TIP - Default Input Values: Default input values are provided in the "QUICK CALC" module. The user should review and assess the applicability of these values to their project. In all cases, the defaults may be overridden by simply entering data in the empty cells to the right of each default value. If a particular default value or values are determined to be acceptable, simply leave the cells to the right of those values empty. "QUICK CALC" will use the default values, user input values or a mixture of both to provide recommendations.

General Notes & References:

1) The QUICK CALC Module is useful to solve soft subgrade problems where limited information/time is available and/or a full design is not warranted.

2) Default values are experience-based and should be reviewed/adjusted by the user as necessary.

3) QUICK CALC results are developed based on experience and the design method developed by Giroud & Han (2004a, 2004b - see SUB SAVE References). When more detailed information is available or comprehensive analysis/design is required, the SUB SAVE Module should be used.

Input Parameters:

Application/Performance Information:

Select Application:
- (•) Working Platform (access for construction)
- ( ) Temporary Road/Parking/Laydown Area
- ( ) Stone Surfaced Road/Parking/Laydown Area
- ( ) Other

Allowable Rut Depth: 2 in (50 mm)

Heaviest Vehicle/Equipment: Highway Legal Truck

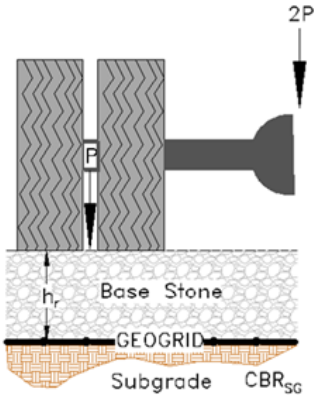


Figure 3-4. QUICK CALC Input Required - Application/Performance Related

|Select Application| Select the closest application to your project. This selection will allow the software to make default service life recommendations.

|Allowable Rut Depth| Select the maximum permissible surface rut depth that is acceptable to the project. Beyond this value, it is assumed that the trafficked structure will require maintained/rehabilitation.

|Heaviest Vehicle/Equipment| Select the heaviest vehicle anticipated to use the trafficked surface being designed. Several commonly used trucks and pieces of construction equipment are listed. This information will allow the software to make default design loading recommendations.

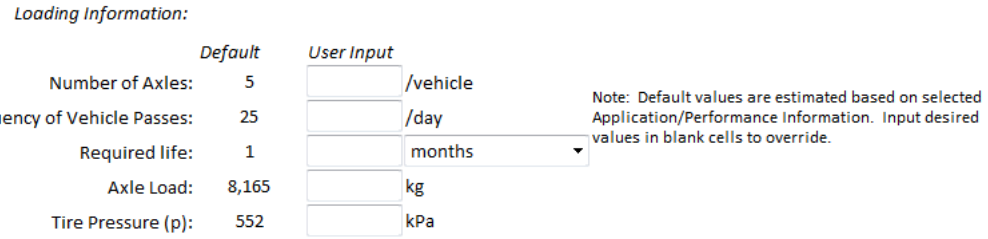


Figure 3-5. QUICK CALC Input Required - Loading Information

|Number of Axles| Input the number of axles on the design vehicle. The Default value is based on the selected |Heaviest Vehicle/Equipment| but may be overridden by entering a value directly into the empty cell at the right.

|Frequency of Vehicle Passes| Input the anticipated frequency of design vehicle passes per day. The Default value is based on the |Select Application | input above but may be overridden by entering a value directly into the empty cell at the right.

|Required Life| Input the required life of the trafficked surface in days, weeks or months. The Default value is based on the |Select Application | input above but may be overridden by entering a value directly into the empty cell at the right.

|Axle Load| Input the maximum design vehicle axle load. The Default value is based on the | Heaviest Vehicle/Equipment | input above but may be overridden by entering a value directly into the empty cell at the right.

|Tire Pressure| Input the design vehicle standard tire pressure. The Default value is based on the | Heaviest Vehicle/Equipment | input above but may be overridden by entering a value directly into the empty cell at the right.

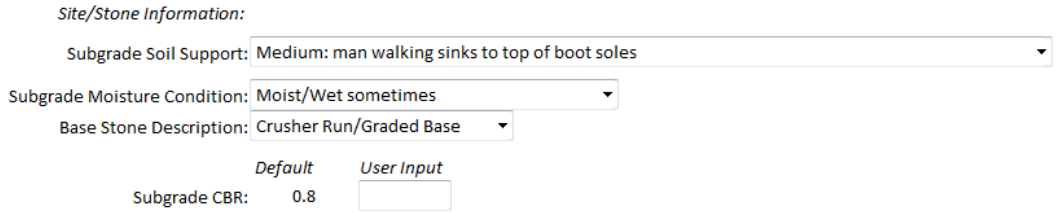


Figure 3-6. QUICK CALC Input Required - Site/Stone Information

|Subgrade Soil Support| Select the level of support available in the existing subgrade based on field observations. Several descriptions are available for selection. This information will allow the software to make a default design subgrade CBR (strength) recommendation.

|Subgrade Moisture Condition| Select the level of moisture observed/anticipated in the subgrade based on field observations. Several descriptions are available for selection. This information will allow the software to make a default design subgrade CBR (strength) recommendation and is considered in determining whether a geotextile is recommended for separation.

|Base Stone Description| Select the type of base stone to be used for the trafficked surface being considered. Several descriptions are available for selection. This information will allow the software to estimate the stone strength and drainage characteristics and is considered in determining whether a geotextile is recommended for separation.

|Subgrade CBR| Input the design subgrade strength in terms of California Bearing Ratio (CBR). The Default value is based on the |Subgrade Soil Support| and |Subgrade Moisture Condition| input above but may be overridden by entering a value directly into the empty cell at the right. The value should represent the LOWEST strength anticipated during the service life of the structure.

3.4.3 Results

"QUICK CALC" produces a graphical section recommendation to solve your soft soil problem based on the input values selected above. Example results are illustrated in Figure 3-7 and described in the paragraphs that follow.

TIP - Buying the Recommended Materials: To receive a quote on the recommended materials or obtain technical assistance, contact your local E'GRID Distributor or simply fill in the Project Information and click the "Submit" button to send your project details directly to us via email.

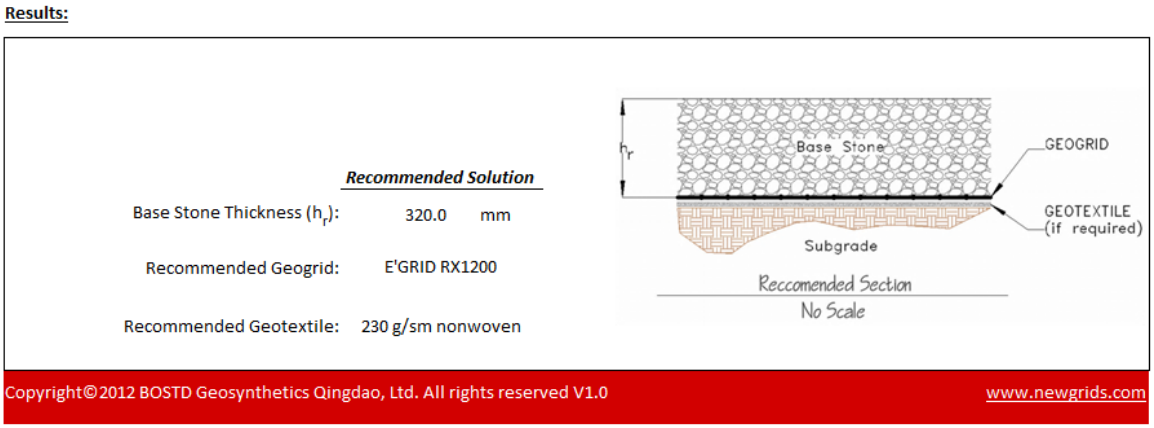


Figure 3-7. QUICK CALC Results

|Base Stone Thickness (h_r)| This is the minimum, compacted thickness of stone required to achieve the desired results.

|Recommended Geogrid| This is the type of geogrid reinforcement required to achieve the desired results.

|Recommended Geotextile| If a geotextile is recommended for the application, this is type of geotextile required to achieve the desired results.

3.5 SUB SAVE

The "SUB SAVE" module is for use where a more rigorous analytical approach and comparison of various geogrid reinforced and non-reinforced scenarios are needed to reduce the potential for subgrade overstressing. It is helpful if the user has access to a project Geotechnical Report and/or recommendations from a Geotechnical Engineer. However, input parameters can also be selected based on the user's experience. As with any technical analysis, results produced by "SUB SAVE" are only as accurate as the input parameters used. The user is strongly encouraged to review and understand the cited references before applying results derived using "SUB SAVE".

3.5.1 Technical Basis

This module uses the design method for geogrid-reinforced unpaved roads developed by Dr. J.P. Giroud and Dr. Jie Han and published in the August 2004 volume of the ASCE Geotechnical and Geoenvironmental Journal (Giroud and Han, 2004a, 2004b). This methodology has been widely used since its publication and been adopted by the Federal Highway Administration in their course "Overview of FHWA Geosynthetic Design and Construction Guidelines (FHWA NHI-07-092).

3.5.2 Input Required

Fairly comprehensive input parameter definition/selection is required to obtain recommendations and section comparisons from "SUB SAVE." Figures 3-8 and 3-9 illustrate required input entry. Descriptions and guidance for each parameter are provided in the paragraphs that follow.

TIP - Default Input Values: Default input values are provided in the "SUB SAVE" module for demonstration purposes ONLY. The user should input project specific information as appropriate. In all cases, the defaults may be overridden by simply typing over or selecting appropriate values.

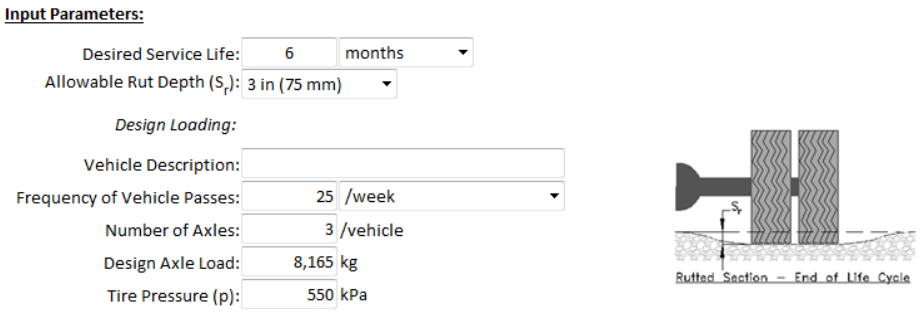


Figure 3-8. SUB SAVE Input Required - Service Life and Loading Information

|Desired Service Life| Input the desired life of the trafficked surface in weeks, months, years or vehicle passages. The Default value is simply for demonstration purposes and may be overridden by entering a new value directly into the cell.

|Allowable Rut Depth| Select the maximum permissible surface rut depth that is acceptable to the project. Beyond this value, it is assumed that the trafficked structure will require maintained/rehabilitation.

|Vehicle Description| Optional - Enter a description of the design (heaviest) vehicle or piece of equipment anticipated to regularly use the trafficked surface being designed.

|Frequency of Vehicle Passes| Input the anticipated frequency of design vehicle passes per day, week or year. The Default value is simply for demonstration purposes and may be overridden by entering a new value directly into the cell.

|Number of Axles| The Default value represents a standard highway legal dump truck and is simply for demonstration purposes and may be overridden by entering a new value directly into the cell.

|Design Axle Load| Input the maximum design vehicle axle load. The Default value represents a standard highway legal dump truck and is simply for demonstration purposes and may be overridden by entering a new value directly into the cell.

|Tire Pressure| Input the design vehicle standard tire pressure. The Default value represents a standard highway legal dump truck and is simply for demonstration purposes and may be overridden by entering a new value directly into the cell.

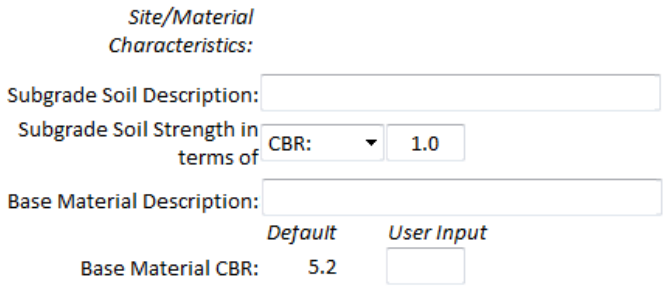


Figure 3-9. SUB SAVE Input Required - Site/Material Characteristics

|Subgrade Soil Description| Optional - Enter a description of subgrade soil at the project site.

|Subgrade Soil Strength| Select the type of strength characterization used to describe the subgrade based on the information available. The user may select to input data in terms of CBR or Undrained Shear Strength (c_u) then enter an appropriate value in the cell to the right. The Default value is simply for demonstration purposes and may be overridden by entering a new value directly into the cell.

|Base Material Description| Optional - Enter a description of base aggregate material to be used at the project site.

|Base Material CBR| Input the anticipated strength of the base material after compaction in terms of (CBR). The Default value is a function of the input subgrade strength and is based on the design method's (Giroud and Han, 2004b) limitation of the modulus ratio between the base material and subgrade to a maximum value of 5. The user may override the default value. However, the analysis will be based on the minimum of the user input value or the default. Entering a higher value than the default will not change the results.

3.5.3 Summary of Design Parameters

A summary of design parameters used in the analysis are provided following the input section. This allows the user to review all inputs before reviewing the results. In addition, it provides a convenient summary for presentation purposes. As illustrated in Figure 3-10, design parameters for the E'GRID geogrid styles being considered are also summarized. These values cannot be overidden as they are based on the product specifications.

Summary of Design Parameters used:

Wheel Load (P):	40 kN			
Tire Pressure (p):	550 kPa			
Contact Radius (r):	0.152 m			
Axle Passages (N):	1,929			
Subgrade Soil CBR (CBR_{sg})	1.0			
Base Material CBR (CBR_{bc}):	5.2			
Modulus Ratio (R_E):	5.0	**Limited to 5.0 (See Giroud & Han, 2004b)**		
Allowable Rut Depth (S_r):	3 in (75 mm)			
	Unreinforced	*RX1100*	*RX1200*	
Bearing Capacity Factor (Nc):	3.14	5.71	5.71	
Aperture Stability Modulus (j):	0.00	0.32	0.65	(mN/deg)

Figure 3-10. SUB SAVE - Summary of Design Parameters

3.5.4 Results

"SUB SAVE" produces graphical section recommendations based on the unreinforced, E'GRID RX1100 and RX1200 reinforced cases. In addition, tabular results are provided for comparison of available reinforcement options versus a traditional, unreinforced section.

TIP - Buying the Recommended Materials: To receive a quote on the recommended materials or obtain technical assistance, contact your local E'GRID Distributor or simply fill in the Project Information and click the "Submit" button to your project details directly to us.

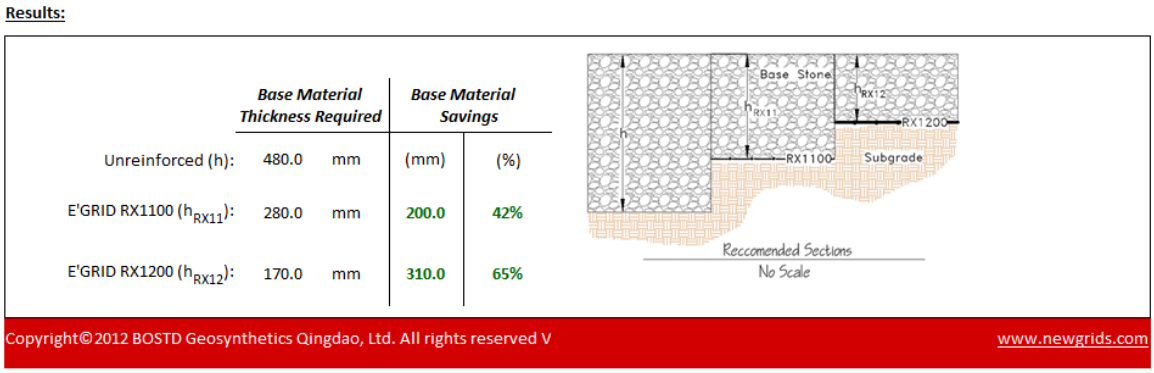


Figure 3-11. SUB SAVE Results

|Unreinforced (h)| This is the minimum, compacted thickness of stone required to achieve the desired results if NO geogrid reinforcement is used.

|RX1100 (h_{RX11})| This is the minimum, compacted thickness of stone required to achieve the desired results if RX1100 geogrid reinforcement is used. In addition, the stone savings realized with this option is provided to the right in terms of reduced thickness and percent reduction compared to the unreinforced case.

|RX1200 (h_{RX12})| This is the minimum, compacted thickness of stone required to achieve the desired results if RX1200 geogrid reinforcement is used. In addition, the stone savings realized with this option is provided to the right in terms of reduced thickness and percent reduction compared to the unreinforced case.

TIP - Geotextile Separation: "SUB SAVE" does not provide geotextile separator recommendations. However, the user may input the base material type and moisture conditions into "QUICK CALC" to determine whether a geotextile is recommended. Alternatively, just contact your local E'GRID Distributor and ask.

3.6 BASE RF

This module allows for analysis of geogrid reinforced flexible pavements to determine the optimum reinforcement geogrid/base course combination to: reduce initial construction costs, increase pavement life span or consider a combination of these benefits. As detailed and specific input information is required, you will find this module most useful if you already have some experience with flexible pavement design. A worked example annotated with reference pages from AASHTO (1993) is also included in the "SPEC PLUS" module.

In addition, results will be most useful if project specific traffic study/planning information, a project Geotechnical Report and/or recommendations from a Geotechnical Engineer are available. However, input parameters can also be selected based on the user's experience. As with any technical analysis, results produced by "BASE RF" are only as accurate as the input parameters used. The user is strongly encouraged to review and understand the cited references before applying results derived using "BASE RF".

3.6.1 Technical Basis

"BASE RF" is based on the empirical pavement design methodology developed by the American Association of State Highway and Transportation Officials (AASHTO, 1993). The software allows application of geogrid-specific-traffic benefit ratios (TBRs) in accordance with the methodology prescribed by the *Standard of Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures* (AASHTO, 2010) and *White Paper II: Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures* (GMA, 2000).

Traffic Benefit Ratios for the geogrids analyzed by "BASE RF" are recommended based on nearly 30 years of worldwide performance history and several research and development projects. In addition, BOSTD Geosynthetics Qingdao, Ltd. and our worldwide distribution partners are currently performing full scale pavement trafficking trials on the E'GRID product line to further refine TBR recommendations and update the BASE RF Module with the latest information.

3.6.2 Input Required

Comprehensive input parameter definition/selection is required to obtain recommendations and section comparisons from "BASE RF." Figures 3-12 and 3-15 illustrate required input entry. Descriptions and guidance for each parameter are provided in the paragraphs that follow.

TIP - Default Input Values: Default input values are provided in the "BASE RF" module. The user should review and asses the applicability of these values to their project. In all cases, the defaults may be overridden by simply entering data in the empty cells to the right of each default value. If a particular default value or values are determined to be acceptable, simply leave the cells to the right of those values empty. "BASE RF" will use the default values, user input values or a mixture of both to provide recommendations.

TIP - Example Calculation: A worked example annotated with reference pages from AASHTO (1993) is provided in the "SPEC PLUS" module. This example will be very helpful in guiding the user through operation of "BASE RF."

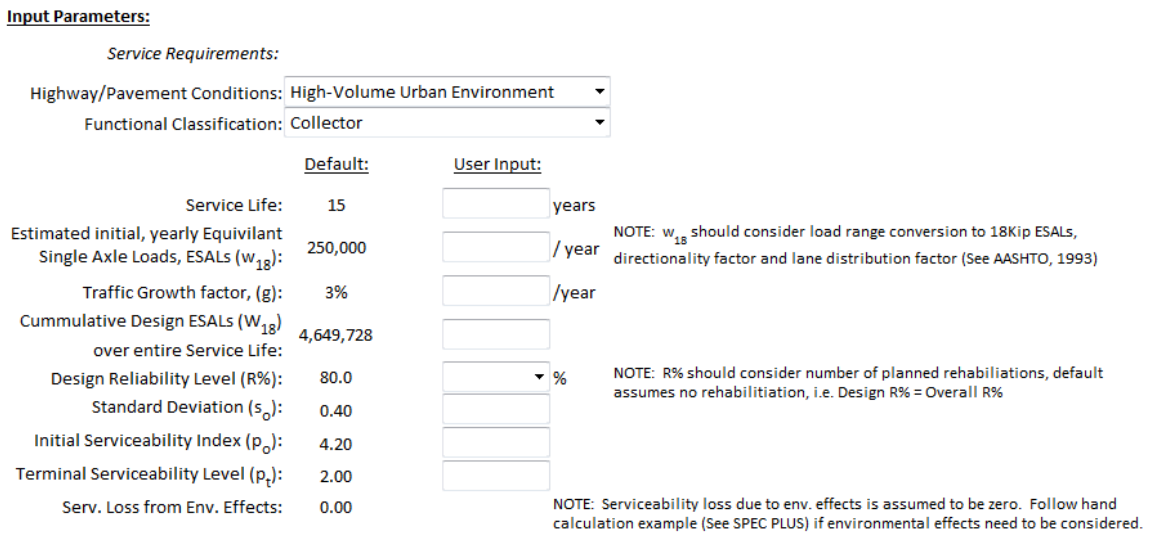


Figure 3-12. BASE RF Input Required - Service Requirements

|Highway/Pav't Conditions| Select the conditions most applicable to your project from the drop down list. This information will allow the software to make a Default recommendation regarding design load passages - Equivalent Single Axle Loads (ESALs).

|Functional Classification| Select the functional classification most applicable to your project from the drop down list. This information will allow the software to make a Default recommendation regarding design load passages - ESALs, Design Reliability (R%) and Terminal Serviceability (p_t).

|Service Life| Input the required service life of the pavement being designed. In "BASE RF," this value represents the time between initial construction and first rehabilitation and is usually 15-20 years. The Default value is simply for demonstration purposes and may be overridden by entering a new value directly into the cell.

|Estimated Initial yr'ly ESALs| Input the initial (year one), ESALs required to be carried by the design lane of the pavement being designed. The input value must be in standard 18-kip ESALs, and factored for directionality and lane distribution. The Default value is based on the |Highway/Pav't Conditions| and |Functional Classification| input above but may be overridden by entering a value directly into the empty cell at the right.

|Traffic Growth Factor| Input the yearly traffic growth factor in percent. The Default value represents a reasonable value under most circumstances, but may be overridden by entering a value directly into the empty cell at the right.

|Cumulative Design ESALs|	Input the total ESALs to be carried by the pavement over its intended design life. The value input must be in standard 18-kip ESALs, and factored for directionality and lane distribution. The Default value is calculated based on the | Service Life |, | Estimated Initial yr'ly ESALs | and |Traffic Growth Factor| values input above but may be overridden by entering a value directly into the empty cell at the right.
|Design Reliability Level|	Input the design reliability level in percent. This is generally between 50 percent for less critical pavements to 99.99 percent for highly critical pavements. The Default value is based on the AASHTO (1993) recommendations for |Functional Classification| input above but may be overridden by selecting a value from the drop down menu on the cell to the right.
|Standard Deviation|	Input the design standard deviation. For flexible pavements this value is generally between 0.35 (no variability in traffic prediction expected) to 0.45 (uncertainty in traffic prediction/growth rate). The Default value represents a reasonable value under most circumstances, but may be overridden by entering a value directly into the empty cell at the right.
|Initial Serviceability Index|	Input the initial serviceability index. This represents the serviceability of the pavement immediately following construction. A value of 5.0 represents perfect serviceably and 0 represents unusable. The Default value represents a reasonable value under most circumstances, but may be overridden by entering a value directly into the empty cell at the right.
|Terminal Serviceability Index|	Input the terminal serviceability index. This represents the serviceability of the pavement at the end of its service life following construction. This value is generally between 2.0 for Collector and Local pavements and 2.5 for Principal Arteries and Highways. The Default value is based on the AASHTO (1993) recommendations for |Functional Classification| input above but may be overridden by selecting a value from the drop down menu on the cell to the right.
|Serviceability Loss from Env. Effects|	No Input Required - This value represents the pavement serviceability loss due to frost heave and road bed soil swelling. At this time, "BASE RF" does not directly account for serviceability loss due to environmental effects. The user may estimate these effects by reducing the initial or increasing the terminal serviceability values by the approximate reduction due to environmental effects. However, this is not strictly correct per the AASHTO (1993) design method. Environmental effects are properly considered in the example calculation provided in the "SPEC PLUS" module to give the user guidance in this regard.

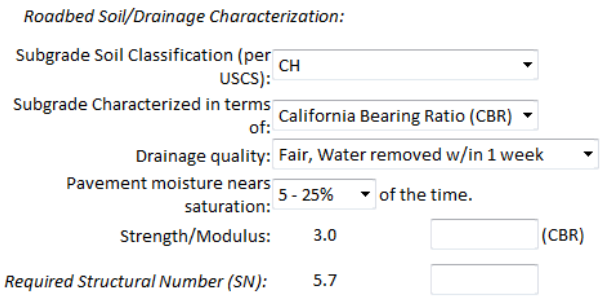


Figure 3-13. BASE RF Input Required - Roadbed Soil/Drainage Characterization

|Subgrade Soil Classification| Select the appropriate Unified Soil Classification System (USCS) classification of the subgrade (roadbed) soil applicable to the design section. This information will allow the software to make a Default recommendation regarding subgrade resilient modulus.

TIP - Soft Subgrade: In most cases, it is not advisable to construct a flexible pavement over a soft (CBR < 3.0, Mr < 4,500 psi) subgrade. If the project involves conditions such as these, run SUB SAVE first to design a subgrade improvement section using geogrid, then select "Use Result of SUB SAVE" from the drop down menu for |Subgrade Soil Classification| in "BASE RF." This will import the strength at the top of the working platform designed in "SUB SAVE" as the subgrade soil strength in "BASE RF." Refer to the Geogrid Stab-BR Detail.PDF in "SPEC PLUS" for a cross section representing this approach.

|Subgrade Characterized in terms of| Select the type of strength characterization used to describe the subgrade based on the information available. The user may select to input date in terms of CBR, Stabilometer-R or M_r. This information will allow the software to make a Default recommendation regarding subgrade strength and correlate any data input by the user to resilient modulus (M_r) for use in computations.

|Drainage Quality| Select drainage quality most applicable to your project from the drop down list. Note that it is always better to design good drainage within your pavement system when possible. This information will allow the software to make a Default recommendation regarding subgrade strength (M_r) and drainage coefficients for the granular pavement layers (m_2 and m_3).

|Pavement moisture nears Saturation| Select the percent of time that the pavement will be subjected to conditions approaching saturation. This is primarily dependent on the local climate at the project site. This information will allow the software to make a Default recommendation regarding drainage coefficients for the granular pavement layers (m_2 and m_3).

|Strength/Modulus|	Input the effective subgrade (roadbed) strength or resilient modulus of the pavement based on consideration of variation over the course of a year. Detailed guidance regarding proper selection of this parameter is provided in AASHTO (1993). The Default value is estimated through published correlations and is based on the |Subgrade Soil Classification| and |Drainage Quality| values selected above but may be overridden by entering a value directly into the empty cell at the right.
|Required Structural Number|	The Structural Number (SN) represents the overall structural capacity of the section for use in layered analysis per AASHTO (1993). The Default value is computed by "BASE RF" based on all input above this point. Therefore, the user should only override the default with caution and understanding of the situation.

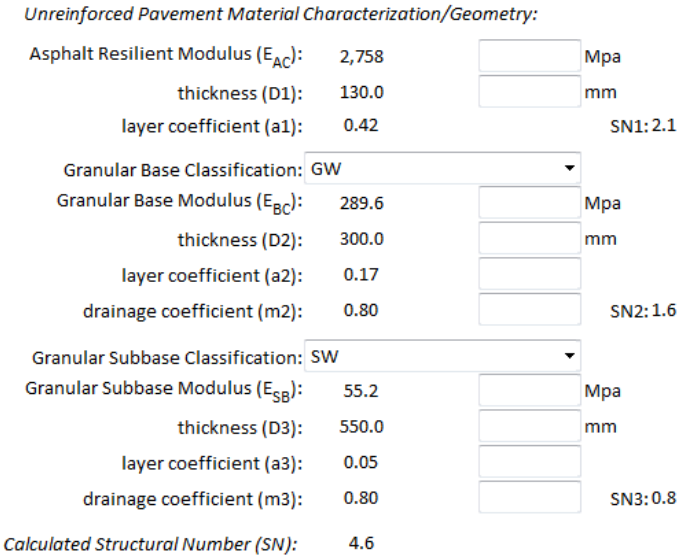


Figure 3-14. BASE RF Input Required - Unreinforced Pavement Material Characterization/Geometry

|Asphalt Resilient Modulus| Input the resilient modulus of the asphalt being specified for your project. The Default value represents a reasonable value for most modern hot mix asphalt, but may be overridden by entering a value directly into the empty cell at the right.

|Granular Base/Subbase Classification| Select the appropriate Unified Soil Classification System (USCS) classification of the base and subbase material specified for your project. This information will be used to allow the software to make a Default recommendations regarding the base (E_{BC}) and subbase (E_{SB}) moduli.

|Granular Base/Subbase Moduli| Input the resilient moduli of the granular base and subbase materials being specified for your project. Detailed guidance regarding proper selection of these parameters is provided in AASHTO (1993). The Default values are estimated through correlations in AASHTO (1993) and are a function of the material type and stress state. The Default values may be overridden by entering values directly into the empty cells at the right of each.

|thickness| The Default thickness values (D_1, D_2 and D_3) are computed by "BASE RF" based on all input above and in this section using layered analysis in accordance with AASHTO (1993). Therefore, the user should only override the default with caution and understanding of the situation.

TIP - Multiple Asphalt Layers: In many cases, more than one grade of hot mix asphalt is specified for a pavement (i.e. wearing course, binder course, etc.). In "BASE RF," the asphalt is treated as a single layer. Therefore, the modulus (E_{AC}) should represent the weighted average (based on thickness) of all grades of

asphalt specified for the project. The asphalt thickness (D_1) should represent the thickness of all asphalt layers combined.

|layer coefficient| The Default layer coefficient values (a_1, a_2 and a_3) are computed by "BASE RF" based on all input above and in this section using layered analysis in accordance with AASHTO (1993). Therefore, the user should only override the default with caution and understanding of the situation.

|drainage coefficient| Input the drainage coefficient values for the granular base and subbase layers representative of project conditions. The Default values are estimated based on guidance provided in AASHTO (1993) and are a function of the |Drainage Quality| and |Pavement moisture nears Saturation| values selected above but may be overridden by entering a value directly into the empty cell at the right.

|Calculated Structural Number| The Calculated (SN) represents the overall structural capacity of the unreinforced pavement as a function of the input values in this section. "BASE RF" determines this value by layered analysis in accordance with AASHTO (1993). Partial SN's (SN1, SN2, SN3) representing the contribution of each layer to the overall SN are provided to the right of each layer. The calculated SN should be greater than or equal to the |Required Structural Number| reported above.

TIP - Manipulation of Layers/Design: Many different combinations of materials and thicknesses may be used to obtain an equivalent structural number. You may directly input modulus, thickness, layer coefficient and drainage coefficient values to see the impact on the sections SN. As long as the default cell to the right of a value is left blank, "BASE RF" will automatically recalculate all other defaults based on your input. This allows you to quickly optimize the design based on material costs and availability or model an existing design precisely.

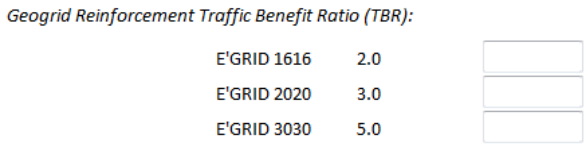


Figure 3-15. BASE RF Input Required - Geogrid Reinforcement Traffic Benefit Ratio (TBR)

|E'GRID XXXX| Traffic Benefit Ratio (TBR) represents a method of quantifying the benefit of geogrid reinforcement verses traditional unreinforced pavement. The ratio is derived from experience and full scale trafficking trials. The value represents the ratio of ESALs carried by a geogrid reinforced section to that of an identical (in all other aspects) unreinforced pavement. For example, a TBR value of 2.0 indicates that the reinforced pavement is capable of carrying 2.0 times the total ESALs of an identical unreinforced pavement before reaching the terminal serviceability level (p_t). Obviously, the TBR value is a function of many variables and is not easily reduced to a single value for all circumstances. Research and testing indicates that TBR varies not only by geogrid product, but also by thickness of pavement layers, location of geogrid in the section, quality of granular materials and other factors. The Default values provided for each geogrid considered by "BASE RF" are considered to be conservative estimates appropriate for most conditions normally encountered. However, the user is strongly encouraged to review the references provided in Section 1.4 and to determine the appropriate value for input relative to each geogrid. The Default values may be overridden by entering values directly into the empty cells at the right.

3.6.3 Summary of Design Parameters

A summary of design parameters used in the analysis are provided following the input section. This allows the user to review all inputs before reviewing the results. In addition, it provides a convenient summary for presentation purposes. Figure 3-16, illustrates the summary provided in "BASE RF."

Summary of Design Parameters used:

Service Life:	16	years		
TOTAL ESALs (W18):	5,187,900			NOTE: W18 is based on the Calculated SN
Design Reliability Level (R%):	80.00	%		
Standard Deviation (So):	0.40			
Initial Serviceability Index (po):	4.2			
Terminal Serviceability Level (pt):	2.0			
Environmental Effects:	0.0			
Roadbed Resilient Modulus (Mr):	31.0	Mpa		
Unreinforced Layer Coefficients:	Di (mm)	ai	mi	
Asphalt, 1	130.0	0.42		
Base Course, 2	300.0	0.17	0.80	
Subbase, 3	550.0	0.05	0.80	
Structural Number (SN):	4.6			
E'GRID 1616, TBR:	2.0			
E'GRID 2020, TBR:	3.0			
E'GRID 3030, TBR:	5.0			

Figure 3-16. BASE RF - Summary of Design Parameters

3.6.4 Results

"BASE RF" produces graphical section recommendations based on the unreinforced, E'GRID 1616, E'GRID 2020 and E'GRID 3030 reinforced cases for two scenarios. The first scenario considers pure extension of pavement life using geogrids. In other words, the pavement section is built to the exact same specifications as the unreinforced case but including geogrid reinforcement. The second scenario represents maximized initial cost reduction for equivalent performance by inclusion of geogrids. In addition, tabular results are provided for comparison of available reinforcement options versus a traditional, unreinforced section of both scenarios.

TIP - Buying the Recommended Materials: To receive a quote on the recommended materials or obtain technical assistance, contact your local E'GRID Distributor or simply fill in the Project Information and click the "Submit" button to your project details directly to us.

Results:

*Maximum Potential **Increase** in ESALs (Life) w/Reinforcement (by Adding Geogrid to Unreinforced Section):*

	Layer Thickness (mm)	SN SNi	Design Life (ESALs)	(yrs)
Unreinforced Case:		4.6		
Asphalt (D1):	130.0	2.1		
Base Course (D2):	300.0	1.6	5,187,900	16
Subbase (D3):	550.0	0.8		
Reinforced with E'GRID 1616:		5.1	10,375,800	27
Reinforced with E'GRID 2020:		5.4	15,563,700	35
Reinforced with E'GRID 3030:		5.8	25,939,500	47

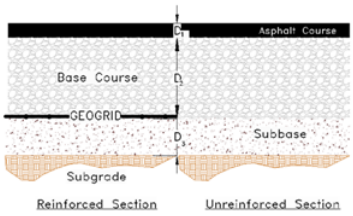


Figure 3-17. BASE RF Results - Life Extension Scenario

|Unreinforced Case| This section shows the various pavement layer thicknesses required to meet the design input criteria entered above. In the life extension scenario, the unreinforced and reinforced layer thicknesses are identical so these values also apply to each of the reinforced sections below. The overall and partial SNs for the unreinforced pavement are provided as well as the Design life in terms of total ESALs and years.

|Reinforced w/ E'GRID XXXX| These lines illustrate the increased overall SN for each reinforced pavement section as well as the increased design life in terms of total ESALs and years, respectively.

*Maximum Potential Initial Cost Reduction w/Reinforcement (by Reducing Granular Layer Thickness for **Identical** Number of ESALs (Life)):*

	Layer Thickness (mm)	SN SNi	Granular Layer Reduction (mm)	(%)
Reinforced with E'GRID 1616:		4.6		
Asphalt (D1):	130.0	2.1		
Base Course ($D2_R$):	260.0	1.6	40.0	13%
Subbase (D3):	450.0	0.8	100.0	18%
Reinforced with E'GRID 2020:		4.6		
Asphalt (D1):	130.0	2.1		
Base Course ($D2_R$):	220.0	1.6	80.0	27%
Subbase (D3):	460.0	0.8	90.0	16%
Reinforced with E'GRID 3030:		4.6		
Asphalt (D1):	130.0	2.1		
Base Course ($D2_R$):	180.0	1.6	120.0	40%
Subbase (D3):	400.0	0.8	150.0	27%

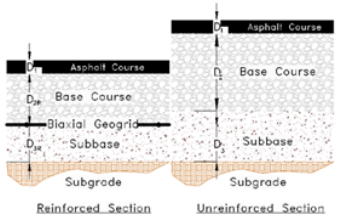


Figure 3-18. BASE RF Results - Cost Reduction Scenario

|Reinforced w/ E'GRID XXXX| These sections show the reduced granular layer thicknesses required to produce equivalent service life to the unreinforced section using E'GRID geogrid reinforcement at the bottom of the base layer. The overall and partial SNs for the reinforced pavement sections are provided as well as the granular layer reduction (compared to the unreinforced case) in terms of thickness and percent.

TIP - Combination of Life Extension and Cost Reduction: At this time, "BASE RF" does not explicitly consider combinations of life extension and initial cost reduction. However, this can be considered by using the "BASE RF" results, the "ESTIMATOR" module and some simple hand calculations. Contact your local E'GRID Distributor or simply hit the "SUBMIT" button and send us your results. We will be happy to assist you in evaluating "mixed" alternatives.

3.7 ESTIMATOR

Results from the "SUB SAVE" and "BASE RF" modules feed into this tool to comparisons amongst geogrid/aggregate combinations being considered. In order to ensure "ESTIMATOR" runs properly, the user must run project specific evaluations in either the "SUB SAVE" or "BASE RF" modules, or both.

TIP - Estimating Costs of QUICK CALC Recommended Section: At this time, "ESTIMATOR" does not directly calculate costs associated with the "QUICK CALC" module results. However, this can be accomplished by running "SUB SAVE" and manipulating the input values until an identical section to that produced by "QUICK CALC" results. Then "ESTIMATOR" may be used to evaluate the cost.

3.7.1 Input Required

Fairly simple and self-explanatory input parameter selection is required to obtain cost and savings estimates from "ESTIMATOR." Figures 3-19 through 3-20 illustrate required input entry. Where appropriate, descriptions and guidance for each parameter are provided in the paragraphs that follow.

TIP - Default Input Values: Default input values are provided in the "ESTIMATOR" module. The user should review and assess the applicability of these values to their project. In all cases, the defaults may be overridden by simply entering data in the empty cells to the right of each default value. If a particular default value is determined to be acceptable, simply leave the cells to the right of those values empty. "ESTIMATOR" will use the default values, user input values or a mixture of both to provide recommendations.

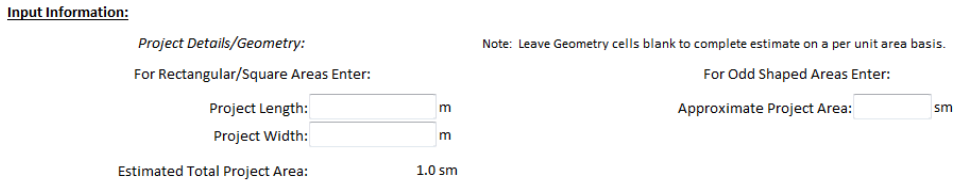


Figure 3-19. ESTIMATOR Input Required - Project Details/Geometry

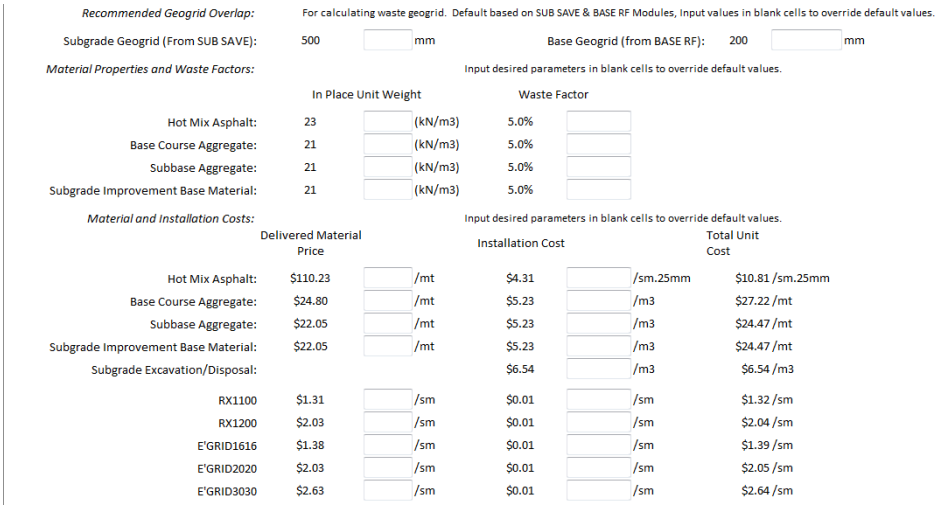
|Project Length/Width| Input project specific dimensions here for roads, parking lots or other projects that are roughly rectangular in shape.

|Approximate Project Area| Input total project area here for odd shaped and/or non-uniformly shaped projects. A value entered here will OVERRIDE any values entered in the |Project Length/Width| cells.

|Est. Total Project Area| This illustrates the total project area that will be used by "ESTIMATOR" in producing cost estimates and comparisons. The Default value of 1.0 will be used if no dimensions are entered above. This allows the user to compare options on a unit area basis if desired.

|Recommended Geogrid Overlap|

Input recommended geogrid overlap for the result(s) being evaluated. This allows "ESTIMATOR" to determine the waste factor cost of the geogrid due to overlap. The Default values represent our recommendations based on the subgrade soil conditions input in the "SUB SAVE" and "BASE RF" modules, respectively. These values may be overridden by entering a value directly into the empty cell at the right.



Recommended Geogrid Overlap: For calculating waste geogrid. Default based on SUB SAVE & BASE RF Modules, Input values in blank cells to override default values.

Subgrade Geogrid (From SUB SAVE): 500 mm Base Geogrid (from BASE RF): 200 mm

Material Properties and Waste Factors: Input desired parameters in blank cells to override default values.

	In Place Unit Weight			Waste Factor	
Hot Mix Asphalt:	23		(kN/m3)	5.0%	
Base Course Aggregate:	21		(kN/m3)	5.0%	
Subbase Aggregate:	21		(kN/m3)	5.0%	
Subgrade Improvement Base Material:	21		(kN/m3)	5.0%	

Material and Installation Costs: Input desired parameters in blank cells to override default values.

	Delivered Material Price			Installation Cost			Total Unit Cost
Hot Mix Asphalt:	$110.23		/mt	$4.31		/sm.25mm	$10.81 /sm.25mm
Base Course Aggregate:	$24.80		/mt	$5.23		/m3	$27.22 /mt
Subbase Aggregate:	$22.05		/mt	$5.23		/m3	$24.47 /mt
Subgrade Improvement Base Material:	$22.05		/mt	$5.23		/m3	$24.47 /mt
Subgrade Excavation/Disposal:				$6.54		/m3	$6.54 /m3
RX1100	$1.31		/sm	$0.01		/sm	$1.32 /sm
RX1200	$2.03		/sm	$0.01		/sm	$2.04 /sm
E'GRID1616	$1.38		/sm	$0.01		/sm	$1.39 /sm
E'GRID2020	$2.03		/sm	$0.01		/sm	$2.05 /sm
E'GRID3030	$2.63		/sm	$0.01		/sm	$2.64 /sm

Figure 3-20. ESTIMATOR Input Required - Material Properties, Waste Factors and Unit Costs

All other inputs are fairly self-explanatory. Representative Default values have been provided for waste factors, unit weights and unit costs. These values should only be used for high level, budgetary estimates. The user should input project specific information to produce the most useful and accurate estimates. As with the rest of BI-DESIGN, Default values may be overridden by entering a value directly into the empty cell at the right.

3.7.2 Results

"ESTIMATOR" produces tabular results showing total and comparative costs for the options selected for evaluation. Savings by incorporation of the various geogrid reinforcement options verses equivalent unreinforced sections are summarized in terms of total dollars, percentage and $/ESAL (where applicable). Results from each option are illustrated in Figures 3-21 through 3-24.

TIP - Accurate Material Prices: To receive a quote on the recommended geogrid materials and/or obtain accurate local aggregate and asphalt materials, contact your local E'GRID Distributor or simply fill in the Project Information and click the "Submit" button to your project details directly to us.

Results:

Reduced Subgrade Stabilization Cost (Using SUB SAVE Module Results): *Check here to Evaluate this Scenario:* ☑

Section Description	*Aggregate Material Thickness Required* (mm)	*Project Cost* Base & Exc.	Geogrid	*Total*	*Project Savings using Geogrid* $	%
Unreinforced:	480.0	$29.80	$0.00	$29.80		
RX1100:	280.0	$17.39	$1.49	$18.88	$10.93	37%
RX1200:	170.0	$10.56	$2.30	$12.86	$16.95	57%

Figure 3-21. ESTIMATOR Results - Savings using Geogrid from SUB SAVE Analysis

Base Reinforcement Increase in ESAL capacity (Life Extension) (Using BASE RF Module Results): *Check here to Evaluate this Scenario:* ☑

Section Description	*Material Thickness Required* (mm) SB	BC	HMA	ESALs /1,000	*Project Cost* Pav't & Exc.	Geogrid	*Total*	*$/1,000 ESALs*	*Savings/1,000 ESALs using Geogrid* $	%
Unreinforced:				5,188	$112.74	$0.00	$112.74	$0.0217		
E'GRID 1616:	550.0	300.0	130.0	10,376	$112.74	$1.46	$114.20	$0.0110	$0.0107	49%
E'GRID 2020:				15,564	$112.74	$2.15	$114.89	$0.0074	$0.0143	66%
E'GRID 3030:				25,940	$112.74	$2.78	$115.52	$0.0045	$0.0173	80%

Figure 3-22. ESTIMATOR Results - Savings using Geogrid from BASE RF Analysis for Life Extension

Base Reinforcement for Reduced Cost w/ Equivalent ESAL capacity (Using BASE RF Module Results): *Check here to Evaluate this Scenario:* ☑

Section Description	*Material Thickness Required* (mm) SB	BC	HMA	ESALs /1,000	*Project Cost* Pav't & Exc.	Geogrid	*Total*	*$/1,000 ESALs*	*Project Savings using Geogrid* $	%
Unreinforced:	550.0	300.0	130.0		$112.74	$0.00	$112.74	$0.0217		
E'GRID 1616:	450.0	260.0	130.0	5,188	$103.80	$1.46	$105.26	$0.0203	$7.48	7%
E'GRID 2020:	460.0	220.0	130.0		$101.69	$2.15	$103.84	$0.0200	$8.91	8%
E'GRID 3030:	400.0	180.0	130.0		$95.23	$2.78	$98.01	$0.0189	$14.74	13%

Figure 3-23. ESTIMATOR Results - Savings using Geogrid from BASE RF Analysis for Initial Cost Reduction

Combination Savings (Using SUB SAVE & BASE RF Module Results): *Check here to Evaluate this Scenario:* ☑

Section Description	*Section Thickness Required* (mm) SG	Pav't	TOTAL	ESALs /1,000	*Project Cost* Pav't & Exc.	Geogrid	*Total*	*$/1,000 ESALs*	*Project Savings using Geogrid* $	%
Unreinforced:	480.0	980.0	1460.0		$142.55	$0.00	$142.55	$0.0275		
RX1100/E'GRID 1616:		840.0	1120.0		$121.18	$2.95	$124.13	$0.0239	$18.41	13%
RX1100/E'GRID 2020:	280.0	810.0	1090.0		$119.07	$3.64	$122.71	$0.0237	$19.83	14%
RX1100/E'GRID 3030:		710.0	990.0	5,188	$112.61	$4.27	$116.88	$0.0225	$25.66	18%
RX1200/E'GRID 1616:		840.0	1010.0		$114.35	$3.76	$118.12	$0.0228	$24.43	17%
RX1200/E'GRID 2020:	170.0	810.0	980.0		$112.24	$4.45	$116.69	$0.0225	$25.85	18%
RX1200/E'GRID 3030:		710.0	880.0		$105.78	$5.08	$110.86	$0.0214	$31.68	22%

Figure 3-24. ESTIMATOR Results - Savings using Geogrid from SUB SAVE and BASE RF Analysis for Subgrade Improvement and Cost Reduction

3.8 SPEC PLUS

The "SPEC PLUS" module offers links to comprehensive example hand calculations, simple "drop-in" engineering specifications, detail drawings and installation guides. All information required by engineers and contractors to support the proper use of geogrid reinforcement technology is available here.

TIP - If you are offline: please be aware that the links in "SPEC PLUS," on the "Home" page and from the "HELP" button will not function if you do not have an internet connection available. To access the "SPEC PLUS" documentation and this manual when offline, go to the folder containing BI-DESIGN on your hard drive and open the subfolder named "Documents."