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ProtaStructure Design Guide

Steel Base Plate Connections

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Publisher

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Steel Base Plates

Base plates play a critical role in steel structures by providing a stable and reliable interface between steel columns and their supporting foundations. These structural members ensure the safe transfer of loads from the steel column to the concrete foundation, allowing for even distribution of forces while preventing local failure or excessive stress concentrations.

A well-designed base plate must be capable of resisting axial loads, shear forces, and bending moments that arise from various structural demands. The primary objectives of base plate design include:

- Load Distribution: Ensuring that the applied forces from the steel column are spread uniformly over the concrete foundation to prevent localized stress failures.
- Structural Stability: Providing a firm and secure connection between the column and the foundation, minimizing movements due to lateral loads or moments.
- Anchorage and Connection Efficiency: Ensuring that the anchor bolts effectively hold the base plate in place and transfer forces safely without excessive deformation or failure.

In practice, several factors influence base plate design, including the plate's thickness, material properties, anchor placement, and edge distances. The selection of these parameters directly impacts the structural performance, durability, and safety of the connection.

In ProtaStructure 2026, we have developed a Steel Base Plate Design Tool, a powerful addition to the structural design toolkit. This tool enables engineers to analyze the necessary failure modes for base plates, ensuring a safe and efficient connection between steel columns and foundations. The analysis is specifically tailored for cast-in anchors, with no anchor reinforcement considered for simplicity. Designed for flexibility, the tool allows users to perform calculations based on their preferred design standards, supporting Eurocode, Turkish Code, and American Code. By automating complex checks and providing clear, code-compliant results, this tool enhances the efficiency and accuracy of base plate design.

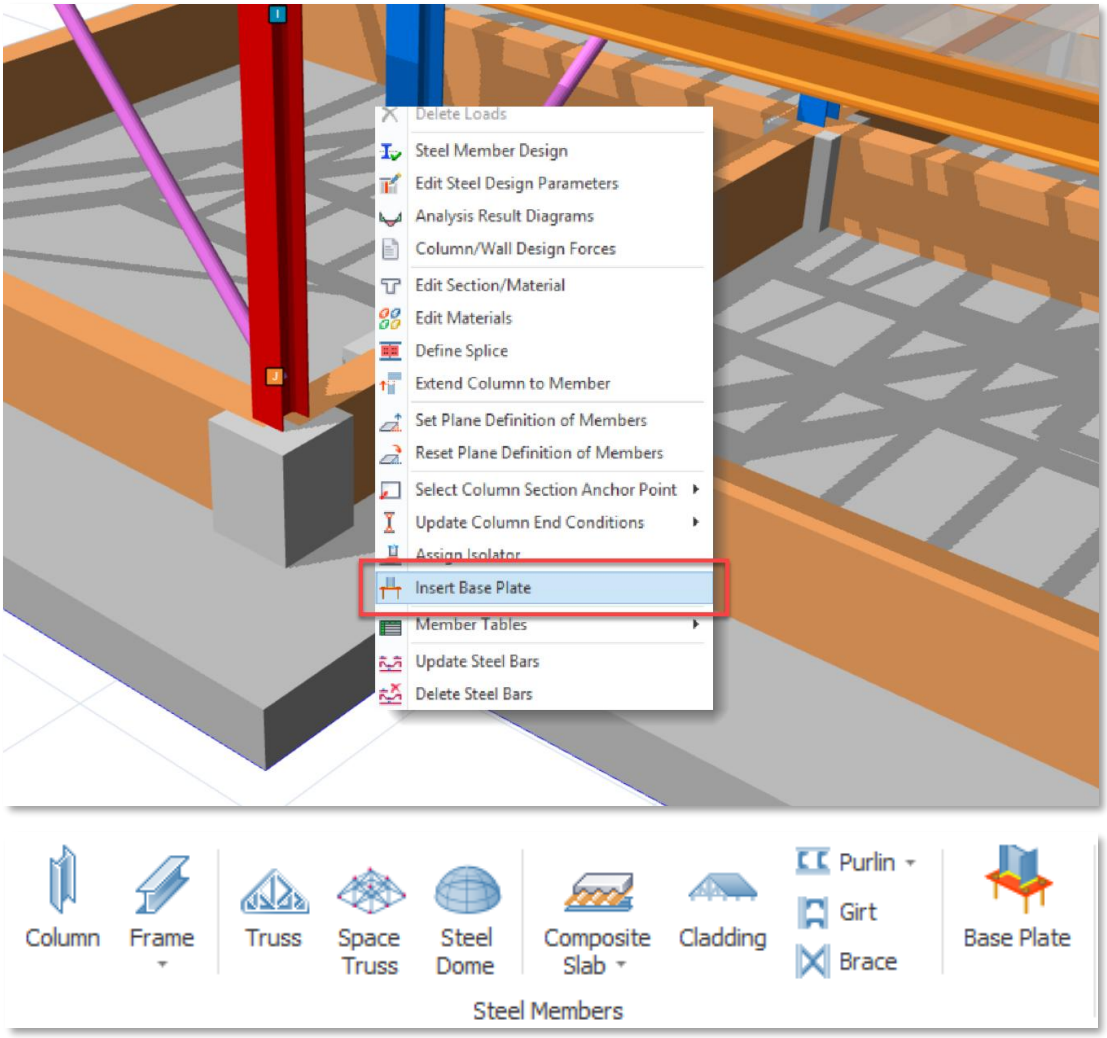
Steel Base Plate Insertion

You can insert steel base plates under steel columns **one at a time** or **as a group**.

Inserting a Steel Base Plate

To insert a single steel base plate under a steel column:

1. Select a steel column
2. Right click and pick **Insert Base Plate** command.
3. Alternatively, you can use **Base Plate** command on **Modeling > Steel Members** ribbon tab.

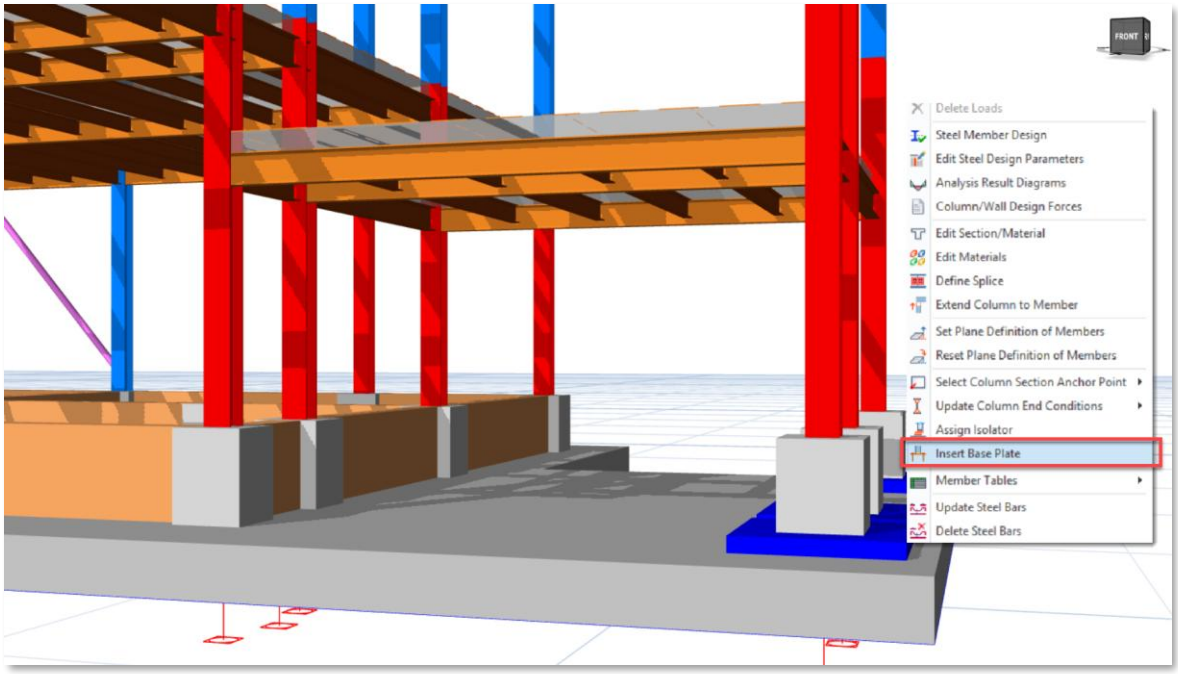


Important Note:
When you insert a single base plate, it will be designed according to the most critical internal forces under the selected column

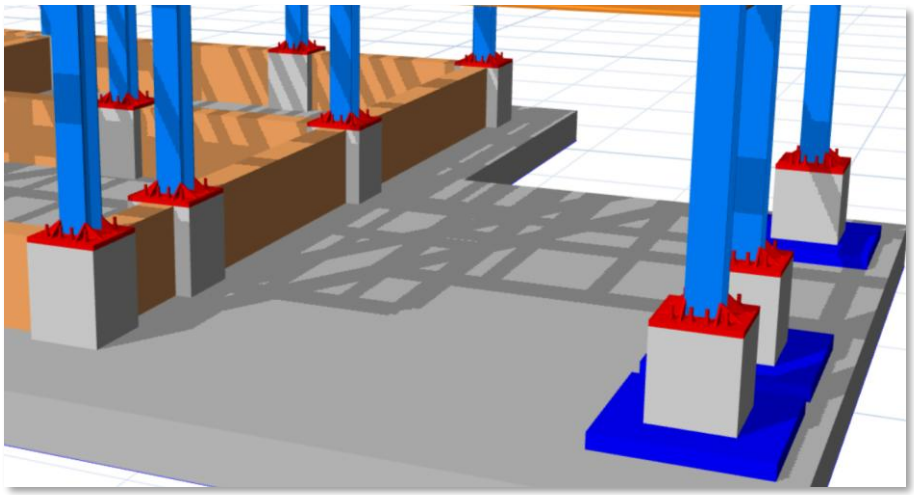
Inserting Multiple Steel Base Plates

To insert multiple steel base plates under multiple columns with a single click:

1. Select **multiple steel columns** on the screen using one of the selection methods in ProtaStructure
2. Right click and pick **Insert Base Plate** command.
3. Alternatively, you can use **Base Plate** command on **Modeling > Steel Members** ribbon tab.
4. Base plates will be inserted under each steel column.

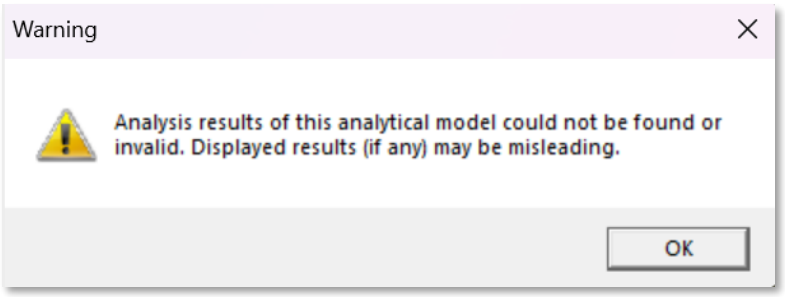


Important Note:
Steel Base Plates inserted this way are **treated as a group**. They are designed according to the most critical internal forces of all selected columns. In addition to this, they will be **selected, modified** or **deleted as a group**.



Steel Base Plates and Building Analysis

Since the design checks depend on column results, the building analysis must be performed before any base plate design can be done. If the building analysis has not been performed or the existing results are out-of-date, ProtaStructure will issue a warning. In this case, the building analysis should be performed, and the validity of the analysis should be checked.



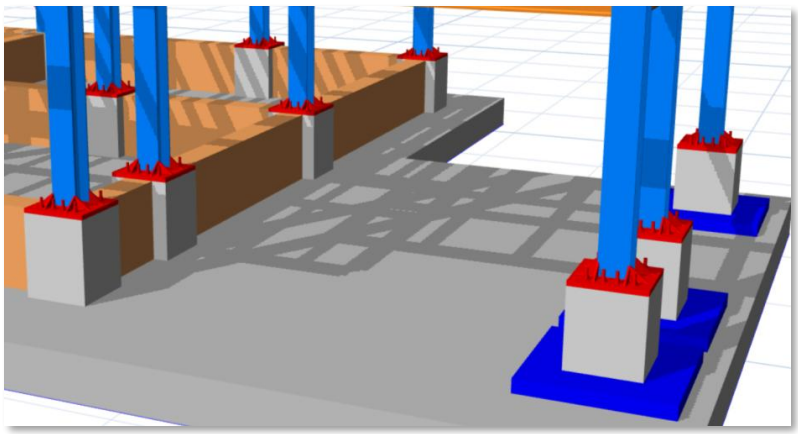
Important Note:
A steel base plate can still be inserted under a column, even though there is no valid analysis results. In this case, the base plate will be inserted but you will not be able to perform design and review the design results. The base plate connection will only be displayed for visual purposes if there are no analysis results.

Inserting Steel Base Plates in Foundation Storey

In order to insert steel plates in the foundation storey, you have two options explained below.

Inserting Base Plates on RC Pedestals

You must define an **RC pedestal** under the steel column before inserting base plate. This is usually the case when bottom of the steel column does not directly sit on a foundation slab or foundation beam.

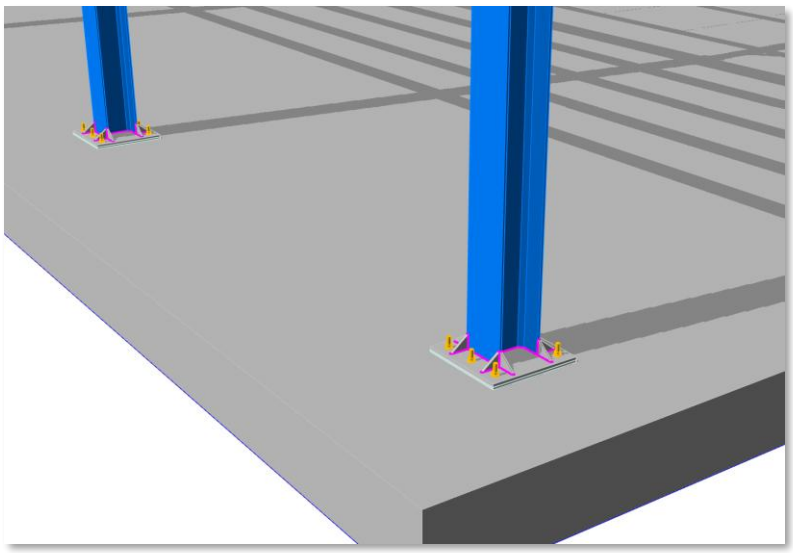


Note:
Modeling, analysis and design of RC Pedestals are out of this document's scope. Please refer to the following document for more information:

ProtaStructure Design Guide – RC Pedestals

Inserting Base Plates on Foundation Slabs

If the foundation beams, foundation walls or foundation slabs are **in direct contact with the bottom of the steel column**, then you can insert base plate without pedestals. ProtaStructure will automatically detect these adjacent members when you insert a base plate. That means the foundation slab depth must be equal to the foundation depth.

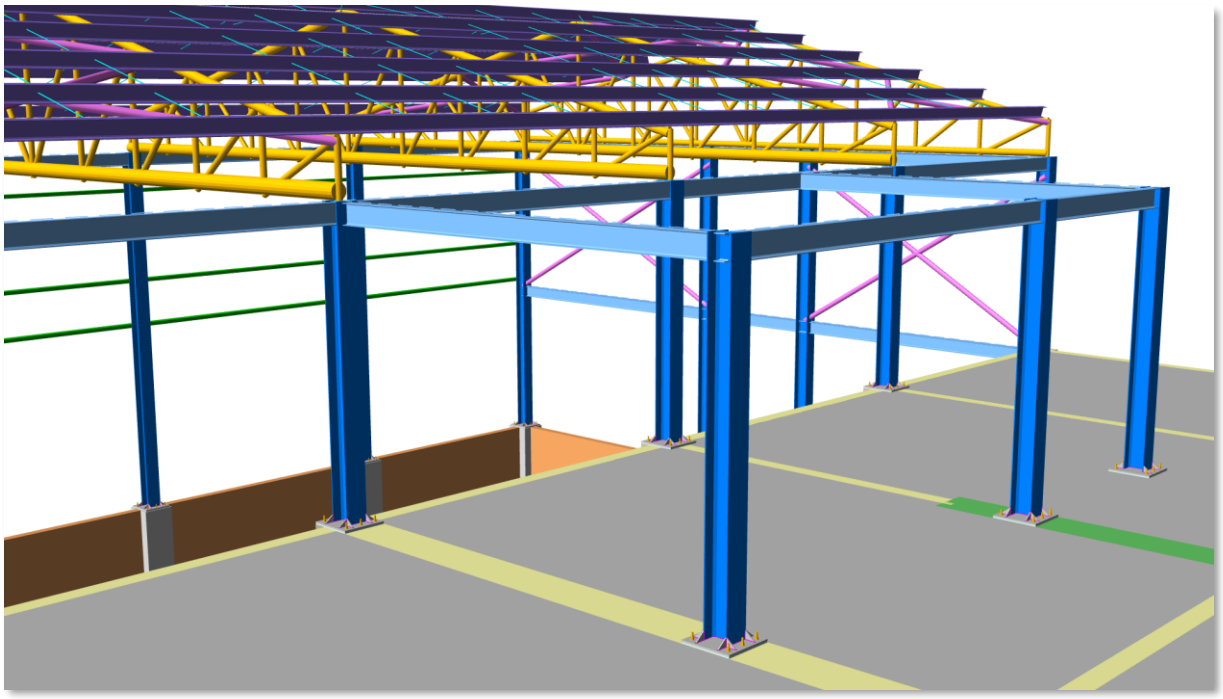


Important Note:
To define base plate on other foundation types such as pad footing, pilecap or strip footing, you have to insert an **RC pedestal first**.

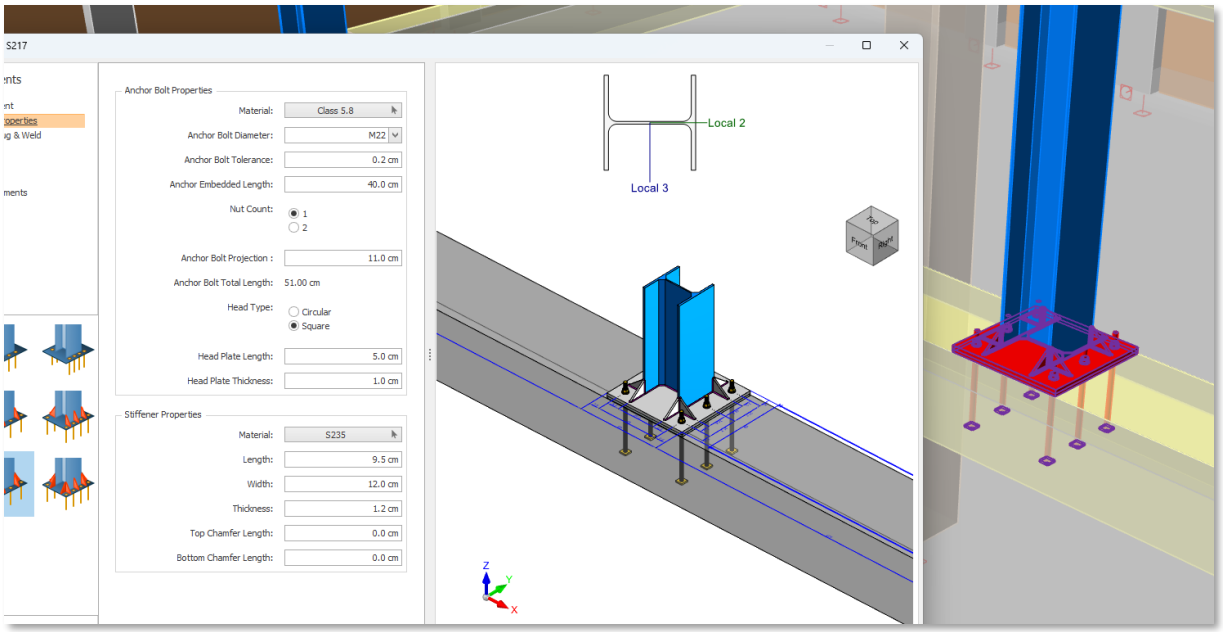
Regardless of the foundation type, **RC pedestals are recommended** where the steel columns are connected to the foundation on the foundation floor to provide a more uniform load distribution and protection against corrosion. The base plate connection tool automatically recognizes the dimensions of the reinforced concrete elements to which the steel column is connected and displays them in the base plate interface for use in calculations.

Inserting Steel Base Plates at Different Floors

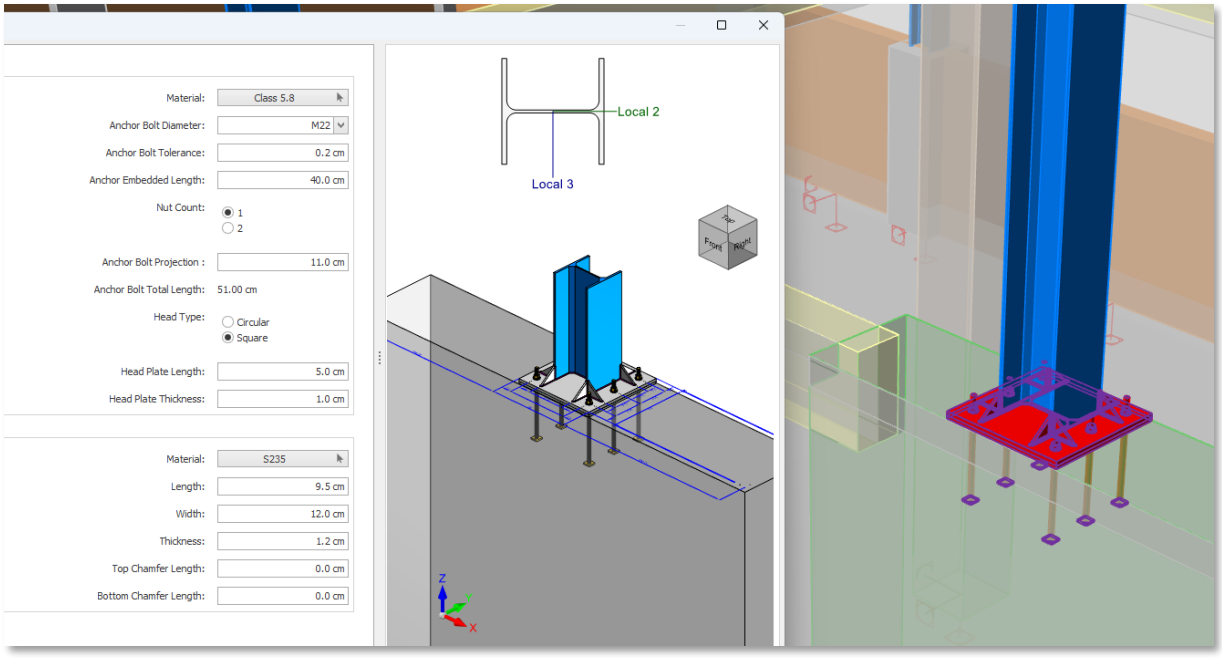
Base plates can be inserted under the steel columns at any floor. This means, You are not constrained to the foundation storeys. There may be cases where you want to sit a steel column on a concrete column, shearwall, beam or a thick slab. The base plate tool can be used for a steel column connected to the foundation at the **Foundation floor (St: 0)**, or for a steel column connected to a reinforced concrete column, wall or beam at any floor. A simple illustration is shown below:



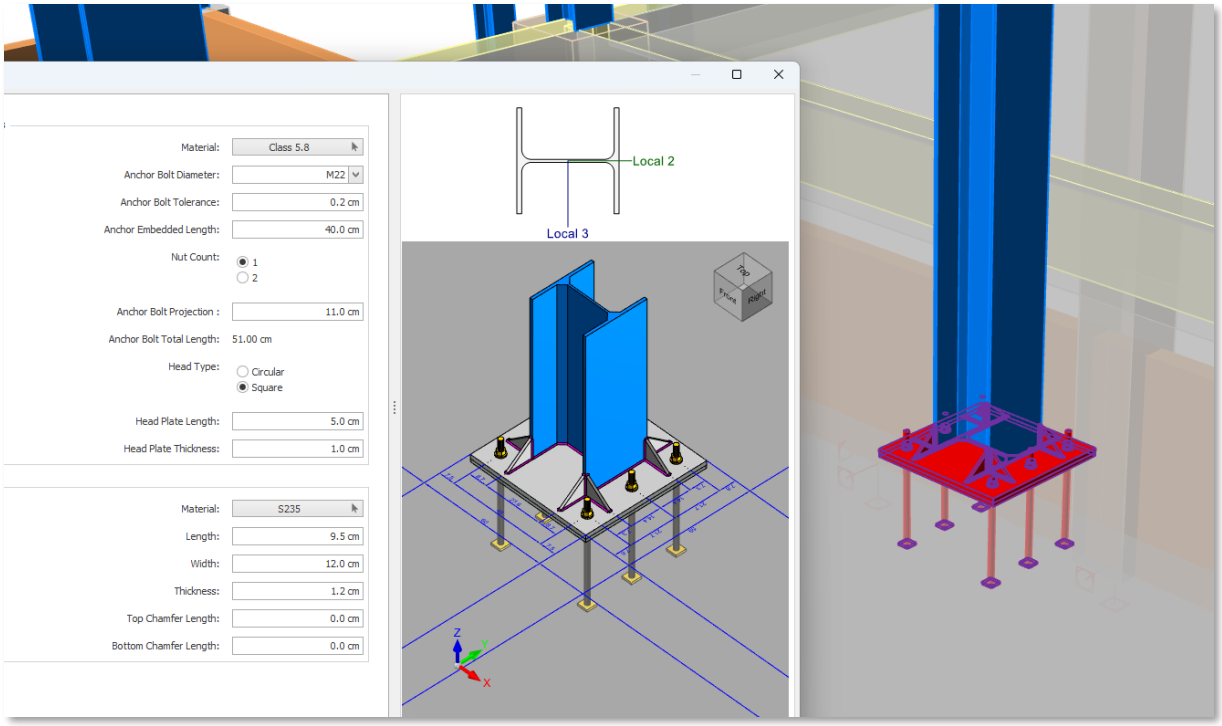
ProtaStructure will automatically recognize the member under the steel column, that will constitute a support for the base plate.



Base plate sitting on a beam at the upper storey



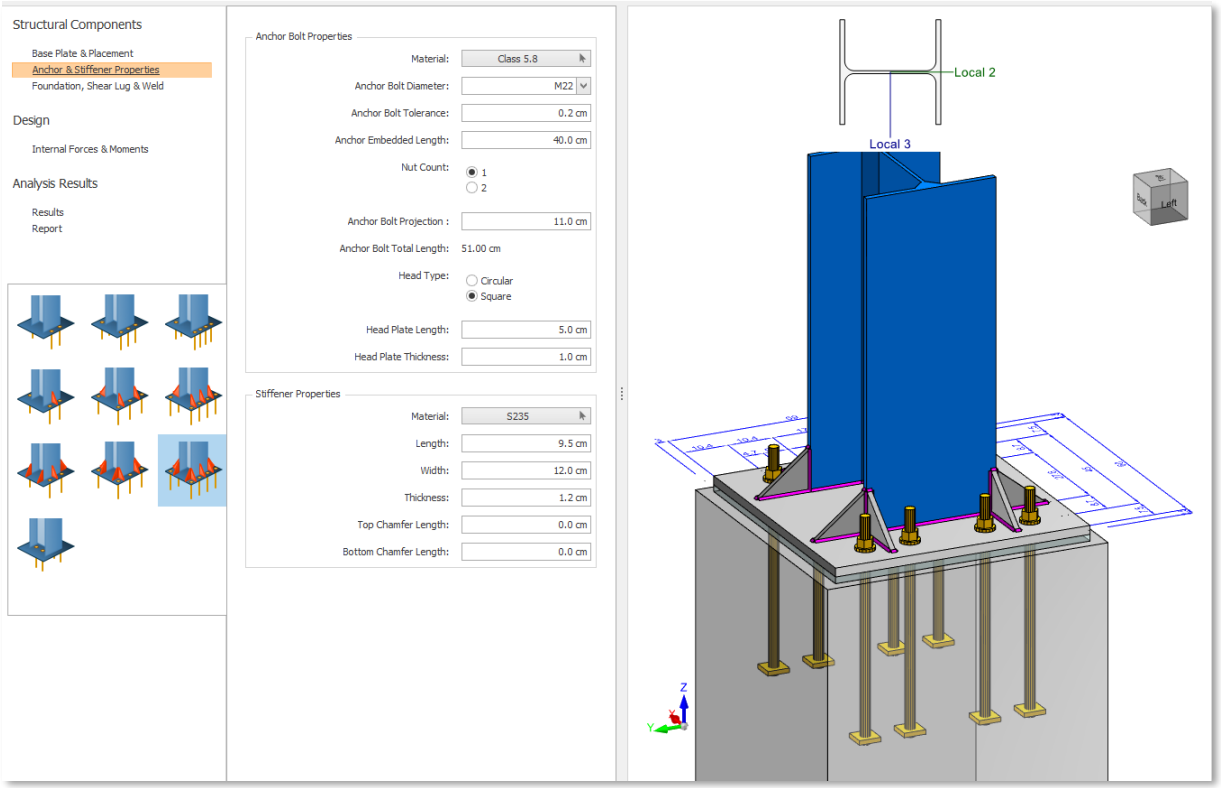
Base plate sitting on a shearwall at the upper storey



Base plate sitting on a thick slab at the upper storey

Base Plate Editor

As soon as you select the **Insert Base Plate** command, the **Base Plate Editor** dialog will appear. The **Base Plate Editor UI** provides a structured layout for defining base plate design parameters.



The user interface is divided into several key sections, each designed to streamline the base plate design process:

- **Structural Components:** This section allows users to navigate between different aspects of base plate design, including **Base Plate & Placement**, **Anchors, Stiffeners & Weld Properties**, and **Foundation & Shear Lug**. Users can also switch between different base plate connection types using the provided icons.

- **Design:** This section represents the loading conditions applied to the base plate and provides a structured interface for defining and analyzing internal forces and moments.

- **Analysis Results**: This section consists of two parts: the **Results** section and the **Report** section. The Results section provides a detailed list of all failure modes along with a brief description of the formulations used to evaluate each one. The Report section enables users to generate the desired report, selecting specific types of data to include in the output.

- **Center Panel:** The main input area adapts based on the selected menu, allowing users to define key parameters with precision and flexibility.

- **3D Visualization:** A real-time 3D model visually represents the base plate, anchors, and column connection. This feature helps to you verify their inputs by providing an interactive preview of the design. The view cube allows you to see the connection from different angles. Especially with the top view, you can quickly adjust the distance between the members. You can rotate

the model by holding down the left mouse button. In addition, the local axes of the section can be viewed in this area. Thus, you can quickly make your assessments regarding the load directions.

- **Base Plate Types Gallery**: The gallery on the bottom left provides a visual selection of base plate preset configurations, allowing you to choose different anchor arrangements, stiffener placements, and load transfer mechanisms. Each gallery item represents a specific base plate type, varying in number of anchors, stiffener orientation, and structural behavior. Selecting a configuration updates the input parameters accordingly, ensuring the design matches the intended structural requirements.

- **Action Buttons:** Users can either accept the design by **"OK"** button**, "Revert Changes"** to reset modifications, or **"Cancel"** to exit without applying adjustments.

Structural Components

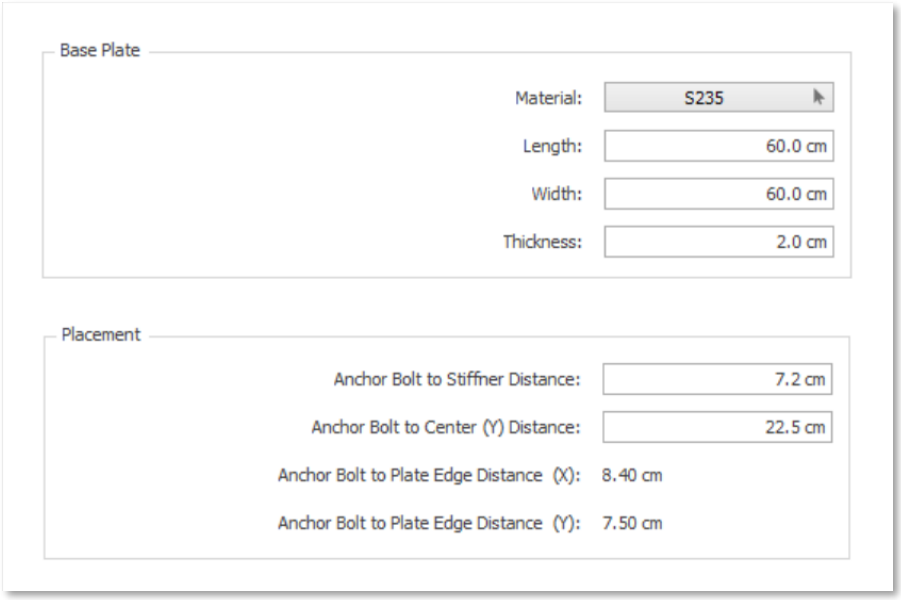
This section on the UI is divided into three parts, each handling specific aspects of base plate design. You can define design parameters and geometric properties in this section, ensuring accurate input for analysis. The available sections and their corresponding inputs are outlined below.

Base Plate and Placement

This section allows you to define the positioning of anchors and the geometric properties of the base plate. It is divided into two main parts:

- **Base Plate Properties:** This part defines the material, length, width, and thickness of the base plate. From here you can select the plate material and manually edit the plate dimensions to suit the structural requirements.

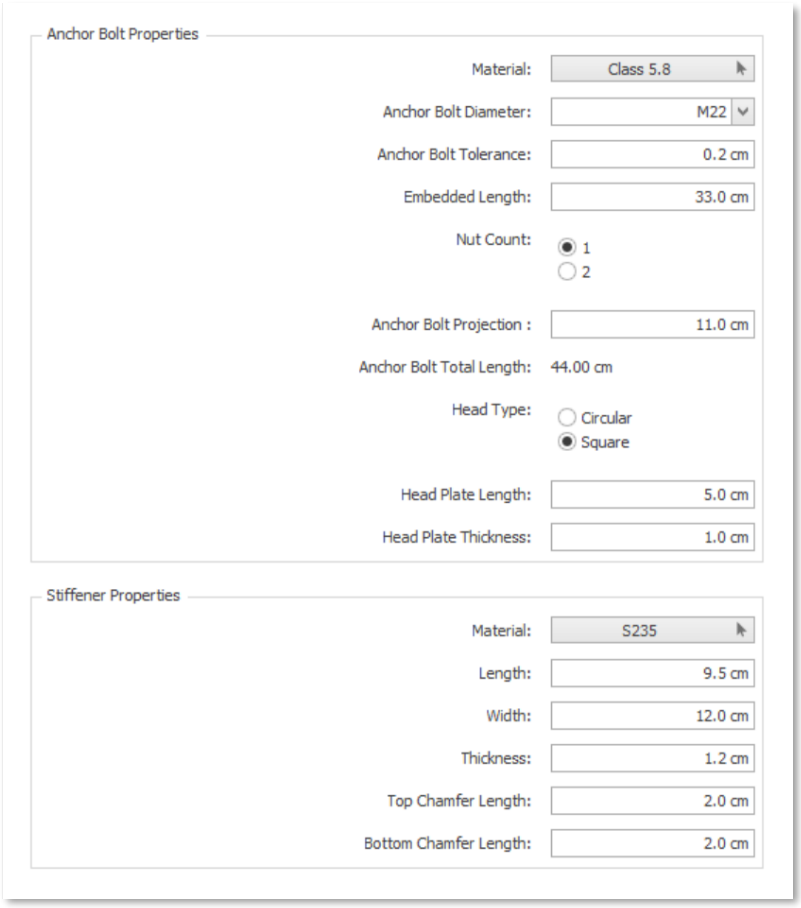
- **Placement:** In this section, you can determine the distance between anchors. The distances between the anchor bolt and the plate edge are calculated automatically. In order to make changes to these distances, the distance between the bolts or the plate dimensions must be changed.



Anchor & Stiffener Properties

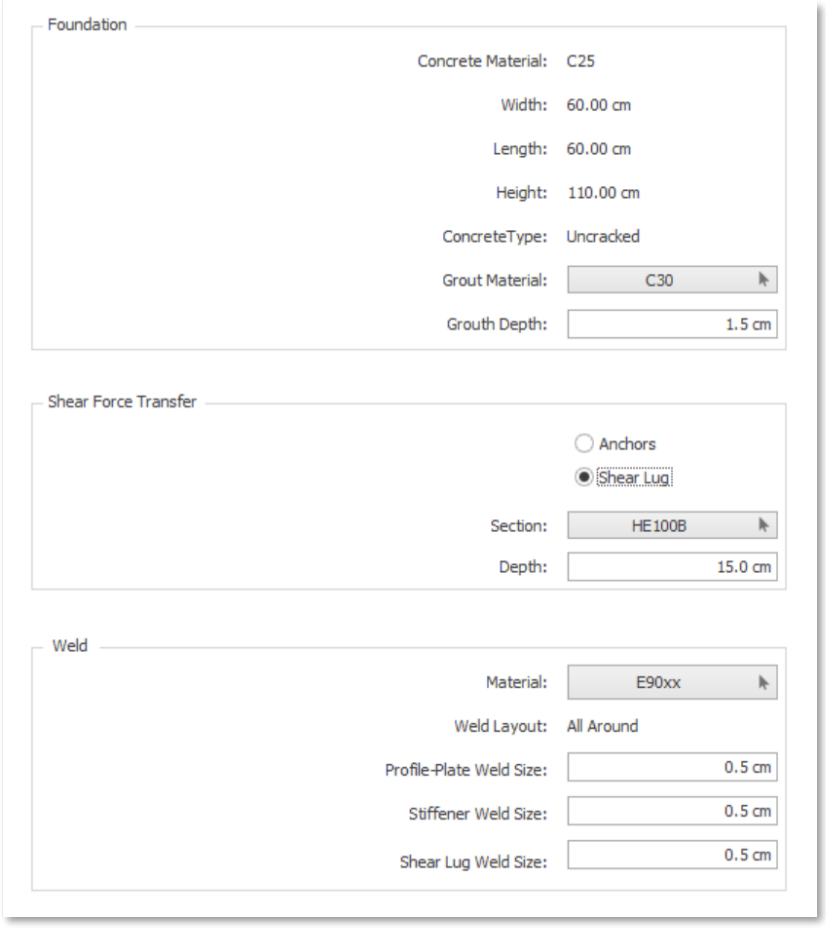
This section is composed of two parts, **Anchor Bolt Properties** and **Stiffener Properties.**

- **Stiffener Properties** appears if a type with stiffener is choosen.



Foundation, Shear Lug and Weld Properties

This section defines the foundation, shear transfer mechanism, and weld properties. If you select a shear lug, all shear forces will be assumed to transfer through it. Otherwise, the shear load will be distributed between the anchors and the frictional resistance of the base. Additionally, the weld properties are presented in a dynamic form, including the weld size for applicable design elements. In the interface, if the anchors are chosen as the shear transfer mechanism, the weld size for the shear lug is not displayed, as the shear lug is not in use.



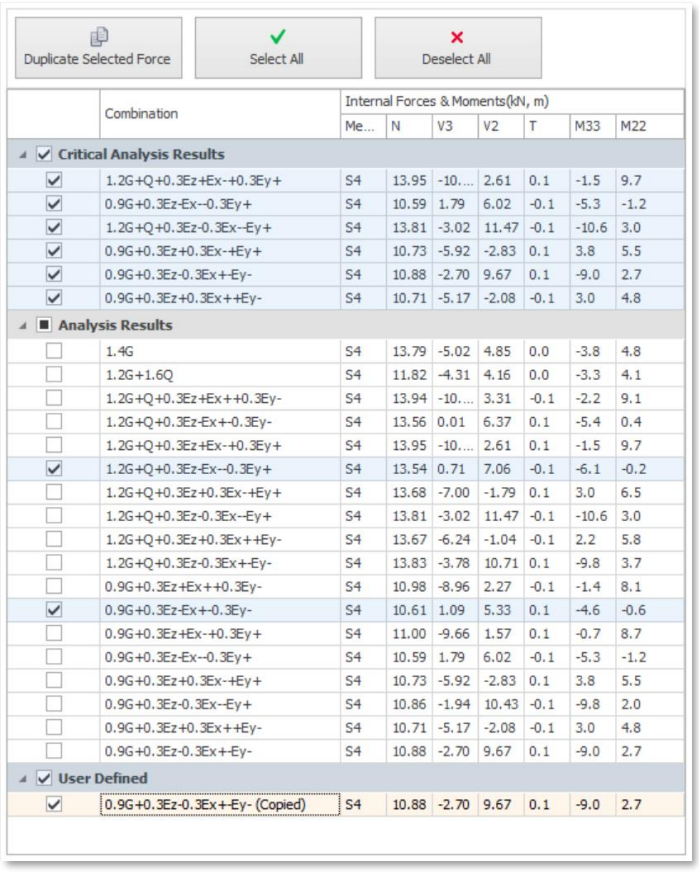
Design

Internal Forces and Moments

The **"Design"** menu allows you to review and select internal forces and moments acting on structural members under different load combinations. This section ensures that the base plate is designed to withstand the applied forces accurately.

- **Duplicate Selected Force:** Allows you to manually input custom force values for analysis. Duplicate a result row and change the values.
- **Select All / Deselect All:** Provides quick selection or removal of load combinations for evaluation.
- **Critical Analysis Results:** Displays the most governing load cases that significantly impact the base plate design. These options have been selected by default; however, you may change your selection if you wish.
- **All Analysis Results:** Lists all available load combinations, allowing users to manually select specific ones for consideration.
- **User Defined :** A duplicated combination is added to this section. The combination name and values of the internal forces and moments can be modified.

Selecting appropriate load combinations helps ensure that the base plate design meets structural requirements under expected loading conditions



	Combination	Internal Forces & Moments(kN, m)						
		Me...	N	V3	V2	T	M33	M22
☑	**Critical Analysis Results**							
☑	1.2G+Q+0.3Ez+Ex-+0.3Ey+	S4	13.95	-10....	2.61	0.1	-1.5	9.7
☑	0.9G+0.3Ez-Ex--0.3Ey+	S4	10.59	1.79	6.02	-0.1	-5.3	-1.2
☑	1.2G+Q+0.3Ez-0.3Ex--Ey+	S4	13.81	-3.02	11.47	-0.1	-10.6	3.0
☑	0.9G+0.3Ez+0.3Ex-+Ey+	S4	10.73	-5.92	-2.83	0.1	3.8	5.5
☑	0.9G+0.3Ez-0.3Ex+-Ey-	S4	10.88	-2.70	9.67	0.1	-9.0	2.7
☑	0.9G+0.3Ez+0.3Ex++Ey-	S4	10.71	-5.17	-2.08	-0.1	3.0	4.8
☐	**Analysis Results**							
☐	1.4G	S4	13.79	-5.02	4.85	0.0	-3.8	4.8
☐	1.2G+1.6Q	S4	11.82	-4.31	4.16	0.0	-3.3	4.1
☐	1.2G+Q+0.3Ez+Ex++0.3Ey-	S4	13.94	-10....	3.31	-0.1	-2.2	9.1
☐	1.2G+Q+0.3Ez-Ex+-0.3Ey-	S4	13.56	0.01	6.37	0.1	-5.4	0.4
☐	1.2G+Q+0.3Ez+Ex-+0.3Ey+	S4	13.95	-10....	2.61	0.1	-1.5	9.7
☑	1.2G+Q+0.3Ez-Ex--0.3Ey+	S4	13.54	0.71	7.06	-0.1	-6.1	-0.2
☐	1.2G+Q+0.3Ez+0.3Ex-+Ey+	S4	13.68	-7.00	-1.79	0.1	3.0	6.5
☐	1.2G+Q+0.3Ez-0.3Ex--Ey+	S4	13.81	-3.02	11.47	-0.1	-10.6	3.0
☐	1.2G+Q+0.3Ez+0.3Ex++Ey-	S4	13.67	-6.24	-1.04	-0.1	2.2	5.8
☐	1.2G+Q+0.3Ez-0.3Ex+-Ey-	S4	13.83	-3.78	10.71	0.1	-9.8	3.7
☐	0.9G+0.3Ez+Ex++0.3Ey-	S4	10.98	-8.96	2.27	-0.1	-1.4	8.1
☑	0.9G+0.3Ez-Ex+-0.3Ey-	S4	10.61	1.09	5.33	0.1	-4.6	-0.6
☐	0.9G+0.3Ez+Ex-+0.3Ey+	S4	11.00	-9.66	1.57	0.1	-0.7	8.7
☐	0.9G+0.3Ez-Ex--0.3Ey+	S4	10.59	1.79	6.02	-0.1	-5.3	-1.2
☐	0.9G+0.3Ez+0.3Ex-+Ey+	S4	10.73	-5.92	-2.83	0.1	3.8	5.5
☐	0.9G+0.3Ez-0.3Ex--Ey+	S4	10.86	-1.94	10.43	-0.1	-9.8	2.0
☐	0.9G+0.3Ez+0.3Ex++Ey-	S4	10.71	-5.17	-2.08	-0.1	3.0	4.8
☐	0.9G+0.3Ez-0.3Ex+-Ey-	S4	10.88	-2.70	9.67	0.1	-9.0	2.7
☑	**User Defined**							
☑	0.9G+0.3Ez-0.3Ex+-Ey- (Copied)	S4	10.88	-2.70	9.67	0.1	-9.0	2.7

Analysis Results

Analysis results consist of two parts: **Results** and **Report**.

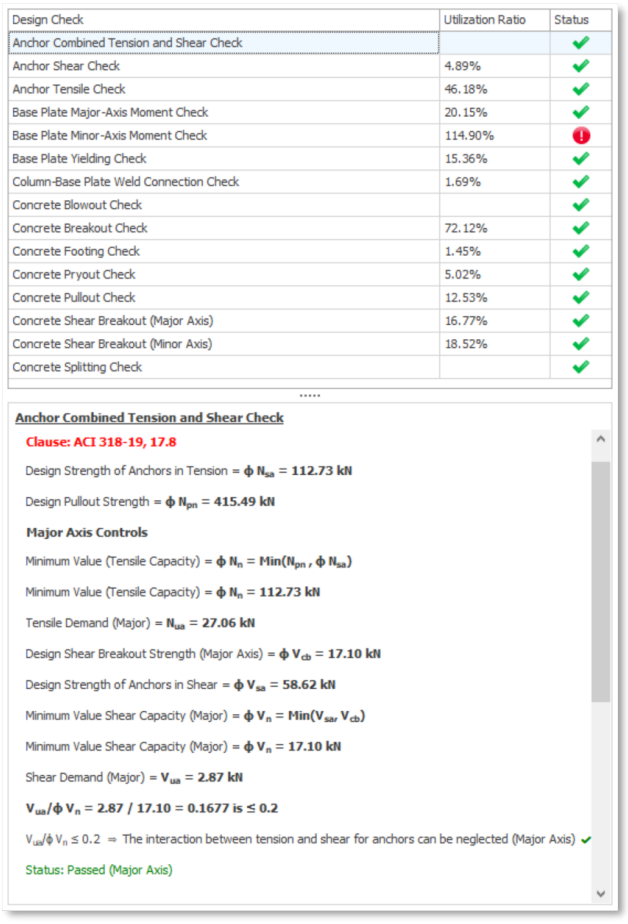
Results

- The **"Results"** section displays the failure modes evaluated during base plate analysis, listing each design check alongside its utilization ratio and status. This helps users determine whether the base plate design meets structural requirements.
- **Design Check :** Lists different failure modes analyzed, along with a dropdown menu explaining the formulation used and the clause numbers for each check.
- **Utilization Ratio :** Indicates the percentage of the capacity utilized for each check. Values above 100% signify failure, requiring design adjustments.
- **Status :** It indicates whether the design is sufficient or not with green and red icons.

  ✅ **Green Check Mark** – The design passes the check.

  🔴 **Red Warning Icon** – The design fails and requires modification.

By reviewing these results, users can identify weak points in the design and make necessary modifications to improve performance and ensure compliance with design codes.



Design Check	Utilization Ratio	Status
Anchor Combined Tension and Shear Check		✔
Anchor Shear Check	4.89%	✔
Anchor Tensile Check	46.18%	✔
Base Plate Major-Axis Moment Check	20.15%	✔
Base Plate Minor-Axis Moment Check	114.90%	!
Base Plate Yielding Check	15.36%	✔
Column-Base Plate Weld Connection Check	1.69%	✔
Concrete Blowout Check		✔
Concrete Breakout Check	72.12%	✔
Concrete Footing Check	1.45%	✔
Concrete Pryout Check	5.02%	✔
Concrete Pullout Check	12.53%	✔
Concrete Shear Breakout (Major Axis)	16.77%	✔
Concrete Shear Breakout (Minor Axis)	18.52%	✔
Concrete Splitting Check		✔

Anchor Combined Tension and Shear Check

Clause: ACI 318-19, 17.8

Design Strength of Anchors in Tension = ϕN_{sa} = **112.73 kN**

Design Pullout Strength = ϕN_{pn} = **415.49 kN**

Major Axis Controls

Minimum Value (Tensile Capacity) = ϕN_n = **Min(N_{pn} , ϕN_{sa})**

Minimum Value (Tensile Capacity) = ϕN_n = **112.73 kN**

Tensile Demand (Major) = N_{ua} = **27.06 kN**

Design Shear Breakout Strength (Major Axis) = ϕV_{cb} = **17.10 kN**

Design Strength of Anchors in Shear = ϕV_{sa} = **58.62 kN**

Minimum Value Shear Capacity (Major) = ϕV_n = **Min(V_{sa}, V_{cb})**

Minimum Value Shear Capacity (Major) = ϕV_n = **17.10 kN**

Shear Demand (Major) = V_{ua} = **2.87 kN**

$V_{ua}/\phi V_n$ = 2.87 / 17.10 = 0.1677 is ≤ 0.2

$V_{ua}/\phi V_n \leq 0.2$ ⇒ The interaction between tension and shear for anchors can be neglected (Major Axis) ✔

Status: Passed (Major Axis)

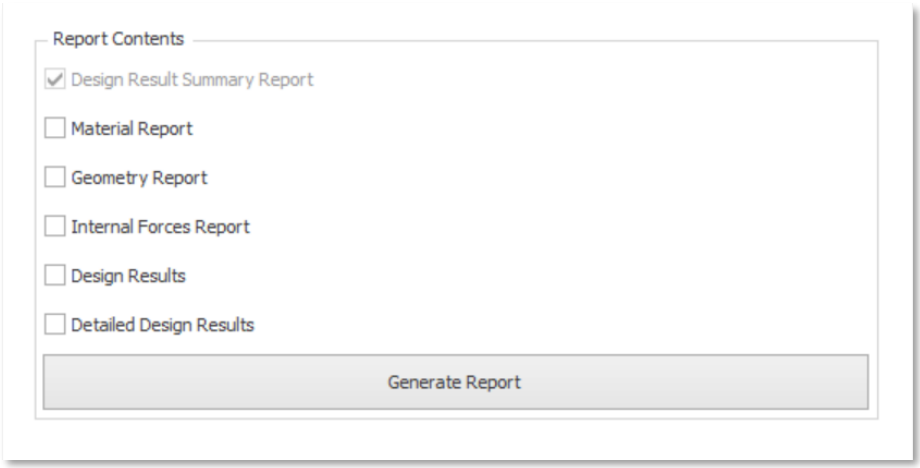
Report

This section allows you to generate a customized report containing relevant data from the base plate analysis. Users can select specific report components by checking the desired options before clicking **"Generate Report"** to compile the document.

Available Report Options are:

- **Design Results Summary Report :** This option adds a summary report to the "Results" section. With this option, the summary report in the 'Results' section is added to all reports by default. Additionally, the summary information of the 3D view, plan view, and the elements forming the connection is also included in all reports by default.
- **Material Report:** Includes details on material properties used in the design.
- **Geometry Report:** Summarizes base plate, anchor bolt, weld, foundation, grout and stiffeners.
- **Internal Forces Report:** Lists the applied loads (marked loads) , moments, and forces.
- **Design Results:** Provides a summary of the analysis outcomes, including utilization ratios and pass/fail status for critical cases.
- **Detailed Design Results:** Offers a comprehensive breakdown of calculations, clause references, and formulation details for each check considering each selected loading combination.

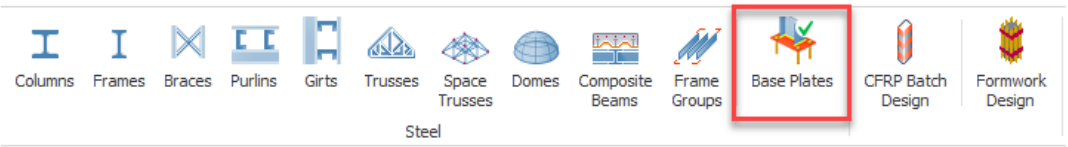
Once generated, the report serves as documentation for design verification, compliance checks, and project record-keeping.



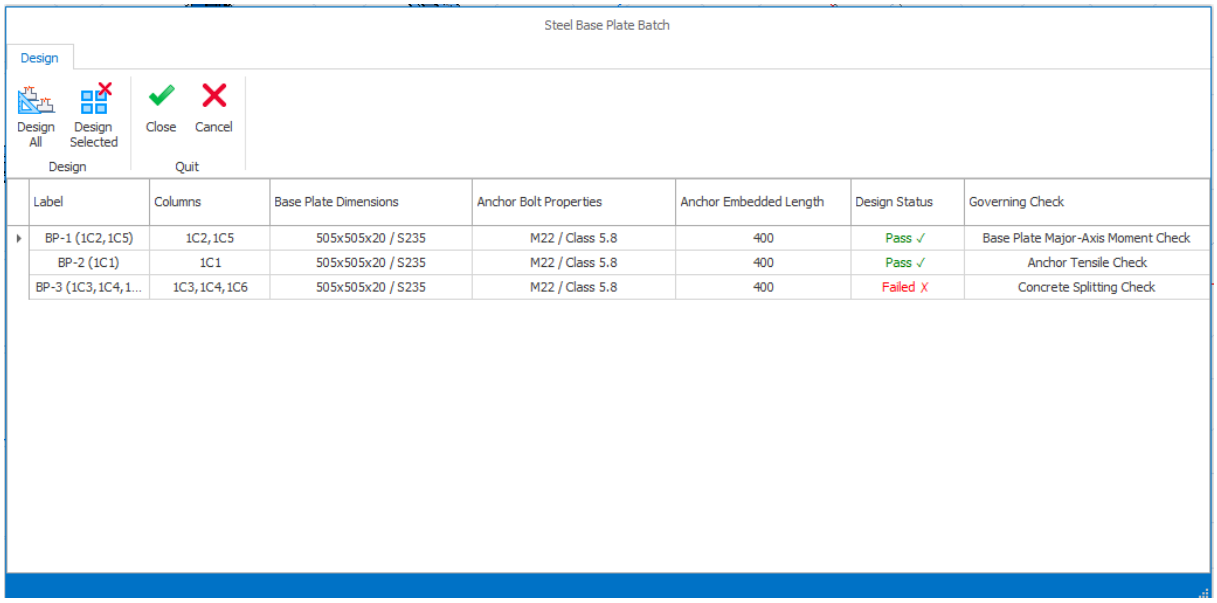
Batch Design

The design checks for base plates can be performed in a unified table within a single interface, covering all base plates.

To view base plate designs in a single table, select the “Base Plates” command from the **“Steel Designs”** section under the **“Design”** tab in the top ribbon menu.



The table presents a summary of essential information related to the base plates.



Label	Columns	Base Plate Dimensions	Anchor Bolt Properties	Anchor Embedded Length	Design Status	Governing Check
BP-1 (1C2, 1C5)	1C2, 1C5	505x505x20 / S235	M22 / Class 5.8	400	Pass ✓	Base Plate Major-Axis Moment Check
BP-2 (1C1)	1C1	505x505x20 / S235	M22 / Class 5.8	400	Pass ✓	Anchor Tensile Check
BP-3 (1C3, 1C4, 1...	1C3, 1C4, 1C6	505x505x20 / S235	M22 / Class 5.8	400	Failed ✗	Concrete Splitting Check

The table includes base plate labels, column labels, base plate dimensions, general anchor bolt properties, dimensions, and embedded anchor depth. Additionally, it displays whether the design is adequate or inadequate, along with a summary of the most critical inadequacy condition.

- **Design All :** Rechecks the designs of all base plates in the table based on the current geometric settings.
- **Design Selected :** Checks the designs of the selected base plates in the table based on the current geometric settings. Use the CTRL key for multiple selections.
- **Close :** Approves the design and exits the interface.
- **Cancel :** Exits the interface without saving changes.
- **Base Plate Label :** Indicates the label number of the base plate. The same label number is used for identical base plates assigned to multiple columns.
- **Column Label :** Specifies the column numbers to which the base plate is assigned. A single base plate can be assigned to multiple columns.

- **Base Plate Properties:** Includes the dimensions, plate thickness, and material information for the base plate types.
- **Anchor Bolt Properties:** Provides the diameter and material quality information of the anchor bolts.
- **Anchor Embedded Length :** Anchor Embedded Length: Specifies the embedded length of the anchor bolt in the foundation.
- **Design Status:** Indicates whether the base plate design is adequate or inadequate based on the performed checks.
- **Governing Check:** Identifies the most critical parameter among the base plate design parameters.

Thank You…

Thank you for choosing the ProtaStructure Suite product family.

Our top priority is to make your experience excellent with our software technology solutions.

Should you have any technical support requests or questions, please do not hesitate to contact us at all times through globalsupport@protasoftware.com and asiasupport@protasoftware.com

Our dedicated online support center and our responsive technical support team are available to help you get the most out of Prota's technology solutions.

The Prota Team

PROTA Structure®
PROTA Steel®
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