PSR Stud Designer User Instructions

Overview

Nelson Stud's PSR Stud Designer provides the user with code-compliant stud assembly designs for reinforced concrete slab-to-column connections. For more information regarding shear reinforcement, refer to ACI 318 and ACI 421.1 codes.

Outputs or results of this application should not be utilized without verification of the accuracy and suitability of results by a licensed professional engineer. The developers of this application disclaim any liability arising from the usage of this application.

Getting Started

In order to get full access to the website and the software, you must register your company with Nelson Stud Welding, Inc. You can do so by clicking the "Create a New User Account" tab in the left column, and then following the steps to complete the registration process.

Creating a New User Account

Before you can register your company, you must create a new account. This consists of an e-mail address (which will be your User Name), password, and a security question with answer. The Password is very secure and must be a minimum length of 7 characters, including one non-alphanumeric character. The Security Question/Answer is a tool used if the Password is forgotten. It enables you to retrieve your password by e-mail by answering a prearranged personal question.

Registration

After creating a new user account, you are to click the "Continue" button which directs you to the User Profile page. You will then need to complete the resulting form with your company's information. After completion, the form will be submitted for validation and approval. Within a few days, you will be notified by email when your account has been approved.

For further assistance about using the site, please click on the "Help" tab in the left column.

Data Input

To access the program, log in, select the "PSR Stud Designer" tab under the "Software" section on the left side of the screen view and accept the disclaimer statement. Then make the following entries:

General Data

Job Detail: In this box, the user enters the job name, the date and "prepared by."

Design Code: The user has the option to choose either ACI 318-05 or ACI 421.1-R08 for the design code.

System Units: The user has the option of selecting either U.S. (in., lbs) or SI (mm, kN) for working units.

Job Detail

Job Name:	Test
Date:	1/23/2012
Prepared By:	Webdev

Design Code

○ ACI 318-05

◉ ACI 421.1 R08

System Units

◉ US (in., lbs)

○ SI (mm, kN)

General Data Entries

Slab Properties

Slab Thickness: The user is able to enter slab thickness.

Flex. Bar Size: The user is able to select reinforcing bar diameter from a drop-down menu, ranging from a #3 bar (approx. 3/8" diameter) to a #10 bar (approx. 1 ¼" diameter).

Concrete Strength: The user enters a concrete compressive strength (psi) and a factor for lightweight concrete as applicable (λ).

Top Cover: The user enters the distance between the top of the slab and the top layer of reinforcing steel.

Bottom Cover: The user enters the distance between the bottom of the slab and the bottom layer of reinforcing steel.

Effective Prestress: The user enters an effective prestress value (psi). If no prestressing is used, the default value is zero (see prestress[*] note at end).

Slab Thickness

7   in.

Flex. Bar Size:

3 (3/8)" ▼

Concrete Weight: Standard ▼

λ 1

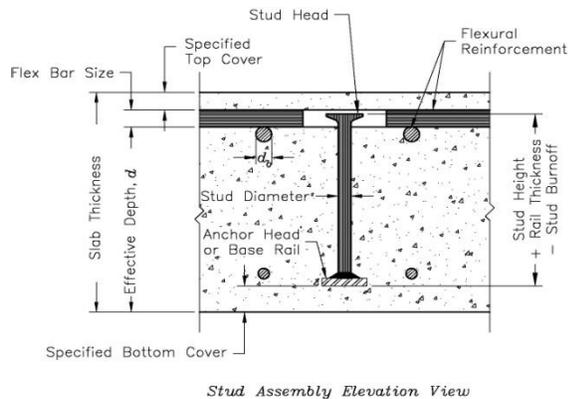Concrete Strength:

4000   psi

Top Cover:

0.75   in.

Bottom Cover:

0.75   in.

Effective Prestress:

0   psi

Slab Data Entries

These details are illustrated graphically in the following Figure:

Stud Assembly Elevation View

P.S. Rail Data

Yield Strength: The user enters the yield strength of the PSR stud. The default value is 51,000psi as specified by AWS D1.1.

Stud Size: The user selects PSR stud diameters ranging from 3/8" to 3/4".

Spacing to 1st Peripheral: The user selects the spacing (in.) from the column face to the first line of PSR studs. The program selects this value in the "Auto Calculate" mode.

Spacing Between Studs: The user selects the preferred spacing between studs along each rail. The program selects this value in the "Auto Calculate" mode.

Total # of Studrails: The user is able to limit the total number of stud assemblies by entering a value in the field presented. The program will then design PSR stud assemblies with total number of stud assemblies entered, divided evenly in the x and y direction. The program may also be allowed to select the number of stud assemblies in the "Auto Calculate"

Auto Calculate: With this enabled, the program will determine the most economical shear reinforcement design with the data provided in terms of number of stud assemblies, spacing to the first peripheral line of studs and inter-stud spacing.

Yield Strength:

    51000
                    psi
Stud Size:

   #   3 (3/8)"   ▼

Stud Spacing 1'st Periferal

                in.
Between Studs

Total # of Studrails
    X-Axis: Y-Axis:

☑   Auto Calculate

Rail Data Entries

Column Properties

Column Shape: The user selects either a rectangular or circular column.

Column Type: The user selects either interior column (surrounded by slab), edge column (slab on three sides) or corner column (slab on two adjacent sides).

Column Size (x, y): The user enters the x- and y- dimensions (in.) for a rectangular column and the diameter (in.) for a circular column.

Slab Overhang (X- or Y-Axis): The use enters the distance the slab extends unsupported in the x- (edge column) or x- and y- (corner column) directions (see note at end regarding slab overhangs[**] and floor openings[***]).
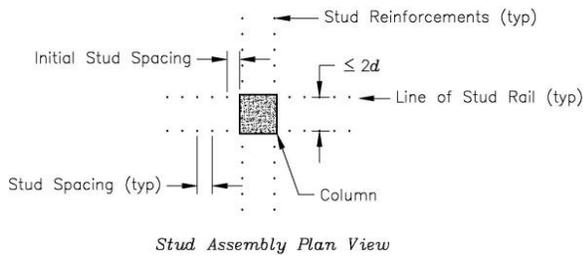
Column Shape:

Rectangular ▼

Column Type:

Interior ▼

Column Size (X, Y):

| 12 | | 20 |
| X | | in. |

Slab Overhang (X-Axis):

0
in.

Slab Overhang (Y-Axis):

0
in.

Column Data Entries

The preceding is illustrated in the following figure showing a typical stud pattern arrangement:

Stud Assembly Plan View

Loads –

Shear Force: The user enters the total factored vertical shear force (kips) acting on the slab-to-column connection.

Moment: The user enters the factored moment (ft-kips) applied at the column centroid in both the x- and y-axis directions.

Shear Force:

110
kips

Moment:

M_{uOx} M_{uOy}

| 0 | 50 |
| | ft-kips |

Load Data Entries

Results

With the aforementioned inputs, the program calculates the shear stress at a critical distance from the column face (i.e., d/2) and determines if reinforcing is required. If it is, the program calculates the ensuing shear stresses progressively outward from the column face until the slab alone can resist the shear stress (see Figures (a), (b), and (c)).

(a) Interior Column

(b) Edge Column

(c) Corner Column
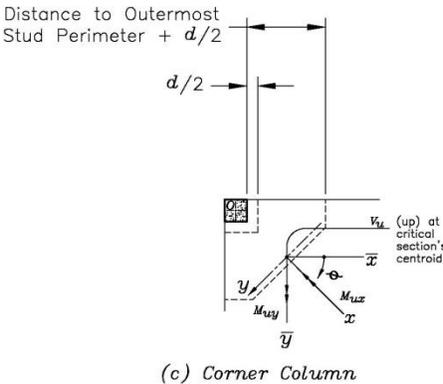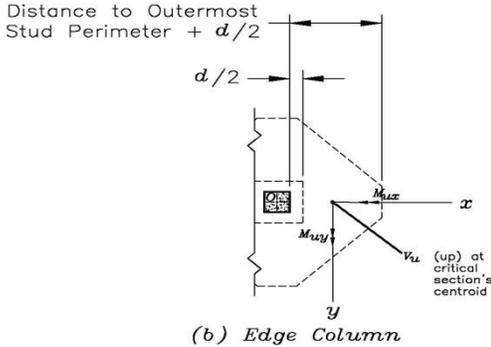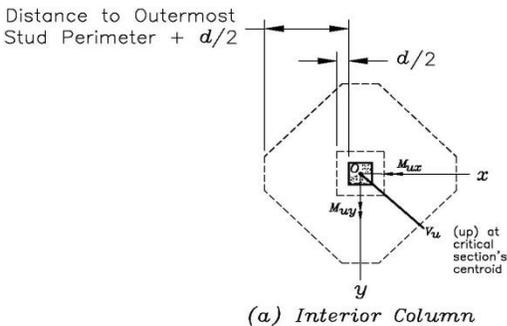
Figures (a), (b) and (c) – inner and outer limits of shear-critical sections of various column positions

The output gives a pictorial representation of the suggested stud layout and summarizes input data and resulting stud configuration and related calculations.

In equational terms, this may be explained as follows:

Design requirements at critical section at (d/2) from column face and in the shear reinforced zone -

$(\frac{v_u}{\phi} > v_n)$ If true, shear reinforcement is required, continue design for shear reinforcement.

$(\frac{v_u}{\phi} \leq v_n)$ If true, no shear reinforcing or further check is required.

$(\frac{v_u}{\phi} > 8\sqrt{f_c'})$ If true, slab thickness is not adequate, increase thickness.

$(\frac{v_u}{\phi} \leq 8\sqrt{f_c'})$ If true, slab thickness is adequate, continue design for shear reinforcement.

Nominal shear strength required at inner critical section: $v_n = v_c + v_s$

Spacing Requirements: $s \leq 0.5d \quad s_o \leq 0.5d$

Design requirements at critical section at (d/2) from outer most peripheral -

$(\frac{v_u}{\phi} > v_n)$ If true, the extent of the shear reinforced zone is inadequate: increase # of peripherals.

$(\frac{v_u}{\phi} \leq v_n)$ If true, the extent of shear-reinforced zone is adequate.

Nominal shear strength required at outer critical section: $v_n = 2\lambda\sqrt{f_c'}$

Analysis at inner critical section -

Shear stress $v_u = \dfrac{V_u}{A_c} + \dfrac{\gamma_{vx}M_{ux}y}{J_x} + \dfrac{\gamma_{vy}M_{uy}x}{J_y} = $ XXX psi

Factored shear stress $\dfrac{v_u}{\phi} = \dfrac{xxx}{0.75} = $ XXX psi

* Select smallest nominal shear strength v_n

$v_n = (2+\dfrac{4}{\beta})\lambda\sqrt{f'c} = $XXX psi, $\quad v_n = (\dfrac{\alpha_s d}{b_o}+2)\lambda\sqrt{f'c} = $XXX psi $\quad$ or $\quad v_n = 4\lambda\sqrt{f'c} = $XXX psi

$\dfrac{v_u}{\phi} > v_n = $ XXX psi $>$ XXX psi, therefore, shear reinforcement is required.

The shear stress resisted by the concrete in the presence of Nelson PSR studs at critical section located at d/2 from the column face is:

$$v_c = 3\lambda\sqrt{f'c} = \text{XXX psi}$$

The following expression must be satisfied:

$$v_s \geq \frac{v_u}{\phi} - v_c$$

The theoretical shear strength v_s required by shear reinforcement =

$$\frac{v_u}{\phi} - v_c = \text{XXX psi}$$

The actual shear strength v_s provided by Nelson PSR studs:

$$v_s = \frac{A_v f_{yt}}{b_o s} = \text{XXX psi}$$

Therefore,

$$v_s \geq \frac{v_u}{\phi} - v_c = \text{XXX psi} \geq \text{XXX psi and design at inner critical section is adequate.}$$

Analysis at outer critical section:

Shear stress $v_u = \dfrac{V_u}{A_c} + \dfrac{\gamma_{vx} M_{ux} y}{J_x} + \dfrac{\gamma_{vy} M_{uy} x}{J_y} = \text{XXX psi}$

Factored shear stress $\dfrac{v_u}{\phi} = \dfrac{xxx}{0.75} = \text{XXX psi}$

Nominal shear strength v_n required at outer critical section:

$$v_n = 2\lambda\sqrt{f_c'} = \text{XXX psi}$$

$\dfrac{v_u}{\phi} \leq v_n = \text{XXX psi} \leq \text{XXX psi Therefore, the extent of the shear reinforced zone is adequate.}$

The program's output will also graphically display elevation and plan views of the suggested stud arrangement and summarize the key design data:
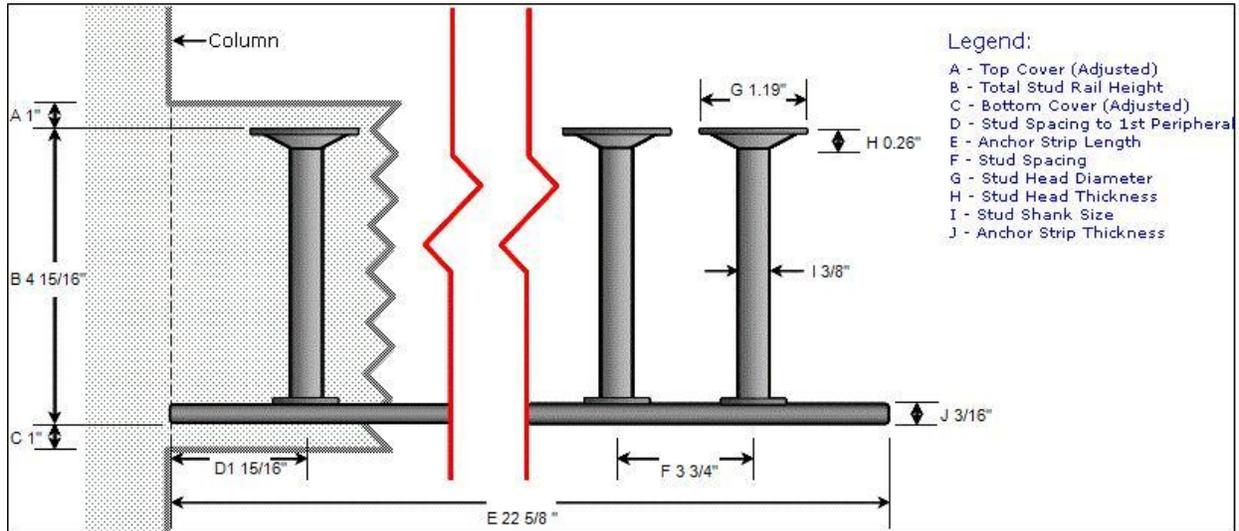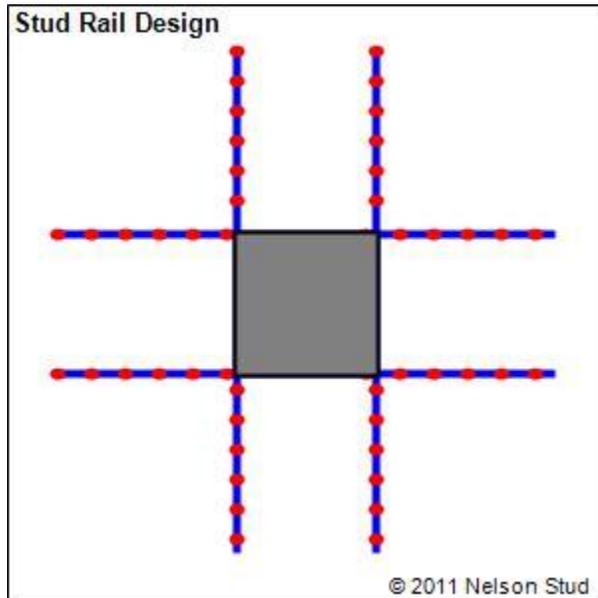

Figure (d) – Stud Elevation View

Figure (e) – Stud Plan View

Suggested Product

Part Number: 102114006 Description: PSRS 3/8" X 4 15/16" MS

Input Data

Slab Properties		Column Properties	
Slab Thickness:	7	Column Shape:	Rectangular
Flex Bar Size:	5/8 in.	Column Type:	Interior
Concrete Strength:	4000 psi	Column Size, X(Cx) in.	12.00 in.
Top Cover:	0.75 in.	Column Size, Y(Cy) in.	12.00 in.
Bottom Cover:	0.75 in.	Slab Overhang, X:	0 in.
Effective Prestress:	0 psi	Slab Overhang, Y:	0 in.
P.S. Rail Data		Loads	
Yield Strength:	51000 psi	Shear Force:	100 kips
Stud Size:	3/8 in.	Moment, X(Mux):	0 ft-kips
		Moment, Y(Muy):	0 ft-kips

Output Data

Number of X-Axis Rails:	4	Number of Y-Axis Rails:	4
Number of Studs / Rail:	6	Stud Height:	4 15/16 in.
Anchor Strip Length:	22 5/8 in.	Total Stud Rail Height:	5 in.
Anchor Strip Thickness:	3/16 in.	Stud Spacing to 1st Peripheral:	1 15/16 in.
Stud Head Diameter:	1.19 in.	Stud Spacing:	3 ¾ in.
Stud Head Thickness:	0.26 in.	Top Cover (adjusted):	1 in.
Stud Shank Size:	3/8 in.	Bottom Cover (adjusted):	1 in.

Figure (f) – Input and Output Data Summary

Input data may be zeroed or returned to defaults for a new iteration by selecting the "New Design" button at the bottom of the output page. A given iteration of the program may be saved for future use and reference by naming the file *then* selecting the "Save Design As:" button. The output results are then stored in the "User PSR Data" tab at the main menu under the applicable file name and the user is returned to the input section. The user may also overwrite/re-enter certain data without completely restarting the input process by selecting the "Return to Design Without Saving" button where the previous values will remain:

New Design	Save Design as:	[ ]	Return to Design Without Saving
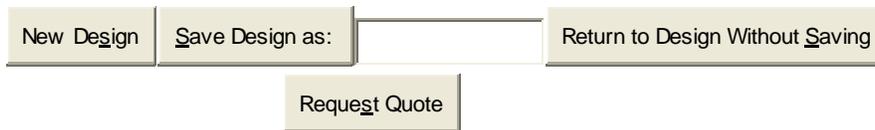
Request Quote

Output Page Actions

Finally, the user may request contact by a Nelson sales representative by selecting the "Request Quote" button. The program will notify the affected Nelson staff member for follow-up.

[*]Note on prestressed conditions:

When the slab is prestressed, ACI allows for higher nominal shear strength at a critical section at d/2 from the column face where shear reinforcement is not provided. The following equation, given by ACI 318-11 (11-34), is taken in place of those for non-prestressed slabs:

$$v_n = \beta_p \lambda \sqrt{f_c'} + 0.3 f_{pc} + \frac{V_p}{b_o d}$$

Where β_p is the smaller of:

$$\beta_p = 3.5$$
$$\beta_p = \frac{\alpha_s d}{b_o} + 1.5$$

The above equation is applicable only if the following conditions are satisfied:
1. No portion of the column cross section is closer to a discontinuous edge than four times the slab thickness, h.
2. f_c' taken in the equation has a maximum of 5000 psi.
3. f_{pc} in each direction is a minimum of 125psi and a maximum of 500psi.

If all of the above criteria are not met, then the slab shall be treated as nonprestressed.

ACI allows an increase equal to the vertical component of the effective prestress forces, Vp, crossing the critical section at $d/2$ from the column face in the nominal shear strength resisted by concrete. If the calculations for the tendon profiles are neglected or not carefully taken into account during construction, the design could be unsafe. ACI 318-11 concludes that Vp contributes only a small amount of shear offset and, for safety factors, ACI 421.1 conservatively takes Vp to be equal to zero. Therefore, the Nelson PSR Stud Designer also conservatively takes Vp to be equal to zero and uses the revised equation:

$$v_n = \beta_p \lambda \sqrt{f_c'} + 0.3 f_{pc}$$

[**]Note on slab overhang(s):

An overhang is defined as the perpendicular distance of a free slab edge from the adjacent column face. The software allows the user to enter an overhang value in the x- (edge column) or x- and y- (corner column) directions recognizing that overhangs contribute to the punching shear resistance of the slab-to-column connection. Currently, ACI 318 does not address this situation. The original version of the software allowed any distance to be entered as overhang values and correspondingly affected the lengths of the sides of the critical sections, l_x and l_y, and the corresponding values of the section properties, J_x and J_y.

 Treatment of slab overhangs in punching shear calculations seems to be a subject of on-going research. Accordingly, Nelson has elected to limit the user-entered values of these inputs in the program to prevent unrestricted reduction in the calculated necessary reinforcing strength and was persuaded by ACI Committee report 352.1R-89 to set these as follows:

Edge Column: overhang max. $(z_x) = d + C_y/2$

Corner column: overhang max. $(z_x + z_y) = 3d + C_x + C_y$

where: z_x = overhang in x-direction
   z_y = overhang in y-direction
   d = effective slab depth
   C_x = column face in x-direction
   C_y = column face in y-direction

If these limits are exceeded, the program will alert the user and suggest modification to the input value(s) which either must be accepted or the values otherwise changed before the calculation proceeds.

[***]Note on floor openings:

ACI recognizes that openings in a floor near a load-imparting column reduce the critical section for resisting punching shear by rendering a portion of its perimeter as "ineffective." The PSR Stud Designer program does not currently model this condition and, therefore, additional analysis should be performed in such a situation to ensure adequate design (see ACI 318-11, section 11.11.6).