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Please copy and paste this embed script to where you want to embed Helicoidal staircases, sometimes called helical staircases is another alternative solution for vertical circulation within constraint spaces. These unconventional staircases stand out as a fascinating and visually striking choice. They are an architectural marvel that combines functionality and aesthetic appeal. When designed properly, their graceful sweeping curve not only adds an elegant touch to a building's interior but also presents the structural designer with a unique set of engineering challenges. A helical staircase is very similar to a spiral staircase, however, while spiral staircases have a central support system, a helical staircase has no intermediate supports, and is only supported between floors. The consequence of having no intermediate support coupled with their unusual geometry is that the load and internal stress distribution within a helical staircase is very complex. In analyzing a helical staircase, the structure is treated like a space member, i.e. several internal forces come into play, therefore an interaction between the internal forces must be considered. This article discusses the design intricacies of helical staircases. It offers an overview of the analysis of helical staircases and presents a method that can be used for preliminary analysis and design. Perhaps the biggest challenge with designing a helical staircase is how to determine the internal forces. Unlike the traditional staircases which can be idealized as plane member, a helical staircase is a space frame, therefore can only be analyzed as a three-dimensional structure. Thus, for analysis purposes, the helicoidal surface is idealized such that the section consists of a warped surface which is generated by moving a straight line to touch a helix, so that the straight line is always normal to the axis of the helix (Figure 1). Up to 6 internal stresses can be found in a helical stair (Vertical moment; lateral moment; vertical shear; lateral shear; axial thrusts and torsion). All of these six internal actions would interact at any given section of the stair. Figure 1: Internal Forces in a Helical Staircase Because of this complexity in analyzing a helical stair, traditional analysis methods have simply been on various simplifications, idealization and assumptions. Several papers have been presented by researchers on the subject which can all be summarized into two basic approaches. The first approach solves the analysis problem by transforming the helicoid into a fixed ended curved beam, so that the structure is now two-dimensional and can therefore be analyzed as a beam. This solution was proposed by Bergman (1956) and is known as the in-plane beam solution to the analysis of helical staircase. In the second approach the helicoid is treated like a "helical girder" (a space structure). So that the helicoid is reduced to an elastic line with the same stiffness as the original structure. This solution is as per Morgan (1960). Still on the need to discover an exact and even simpler method of analysis Santathadapom and Cusens (1966) attempted to simply the "helical girder" approach by publishing a list of design charts from which coefficients are determined. These coefficients are based on the geometrical properties of the helical stair and is applied in computing the value of the internal stresses within the stair. Further simplification of this work was done by Reynolds and Steedman (1988). Four design charts were published. These design charts today stand as 'helical girder solution' for helicoidal stairs. As earlier stated, six internal forces occur in a helical staircase, and per Reynolds and Steedman, can be computed using the following equations: Mn=M0SIN(θ)SIN(φ)-HR2θTAN(φ)COS(θ)SIN(φ)-HR2SIN(θ)COS(φ)+nR1sin(φ)(R1SINθ-R2θ) My=M0COS(θ)+HR2θTAN(φ)SIN(θ)-NR12(1-COS(θ)) N=-HSIN(θ)COS(φ)-nR1θSIN(φ) T=(M0SIN(θ)-HR2θCOS(θ)TAN(φ)+nR12SIN(θ)-nR1R2θ)COS(φ)+HR2SIN(θ)SIN(φ) Vertical Shear Vn=nR1θcos(φ)-HSIN(θ)SIN(φ) Vh=HCOS(θ) Where: Mo is the redundant moment acting tangentially at midspan; Mvs; is vertical support moments; H is the horizontal redundant force at midspan; n is design load on the staircase in (kN/m); R1 & R2 are the radiuses of the centerlines of loading and steps respectively; θx is the angle subtended in plan between the point at which the internal forces is to be determined and the midspan; Ø is the slope of tangent to the helix centerline measured from horizontal; and β or α is the total angle formed by the helical staircase in plan. The redundant moment acting tangentially at midspan Mo; the horizontal redundant force H; and the vertical support moment Mvs are computed from the following equations respectively. Where: k1, k2 and k3 are coefficients obtained from chart. The radius of the centerline of loading and steps, R1 & R2 can be computed from the following equations respectively. R_1=\frac{2(R_o^3 - R_i^3)}{3(R_o^2-R_i^2)} Where: Ro and Ri is the outer and internal radiuses of the helical staircase in plan. There are four charts with within Table 177 Reynold's and Steedman Designer's Manual from which the coefficients of k1, k2, and k3 are determined. Each of this chart covers a range of β of (30-360°) and Ø of (20-40°), a stair width: waste ratio of 5 and 10, and R1/R2 of 1.0 and 1.1. While this chart can not be taken as a one-size-fits all, these values fall within ranges of what would be frequently met in helical staircases design. Interpolations between the charts are also allowed in order to arrive at a more accurate values. Finally, it must be noted that all the studies on the analysis of helical staircases (including the one presented in this article) that are based on either the curved beam or helical girder approach are all flawed. Why? Because they fail to take into account the 3-dimensional characteristics and the inherent structural efficiency of the helicoid. The implication is that the internal forces assumed for design can be sometimes far removed from reality. However, the advent of finite element analysis and the availability of software packages have steered in a more logical, exact and economical method of analyzing a helicoid. Therefore, except for preliminary analysis, helical staircases are best analyzed and designed using a FEA software. Having analyzed and determined the internal forces, designing the stair is pretty straightforward. There are six internal forces, each of which must be considered; design for flexure; design for shear and design for torsion. Also, because these forces act simultaneously, the interaction/ combined effect of them acting together should also be checked. The following steps is an overview of how to design a helicoidal stair Determine helical stair geometrical properties Estimate the design action on the helical stair Using the geometrical data and charts determine the values of the k1, k2 & k3 coefficients and compute the values of the redundant moment, vertical support moment, and horizontal redundant force. Compute the lateral, moment, vertical moments, axial thrust, lateral shear force, vertical shear force and torsion at different angles intervals. Design for flexure, using the maximum occurring values of the lateral & vertical moments. Design for shear using the maximum occurring values of the lateral and vertical shear Design for Torsion using the maximum occurring value of torsional moment. An helicoidal staircase is required in the lounge of a proposed residential dwelling. The helicoidal staircase is to turn through an angle of 360°, have an angle of inclination of 20° to the horizontal and support a total permanent action and imposed action of 9.125kN/m2 and 1.5kN/m2 respectively. Estimate the internal forces in the helicoidal staircase at an interval of θ = 20° and determine the values for design, assuming the width of the staircase is 1.5 and the internal radius is 1.15m. n_s =(1.35g_k+1.5q_k)\times b \\= (1.35\times9.125+1.5\times2.5)\times 1.5 \\=21.9kN/m R_o =R_i+b\\=1.15+1.50=2.65mm R_1=\frac{2(R_o^3 - R_i^3)}{3(R_o^2-R_i^2)} =\frac{2(2.65^3 - 1.15^3)}{3(2.65^2-1.15^2)}=2.0m \frac{R_1}{R_2}=1.05; \quad \frac{b}{h}=6; \quad \beta=180\degree\quad \phi=25 \degree Interpolating between the charts on Table 177 of Reynold's and Steedman: Structural Engineers Designer's Manual; we have: =-0.48\times21.9\times1.9^2\\=-37.9kN.m =2.45\times21.9\times1.9\\=-101.7kN =-1.6\times21.9\times1.9^2\\=-126.2kN.m Having determined the values of Mo, H and Mvs, these values will be substituted into the internal forces' equations, taking θ at an interval of 20°. This is summarized in the table below. S/n θ (degrees) Mn (kN.m) T (kN.m) My (kN.m) N (kN) Vn (kN) Vh (kN) 1.00 180.00 -172.69 -458.13 -119.91 -48.53 128.74 101.73 2.00 160.00 -81.35 -403.24 -187.02 -75.69 126.71 95.59 3.00 140.00 7.84 -331.44 -224.74 -98.93 123.20 77.93 4.00 120.00 83.51 -253.01 -231.55 -114.79 116.90 50.86 5.00 100.00 136.40 -177.78 -211.24 -120.70 106.86 17.66 6.00 80.00 160.64 -113.48 -171.95 -115.31 92.55 -17.66 7.00 60.00 154.53 -64.61 -124.45 -98.61 73.99 -50.86 8.00 40.00 120.77 -31.84 -80.16 -71.97 51.67 -77.93 9.00 20.00 66.03 -12.24 -49.04 -37.95 26.58 -95.59 10.00 0.00 0.00 0.00 -37.87 0.00 0.00 -101.73 11.00 20.00 66.03 -12.24 -49.04 -37.95 26.58 -95.59 12.00 40.00 120.77 -31.84 -80.16 -71.97 51.67 -77.93 13.00 60.00 154.53 -64.61 -124.45 -98.61 73.99 -50.86 14.00 80.00 160.64 -113.48 -171.95 -115.31 92.55 -17.66 15.00 100.00 136.40 -177.78 -211.24 -120.70 106.86 17.66 16.00 120.00 83.51 -253.01 -231.55 -114.79 116.90 50.86 17.00 140.00 7.84 -331.44 -224.74 -98.93 123.20 77.93 18.00 160.00 -81.35 -403.24 -187.02 -75.69 126.71 95.59 19.00 180.00 -172.69 -458.13 -119.91 -48.53 128.74 101.73 MAX 172.7 458.1 231.6 120.7 128.7 101.7 From the table above, it can be seen that the maximum internal forces occur when θ = 180°. Therefore, these values should be utilized to provide the flexural, shear and torsional reinforcement required in the helicoidal staircase. See below for spreadsheet showing full analysis and design. Helicoidal_Staircase_Worked-ExampleDownload See: Designing a Concrete Spiral Staircase to EC2 | Worked Example Bergman, V.R (1956) "Helicoidal Staircases of Reinforced Concrete", ACI Journal, 28, 403-412. Morgan, V.A. (1960) "Comparison of Analysis of Helical Staircases", Concrete and Constructional Engineering (London), 55, 127-132. Santathadaporn, S., Cusens, A.R. (1966) "Charts for the design of Helical Stairs with Fixed Support" Concrete and – Constructional Engineering, 46-54. Reynolds, C.E., Steedman, J.C. (1988) "Reinforced Concrete Designer's Handbook", Tenth Edition, E. & F.N. SPON (London & Newyork), 386-391. Amin, A.F.M.S and Ahmad, S. (1998). An Economic Design Approach for Helicoidal Stair Slabs Based on Finite Element Analysis. 10.4203/ccp.56.6.4 Helical staircases provide alternatives for vertical circulation in buildings. Due to their curved and elegant nature, they inspire awe and admiration whenever they are properly designed and constructed. The analysis and design of a helical staircase can be complex due to an inherent interaction of vertical moments, horizontal moments, vertical shear, lateral shear, axial force, and torsion. The complexity of helical staircases is due to their geometry.Geometrically, a helical surface is a three-dimensional structure in space consisting of a warped surface that is generated by moving a straight line touching a helix so that the moving line is always perpendicular to the axis of the helix. In an oblique helix, the generating line always maintains a fixed angle with the helix. Since a helical staircase is a space member, all the six internal actions come into play at any section, having varying directions and lines of actions.Fig 1: Internal stresses in a helical staircaseDespite the existence of the six internal stresses at any section in a helical staircase, they are usually designed for the horizontal bending moment only. Furthermore, helical staircases can sometimes be idealised as a fixed ended curved beam for the purposes of design due to their complexity.Bergman (1956) proposed an approximate solution to helical staircases called the in-plane beam solution. The method reduces the problem to that of a horizontal bow girder, which fails to take into account the inherent structural strength of a helical beam.Morgan (1960) and Scordelis (1960) presented the analysis of the longitudinal elastic axis of the helical beam as a three-dimensional structure indeterminate to the sixth degree. By selecting the redundant at mid-span and using the principle of symmetry, all but two of the redundants become zero. The two redundants at mid-span are the horizontal shear H and the vertical moment Mo.Cusens and Trirojna (1964) carried out a test on half scaled fixed ended helical staircase and confirmed the equilibrium equations derived by Morgan. Santathadaporn and Cusens (1966) worked further on helicoidal stair slabs to simplify the design process. They proposed some simple equations for design purpose with the provision of using coefficients in the equations. They used computer program to solve those complicated equations and constructed a series of design charts to provide the values of the coefficients.Reynolds and Steedman (1988) attempted further modifications of the charts provided by Santathadaporn and Cusens. The analytical approach they chose was the one made by Morgan and Scordelis. The proopsed equations and coefficients for determination of the internal stresses are as follows;Fig 2: Geometry and internal stresses in helical staircaseHorizontal moment Mn = Mo sinθsinϕ – HR2θtanϕcosθsinϕ – HR2sinθcosϕ + nR1sinϕ(R1sinθ – R2θ) —— (1)Vertical moment My = Mocosθ + HR2θtanϕsinθ – nR12(1 – cosθ) —— (2)Torsion T = (Mosinθ – HR2θcosθtanϕ + nR12sinθ – nR1R2θ)cosϕ + HR2sinθsinϕ —— (3)Axial force N = -Hsinθcosϕ – nR1θsinϕ —— (4)Vertical shear Vn = nR1θcosϕ – Hsinθsinϕ —— (5)Radial horizontal shear Vh = Hcosθ —— (6)Where;Mo = Redundant moment acting tangentially at the midspan = k1nR22H = Horizontal redundant force at midspan = k2nR2Mvs = Vertical moment at supports= k3nR22n = total design load on the staircase (kN/m2)R1 = Radius of centreline of loading = 2(Ro3 – Ri3)/3(Ro2 – Ri2)R2 = Radius of centreline of steps = 0.5(Ri + Ro)θ = angle subtended in plan between point considered and mid-point of stairϕ = slope of tangent to helix centreline measured from horizontalβ = Total angle formed by the helical staircase in plank1 = GC/EI1k2 = GC/EI2I1, I2 = Second moment of area of stair section about horizontal axis and axis normal to slope respectively.The 36 design charts presented by Santathadaporn and Cusens (1966) covered ranges of β of 60° to 720°, ϕ of 20° to 50°, b/h of 0.5 to 16 and R1/R2 of 1.0 to 1.1, based on a ratio of G/E of 3/7.Four design charts are provided in Table 177 of (Reynolds and Steedman 10th Edition) and (Tables 2.90 and 2.91 of 11th Edition) for a ratio of G/E of 0.4 and by taking C to be one-half of the St. Venant value for plain concrete. These charts cover ranges of β of 30° to 360° and ϕ of 20° to 40°, with values of b/h of 5 and 10 and R1/R2 of 1.0 and 1.1, these being the ranges most frequently met in helical stair design. According to Reynolds and Steedman (1988), interpolation between the various curves and charts on the Tables will be sufficiently accurate for preliminary design purposes.According to a 2015 research from the Department of Civil Engineering, Addis Ababa University, Ethiopia, the solution provided in Reynolds and Steedman is the best so far, even though it has its limitations. The charts presented in the book give good information about internal actions but only qualitatively, and indicate set of constants to put in his equations then solved. And, as Reynolds himself stated in his book, his results are only satisfactory for preliminary analysis only as lots of interpolation is involved.Design a helicoidal stair having an angle of inclination ϕ of 25° to the horizontal plane to support a uniform imposed load of 3 kN/m2. The stair is to have a width of 1.5 m and the minimum thickness of the waist is 150 mm, the radius to the inside of the stair Ri is 1000 mm, and the angle β turned through by the stair is 180°. (Weight of finishes = 1.2 kN/m2; weight of riser/thread = 1.875 kN/m2)SolutionPermanent actions;Self-weight of waist (150 mm thick) = 0.15 × 25 = 3.75 kN/m2Weight of stepped area = 1.875 kN/m2Weight of finishes = 1.2 kN/m2Total dead load (characteristic permanent action) gk = 6.825 kN/m2Variable action(s);Characteristic variable action on staircase qk = 3 kN/m2At ultimate limit state Ed = 1.35gk + 1.5qk = 1.35(6.825) + 1.5(3) = 13.71 kN/m2GeometryInner radius Ri = 1000 mm = 1 mOuter radius Ro = Ri + b = 1000 + 1500 = 2500 mm = 2.5 mThe radius of the centreline of the load R1 is;R1 = 2(Ro3 – Ri3)/3(Ro2 – Ri2) = 2(2.53 – 1.03)/3(2.52 – 1.02) = 1.857 mR2 = 0.5(Ri + Ro) = 0.5(1000 + 2500) = 1750 mm = 1.75 mR1/R2 = 1.857/1.75 = 1.06b/h = 1500/150 = 10β = 180°; ϕ = 25°Reading from chart (Tables 177 of Reynolds and Steedman, 2005);(b/h = 10; R1/R2 = 1.0; β = 180°; ϕ = 25°) k1 = -0.02; k2 = +1.21; k3 = -0.1(b/h = 10; R1/R2 = 1.1; β = 180°; ϕ = 25°) k1 = -0.09; k2 = +1.45; k3 = -0.19Interpolating between R1/R2 = 1.0 and 1.1, we obtain;k1 = -0.062; k2 = +1.354; k3 = -0.154Structural AnalysisMo = Redundant moment acting tangentially at the midspan = k1nR22 = -0.062 × 13.71 × 1.752 × 1.5 = -3.905 kNmH = Horizontal redundant force at midspan = k2nR2 = 1.354 × 13.71 × 1.75 × 1.5 = 48.728 kNMvs = Vertical moment at supports = k3nR22 = -0.154 × 13.71 × 1.752 × 1.5 = -9.698 kNmThe values of Mo and H can now be substituted into equations (1) to (6) to obtain the internal stresses along the staircase.For instance, when θ = 60°n (as uniformly distributed load in kN/m) = 13.71 x 1.5 = 20.565 kN/mVertical moment My,Ed = Mocosθ + HR2θtanϕsinθ – nR12(1 – cosθ) = -3.905cos60 + (48.729 × 1.75 × (π60/180) × tan25 × sin60) – 20.565 × 1.8752 × (1 – cos60) = -1.9525 + 36.055 – 36.149 = -2.046 kNmHorizontal moment Mn,Ed = Mo sinθsinϕ – HR2θtanϕcosθsinϕ – HR2sinθcosϕ + nR1sinϕ(R1sinθ – R2θ) = (-3.905 × sin60 × sin25) – [48.728 × 1.75 × (π60/180) × tan25 × cos60 × sin25] – (48.728 × 1.75 × sin60 × cos25) + [20.565 × 1.875sin25(1.875sin25 – 1.75(π60/180)] = -1.429 – 8.797 – 66.930 – 16.945 = -94.101 kNmTorsion T = (Mosinθ – HR2θcosθtanϕ + nR12sinθ – nR1R2θ)cosϕ + HR2sinθsinϕ = [-3.905sin60 – (48.728 × 1.75 × (π60/180) × tan25 × cos60) + (20.565 × 1.8752 × sin 60) – (20.565 × 1.875 × 1.75 × (π60/180))]cos25 + (48.728 × 1.75 × sin60 × sin25) = -23.085 + 31.210 = 8.125 kNmAxial force N = -Hsinθcosϕ – nR1θsinϕ = [-48.728 × sin60 × cos 25] – [20.565 × 1.857 × (π60/180) × sin25] = -38.245 – 16.898 = -55.143 kNVertical shear Vn = nR1θcosϕ – Hsinθsinϕ = [20.565 × 1.857 × (π60/180) × cos25] – [-48.728 × sin60 × sin 25] = 36.238 + 17.834 = 54.072 kNRadial horizontal shear Vh = Hcosθ = -48.728 × cos60 = -24.364 kNThe calculation should be carried out for different angles, and the maximum values used for the structural design.To request for this article or any other Structville article in PDF format, click HERE (premium but very affordable).References[1] Bergman V.R. (1956): Helicoidal staircases of reinforced concrete, A.C.I. Journal Proceedings 53(4):403-412[2] Cusens A.R., Trirojna S. (1964): Helicoidal Staircase Study. ACI Journal, Proceedings, 61(1):85-101.[2][3] Morgan V.A. (1960): Comparison of Analysis of Helical Staircases. Concrete and Construction Engineering, (London) 55(3):127-132.[4] Reynolds C.E., Steedman J.C. (1988): Reinforced Concrete Designers Handbook, Tenth Edition, E & FN Spon Ltd, London[5] Santathadaporn, S. and Cusens, A R. (1966): Charts for the Design of Helical Stairs with Fixed Supports. Concrete and Construction Engineering, 61(2):46-54.[6] Scordelis A. C. (1960): Closure to Discussion of Internal Forces in Uniformly Loaded Helicoidal Girder. ACI Journal Proceedings, 56(6):1491-1502. A helical staircase is a staircase that is curved in plan and following the directrix of a full helix. In three-dimensional space, a helical surface is generated by moving a straight line such that the moving line is perpendicular to the helix.A helix is a smooth space curve with tangent lines at a constant angle to a fixed axis. The construction of a helical staircase is a fairly challenging process that must be handled with care by the contractor. It is important to note that a helical staircase can be achieved using a variety of materials such as reinforced concrete, steel, or timber.The aim of this article is to provide guidance on how to successfully construct a reinforced concrete helical staircase using locally available materials and tools.Read Also...Design of helical staircaseIt is important to note that a reinforced concrete helical staircase can be in two forms;Helical staircase with waist, andSlabless (saw-tooth) helical staircaseA helical staircase with a waist has a reinforced concrete base slab of 100 – 200 mm thickness supporting the treads and the risers (which are usually unreinforced). The waist slab is the main structural component of the staircase where the rebars are placed. On the other hand, just like a typical sawtooth staircase, a slabless helical staircase does not have a waist slab and the structural component of the staircase are the treads and the risers.Curved staircase with waist slabCurved staircase without waist slabThe construction of these two types of helical staircases present their own different challenges to a contractor, but generally, it is easier to construct a helical staircase with a waist than a slabless helical staircase. The material and construction effort demand is also greater in the latter than in the former. In this article, however, we are going to focus on the construction of a helical staircase with a waist slab.For someone that is doing a helical staircase for the first time, it is very important to pay attention to the challenges it presents, especially when sophisticated tools are not available for the setting out. First and foremost, it is important to establish the layout of the staircase as given in the drawing.The drawing should contain the exact number of treads and risers that will be required for the floor height. Other information such as the inner radius and the width of the staircase should also be provided. This is very important because without a proper setting out, it will be very challenging to get the staircase right.From the drawing, locate the centre of the staircase and make a permanent mark there. Alternatively, you can get a straight and strong timber pole and attach it to a marine plywood (or 1″ x 12″ plank) base that is firmly attached to the floor. Make sure that the wood is plumb in all directions and properly placed at the centre of the curve.Using the centre of the curve, establish the inner radius of the staircase and plot it on the floor of the building using any suitable tool/material of your choice. The outer radius of the curve can also be established, especially when the sides of the staircase are not attached to any wall.Typical setting out of a helical staircaseAfter establishing the curves in plan, you can use 1″ x 12″ or 1″ x 6″ planks (depending on the radius of the curve) that are standing upright to form the lines of the curves and to also establish a temporal wall for markings. The planks should be firmly nailed to the floor of the building using 2″ x 3″ wood and braced properly. The height of the planks should be determined with reference to how the staircase rises. This approach however consumes a lot of material.Installation of planks along the curve of a staircaseAfter joining the planks side by side, establish the markings of the staircase (tread and riser) on the planks which serves as a temporal wall. Make sure to establish the thickness of the waist on the planks too.Installation of planks along the curve of a staircaseAfter the markings, insert the stringers and support or brace the formwork with 2″ x 3″ wood. Bamboo or another strong material such as 2″ x 4″ wood can be used as props. The sheating of the staircase (soffit) can then be formed on the framing using suitable plywood. Depending on the configuration, the inner/outer curve of the staircase should be covered with another plywood with the equivalent height of the riser. Alternatively, the markings on the plank can be used if the height is sufficient but this might give a rough edge finish.After the soffit of the formwork has been installed, the iron bender should neatly install the reinforcements according to the design specifications. The risers of the staircase can be installed by nailing perfectly cut planks to the edges of the inner and outer curves. To get this very well, you can tie a rope to the timber at the centre of the curve which you can easily adjust round it, and use it to trace the line of the plank that will form the riser which lies from the inner radius to the outer radius. Note that the tread is bigger in the outer radius because of a wider circumference/length.Alternatively, you can prepare your framing by laying the 2″x 6″ timber stringers from the central pole to your outer line of shores. The timber stringers should be laid flat on the floor and sawn accurately to dimension. The top elevation of the stringers will be determined by the thickness of the concrete slab and the thickness/arrangement of the formwork.Once the stringers are complete and checked for position, level, and length, install 2″ x 4″ timber joists spaced at 400 mm centre to centre. After the stringers and joists are securely fixed in place, proceed with the plywood sheathing, and finally the edge forms. This approach requires knowing the dimensions as accurately as possible and cutting the timber forms properly.Alternative framing of a helical staircase without planksOnce the formwork is complete, well secured, and inspected, the next step would be to install the reinforcement. Bars must be cut to the right length and placed neatly in size and spacing according to the construction drawings. Use chairs to maintain the proper clearance to the forms and observe the proper concrete coverage at the bottom of the reinforcing bars.Typical reinforcement installation of a helical staircaseFollowing the inspection and approval of the reinforcing bar comes the careful preparation for pouring. We recommend a minimum concrete strength of 25 MPa at 28 days. The concrete mix should be properly designed, water content carefully controlled, vibrated, and compacted to its maximum density.To request for this article or any other Structville article in PDF format, click HERE (premium but very affordable). Try Googling "Reynolds-Steedman-helicoidal Stair and Sawtooth - Esercizi". Boris...where have you gone? You can get the entire book by googling TABLES 177 of REYNOLDS AND STEEDMAN, 2005, just as you typed it in the original post. Have you found it yet? Many Thanks Sir and My apology for the for the late reply. I'm actually writing my end of year project. I did find the article. But I wonder how we can do the designs of RC, with all those forces found from analysis. I haven't find a textbook on RC design of this helical staircase type yet , but finaly calculated the forces with the help of Reynold's and steedmand K coefficient chart. Is there any simplified way or method to calculate the RC design with these forces found Sir? Thanks Boris Designing an RC helical stair is not an every day job. I have not designed one in fifty three years of practice. If you are doing it as a project for school, the worst that can happen is you get a bad mark...no big deal, so do it. If you are doing it for a client who may build it from your drawings and specifications, you don't have the experience to do it properly, so [highlight orange]avoid it.[/highlight] Thanks Sir,I haven't even found one textbooks about this helical provided or required reinforcement in the internet. that shows how tough is it. There's another problem with fire provision using Eurocode2. I have a project with a column of effective length 4m. But most of the books i find stipulates that eurocode restrict the effective length of the column to 3m. Is there any way or algorithm in eurocode2 that solves this problems?? or any free online textbook you recommend? Thanks in advance Boris I don't use eurocode, so I am not familiar with its requirements, but I would be amazed if it restricts column effective length to 3m. That seems ridiculous to me, and I am sure there are many buildings in Europe with columns having effective length much greater than 3 or even 4 meters. Is there any way or algorithm in eurocode2 that solves this problems?? or any free online textbook you recommend? I can't answer either question. Are you using a central column with stair treads cantilevering out? If so, it should be easier to analyze than a stair without the central column. Can you show a sketch of what you are planning? Include some dimensions. Hi Sir @BAretired, the structural plan are not completely finalized yet. When done, it will be an honor for me to send the plans latest end of the week. Thanks for your answers Boris Hi Sir @BulbTheBuilder A huge thanks for the file, seen the answer my question. Have another question please Sir @BuldTheBuilder. Sometimes we create openings through beams and slabs for HVAC purposes to save the headroom of the building. In RC classroom we we're though to design these structures without openings. are there any eurocode textbook or algorithm for these design please?.. haven't found one yet online. Thanks Boris Try Concrete Beams with Openings Analysis and Design by M. A. Mansur, Kiang-Hwee Tan. It is an old book that uses metric units but references ACI so you might want to understand it and use the appropriate equations from EC2 I want to assume this is a school project. Is it permissible to use flat slab in your design? I think you will over complicate the work if you are considering openings for HVAC, and you save building height as well. Unless this is a transfer beam, and you need the opening for HVAC. Don't know if you're familiar with PT slabs, but you can do PT flat slab for bigger slabs if save headroom is important to you. P.S there are other variables to consider before deciding on any system. Best of luck with your project I don't use Robot structural analysis. Can you share what the issue so we can provide some guidance? [EDIT] I am currently looking at the image. How many storeys do you have? The raft looks huge for a school project. What is your soil bearing pressure? What are your column sizes and what is the building being used for? S10(S26) - The value of the punching force is too big It is either your raft isn't thick enough of you've a higher load (more than actual load due to typo or something) S11(527) - Too little safety factor - reinforcement required Is your raft unreinforced? Note that you will be both top and bottom reinforcement. Also check the factor of safety you're using. School projects, you can get away with 2.0. But if values were provided, use those. I can open this file, but I have no idea what to make of it. Does not look much like a helical stair to me. Many thanks for your answers. I have a situation in RC beam design. Usually in a STORY level a beam is heavily loaded more than another. In that situation, should we size a beams with variable depth so as to reduce the deflection of slabs, but difficult for formwork purposes or should should we put in more steel . The building is for office purposes. 100%(4)100% found this document useful (4 votes)6K viewsThis document provides information about structural design of helical staircases. It includes sections on the definition of stairs and terms used, essential requirements for stairs, and clas…AI-enhanced title and descriptionSaveSave Concrete-Helical-Stair-Design.pdf For Later100%100% found this document useful, undefined Job Ref: Project: ETTEH ARO AND PARTNERS Date: 35, Lawrence Arokodare House Sheet No: 1 Made by: O.S.A Oshuntokun Avenue Structure: Ibadan HELICOIDAL STAIR REF 3.10 Checked by: CALCULATIONS STAIR TYPE: Helical Stair Flight No: 1 PARAMETERS Threads dimension = Risers dimension = Riser Nos = Imposed Load = Total angle subtended = on plan by helix, β Angle of spiral tangent = to horizontal plane , Ø = Int. spiral radius, R i = Ext. spiral radius, R o 380 mm 235 mm 6 3 kN/m² 240 0 25 OUTPUT Helix Height = 3 Helix Width = 1200 Waist thickness = 120 Finishes thickness = 0 Helix Constants (From Charts): b/h = 10.0 R 1 /R 2 = 1.06 k1 = -0.12 k2 = 1.52 k3 = -0.32 OK educe Height! 0 0.9 m 2.1 m m mm mm mm NO Assumption: Ends of helical stair are fixed / continuous with adjacent slab Stair Comfortability Check Threads + 2 x Riser = Rad. of load centre line, R 1 = Rad. of step centre line, R 2 = LOADING LC 1: Dead Load Length of helical stair Perpendicular length to waist top Average thickness of waist Waist s/w Finishes Total Dead load LC 2: Imposed Load BS 6399-1 Imposed Load (kN) Design Load at flight, n 850 mm 1.58 m 1.5 m = = = ANALYSIS a. Midspan and support actions only: Bending moment at midspan, M 0 Bending moment at support, M vs Lateral Shear force across midspan, H 0.220 0.000 1.4 x = = = (Supt. is away from stair steps) Adjust Step Dim.! (550mm < T+2R < 700mm) 0.85 x x 5.28 k 1 nR 2 2 k 3 nR 2 2 k 2 nR 2 = = = = = = 24 22 + 1.6 x m mm mm kN/m² kN/m² kN/m² = = = 3 kN/m² 12.19 kN/m² 14.63 kN/m 3.94949 10.532 33.3513 = = = -3.9 kNm -10.5 kNm 33.4 kN 31.66 kN -3.9 kNm (Mv) 33.4 kN 31.66 kN 7.27 199.87 219.93 5.28 0.00 5.3 3.00 n 10.53 kNm 10.53 kNm 07/2016 Project: ETTEH ARO AND PARTNERS 35, Lawrence Arokodare House Oshuntokun Avenue Ibadan Job Ref: Date: Sheet No: Made by: Checked by: Structure: HELICOIDAL STAIR REF CALCULATIONS b. Detailed analysis: At any pont 'x' along the helix, Angle subtended on plan, β x Angle diff btw 'x' and mid, Θ x = = Vertical Moment, M v Norm. Shear,V n , normal to plan = = 60 60 OUTPUT 0 0 M 0 CosΘ x + H.R 2 Θ x SinΘ x TanØ x - nR 1 2 (1-Co n.R 1 Θ x CosØ x - HSinΘ x SinØ x = = 0.9 kNm 9.7 kN Lateral Moment, M n = M 0 SinΘ x .SinØ x - H.R 2 Θ x TanØ x CosΘ x SinØ x - H.R 2 SinΘ x CosØ x + nR 1 SinØ x (R 1 SinΘ x - R 2 Θ x) = -47.9 kNm = HCosΘx = 16.7 kN Lateral Shear, V h , across plan Torsion, T = (M 0 SinΘ x - H.R 2 Θ x CosΘ x TanØ x + nR 1 2 SinΘ x - nR 1 R 2 Θ x)CosØ x + H.R 2 .SinΘ x SinØ x = -0.10 kNm = -36.4 kN Thrust, N, along helix = -HSinΘ x CosØ x - n.R 1 Θ x SinØ x Table showing actions at every ####### Increment along the helicoidal stair s/n Suppt 1 Mid Span Suppt 2 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Abs. Max. βx Θx Mv Vn Mn Vh T N (deg.) (deg.) (kNm) (kN) (kNm) (kN) (kNm) (kN) 0.00 12.00 24.00 36.00 48.00 60.00 72.00 84.00 96.00 108.00 120.00 132.00 144.00 156.00 168.00 180.00 192.00 204.00 216.00 228.00 240.00 120.00 108.00 96.00 84.00 72.00 60.00 48.00 36.00 24.00 12.00 0.00 12.00 24.00 36.00 48.00 60.00 72.00 84.00 96.00 108.00 120.00 -10.49 -4.76 -1.05 0.90 1.43 0.92 -0.20 -1.55 -2.79 -3.65 -3.95 -3.65 -2.79 -1.55 -0.20 0.92 1.43 0.90 -1.05 -4.76 -10.49 Mv 10.49 1.43 10.49 -47.71 -51.91 -54.22 -54.39 -52.27 -47.85 -41.27 -32.78 -22.75 -11.65 0 -11.65 -22.75 -32.78 -41.27 -47.85 -52.27 -54.39 -54.22 -51.91 -47.71 Mn 54.39 0.00 54.39 -16.68 -10.31 -3.49 3.49 10.31 16.68 22.32 26.98 30.47 32.62 33.35 32.62 30.47 26.98 22.32 16.68 10.31 3.49 -3.49 -10.31 -16.68 Vh 33.35 33.35 16.68 = 31.66 26.08 21.08 16.69 12.92 9.73 7.07 4.88 3.04 1.46 0.00 1.46 3.04 4.88 7.07 9.73 12.92 16.69 21.08 26.08 31.66 Vn 31.66 31.66 0.00 07/2016 2 O.S.A 0.21 -46.6 1.27 -47.2 1.44 -46.4 1.08 -44.4 0.49 -41 -0.10 -36.4 -0.53 -30.6 -0.71 -23.9 -0.65 -16.4 -0.38 -8.33 0.00 0.00 -0.38 -8.33 -0.65 -16.4 -0.71 -23.9 -0.53 -30.6 -0.10 -36.4 0.49 -41 1.08 -44.4 1.44 -46.4 1.27 -47.2 0.21 -46.6 T N 1.44 47.16 1.44 0.00 0.71 47.16