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CHAPTER I

Introduction

1.1 Introduction

Blast Resistant Glazing Design 2003 (BRGD 2003) uses ASTM standards to size rectangular laminated glass and insulating glass constructions fabricated with at least one laminated glass lite to resist an explosive threat. The software finds its basis in the paper “Considerations for Blast Resistant Design,” by H. Scott Norville and Edward J. Conrath published in the ASCE *Journal of Architectural Engineering* published September 2001; ASTM F 2248-03, *Standard Practice for Specifying an Equivalent 3-Second Design Loading for Blast Resistant Glazing Fabricated with Laminated Glass*; and ASTM E 1300-02/03, *Standard Practice for Determining Load Resistance of Glass in Buildings*.

1.2 Features

Blast Resistant Glazing Design 2003 uses an ISC Medium Threat Level (GSA Level C), an ISC Higher Threat Level (GSA Level D), or a user defined threat level in terms of an equivalent TNT charge size and standoff distance. Blast Resistant Glazing Design 2003 converts this threat level to a 3-second duration equivalent design load following procedures in ASTM F 2248-03, and sizes laminated glass or symmetric insulating glass fabricated with at least one laminated glass lite using procedures in ASTM E1300-02/03 to resist the 3-second duration equivalent design load. The resulting single laminated glass lite or insulating glass unit, when supported properly, will fracture safely and provide blast resistance in explosions up to the design threat level. For larger explosions, the blast resistant glazing still affords some protection. Blast Resistant Glazing Design 2003 provides recommendations concerning the appropriate size of a sealant bead to attach the blast resistant glazing to the window frame and gives forces necessary to design connections to attach window frames to the structure.

As input to BRGD 2003, the user provides the threat level, the rectangular dimensions of the fenestration, and the desired window glass construction, i.e., single laminated glass or an insulating glass unit fabricated with at least one laminated glass lite. The window frame must support the blast resistant glazing continuously along all four sides. Blast Resistant Glazing Design 2003 uses the following constructions for blast resistant glazing: single laminated glass, fabricated with either annealed or heat strengthened glass plies and a PVB interlayer, or insulating glass units. The program allows one of the two following insulating glass constructions: (1) a monolithic glass lite facing the outside of the building and a laminated glass lite facing the inside, or (2) laminated glass for both lites of the insulating glass unit. As stated above, all glass plies can be either annealed or heat strengthened glass, not fully tempered.

BRGD 2003 displays the equivalent 3-second duration design loading, the approximate maximum air blast pressure, the nominal glass thickness for a single laminated glass lite or the nominal thicknesses for the lites that comprise the insulating glass unit required to resist the 3-second duration equivalent design loading according to ASTM E1300-02 after it completes the blast resistant glazing design calculation. Blast Resistant Glazing Design 2003 always uses lites having equal nominal thicknesses in insulating glass units. The program also displays the recommended size of the structural sealant bead to attach the blast resistant glazing to the window frame, and the loads required to design the window frame members and to connect the window frame to the building.


Blast Resistant Glazing Design 2003 prints a blast resistant glazing report with the design load details, the project details, the glazing information, the glass construction, design load details, and the framing and attachment requirements and loads.

CHAPTER II Getting Started

2.1 Opening Blast Resistant Glazing Design 2003

Blast Resistant Glazing Design 2003 opens in three ways. (1) The user can follow the path “start/All Programs/Standards Design Group, Inc/ Blast Resistant Glazing Design 2003”; (2) the user can double click on a program file with the extension “.brd”; or, (3) if the user creates a program shortcut, the user can open the program by double clicking on this shortcut.

2.2 Disclaimer and Limitations

When the program opens, the “Disclaimer and Limitations” window appears as shown in Figure 2.1. Before continuing, the user must read and understand the disclaimer and the limitations of the software. After reading, click on the “I have read and understand the limitations of this software” check box after reading and understanding the limitations of BRGD 2003. Press the  button to continue.

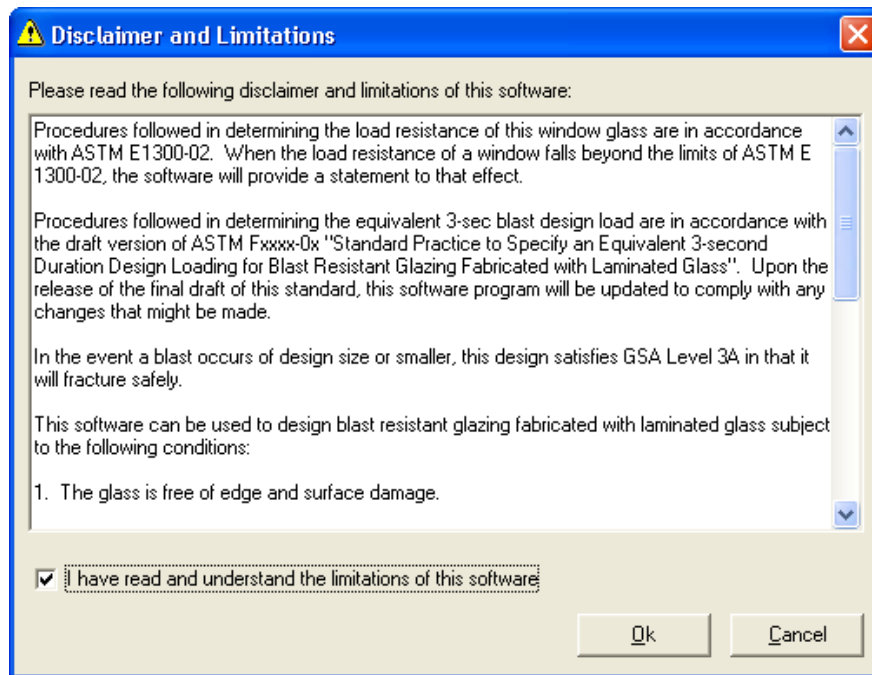


Figure 2.1: Disclaimer and Limitations

The Disclaimer and Limitations states:

Procedures followed in determining the load resistance of this window glass is in accordance with ASTM E1300-02. When the load resistance of a window falls beyond the limits of ASTM E 1300-02, the software will provide a statement to that effect.

Procedures followed in determining the equivalent 3-sec blast design load are in accordance with the draft version of ASTM F2248-03, "Standard Practice to Specify an Equivalent 3-second Duration Design Loading for Blast Resistant Glazing Fabricated with Laminated Glass."

In the event a blast occurs of design size or smaller, this design satisfies GSA Level 3A in that it will fracture safely.

This software can be used to design blast resistant glazing fabricated with laminated glass subject to the following conditions:

- 1. The glass is free of edge and surface damage.*
- 2. The blast resistant glazing assembly is continuously supported along all four edges.*
- 3. The software user has the responsibility of selecting the correct procedures for the required application from the software.*
- 4. The stiffness of members supporting any glass edge shall be sufficient that under an equivalent 3 sec. design load, edge deflections of glazing shall not exceed $L/160$, where L denotes the length of the supported edge.*
- 5. The non-factored load values for laminated glass are representative of test data and calculations performed for polyvinyl butyral interlayer at a temperature of 50°C (122°F).*





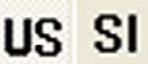
For other limiting conditions that may apply, refer to Section 5 of ASTM E1300, local building codes, and ASTM Fxxxx-0x "Standard Practice to Specify an Equivalent 3-second Duration Design Loading for Blast Resistant Glazing Fabricated with Laminated Glass".

SDG does not guarantee and disclaims any responsibility for any particular results relating to the use of the Blast Resistant Glazing Design 2003 Software Program.

SDG disclaims any liability for any personal injury or any loss or damage of any kind, including all indirect, special, or consequential damages and

lost profits, arising out of or relating to the use of the Blast Resistant Glazing Design 2003 Software Program.

2.3 Tool Bar

The tool bar shown in Figure 2.2 allows one click access to many important features in Blast Resist Glazing 2003. The new design icon  allows the user, with one click, to create a new design as described in section 2.4. The open design icon  allows the user, with one click, to open a previously saved blast resistant glazing design as described in section 2.5. The save design icon  allows the user, with one click, to save the current design as described in section 2.6. The print design icon  allows the user, with one click, to print a design report as described in section 2.8. The system of units icon  allow the user to toggle between US and SI units with a simple click of the button as described in section 2.7.

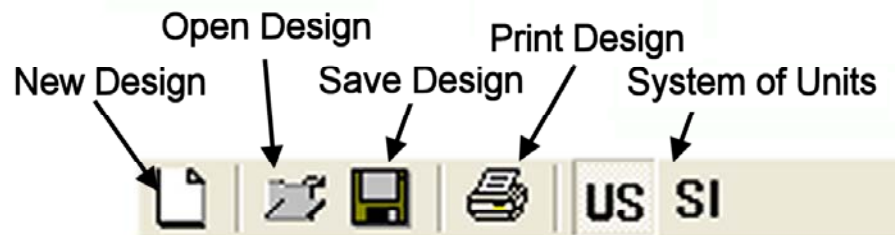


Figure 2.2 Toolbar

2.4 Starting a New Design

To start a new design, click “File/New Project” as Figure 2.3 shows. If a current project is open, the program asks “Save changes to Design before closing?” as Figure 2.4 shows. Press “Yes” to save current project information before starting the new project. This action brings up either the “Save As ...” or the “Save ...” dialog box. Use of these dialog boxes is described below. Press “No” to discard current project information. This action resets all values to default settings. Press “Cancel” to return to the current project information.

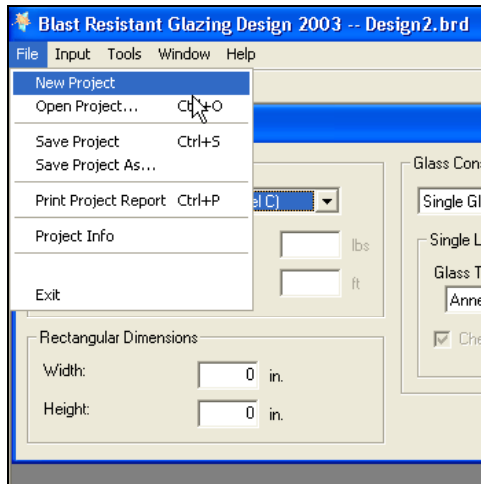


Figure 2.3: New Project

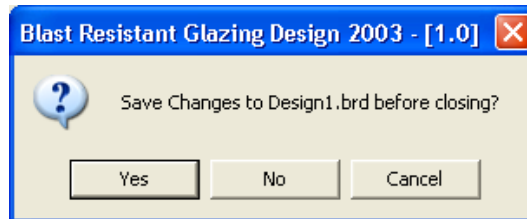

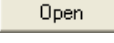
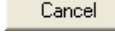


Figure 2.4: Save Changes to Design

2.5 Opening an Existing Design

The user can open an existing document in three ways. The first consists of pressing “File/Open Project...” as Figure 2.5 shows. The second consists of pressing , i.e., the open file button on the tool bar. The “Open” window (Figure 2.6) then appears. Follow the path to the desired project file and press the  button on the bottom of the “Open Window” as Figure 2.7 shows. This opens the details of the design from the file. If the Open Project button was pressed by mistake, simply press the  button and the programs returns to the current project. The third consists of double clicking on the desired file without first opening the program. This action automatically opens BRGD 2003 with the design information from the previously saved file loaded.

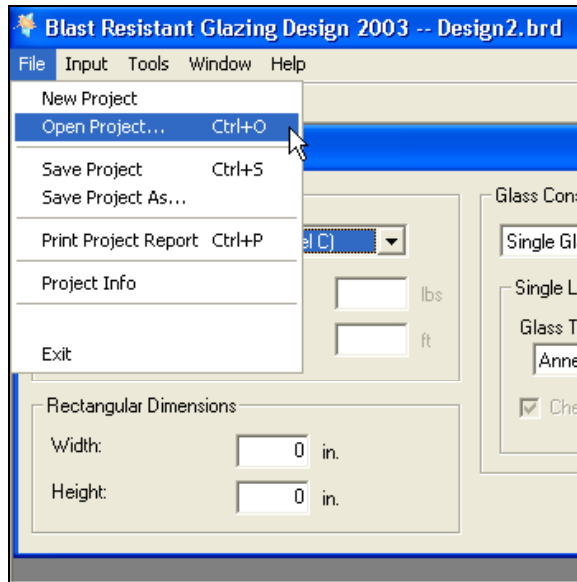


Figure 2.5: Opening an Existing Project

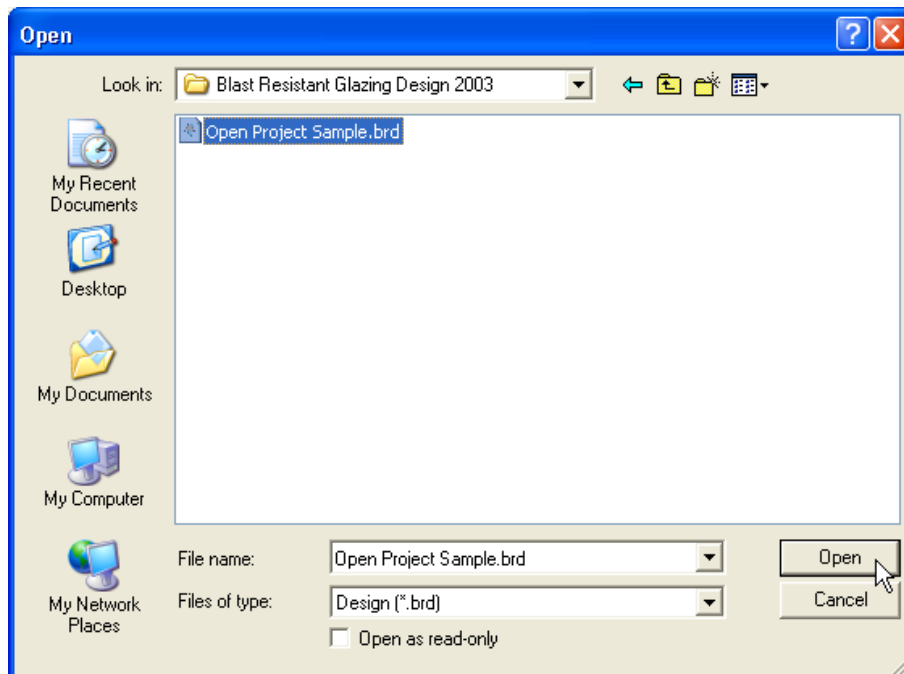


Figure 2.6: Open Window

2.6 Saving a Design

To save a design, press “File/Save Project” (Figure 2.7) or “File/Save Project As...” (Figure 2.8). Pressing the  button produces the same result as pressing “File/Save Project.”

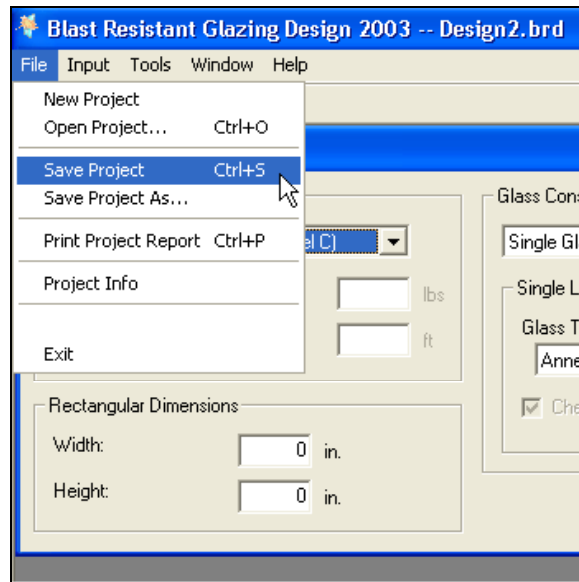


Figure 2.7: Save Project

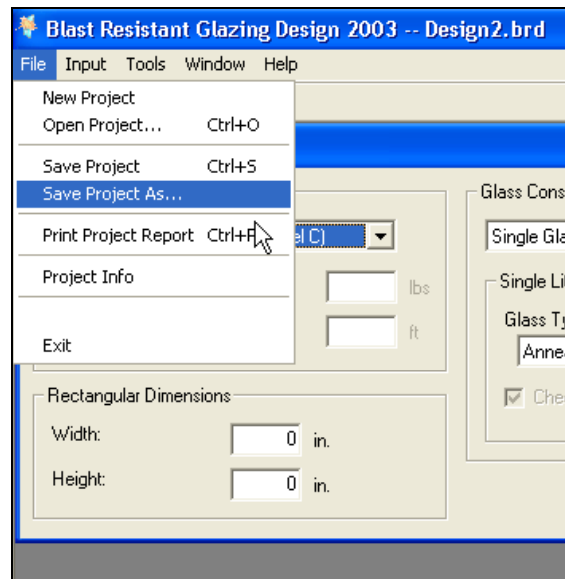


Figure 2.8: Save Project As

2.6.1 Save Project

If the project has not been previously saved, the program brings up the “Save As” window as Figure 2.9 shows. Type in a file name to the left of the button and press the button to save the current project. If the project has been previously saved, the program automatically writes the data for the current project to the previously saved file.

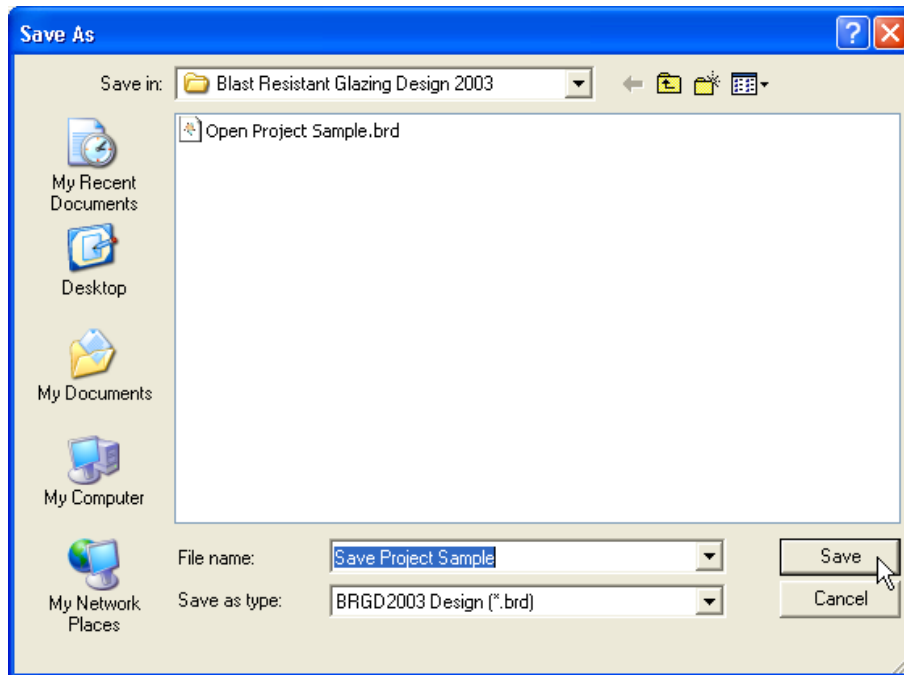


Figure 2.9: Save As Window

2.6.2 Save As

Pressing “File/Save As...” always brings up the “Save As” window shown in Figure 2.9. This allows the renaming of the current project or the saving of a new project. Follow the steps in Section 2.4 of the document to save a file using the “Save As...” command.

2.7 System of Units

Blast Resistant Glazing Design 2003 uses both US and SI units. The program allows the user to toggle between the US and SI systems of units, automatically updating all data in the current design. To change the system of units click on the path “Tools/System of Units/ *System of Units*” as Figure 2.10 shows. Blast Resistant Glazing Design 2003 also has “System of Units” buttons on the toolbar. Press the desired “System of Units” button for the project.

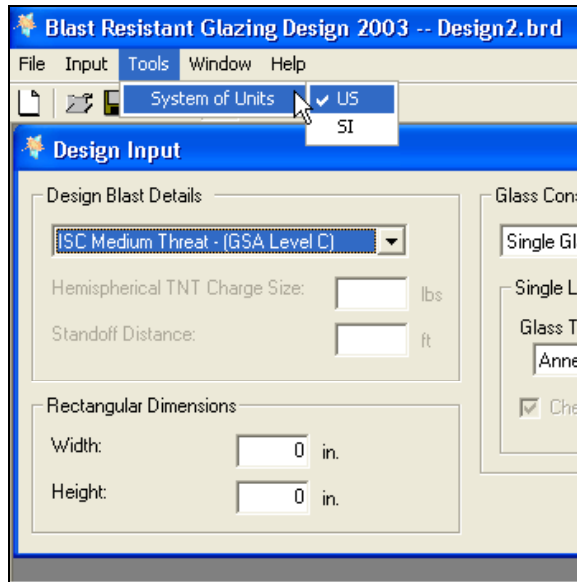




Figure 2.10: System of Units

2.8 Printing a Document

Blast Resistant Glazing Design 2003 prints a design report for the current project. To print a design report press “File/Print Project Report” as Figure 2.11 shows or press the  button located on the toolbar. A “Print” dialog box appears, shown in Figure 2.12. Select the current printer and press the  button to print the current blast resistant glazing design.

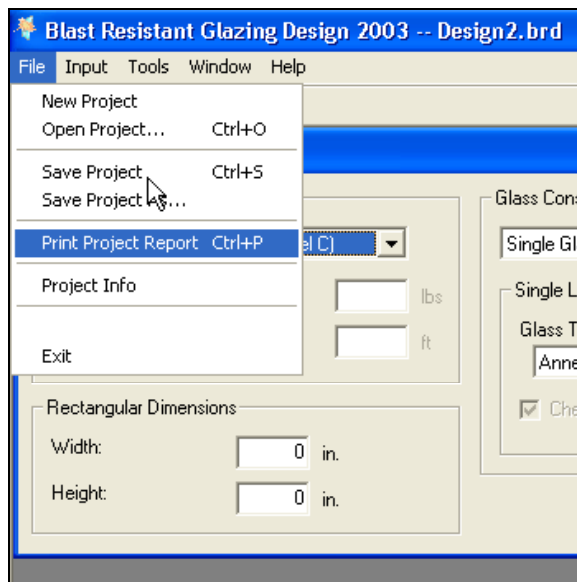


Figure 2.11: Print Project Report

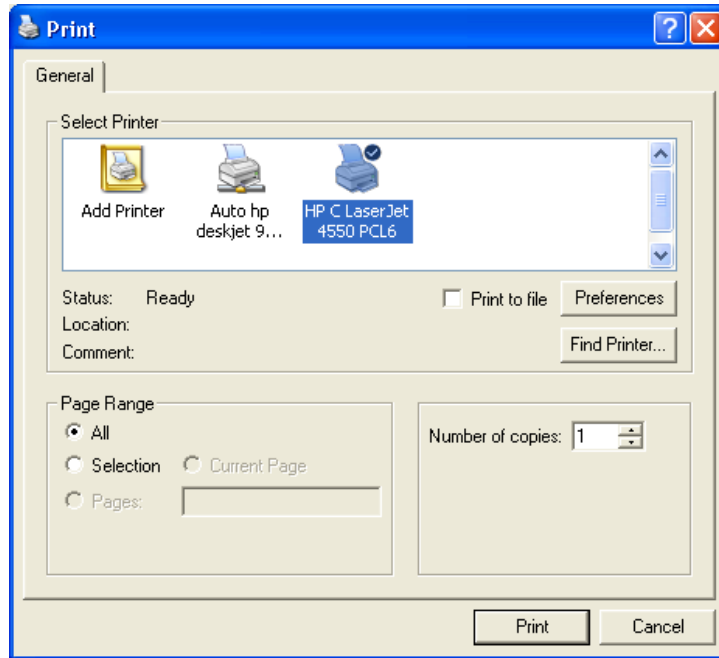


Figure 2.12: Print Window

2.9 Cascade Windows

To cascade all the windows in the current blast resistant glazing design project, press “Window/Cascade” as shown in Figure 2.13:

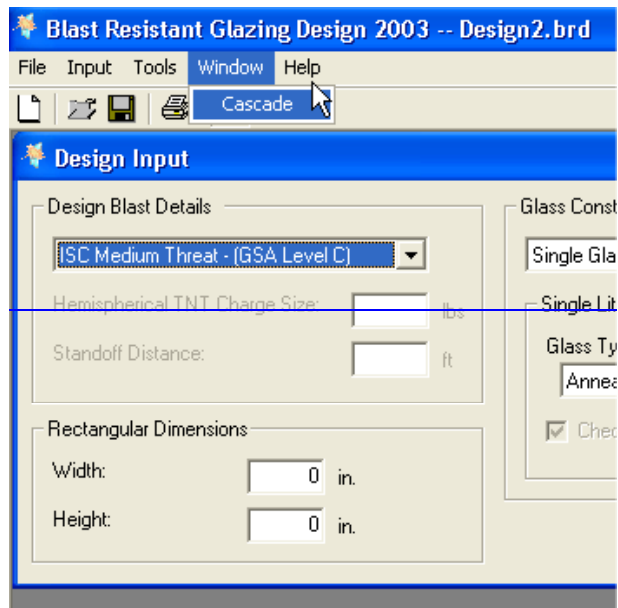


Figure 2.13: Cascade Windows

CHAPTER III Project Information

3.1 Access

To access the “Project Information” window click on “File/Project Info” as Figure 3.1 shows.

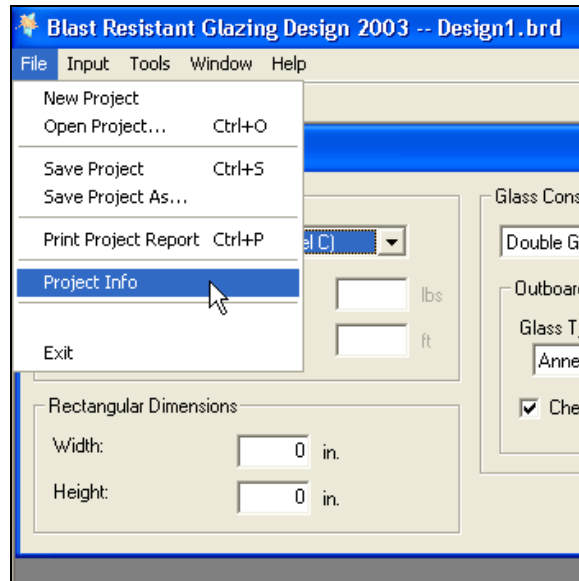


Figure 3.1: Project Information Access

3.2 Description

The “Project Information” window (Figure 3.2) contains reference information about the design project that includes the project name, location and designer. The window provides a field for comments and other information relevant to the project. These data are for the user’s information only. The software does not require this information to perform design calculations.

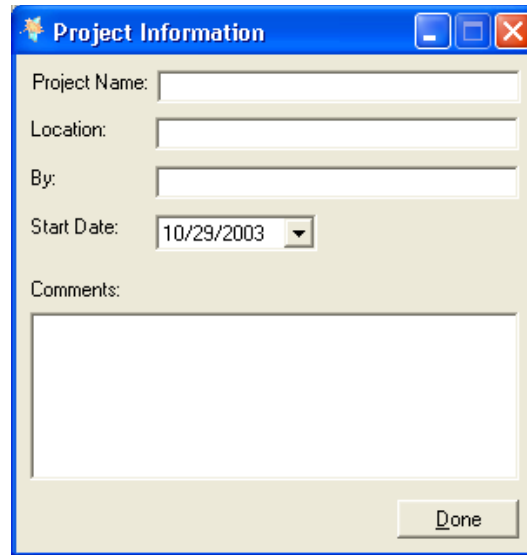





Figure 3.2: Project Information Window

3.3 Closing the Project Information Window

To close the Project Information window click on the  button or press the  button. Although the window is closed, the program stores all the information for the current project. To edit the data in this window, simply reopen the Project Information window.

Chapter IV: Design Input

4.1 Access

Upon opening, BRGD 2003 automatically displays the “Design Input” window. From time to time the user might close or minimize this window. Although this window is closed, BRGD 2003 stores all the information for the current project. If the window is minimized, BRGD 2003 places the window in the bottom left hand corner of the window as shown in Figure 4.1. Simply press the  button to activate the window. If the window is closed, the program hides the window. To access the “Design Input” window click on “Input/Individual Lite” as Figure 4.2 shows.

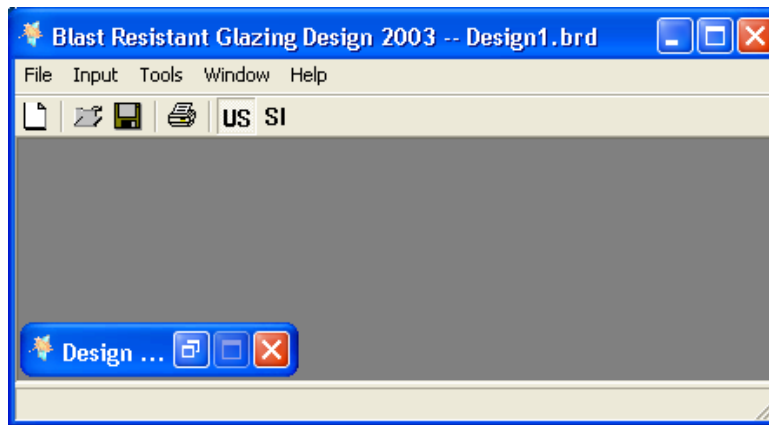


Figure 4.1: Minimized Design Input Window

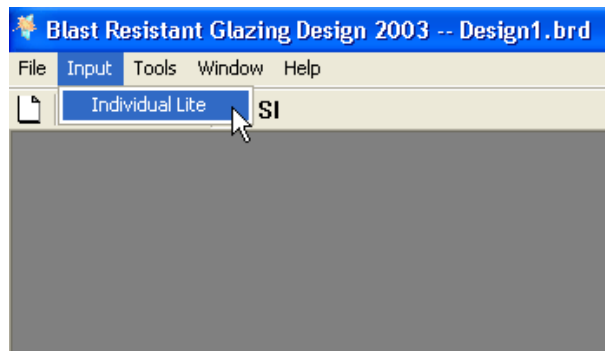
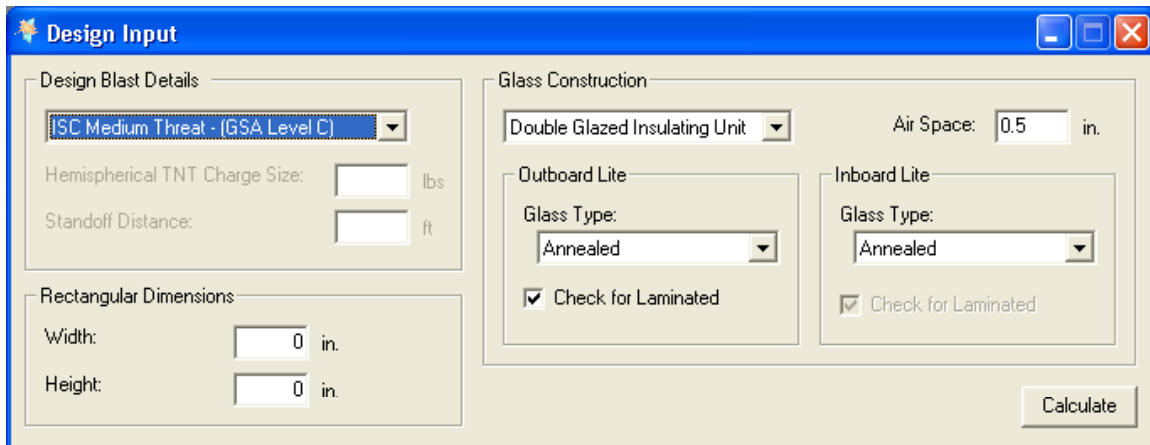


Figure 4.2: Design Input Access

4.2 User Input

Figure 4.3 shows the “Design Input” window. This window facilitates input of the required information for a blast resistant glazing design. This window has three sections: the “Design Blast Details” section, the “Rectangular Dimensions” section, and the “Glass Construction” section.



The screenshot shows a software window titled "Design Input" with a blue title bar and standard window controls. The window is divided into three main sections:

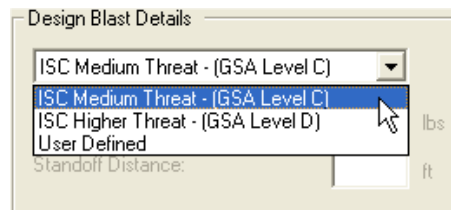
- Design Blast Details:** Contains a dropdown menu set to "ISC Medium Threat - (GSA Level C)", two input fields for "Hemispherical TNT Charge Size" (with "lbs" unit) and "Standoff Distance" (with "ft" unit).
- Rectangular Dimensions:** Contains two input fields for "Width" and "Height", both currently set to "0" with "in." units.
- Glass Construction:** Contains a dropdown menu set to "Double Glazed Insulating Unit", an "Air Space" input field set to "0.5" with "in." unit, and two sub-sections for "Outboard Lite" and "Inboard Lite". Each sub-section has a "Glass Type" dropdown menu set to "Annealed" and a checked checkbox for "Check for Laminated".

A "Calculate" button is located at the bottom right of the window.

Figure 4.3: Design Input Window

4.3 Design Blast Details

The “Design Blast Details” section allows the user to define the design blast threat by selecting an ISC Medium Threat (GSA Level C), an ISC High Threat (GSA Level D), or a User-Defined blast as shown in Figure 4.4. A user-defined blast requires an equivalent hemispherical TNT charge size and standoff distance to calculate the equivalent 3-second duration equivalent design load acting on the glazing.



This close-up screenshot shows the "Design Blast Details" section of the software. It features a dropdown menu with three options: "ISC Medium Threat - (GSA Level C)", "ISC Higher Threat - (GSA Level D)", and "User Defined". A mouse cursor is pointing at the "ISC Medium Threat - (GSA Level C)" option. Below the dropdown menu are two input fields: "Hemispherical TNT Charge Size" with a "lbs" unit and "Standoff Distance" with a "ft" unit.

Figure 4.4: Design Blast Details

4.3.1 ISC/GSA

Choosing “ISC Medium Threat – (GSA Level C)” or “ISC Higher Threat – (GSA Level D)” defines a blast threat consistent with existing US government definitions.

4.3.2 User-Defined

A user-defined blast requires the user to input the equivalent hemispherical TNT charge size and standoff distance associated with a design threat. Blast Resistant Glazing Design 2003 accepts TNT charge sizes ranging from 10 lb. (4.54 kg) to 2000 lb. (907 kg).

4.4 Rectangular Dimensions

The Rectangular Dimensions section allows the user to input the size of the fenestration to be glazed. Ambiguity exists in the design community as to whether these dimensions represent the size of the blast resistant glazing itself or the raw opening size. This is a question that the glazing designer must answer. In general, using the raw opening dimensions will result in acceptable, if conservative, glass thickness selection

4.5 Glass Constructions

Blast Resistant Glazing Design 2003 designs for glazing constructions of a single glazed lite or double glazed insulating unit as indicated by Figure 4.5.

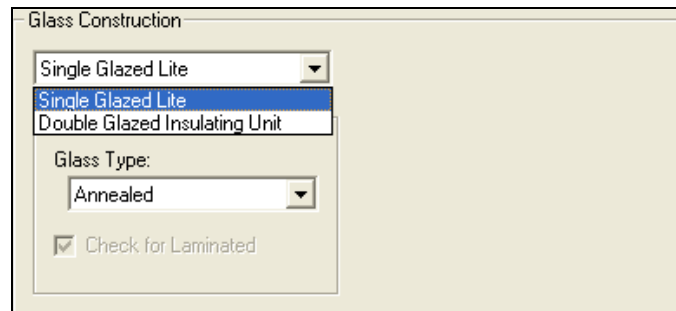


Figure 4.5: Glass Constructions

4.5.1 Single Glazed Lite

For a single glazed lite, BRGD 2003 facilitates designs only with laminated glass fabricated with annealed or heat strengthened glass plies as shown in Figure 4.6.

The program uses only laminated glass with nominal 6 mm (1/4 in.) or larger thickness for blast resistant glazing design.

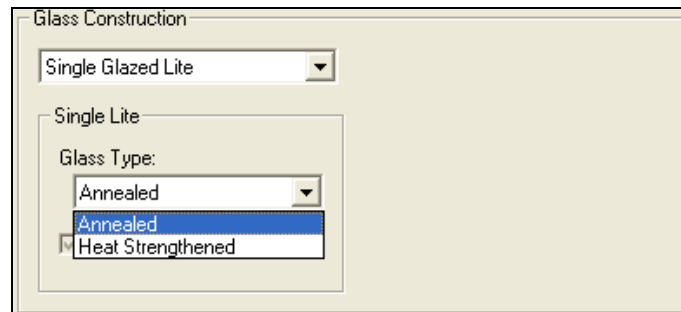


Figure 4.6: Single Glazed Lite

4.5.1.1 Annealed Glass

Annealed Glass consists of a flat monolithic glass lite of uniform thickness having residual surface stresses that are nearly zero.

4.5.1.2 Heat Strengthened Glass

Heat strengthened glass consists of a flat monolithic glass lite of uniform thickness that has been subjected to a special heat treatment process where the residual surface compression ranges from 24 MPa (3500 psi) to 52 MPa (7500 psi).

4.5.2 Double Glazed Insulating Unit

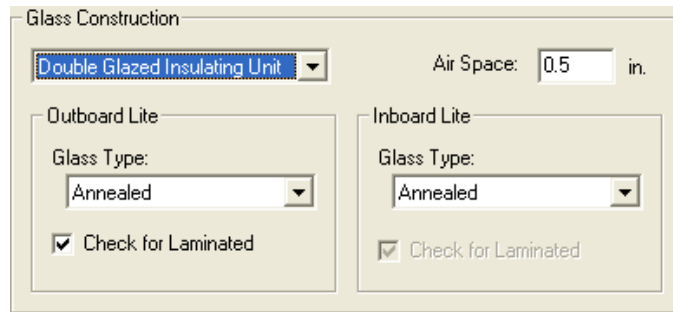
Any combination of two glass lites enclosing a sealed space filled with air or other gas.

4.5.2.1 Outboard Lite

The outboard lite of an insulating glass unit is the lite that faces toward the outside of the building. Blast Resistant Glazing Design 2003 allows the user to select laminated or monolithic glass fabricated with annealed or heat strengthened glass for the outboard lite. To select the outboard lite as monolithic, uncheck the box marked "check for laminated" shown in Figure 4.7.

4.5.2.2 Inboard Lite

The inboard lite is the lite of an insulating glass unit that faces toward the inside of the building. Consistent with ASTM F 2248-03, BRGD 2003 requires laminated glass for the inboard lite. Blast Resistant Glazing Design 2003 allows fabrication of the laminated glass with either annealed or heat strengthened glass.



The image shows a software dialog box titled "Glass Construction". At the top, there is a dropdown menu set to "Double Glazed Insulating Unit". To the right of this menu is a text input field for "Air Space:" containing the value "0.5" followed by the unit "in.". Below the main menu, there are two columns of settings. The left column is labeled "Outboard Lite" and contains a "Glass Type:" dropdown menu set to "Annealed" and a checked checkbox labeled "Check for Laminated". The right column is labeled "Inboard Lite" and also contains a "Glass Type:" dropdown menu set to "Annealed" and a checked checkbox labeled "Check for Laminated".

Figure 4.7: Double Glazed Insulating Unit

4.5.2.3 Air Space

The air spaced is the sealed space in an insulating glass unit. The air space thickness consists of the distance between the glass lites in the insulating glass in inches (mm). The program uses a default value 0.5 in. (12.7 mm) for the air space. The user can change this value.

4.5.2.4 Other Definitions

For other definitions related to glass and glazing, refer to ASTM E 1300 or ASTM C 1048.

Chapter V Design Results

5.1 Access

To access the “Design” window, click the button on the Design Input window shown in Figure 5.1. This calculates the nominal thickness(es) of the blast resistant glazing, the recommended size of the structural sealant bead, and the uniformly distributed loads required to design the window glass frame and attach it to the structure.

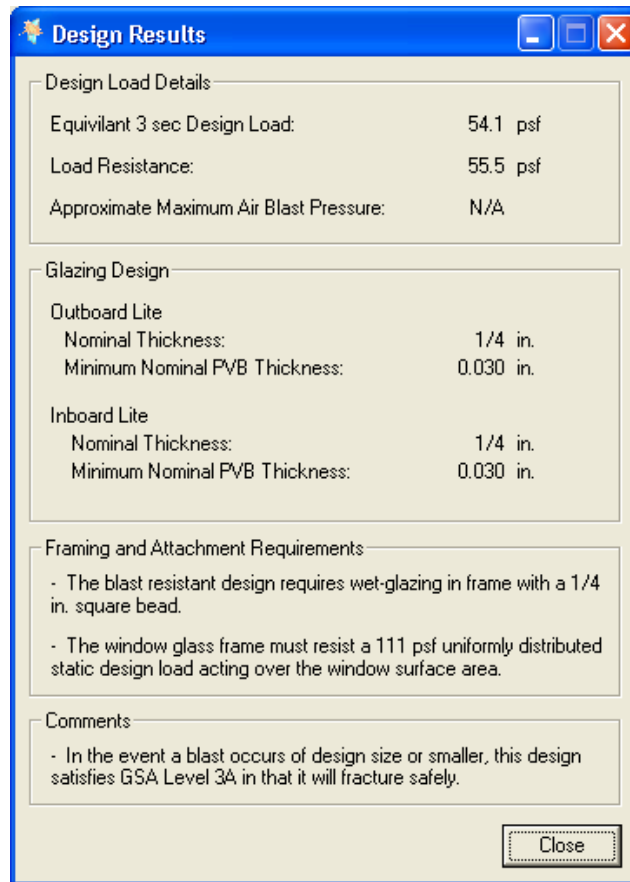


Figure 5.1: Design Results Window

5.2 Design Load Details

The “Design Load Details” section (Figure 5.2) of the “Design Results” window, displays the equivalent 3-second duration design load, the load resistance of the blast resistant glazing, and the approximate maximum air blast pressure.

Design Load Details	
Equivalent 3 sec Design Load:	54.1 psf
Load Resistance:	55.5 psf
Approximate Maximum Air Blast Pressure:	N/A

Figure 5.2: Design Load Details

5.2.1 Equivalent 3–Second Duration Design Load

Blast Resistant Glazing Design 2003 uses the procedures in ASTM E 2248-03 to determine the equivalent 3-second duration design load for the blast resistant glazing. It then follows procedures in ASTM E 1300-02/02 to determine the required glazing thickness(es) for the blast resistant glazing so that its load resistance exceeds the equivalent 3-second duration design load.

5.2.2 Load Resistance

The load resistance is the uniform lateral load that a glass construction can sustain based upon a given probability of breakage and load duration. ASTM E 1300-02/03 uses a 3-second load duration and a probability of breakage of 8 lites per 1000 at its first occurrence of the design loading. In the event of a blast loading occurring equal to the design threat, blast resistant glazing will fracture safely. If the load resistance of a blast resistant glazing falls beyond the limits of ASTM E 1300-02 for the current design, BRGD 2003 displays a load resistance of “N/A” for the current design, and does not display the glazing design section explained in Section 5.2.

5.2.3 Approximate Maximum Air Blast Pressure

If a “User-Defined” threat is selected, the program displays an approximate maximum air blast pressure. For “ISC Medium Threat – (GSA Level C)” or “ISC Higher Threat – (GSA Level D)” air blast pressure loading, the program does not display an approximate maximum air blast pressure for security reasons.

5.3 Glazing Design

The glazing design (Figure 5.3) section displays the calculated nominal thickness of glass that has load resistance greater than the equivalent 3-second duration design load according to ASTM E1300-02/03. The program also displays the minimum nominal thickness of the PVB Interlayer for the each laminated glass lite. If the load resistance of a blast resistant glazing falls beyond the limits of

ASTM E 1300-02/03 for the current design, the program does not display the “Glazing Design” section.

Glazing Design	
Outboard Lite	
Nominal Thickness:	1/4 in.
Minimum Nominal PVB Thickness:	0.030 in.
Inboard Lite	
Nominal Thickness:	1/4 in.
Minimum Nominal PVB Thickness:	0.030 in.

Figure 5.3: Glazing Design Section

5.3.1 PVB Interlayer Nominal Thickness

Blast Resistant Glazing Design 2003 determines the minimum nominal thickness for the PVB interlayer for each lite. For laminated glass with heat strengthened lites, the minimum PVB interlayer nominal thickness shall be 1.52 mm (0.060 in.). For laminated glass with annealed glass lites, the minimum PVB interlayer nominal thickness shall be 0.76 mm (0.030 in.).

5.4 Framing and Attachment Requirements

This section gives the design requirement for the framing and window attachment as Figure 5.43 shows. The first comment displays the recommended size of the structural sealant bead to attach the blast resistant glazing to the frame. The second comment gives the uniformly distributed static design load acting over the window surface area that the frame and its attachment to the building must resist in the event that the design blast occurs.

Framing and Attachment Requirements
- The blast resistant design requires wet-glazing in frame with a 1/4 in. square bead.
- The window glass frame must resist a 111 psf uniformly distributed static design load acting over the window surface area.

Figure 5.4: Framing and Attachment Section

5.5 Comments

The comment section (Figure 5.5) gives additional information for the blast resistant glazing design. The comment section explains the GSA

Hazard/Protection level for the design. A GSA level 3A is a “High Protection, Very Low Hazard” performance criterion. Under this criterion in the event of a design level blast the glazing cracks, and fragments enter the space and land on the floor no further than 3.3 ft (1.0 m) from the window.

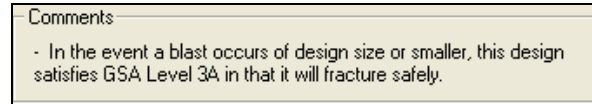


Figure 5.5: Comment Section, Within ASTM E 1300-02

If the load resistance of a blast resistant glazing falls beyond the limits of ASTM E 1300-02, the software only displays the equivalent 3-second design load and does not provide any other results. The comment block shown in Figure 5.6, states that for the particular design additional design considerations are required.

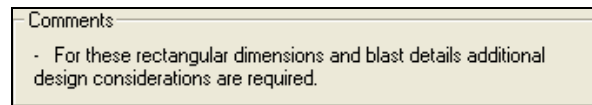
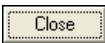



Figure 5.6: Comment Section, Beyond ASTM E-1300-02

5.6 Closing the Design Results Window

To close the design results window press the  button on the bottom of the window or press the  button located on the top right hand corner of the Design Results window. To recalculate the results, follow the instruction in Section 5.1 of this document.