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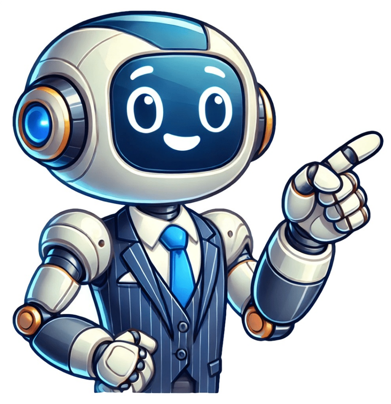

Punching shear is a phenomenon in structural engineering which describes the failure of flat slabs due to concentrated loads such as columns. In this guide, well show step-by-step, how you design and verify flat slabs for punching shear. Punching shear failure of a flat slab due to concentrated force at column support. Punching Shear YouTube Tutorial. Lets get started. Punching shear is a type of shear failure that occurs close to where a concentrated load is applied to a slab. The failure happens in a cicular shape around the concentrated load. The 2 main situations where punching shear occurs are: flat slabs supported by a column and pad footings or foundation rafts that support a column. The design and verification of punching shear is covered by EN 1992-1-1 6.4. Punching shear failure. Punching shear has to be verified for flat slabs that are supported by columns as in the next picture. The most critical will be at the center column as this column takes up the most load. Before we dive into the nerdy calculations, its good to get an overview of the steps that need to be taken to design and verify punching shear. Define geometry properties of the slab and column Calculate characteristic area loads that act on the slab Load combinations to find the design loads Define material properties of the slab and column ULS punching shear verification without shear reinforcement ULS punching shear verification with shear reinforcement We are showing all calculation steps for the following simplified example where 9 columns support a reinforced concrete slab. Example structure for punching shear design with column spacing l and b. In this post, well verify punching shear for the slab above the center column, because its the most critical location of the slab leading to the highest shear force. The slab and the column have the following geometric properties: Slab/Plate thickness$t_{p} = 0.2 m$Column cross-section width$w = 0.2 m$Column cross-section height$h = 0.3 m$Column spacing$l = 7.5 m$Column spacing$b = 6.5 m$ In this tutorial well simplify the calculation of the loads. We assume that we design a reinforced concrete slab with thickness tp = 0.2m that is supported by 9 columns. The slab is exposed to the following area loads: Characteristic dead load of the rc slab$g_{k.s} = 25 kN/m^3 \cdot t_p = 5 kN/m^2$Characteristic dead load of the flooring$g_{k.f} = 1.6 kN/m^2$Live load (value for offices in Denmark)$q_k = 2.5 kN/m^2$ The vertical area loads are taken up by the reinforced concrete slab and transferred to the columns. In regular cases like our example where the column distance is the same, we can use formulas to calculate the reaction forces of the columns (shear force of the slab). However, the more irregular the supports of the slab are, the better and more accurate it is to use a FE model. We use the formula of a 2-span continuous beam to find the reaction force of the center column. Moment diagrams of a flat reinforced concrete slab. $$V_{Ed} = 2 \cdot \frac{5}{8} \cdot l \cdot 2 \cdot \frac{5}{8} \cdot b \cdot q_d$$ As a next step, lets find the design area load qd. Load combinations combine several load cases and multiply the characteristic loads with safety factors. Luckily, we have already written an extensive article about what load combinations are and how we use them. In case you need to brush up on it or want to check how we derived the safety factors, you can read the blog post here. LC1$1.35 \cdot (g_{k.s} + g_{k.f}) + 1.5 \cdot q_k $$12.67 kN/m^2$ Now, in our case, we only use one load combination, because we simplify this tutorial. Usually, you have to consider multiple load combinations. However, from experience, we can say that for an indoor office slab, this load combination is governing in most situations. With the design load qd of 12.67 kN/m2, we can now calculate the shear force of the slab at the location of the center column: $$V_{Ed} = 2 \cdot \frac{5}{8} \cdot l \cdot 2 \cdot \frac{5}{8} \cdot b \cdot q_d = 964.3 kN$$ Info: If you calculate the shear force of the slab / normal force of the column with a FE model, you wont get the exact same result. The beams and slabs dont have exactly the same behaviour, and we used beam formulas to calculate the reaction forces. The stiffness of the slab and columns in the FE model also have an influence of the size of the reaction forces. Concrete compression$f_{c.k} = 30 MPa$Partial factor in-situ concrete (Denmark)$\gamma_c = 1.45$Design concrete compression strength $f_{c.d} = 20.7 MPa$Reinforcement yield strength$f_{y.k} = 500 MPa$Partial factor reinforcement (Denmark)$\gamma_s = 1.2$Design yield strength$f_{y.d} = \frac{f_{y.k}}{\gamma_s} = 416.7 MPa$Rebar cover$c = 30 mm$ Well also assume the longitudinal reinforcement of the slab. Keep in mind that we didnt calculate that. Rebar diameter (x-direction)$d_{s.x} = 10 mm$Spacing of rebars (x-direction)$a_x = 100 mm$Reinforcement area (x-direction)$A_{s.x} = \pi \cdot (\frac{d_{s.x}}{2})^2 = 78.54 mm^2$Rebar diameter (y-direction)$d_{s.y} = 10 mm$Spacing of rebars (y-direction)$a_y = 100 mm$Reinforcement area (y-direction)$A_{s.x} = \pi \cdot (\frac{d_{s.x}}{2})^2 = 78.54 mm^2$ The following checks have to be carried out according to EN 1992-1-1 6.4.3 (2): At the perimeter of the loaded area (column perimeter) the maximum shear resistance stress should not be exceeded:$$\tau_{Ed} < \tau_{Rd.max}$$ Punching reinforcement is not required if the shear stress does not exceed the punching shear resistance without punching reinforcement along the control section:$$\tau_{Ed} < \tau_{Rd.c}$$ If $\tau_{Ed} > \tau_{Rd.c}$ punching reinforcement must be added and verified. We start by calculating the effective depth of the longitudinal reinforcement by finding the depths of the reinforcement in x- and y- direction. $$d_{eff} = \frac{d_x + d_y}{2}$$ Depth of longitudinal reinforcement. Depth of reinforcement in x-direction$d_x = t_p c d_{s.y} \frac{d_{s.x}}{2} = 155 mm$Depth of reinforcement in y-direction$d_y = t_p c \frac{d_{s.y}}{2} = 165 mm$Effective depth of slab$d_{eff} = d = \frac{d_x + d_y}{2} = 160 mm$ Next, the shear force/stress of the slab can be reduced with a factor β. This β factor is calculated with formulas EN 1992-1-1 (6.39) (6.46). If the columns are not used to stabilize the structure approximate values for β from EN 1992-1-1 Figure 6.21N can be used. In our structure there are no shear walls and therefore the columns are used as frame action to stabilize the structure. However, well simplify in this tutorial. Usually, a structure like this has shear walls and therefore, well use EN 1992-1-1 Figure 6.21N to determine β. For the center column EN 1992-1-1 Figure 6.21N recommends a value of: $$\beta = 1.15$$ The reduced shear stress is calculated as: $$\tau_{Ed} = \beta \cdot \frac{V_{Ed}}{u \cdot d}$$ Where u is calculated as the perimeter of the column u0 for verification (1) and the perimeter of the column with a distance of 2d (control perimeter = u1) from all of its edges for verification (2). Perimeter of column u0 and control perimeter u1 of center column. The first check well do is the verification of punching shear at the column perimeter using to EN 1992-1-1 (6.53): $$\tau_{Ed} = \frac{\beta \cdot V_{Ed}}{u_0 \cdot d} < \tau_{Rd.max}$$ The shear stress is calculated with the following parameters: β factor$\beta = 1.15$Shear force$V_{Ed} = 964.3 kN$Column perimeter$u_0 = 2h + 2w = 1m$Effective depth$d = 0.16 m$ $$\tau_{Ed} = \frac{\beta \cdot V_{Ed}}{u_0 \cdot d} = 2.08 MPa$$ The shear resistance $\tau_{Rd.max}$ is calculated as (EN 1992-1-1 (6.53)): $$\tau_{Rd.max} = 0.5 \cdot u \cdot f_{cd}$$ With, Strength reduction factor for concrete cracked in shear (EN 1992-1-1 (6.6))$u = 0.6 \cdot (1- \frac{f_{ck}}{250}) = 0.528$Design compression strength of concrete C30$f_{cd} = 20.69 MPa$ Design shear punching shear resistance $\tau_{Rd.max}$ (EN 1992-1-1 (6.53)): $$\tau_{Rd.max} = 0.5 \cdot u \cdot f_{cd} = 5.46 MPa$$ Utilization: $$\eta = \frac{\tau_{Ed}}{\tau_{Rd.max}} = 0.38 < 1$$ This means that the first check verifies. Next, well check if punching shear reinforcement is required. As a first step, well calculate the shear stress at the control perimeter u1: $$\tau_{Ed} = \frac{\beta \cdot V_{Ed}}{u_1 \cdot d}$$ The shear stress is calculated with the following parameters: β factor$\beta = 1.15$Shear force$V_{Ed} = 964.3 kN$Control perimeter$u_1 = 2h + 2w + 2 \pi \cdot 2 \cdot d = 3.01 m$Effective depth$d = 0.16 m$ This leads to a shear stress of: $$\tau_{Ed} = \frac{\beta \cdot V_{Ed}}{u_1 \cdot d} = 0.69 MPa$$ Next, well calculate the punching shear resistance $\tau_{Rd.c}$: EN 1992-1-1 (6.47)$k = min(1+ \sqrt{\frac{200}{d}}; 2) = 2$Bonded tension steel (x-direction)$\rho_x = \frac{A_{s.x}}{d_x \cdot a_x} = 0.0051$Bonded tension steel (y-direction)$\rho_y = \frac{A_{s.y}}{d_y \cdot a_y} = 0.0048$EN 1992-1-1 (6.47)$\rho = min(\sqrt{\rho_x \cdot \rho_y}; 0.02) = 0.0049$EN 1992-1-1 (6.47)$k_1 = 0.1$EN 1992-1-1 (6.3N)$u_{min} = 0.035 \cdot k^{3/2} \cdot f_{ck}^{1/2} = 0.54 MPa$Recommended value. Confirm with National Annex.$C_{Rd.c} = \frac{0.18}{\gamma_c} = 0.124$ Design punching shear resistance (EN 1992-1-1 (6.47)): $$\tau_{Rd.c} = C_{Rd.c} \cdot k \cdot (100 f_{ck})^{1/3} = 0.60 MPa$$ Minimum requirement (EN 1992-1-1 (6.47)): $$\tau_{Rd.c} > u_{Rd.c.min} = u_{min} = 1$$ Utilization: $$\eta = \frac{\tau_{Ed}}{\tau_{Rd.c}} = 1.13 > 1.0$$ Punching shear without shear reinforcement does not verify and we will therefore add punching reinforcement and follow EN 1992-1-1 6.4.5. Detailing requirements for punching shear reinforcement are given in EN 1992-1-1 9.4.3. Before detailing the reinforcement we need to calculate the perimeter uout where no shear reinforcement is required (EN 1992-1-1 (6.54)): $$u_{out} = \frac{\beta \cdot V_{Ed}}{\tau_{Rd.c} \cdot d} = 3.42 m$$ Well use the following punching reinforcement layout. Punching shear reinforcement. Number of shear reinforcement legs in radial direction$n_p = 3$Radial spacing of perimeters of shear reinforcement$s_r = 0.4 \cdot d = 64 mm$Effective design tensile strength of reinforcement (EN 1992-1-1 (6.52))$f_{ywd.ef} = min((250 + 0.25 \cdot d/mm) N/mm^2; f_{yd}) = 290 MPa$Control perimeter where shear reinforcement is not required $u_{out} = 3416 mm$Number of reinforcement lines$n_1 = 12$Angle of one perimeter of shear reinforcement around the column$\alpha = 90 deg$Rebar diameter$d_{s.s} = 10 mm$Area of one perimeter of shear reinforcement around the column$A_{sw} = \pi \cdot (\frac{d_{s.s}}{2})^2 \cdot n_1 = 942.5 mm^2$ Design punching shear resistance stress (EN 1992-1-1 (6.52)): $$\tau_{Rd.cs} = 0.75 \cdot \tau_{Rd.c} + 1.5 \cdot 0.67 \cdot A_{sw} \cdot f_{ywd.ef} \cdot \frac{1}{u_1 \cdot d} \cdot sin(\alpha) = 1.03 MPa$$ Design punching shear resistance force: $$V_{Rd.cs} = \frac{\tau_{Rd.cs} \cdot u_1 \cdot d}{\beta} = 430.07 kN$$ Utilization: $$\eta = \frac{V_{Ed}}{V_{Rd.cs}} = 0.67 < 1.0$$ The verification for punching shear with shear reinforcement verifies. Et voila, the slab is verified and dimensioned for the highest punching shear force. If you are new to structural design, then check out more of our design tutorials where you can learn how to design elements such as: But now, I would like to hear from you: Are you designing a reinforced concrete slab for a uni project? Or are you renovating your own house? Tell us a bit about the structure, as we all want to learn from each other. Hi! I am Laurin and I started Structural Basics in January 2022 with the aim to improve the online knowledge about structural engineering. I am a full-time structural engineer with a passion for content creation and digital tools to improve the AEC industry. I have a background in BIM too. Punching shear calculations are provided for columns/pedestals that land on concrete slabs. The following contains more detailed information on those calculations in RISAFoundation. Punching Shear Basics Punching shear is a phenomenon where a concentrated force on a slab causes a shear failure cone that "punches" through the slab. Punching shear calculations require a demand value and a capacity value. Many hand calculations will consider a punching shear force against a punching shear capacity. This works if only shear force is present, but is insufficient if a moment is occurring on the column/pedestal. Thus, a stress demand/stress approach is taken. The applied shears and moments, along with the shape of the punching shear failure cone, are used to calculate a maximum punching shear stress. Punching Shear Calculation Values Effective Depth, d The effective depth of the slab is used to define the punching shear perimeter at a distance of d/2 beyond the edge of the column/pedestal. The effective depth is based on the smallest depth to centroid of reinforcing for the Design Strips that encompass the pedestal. In cases where no design strips are defined at the pedestal location, the program will assume the bar size and cover specified in the first rule defined in the Design Rules Spreadsheet. L1 and L2 L1 and L2 represent the length of the critical section along the local axes. This value is used to define the punching shear perimeter as well as how much of the moment is transferred by eccentricity of shear (as opposed to the portion transferred by flexure). Note: >Note: For further discussion, refer to ACI318-14 section 22.6.4 and 8.4.2.3. The polar Moment is a property (Jc) of the critical section which is analogous to polar moment of inertia about the local yy axes. This value is used to determine the shear stress in the critical location due to unbalanced moment. Note: >Note: This calculation is very different depending on interior, edge or corner punching shear cases. For further discussion and equations, refer ACI 318-14 Section 8.4.4.2.3 (ACI318-11 Section R11.11.7.2) and Chapter 13-8 of the Reinforced Concrete Mechanics and Design textbook by MacGregor & Wight. The centroid gives the distance from the shear perimeter edge to the centroid of the shear perimeter. For an interior punching shear perimeter, this will always be L1/2 or L2/2. For edge and corner cases, this value is calculated as the moment of area of the shear perimeter/area of the sides. Note: >Note: For further discussion and equations, refer to Chapter 13-8 of the Reinforced Concrete Mechanics and Design textbook by MacGregor & Wight. This is calculated from the dimensions of the assumed punching shear perimeter. It represents the fraction of the unbalanced moment for each axis that is transferred by eccentricity of shear. Note: >Note: For further discussion, refer to ACI 318-14 Sections 8.4.4.2.2 and 8.4.2.3 (ACI 318-11 sections 11.11.7.1 and 13.5.3). The Total Stress is the direct shear stress plus the shear stress due to moment. This calculation uses the geometry of the punching shear failure cone, along with the induced shear and moment forces, to come up with a maximum stress. This will always occur at one of the failure cone corner locations. For an example calculation, see the ACI 318-14 Section R8.4.4.2.3 (ACI 318-11 Section R11.11.7.2). Note: For more information, see Punching Shear Loading. Phi*Vny This represents the shear stress capacity of the slab, calculated based on the three ACI equations for two-way or punching shear capacity of the slab. For more information, refer to ACI 318-14 Section 22.6 (ACI 318-11 Section 11.11.7.2). When ACI 318-19 is selected, the shear strength of concrete (Vc) uses equations in Table 22.6.5.2. Note that an additional size effect factor s is added in the equation. s is a function of the effective depth of the slab 'd', and is calculated per Equation (22.5.5.1.3). Note: >Note: This value does NOT include any additional capacity due to shear reinforcing in the slab. ACI 318-19 requires a minimum slab reinforcement at punching shear critical section if vuv>2sfc per Section 8.6.1.2. As,min is calculated and presented in the punching shear result of columns under this condition. Please note that the reinforcement design in RISA programs for elevated slabs does NOT consider this requirement. Users need to consider separately the required additional slab reinforcement at punching shear critical sections to account for this code requirement. RISA provides the calculations of As,min per Equation (8.6.1.2) in the Detail Report. Punching Shear Loading Punching shear loading includes a direct shear component, as well as biaxial moments. It is these combined forces that are used to determine the punching shear stress and code check. Direct Punching Shear The direct punching shear demand is not exactly just the axial force in the Pedestal/Post. The area within the punching shear perimeter loading is assumed to pass directly into the support, so that force must be discounted. This includes soil pressure resistance that occurs within the punching shear perimeter. In the image above, the Vu demand equals Ppedestal - Pdirect Moment Consideration The moments used are also not necessarily just the moments directly from the Pedestal/Post. If the centroid of punching shear area is not the same as the centerline of the Pedestal/Post, then there will be an eccentricity that also adds/subtracts moment. Take the edge punching shear situation, shown below: The punching shear perimeter is to the right of the center of the Pedestal/Post location. This causes a moment in the punching shear calculation, even if a moment is not explicitly applied on the Pedestal/Post. This eccentricity is automatically accounted for in the punching shear stress calculation. This same inherent eccentricity occurs in corner punching shear conditions. However, in this case, you get an induced moment in both local axis directions because of the centroid of shear perimeter location. This, similar to the edge condition, is automatically considered in the calculation of the maximum shear stress. Note: >Note: The moments due to eccentricity are not accounted for in the detail report moment output. The moments shown there are taken directly from the Pedestal/Post. The program considers as many as nine different punching shear perimeters for each column in the model. We look at the interior, four edges and four cornercases and determine which configuration produces the largest code check and present that in the results. For example, let's consider a Pedestal/Post that has an interior punching shear perimeter close to a corner. Here, the program will also check out any EDGE punching shear perimeter considerations. The two examples below would be the most likely ones for this given geometry. However, these other two edge conditions would also be checked: In most cases, these odd situations will not govern. However, large moments in a given direction can cause punching shear perimeters with larger areas to govern in specific cases. The program will also check out any CORNER punching shear considerations. The one below would be the most likely for this given geometry. However, these other three corner conditions will also be checked: Again, in most cases these odd situations will not govern. However, large moments in a given direction can cause punching shear perimeters with larger areas to govern in some specific cases. Whichever configuration produces a maximum code check will be reported in the punching shear results. Note: >Note: The punching shear perimeter lengths shown pictorially above will be shown as the L1 and L2 value for punching shear calculations. To limit the total punching shear checks for a given column, we have added two caveats to the above behavior. For any of the four Edge or four Corner cases, the program will NOT perform a punching shear check if:The punching shear perimeter of any punching shear case is more than 50% larger than the minimum Edge/Corner punching shear perimeter.The punching shear perimeter of a punching shear case encompasses a column within it. When the program tests all different cases to determine whether a corner or edge situation governs, it bases the controlling case on the maximum code check produced. There are instances where an edge case is governing that by inspection you might think would be governed by a corner case. See the images below: In the two punching shear scenarios shown above, by inspection you would likely expect the corner condition to control over the edge ones. Punching shear capacity is based on a minimum of three equations in the ACIcode.One of these equations has an alpha term in it, where alpha is smallest for a corner condition. If this equation governs, this would guarantee the corner condition would have the smallest capacity. However, if this equation does not govern, then these capacities may not be as different as you might expect. Also, the demand portion of the equation will be different based on the geometry of the shear perimeter. It is possible that the edge cases produce a larger maximum stress than the corner cases. In summary, our testing has shown that these non-intuitive scenarios where an edge controls over a corner can occur in some instances. Other Punching Shear Considerations/Limitations Punching Shear Perimeters That Cross Different Slab Thicknesses It is possible to have different slab thicknesses within a single column/pedestal's punching shear perimeter. If there is a different thickness at any point along the punching shear perimeter, the program will use the thinnest thickness for the entire calculation. Also, there will be a warning message in the Detail Report when there is a different thickness detected. The L1 and L2 values used when calculating bo will use the depth at the location of the pedestal/column. Pedestal/Post Groups It may be possible for multiple, closely spaced pedestals/posts, to create a punching shear perimeter around the GROUPat a lower force level than would be observed by investigating one of the individual pedestals/posts. This is NOT currently considered in the punching shear code checks. Beams, Columns and Walls intersecting the influence area of a Pedestal/Post When a beam or wall is co-linear with the Pedestal/Post joint, the program will not provide a punching shear check on the Pedestal/Post. In these cases a code check of NC or "no calc" will be listed. Note: >Note: This would also refer to situations where a column from a floor above lands on either a beam or a wall. In that case, punching shear checks would be omitted as well. When a beam or column isn't co-linear with the column, but is located within the punching shear perimeter, then punching shear checks will still be performed. However, the calculations will not be influenced by the presence of that column or beam. When the Pedestal/Post Local Axes Do Not Correspond to the Slab Geometry The punching shear perimeters are always investigated with respect to the Pedestal/Post local axes. As shown below, there may be cases where these local axes do not correspond to the slab edge or corner geometry adjacent to that Pedestal/Post. In cases like these, it is possible for this to result in an artificially large assumed punching shear perimeter. Edge Conditions It is possible to get edge shear perimeters if either the slab edge is sloping, or a column local axis is rotated, as shown below: The program calculates this perimeter by drawing a line in the local axis direction along the centerline of the Pedestal/Post, as shown below: From here, the program offsets this line on either side of the Pedestal/Post at a distance d/2 from the face. This produces a shear perimeter that looks like this: Though this shear perimeter is not technically correct, it typically produces a nearly identical shear perimeter to the actual shear perimeter shown above. Corner Conditions If either the slab edge is sloping, or the pedestal local axis is rotated, it is possible to get a corner shear perimeter. The program starts by trying to draw the full shear perimeter. In this case, we find that the shear perimeter has two sides that run into a slab edge. When this occurs, the program considers this a corner. There are two extremes for what the punching shear perimeter might look like for this case. In reality, the punching shear is likely somewhere between these two extremes. What the program does here is similar to what is done for the edge case, except now this is done for both axes on one side only. Lines are drawn along the local axes of the Pedestal/Post until they reach the edge: From here, the program offsets this line on the side away from the edge at a distance d/2 from the face. This produces a shear perimeter that looks like this: The red line represents the L1 and L2 values the program uses to calculate punching shear perimeter. This perimeter doesn't actually hit the edge of the slab in our calculation, but this puts us in a situation where we are between the two extremes shown above and is a conservative approximation. Note: >Note: Pedestals/posts are defined at a single node in the model. If this node lands inside of the slab, then a punching shear check will be performed. If the node does NOT land on the slab, then the Pedestal/Post will not be considered attached to the slab and no punching shear check will be done. Using Equivalent Square Pedestal/Post When calculating the punching shear perimeter for a round Pedestal/Post, the program always converts the dimension into an equivalent square of equal perimeter. This greatly simplifies the calculation of punching perimeters when close to an edge or corner. For an example of this let's use a 12" diameter cross-section. The perimeter = Pi*Diameter = 37.7 in. An equivalent square would have a side dimension = 37.7 in/4 = 9.424". Thus, a 12" diameter round Pedestal/Post would be considered a 9.424" x 9.424" square for use in punching shear checks. Punching Shear Reinforcement The program currently does not allow for shear reinforcement. The only capacity considered for punching shear is the concrete itself. ACI 318-14 sections 22.6.6(shear reinforcement), 22.6.9 (shearheads) and 22.6.8(headed shear stud reinforcement) are not supported. ACI 318-11 sections 11.11.3(shear reinforcement), 11.11.4 (shearheads) and 11.11.5(headed shear stud reinforcement) are not supported. Punching Shear Checks for Walls, Point Loads, and non-Concrete Columns It is possible that punching shear failures can occur around walls (especially walls with a short length). It is also possible that punching shear failures can occur around point loads or non-concrete columns bearing on the slab. 2025 Tekla Structural Designer Once you have created your punching check items you can proceed to design or check them. You can design/check individually, by floor, or for the whole model, (although some of the methods described below are only available when working to the Eurocode or ACI regional code). Note: As the checks are dependent on using the correct levels of slab reinforcement (typically provided by patch reinforcement), you should only design or check punching shear after you have designed the slabs and designed the patches at the check locations. Note: This method is only available when working to the Eurocode or ACI head code. Do one of the following: To Do this Design an individual punching check item from within the Punching Shear Reinforcement Properties dialog Hover the mouse pointer over the punching check. If a different entity is highlighted, press the cursor key until the correct reference is shown in the Select Entity tooltip. Right-click, and from the context menu that appears, select Edit Reinforcment. Select Auto-design Select Check.... To Do this Design an individual punching check item from a 2D or 3D view Hover the mouse pointer over the punching check. If a different entity is highlighted, press the cursor key until the correct reference is shown in the Select Entity tooltip. Right-click, and from the context menu that appears, select Design Punching Shear. To Do this Design an individual punching check item from the Structure Tree In the Project Workspace, click Structure tab. In the Slabs> Punching Checks branch, locate the check reference. Right click and select Design Punching Shear. Tekla Structural Designer displays the results of the design in a new dialog box. Note: This method is only available when working to the Eurocode or ACI head code. In the Project Workspace, click Structure tab. In the Levels branch, right click the required Level and select Design Punching Shear. Do one of the following: To Do this Design all punching check items from the ribbon On the Design tab, click Design Punching Shear. To Do this Design all punching check items from the Structure Tree Note: This method is only available when working to the Eurocode or ACI regional code. In the Project Workspace, click Structure tab. Right click the Structure branch and select Design Punching Shear. If working to the Eurocode or ACI regional code, Tekla Structural Designer performs punching shear checks for all punching check items in the model based on their individual auto-design setting. If working to other regional codes, Tekla Structural Designer checks all punching check items in the model. If the punching check item does not connect to a flat slab, punching shear is flagged as beyond scope. Do one of the following: To Do this Check an individual punching check item from a 2D or 3D view Hover the mouse pointer over the punching check. If a different entity is highlighted, press the cursor key until the correct reference is shown in the Select Entity tooltip. Right-click, and from the context menu that appears, select Check Punching Shear. To Do this Check an individual punching check item from the Structure Tree In the Project Workspace, click Structure tab. In the Slabs> Punching Checks branch, locate the check reference. Right click and select Check Punching Shear. To Do this Check an individual punching check item from within the Punching Shear Reinforcement Properties dialog Hover the mouse pointer over the punching check. If a different entity is highlighted, press the cursor key until the correct reference is shown in the Select Entity tooltip. Right-click, and from the context menu that appears, select Edit Reinforcment. Unselect Auto-design Select Check.... In the Project Workspace, click Structure tab. In the Levels branch, right click the required Level and select Check Punching Shear. In the Project Workspace, click Structure tab Right click the Structure branch and select Check Punching Shear. Previous Next Join TheConstructor to ask questions, answer questions, write articles, and connect with other people. When you join you get additional benefits. Have an account? Sign In Our previous article, CSI SAFE Slab Considerations Prior to Analysis, discusses the points required in modeling a slab using CSI SAFE before performing slab analysis and design. To deliver a complete slab design procedure using SAFE software, the designer should consider and exercise the three major post-analysis checks accordingly.The below-mentioned design considerations are important points that have to be checked by the designer once the slab model has been analyzed and all the considerations according to the previous article has been completed.1. Check for Long Term DeflectionAfter the run-analysis of the slab, the designers first thing to check is if the slab satisfies the long term deflection. The long term deflection should not be less than L/240 according to ACI code and ideally not more than 24 millimeters. To set the model for a long term deflection analysis, you can refer to our previous article, Long Term Deflection Analysis using SAFE. Once the load cases and load combinations have been set for a long term deflection analysis, check the model by going to Display>Show Deformed Shape, scroll down the Long Term Deflection Combinations that previously set and hit apply. To check the long term deflection values, navigate your cursor to the contour provided by the analysis.If in case the results of long term deflection are not satisfactory, you can either increase the slab thickness or provide a beam just to lessen the excessive deflection on the entire area or on the area of slab being checked.Figure 1: SAFE Cracked Deformed Shape for Long Term DeflectionREAD ALSO: 8-Reasons Why ETABS takes too Long to Run Analysis2. Check for Punching Shear RatiosThe safe and sound slab should also be satisfies punching shear. To check this in the model, go to Display>Show Punching Shear Design. Investigate the column supports for punching shear capacity ratios. The slab is safe for punching shear if the capacity ratios of each column support are less than unity. Punching shear links or even a drop panel is needed for that column support with values of more than one, which needs to be designed accordingly. To check for columns that are modeled as wall properties, draw design strips along X and Y direction and investigate the shear and moment output results of the design strips needed in punching shear checks.Figure 2: SAFE Punching Shear Capacity Ratios3. Slab DesignOnce the above two checks have been satisfied, the designer can proceed to the slab design-proper. To display the reinforcement results needed in the slab go to Display>Show Slab Design and the slab design window will appear. From there you can input the main mesh reinforcement of the slab for top and bottom and the program will show you the area of the extra top and bottom reinforcement and the location from where it will place. Refer to our previous article, how to interpret the SAFE reinforcement for your reference.Figure 3: SAFE Extra Reinforcements for Top and Bottom Additional to Main MeshProvide Mark-UpsThe locations of the top and bottom reinforcement as a result of the SAFE design should be marked up by the designer in the plan/drawing. These markups will be handed over to the structural draftsman for the detailing process and should eventually be check by the designer to complete the design.READ ALSO: 7 Dynamic Analysis Checks to Consider in ETABS ModelWhat do you think about this article? Any considerations that we missed? We love to hear from you! Leave a messagein a comment section below. You can also follow, like and subscribe to our social media pages below to be updated with the latest posts. Well, technically ACI 318 requires a minimum thickness for footings which is more than 4" so your slab can't serve as a footing. But if this is a minor loading, not part of a major load carrying column, then a check for punching shear might be referenced through the "Plain Concrete" section 22 of 318. Short of that I'd use 0.8T to 0.6T to be conservative.But with no reinforcing, I'd stick to what Chapter 22 of ACI says. Got it. Equation (22-10) from ACI Chapter 22 is what I was looking for. Good thing because the punching shear capacity I got from using the equations in Chapter 11 was adequate, and that would have been wrong in this case. Thanks a lot! Punching shear is a failure mechanism when structural elements subjected to concentrated load. Failure occurs in perimeter defined away from the concentrated load. Slabs, pile caps, footings, raft foundations, etc. element is subjected to punching action and they need to be designed for it.The punching shear perimeter is considered as the critical section that a shear failure could occur. The following figure indicates the typical punching shear perimeter. The selection of the critical perimeter could be varied depending on the relevant standard.As indicated in the above figure, different standards use different values to define the punching shear perimeter. The selection of the perimeter could be varied with the other factors also.Punching Shear Stress = V/bdWhereV applied forceb length of the perimeterd effective depth.Punching shear stress shall be less than allowable shear stress; V