Calculate the polar radius of gyration of the shaded area about the center o of the larger circle.

The behavior of the structural member is dictated by its material and its geometry. The cross-section and length of the structural penis affect how much that member deviates under load, and the cross-section determines the stresses that exist in the penis at this load. The form centroid represents the point where the section area is evenly distributed. If the area is doubly symmetrical about two orthogonal axes, the centroid lies at the intersection of these axes. If the area is symmetrical on only one axis, the centroid lies somewhere along this axis (the other coordinate should be calculated). If the exact location of the centroid cannot be determined by inspection, it can be calculated by: where dA represents an area of infinitely small element, A is a total cross-section area, and x and y are the coordinates of the dA element in relation to the axis of interest. The centralities of common cross-section are well documented, so there is usually no need to calculate the location with the equations above. If the cross-section consists of a collection of basic forms whose centoidal locations are known in relation to a point of reference, the centraloid arrangement of the composite section can be calculated as: where xc,i and yc, i are the rectangular coordinates of the central ith location of the ith section in relation to the reference point, and Ai is the ith section area. The centroid distance of the Centroid distance, c, is the distance from the cross-section centoid to the extreme fiber. The centipede distance in the direction of the rectangular cross section is shown in the image below: Common uses for centroid distance include: The first point of the region's first point in relation to the axis of interest is calculated as: where qx is the first point on the x-axis and y is the first point about the axis. If the area consists of a collection of basic forms whose centoid locations are known in relation to the axis of interest, the first point of the composite area can be calculated as: Note that the first point of the region is used in the calculation of the cross-section centroid in relation to some origin (as discussed earlier). The first point is also used to calculate the stress of a haircut at a certain point of cross-section. In this case, the first point is calculated for the area that makes up a smaller part of the cross section, where the area is limited by the point of interest and extreme fiber (top or bottom) of the cross section. The first point is calculated about the axis that passes through the centraloid cross-section. In the picture above, the shaded blue area is of interest within the general section. The first point of this area in relation to the x-axis (which runs through the cross-section of the centroid, dot O in the picture above) is calculated as: If The location of the area of interest is known, the first point of the area in relation to the axis can be calculated as (link to the figure above): it should be noted that the first point of the area will be positive or negative depending on the position of the area in relation to the axis of interest. Thus, the first point of the entire cross-section area in relation to its own centroids will be zero. The area moment of inertia second point of the area, better known as the moment of inertia, I, cross-section is a sign of the ability of the structural member to resist the bend. (Note 1) Ix and Iy are moments of inertia about x- and y-axes, respectively, and are calculated by: Ix No ∫ y2 dA Iy and ∫ x2 dA, where x and y are coordinates of the dA element in relation to the axis of interest. Most often moments of inertia are calculated in relation to the centroid section. In this case, they are called centroidal moments of inertia and are designated as Icx for x-axis inertia and icy for inertia about the axis. Moments of inertia in common cross-section are well documented, so there is usually no need to calculate them using the equations above. Properties of several common cross-sections are given at the end of this page. If the cross-section consists of a collection of basic forms, the centroids of which coincide, the moment of inertia of the composite section is simply the sum of individual moments of inertia. An example of this is a box beam that consists of two rectangular sections, as shown below. In this case, the outer section has a positive area and the inner part has a negative area, so the constituent point of inertia is subtracting the moment of inertia of the inner section from the outer section. In the case of a more complex composite cross-section, in which the centroid locations do not match, the moment of inertia can be calculated using the theorem of a parallel axis. It is important not to confuse the moment of inertia of the area with the massive moment of solid inertia. The moment of the region of inertia indicates the resistance of the cross-section to the bend, while the moment of mass of inertia indicates the body's resistance to rotation. Parallel axis theorem If the moment of inertia of the cross-section on the centroidal axis is known, then the parallel axis theorem can be used to calculate the moment of inertia on any parallel axis: the axis of Iparallel and Ic s d2, where Ic is the moment of inertia on the centroidal axis, d is the distance between the centroid axis and the parallel axis, and the A is the region of the cross-section. If the cross-section consists of a collection of basic forms, the centroid moments of inertia of which are known together with the distances of centroids to a certain point of reference, then the theorem of the parallel axis can be used to calculate the moment of inertia of the composite section. For example can be close to the 3 rectangle, as shown below. Since this composite section is symmetrical on both x- and axis, the centraloid section can be located by inspection at the intersection of these axes. The centroid is in place, O, in the picture. The moment of inertia of the composite section can be calculated with the help of a parallel axis theorem. The central moment of inertia of the x-axis section, Icx, calculated as: Icx.IBeam - Icx.W (Icx.F1 - AF1 d12) - (Icx.F2 - AF2 d22), where the terms Icx are moments of inertia of individual sections about their own centroids in the orientation of x-axis, d terms are the distances of individual section centroid centroid, and terms A-section. Because the centeroids of the W section and the centroid of the composite section are the same, d is zero for this section and therefore there is no term Ad2. It is important to note the effects of the parallel axis theorem, that as a separate section moves further away from the composite section's centroid, the contribution of this section at the time of the composite section's inertia doubles. Therefore, if the goal is to increase the moment of inertia of the section on a particular axis, then it is most effective to find an area as far away from this axis as possible. This explains the shape of I-Beam. Flanks are the main contributors at the moment of inertia, and the web serves to separate the flanks from the bend axis. The web needs to maintain some thickness however to avoid bucking and because the web takes up much of the stress of the haircut in the section. The polar moment of inertia Polar moment of inertia, i, cross-section is a sign of the ability of the structural member to resist the xersion on the axis, the perpendicular section. The polar moment of inertia for the section in relation to the axis can be calculated by: J and ∫ r2 dA ∫ (x2 and y2) dA, where x and y are the coordinates of the dA element in relation to the axis of interest, and r is the distance between the dA element and the axis of interest. While the polar moment of inertia can be calculated using the equation above, it is generally more convenient to calculate it using the perpendicular axis theorem, which states that the polar moment of the region's inertia is the sum of moments of inertia about any two orthogonal axes that pass through the axis of interest: Most often, the axis of interest passes through the centraloid cross-section. The Modulus Maximum Stress Bend section in the beam is calculated as qb y Mc/Ic, where c is the distance from the neutral axis to the extreme fiber, Icis is the centrifanal moment of inertia, and M is the moment of bending. The section module combines the terms C and Ic in the stress-bending equation: Using a section module, stress bend is calculated by both qb and M/S. Usefulness modulus is that it characterizes the bend of cross-section resistance in one term. This allows you to optimize the cross-section of the beam to resist the bend, maximizing one parameter. The Gyration Radius gyration radius represents the distance from the centroid section on which all areas can be concentrated without any effect at the time of inertia. The rotation radius of the form relative to each axis is given: the polar rotation radius can also be calculated for problems associated with the xersia near the centroid axis: Rectangular radios of rotation can also be used to calculate the polar radius of rotation: The properties of the common cross sections Table below gives the properties of the common cross sections. More extensive tables can be found in these links. Properties calculated in the table include an area, a centroidal moment of inertia, a section module, and a gyration radius. Form Of Representation Properties Rectangle Circle Circle Tube I-Beam Notes Note 1: The deviation of the beam deviation beam under the bend is determined by the moment of inertia of the cross section, the length of the beam, and the elastic material module. More information is given in this discussion of beam deviation. Links Links