

BRADD Software Executive Summary

Software Description and Functionality

PennDOT's **Bridge Automated Design and Drafting Software (BRADD)** is a computer software program that was developed for PennDOT to automate the bridge design process from problem definition through contract drawing development. BRADD combines and automates the design, analysis, and drafting process for specific types of simple span bridges. The software provides user friendly Windows-based Graphical User Interface (GUI) menu driven input, numerous application design programs, and a drawing generation built around Bentley's MicroStation CADD technology to enable an engineer to design and produce scaled contract drawings automatically for simple span bridges.

The BRADD Software was written as a tool for the Load and Resistance Factor Design of simple span concrete, steel, and prestressed concrete bridges with span lengths ranging from 18 feet to 200 feet. The software supports tangent geometry, horizontal curves (chord beams) and vertical curves. The bridge skew (PennDOT definition) can range from 25 degrees to 90 degrees. Available cross-section types are normal, symmetrical, superelevation, and superelevation transition. The maximum bridge width is limited by the following: a maximum of 20 beams in the cross section for all structure types, with or without sidewalks; a maximum of 8 design (12 feet) lanes (curb-to-curb) in the cross section for all structure types, with or without sidewalks; and an absolute maximum (out-to-out) of 125.54 feet. The minimum bridge width is limited to 13 feet.

Available superstructure types are P/S Adjacent Box Beams, P/S Spread Box Beams, P/S I-Beams, Steel Rolled Beams and Steel Plate Girders. The Abutment types, referred to in this documentation as traditional abutments, can be either Stub Abutment, Cantilever Abutment, or Wall Abutments supported by either spread footings or footings on piles. The user can also select an integral abutment and enter input to draft integral abutments, although no design for the integral abutments or wings is provided. BRADD can also be run to design and draft the superstructure only using a "Superstructure Only" option. For the "Superstructure Only" option, the abutment type is specified as "SuperOnly" and the user needs only to input if there is a backwall and the type of wingwall at each abutment. In addition, for spread superstructures, BRADD can design and draft the superstructure only for integral abutments with minimum input for the abutment wingwalls. Superstructure details related to integral abutments are drafted as part of the superstructure drawings. However, no design or drafting for the integral abutments or wings is provided for the superstructure only option.

BRIDGE AUTOMATED DESIGN AND DRAFTING SOFTWARE

The current version of the BRADD Software only supports English (US) units. Previous versions of BRADD, including Versions 3.1.0.0 through 3.1.4.1 supported both US and metric units.

The BRADD Software consists of approximately:

- 4600 FORTRAN routines (730,000 lines of code)
- 590 dimensions/parameter/data files (92,500 lines of data)
- 260 graphics details containing 976 overlays

The software is compiled using Intel(R) Fortran Compiler with Microsoft Visual Studio 2019. The Graphical User Interface for BRADD is compiled using Microsoft Visual Basic 2017. It consists of approximately 150 files with 83,000 lines of code.

BRADD's generation of design drawings is accomplished by three FORTRAN programs that are linked by a fourth FORTRAN program. The first program, the sheet generation program, evaluates key parametric values such as superstructure type, substructure type, span length, etc. to determine the appropriate design drawings that need to be produced. A subroutine is then called for each bridge layout drawing, which evaluates other parametric values and decides which details need to be placed. Each detail is divided into a series of layers, which can be overlaid on top of each other to construct the final bridge detail. All engineering details are created using a generic drawing generation system that utilizes two additional FORTRAN programs.

This system brings together information from design and dimensioning programs with specific detail information, which has been defined using a parametric drafting language (PDL). This allows details to be defined by coordinates that are located by design and dimensioning variables and constants. After definition of the coordinates, the detail is built by connecting control points together to form elements, which are placed to scale in a MicroStation design file (.DGN) by calling command line MicroStation applications to generate the MicroStation design file elements. The presence of a supported Bentley product (one of MicroStation, PowerDraft, OpenBridge Modeler, or OpenRoads Designer) is required during DGN design drawing generation to place the elements. Also, BRADD is able to create generic exchange design file format (.DXF) drawings, which can then be interpreted by most CADD software.

Software Information Version 3.2.8.0

The BRADD Software automates the bridge design process by incorporating PennDOT's bridge geometry (BRGEO), superstructure (STLRFD, PSLRFD, BPLRFD), and substructure (ABLRFD) design programs into the subsystem that designs and analyzes the specific types of simple span bridges.

The version number and date of the programs incorporated into this version of BRADD are as follows:

<u>Program</u>	<u>Description</u>	<u>Version</u>	<u>Release Date</u>
BRGEO*	Bridge Geometry	1.1	June 2003
ABLRFD**	LRFD Abutment and Retaining Wall Design and Analysis	1.18.0.0	March 2022
BPLRFD**	LRFD Bearing Pad Design and Analysis	1.10.0.0	May 2020
PSLRFD**	LRFD Prestressed Concrete Girder Design and Rating	2.15.0.0	June 2022
STLRFD**	LRFD Steel Girder Design and Rating	2.7.0.0	August 2021

Note: * This program is not modified from the standalone version, but is enhanced by additional functionality when installed and used in BRADD.

** These programs are unchanged from the standalone version when installed and used in BRADD.

Workstation Hardware and Software Requirements for Version 3.2.8.0

BRADD is supported on Windows 10 and Windows 11 operating systems. In order to load BRADD and produce design files and drawings, it is recommended that a workstation (PC) has 1,100 MB of free space.

BRADD contains features with two non-critical dependencies on Microsoft Office. One feature is the option to export BRADD input tabular information directly to an Excel spreadsheet. Microsoft Office 2007 or newer must be installed in order for this to work properly. Another feature is the option to open both the "BRADD Technical Questions" and the "BRADD Revision Requests" on the "Help" pull-down menu as templates and the option to open Excel spreadsheets like the Designer Checklist. Microsoft Office 2003 or newer must be installed in order for these features to work properly. However, BRADD can be run without using these features.

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In order to produce design drawing files in MicroStation format (.DGN), one of Bentley's **MicroStation V8i**, **PowerDraft V8i**, **OpenBridge Modeler**, or **OpenRoads Designer** must be installed and operating on your workstation. The following versions of each product are acceptable:

MicroStation: V8i (SELECTSeries 1, version 08.11.07 or newer).

MicroStation: CONNECT (Update 9 or newer).

PowerDraft: V8i (SELECTSeries 1, version 08.11.07 or newer).

OpenBridge Modeler: CONNECT Edition (version 10.08.0.60 or newer).

OpenRoads Designer: CONNECT Edition (version 10.08.0.60 or newer).

Due to Bentley restrictions, Bentley product OpenBridge Designer currently may not be used by BRADD for generating design file drawings. If those restrictions are eliminated it may be possible for BRADD to use additional Bentley products for design file generation in the future.

BRADD drawings cannot be generated using the initial version of MicroStation V8i (version 08.11.05), any version of PowerDraft CONNECT, or any version of OpenBridge Designer due to restrictions from Bentley.